

# Complete Listing of CWP Free Program Self-Documentations

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# Names and Short descriptions of the Codes

CWPROOT = /usr/local/cwp

Mains:

In CWPROOT/src/cwp/main:

- \* CTRLSTRIP - Strip non-graphic characters
- \* DOWNFORT - change Fortran programs to lower case, preserving strings
- \* FCAT - fast cat with 1 read per file
- \* ISATTY - pass on return from isatty(2)
- \* MAXINTS - Compute maximum and minimum sizes for integer types
- \* PAUSE - prompt and wait for user signal to continue
- \* T - time and date for non-military types
- \* UPFORT - change Fortran programs to upper case, preserving strings

In CWPROOT/src/par/main:

- A2B - convert ascii floats to binary
- B2A - convert binary floats to ascii
- CELLAUTO - Two-dimensional CELLular AUTomata
- CSHOTPLOT - convert CSHOT data to files for CWP graphers
- DZDV - determine depth derivative with respect to the velocity "
- FARITH - File ARITHmetic -- perform simple arithmetic with binary files
- FTNSTRIP - convert a file of binary data plus record delimiters created
- FTNUNSTRIP - convert C binary floats to Fortran style floats
- GRM - Generalized Reciprocal refraction analysis for a single layer
- H2B - convert 8 bit hexadecimal floats to binary
- HTI2STIFF - convert HTI parameters alpha, beta, d(V), e(V), gamma
- HUDSON - compute effective parameters of anisotropic solids
- KAPERTURE - generate the k domain of a line scatterer for a seismic array
- LINRORT - linearized P-P, P-S1 and P-S2 reflection coefficients

MAKEVEL - MAKE a VELOCITY function v(x,y,z)

MKPARFILE - convert ascii to par file format

MRAFZWT - Multi-Resolution Analysis of a function F(X,Z) by Wavelet

PDFHISTOGRAM - generate a HISTOGRAM of the Probability Density function

PRPLOT - PRinter PLOT of 1-D arrays f(x1) from a 2-D function f(x1,x2)

RANDVEL3D - Add a random velocity layer (RVL) to a gridded

RAYT2DAN -- P- and SV-wave raytracing in 2D anisotropic media

RAYT2D - traveltimes Tables calculated by 2D paraxial RAY tracing

RECAST - RECAST data type (convert from one data type to another)

REFREALAZIHTI - REAL AZImuthal REFL/transm coeff for HTI media

REFREALVTI - REAL REFL/transm coeff for VTI media and symmetry-axis

REGRID3 - REwrite a [ni3][ni2][ni1] GRID to a [no3][no2][no1] 3-D grid  
 RESAMP - RESAMple the 1st dimension of a 2-dimensional function f(x1,x2)  
 SMOOTH2 --- SMOOTH a uniformly sampled 2d array of data, within a user-  
 SMOOTH3D - 3D grid velocity SMOOTHing by the damped least squares  
 SMOOTHINT2 --- SMOOTH non-uniformly sampled INterfaces, via the damped  
 STIFF2VEL - Transforms 2D elastic stiffnesses to (vp,vs,epsilon,delta)  
 SUBSET - select a SUBSET of the samples from a 3-dimensional file  
 SWAPBYTES - SWAP the BYTES of various data types  
 THOM2HTI - Convert Thompson parameters V\_p0, V\_s0, eps, gamma,  
 THOM2STIFF - convert Thomsen's parameters into (density normalized)  
 TRANSP - TRANSPose an n1 by n2 element matrix  
 TVNMOQC - Check tnmo-vnmo pairs; create t-v column files  
 UNIF2ANISO - generate a 2-D UNIFormly sampled profile of elastic  
 UNIF2 - generate a 2-D UNIFormly sampled velocity profile from a layered  
 UNISAM2 - UNIformly SAMple a 2-D function f(x1,x2)  
 UNISAM - UNIformly SAMple a function y(x) specified as x,y pairs  
 UTMCONV - CONVert longitude and latitude to UTM, and vice versa  
 VEL2STIFF - Transforms VELOCities, densities, and Thomsen or Sayers  
 VELCONV - VELOCITY CONVersion  
 VELPERTAN - Velocity PERTurbation analysis in ANisotropic media to  
 VELPERT - estimate velocity parameter perturbation from covariance  
 VTLVZ -- Velocity as function of Time for Linear V(Z);  
 WKBJ - Compute WKBJ ray theoretic parameters, via finite differencing  
 XY2Z - converts (X,Y)-pairs to spike Z values on a uniform grid  
 Z2XYZ - convert binary floats representing Z-values to ascii

In CWPROOT/src/psplot/main:

PSBBOX - change BoundingBOX of existing PostScript file  
 PSCONTOUR - PostScript CONTOURing of a two-dimensional function f(x1,x2)  
 PSCUBE - PostScript image plot with Legend of a data CUBE  
 PSCONTOUR - PostScript Contour plot of a data CUBE  
 PSEPSI - add an EPSI formatted preview bitmap to an EPS file  
 PSGRAPH - PostScript GRAPHer  
 PSIMAGE - PostScript IMAGE plot of a uniformly-sampled function f(x1,x2)  
 PSLABEL - output PostScript file consisting of a single TEXT string  
 PSMANAGER - printer MANAGER for HP 4MV and HP 5Si Mx Laserjet  
 PSMERGE - MERGE PostScript files  
 PSMOVIE - PostScript MOVIE plot of a uniformly-sampled function f(x1,x2,x3)  
 PSWIGB - PostScript WIGgle-trace plot of f(x1,x2) via Bitmap  
 PSWIGP - PostScript WIGgle-trace plot of f(x1,x2) via Polygons

In CWPROOT/src/xplot/main:

\* LCMAP - List Color Map of root window of default screen

- \* LPROP - List PROPERTIES of root window of default screen of display
- \* SCMAP - set default standard color map (RGB\_DEFAULT\_MAP)
- XCONTOUR - X CONTOUR plot of  $f(x_1, x_2)$  via vector plot call
- \* XESPB - X windows display of Encapsulated PostScript as a single Bitmap
- \* XEPSP - X windows display of Encapsulated PostScript
- XIMAGE - X IMAGE plot of a uniformly-sampled function  $f(x_1, x_2)$
- XPICKER - X wiggle-trace plot of  $f(x_1, x_2)$  via Bitmap with PICKing
- \* XPSP - Display conforming PostScript in an X-window
- XWIGB - X WIGgle-trace plot of  $f(x_1, x_2)$  via Bitmap

In CWPROOT/src/Xtcwp/main:

- XGRAPH - X GRAPHer
- XMOVIE - image one or more frames of a uniformly sampled function  $f(x_1, x_2)$
- XRECTS - plot rectangles on a two-dimensional grid

In CWPROOT/src/Xmcwp/main:

- \* FFTLAB - Motif-X based graphical 1D Fourier Transform

In CWPROOT/src/su/graphics/psplot:

- SUPSCONTOUR - PostScript CONTOUR plot of a segy data set
- SUPSCUBE - PostScript CUBE plot of a segy data set
- SUPSCUBECONTOUR - PostScript CUBE plot of a segy data set
- SUPSGRAPH - PostScript GRAPH plot of a segy data set
- SUPSIMAGE - PostScript IMAGE plot of a segy data set
- SUPSMAX - PostScript of the MAX, min, or absolute max value on each trace
- SUPSMOVIE - PostScript MOVIE plot of a segy data set
- SUPSWIGB - PostScript Bit-mapped WIGgle plot of a segy data set
- SUPSWIGP - PostScript Polygon-filled WIGgle plot of a segy data set

In CWPROOT/src/su/main:

- BHEDTOPAR - convert a Binary tape HEaDer file to PAR file format
- DT1TOSU - Convert ground-penetrating radar data in the Sensors & Software
- LAS2SU - convert las2 format well log curves to su traces
- SEGYCLEAN - zero out unassigned portion of header
- SEGYHDRMOD - replace the text header on a SEG-Y file
- SEGYHDRS - make SEG-Y ascii and binary headers for segywrite
- SEGYREAD - read an SEG-Y tape
- SEGYWRITE - write an SEG-Y tape
- SETBHED - SET the fields in a SEG-Y Binary tape HEaDer file, as would be
- SU3DCHART - plot x-midpoints vs. y-midpoints for 3-D data
- SUABSHW - replace header key word by its absolute value
- SUACOR - auto-correlation

SUADDHEAD - put headers on bare traces and set the tracl and ns fields  
SUADDNOISE - add noise to traces  
SUADDSTATICS - ADD random STATICS on seismic data  
SUALFORD - trace by trace Alford Rotation of shear wave data volumes  
SUAMP - output amp, phase, real or imag trace from  
SUASCII - print non zero header values and data in various formats  
SUATTRIBUTES - instantaneous trace ATTRIBUTES  
SUAZIMUTH - compute trace AZIMUTH, offset, and midpoint coordinates  
SUBFILT - apply Butterworth bandpass filter  
SUCCW - Complex continuous wavelet transform of seismic traces  
SUCDECON - DECONvolution with user-supplied filter by straightforward  
SUCENTSAMP - CENTROID SAMPLE seismic traces  
SUCHART - prepare data for x vs. y plot  
SUCHW - Change Header Word using one or two header word fields  
SUCLIPHEAD - Clip header values

SUCOMMAND - pipe traces having the same key header word to command  
SUCONV - convolution with user-supplied filter  
SUCOUNTKEY - COUNT the number of unique values for a given KEYword.  
SUCVS4FOWLER --compute constant velocity stacks for input to Fowler codes  
SUCWT - generates Continuous Wavelet Transform amplitude, regularity  
SUDATUMFD - 2D zero-offset Finite Difference acoustic wave-equation  
SUDATUMK2DR - Kirchhoff datuming of receivers for 2D prestack data  
SUDATUMK2DS - Kirchhoff datuming of sources for 2D prestack data  
SUDIPDIVCOR - Dip-dependent Divergence (spreading) correction  
SUDIPFILT - DIP--or better--SLOPE Filter in f-k domain  
SUDIVCOR - Divergence (spreading) correction  
SUDIVSTACK - Diversity Stacking using either average power or peak  
SUDMOFK - DMO via F-K domain (log-stretch) method for common-offset gathers  
SUDMOFKCW - converted-wave DMO via F-K domain (log-stretch) method for  
SUDMOTIVZ - DMO for Transeversely Isotropic V(Z) media for common-offset  
SUDMOTX - DMO via T-X domain (Kirchhoff) method for common-offset gathers  
SUDMOVZ - DMO for V(Z) media for common-offset gathers  
SUDUMPTRACE - print selected header values and data.  
SUEA2DF - SU version of (an)elastic anisotropic 2D finite difference  
SUEEDIT - examine segy diskfiles and edit headers  
SUEIPOFI - EIGenimage (SVD) based POLarization FILTER for  
SUFCTANISMOD - Flux-Corrected Transport correction applied to the 2D  
SUFDMOD1 - Finite difference modelling (1-D 1st order) for the  
SUFDMOD2 - Finite-Difference MODeling (2nd order) for acoustic wave equation  
SUFDMOD2\_PML - Finite-Difference MODeling (2nd order) for acoustic wave  
SUFFT - fft real time traces to complex frequency traces  
SUFILTER - applies a zero-phase, sine-squared tapered filter

SUFLIP - flip a data set in various ways  
 SUFNZERO - get Time of First Non-ZERO sample by trace  
 SUFRAC -- take general (fractional) time derivative or integral of  
 SUFXDECON - random noise attenuation by FX-DECONvolution  
 SUGABOR - Outputs a time-frequency representation of seismic data via  
 SUGAIN - apply various types of gain to display traces  
 SUGAUSSTAPER - Multiply traces with gaussian taper  
 SUGAZMIGQ - SU version of Jeno GAZDAG's phase-shift migration  
 SUGET - Connect SU program to file descriptor for input stream.  
 SUGETHW - sugethw writes the values of the selected key words  
 SUGOUPILLAUD - calculate 1D impulse response of  
 SUGOUPILLAUDPO - calculate Primaries-Only impulse response of a lossless  
 SUHARLAN - signal-noise separation by the invertible linear  
 SUHILB - Hilbert transform  
 char \*sdoc[] = {  
 SUHROT - Horizontal ROTation of three-component data  
 SUHTMATH - do unary arithmetic operation on segy traces with  
 SUIFFT - fft complex frequency traces to real time traces  
 SUILOG -- time axis inverse log-stretch of seismic traces  
 SUIIMP2D - generate shot records for a line scatterer  
 SUIIMP3D - generate inplane shot records for a point  
 SUIIMPEDANCE - Convert reflection coefficients to impedances.  
 SUIINTERP - interpolate traces using automatic event picking  
 SUIINTERPFWOWER - interpolate output image from constant velocity panels  
 SUIINTVEL - convert stacking velocity model to interval velocity model  
 SUIINVXZCO - Seismic INVersion of Common Offset data for a smooth  
 SUIINVZCO3D - Seismic INVersion of Common Offset data with V(Z) velocity  
 SUK1K2FILTER - symmetric box-like K-domain filter defined by the  
 SUKDMIG2D - Kirchhoff Depth Migration of 2D poststack/prestack data  
 SUKDMIG3D - Kirchhoff Depth Migration of 3D poststack/prestack data  
 SUKDSYN2D - Kirchhoff Depth SYNthesis of 2D seismic data from a  
 SUKEYCOUNT - sukeycount writes a count of a selected key  
 SUKFILTER - radially symmetric K-domain, sin<sup>2</sup>-tapered, polygonal  
 SUKFRAC - apply FRACTIONal powers of  $i|k|$  to data, with phase shift  
 SUKILL - zero out traces  
 SUKTMIG2D - prestack time migration of a common-offset section with  
 SULOG -- time axis log-stretch of seismic traces  
 char \*sdoc[] = {  
 SUMEAN - get the mean values of data traces ",  
 SUMEDIAN - MEDIAN filter about a user-defined polygonal curve with  
 SUMIGFD - 45-90 degree Finite difference depth migration for  
 SUMIGFFD - Fourier finite difference depth migration for  
 SUMIGGBZOAN - MIGration via Gaussian beams ANisotropic media (P-wave)

SUMIGGBZO - MIGration via Gaussian Beams of Zero-Offset SU data  
SUMIGPREFD --- The 2-D prestack common-shot 45-90 degree  
SUMIGPREFFD - The 2-D prestack common-shot Fourier finite-difference  
SUMIGPREPSPI --- The 2-D PREstack commom-shot Phase-Shift-Plus  
SUMIGPRES - The 2-D prestack common-shot split-step Fourier ",  
SUMIGPS - MIGration by Phase Shift with turning rays  
SUMIGPSPI - Gazdag's phase-shift plus interpolation depth migration  
SUMIGPSTI - MIGration by Phase Shift for TI media with turning rays  
SUMIGSPLIT - Split-step depth migration for zero-offset data.  
SUMIGTK - MIGration via T-K domain method for common-midpoint stacked data  
SUMIGTOPO2D - Kirchhoff Depth Migration of 2D postack/prestack data  
SUMIX - compute weighted moving average (trace MIX) on a panel  
SUMIXGATHERS - mix two gathers  
SUMUTE - mute above (or below) a user-defined polygonal curve with ",  
SUNAN - remove NaNs & Infs from the input stream  
SUNHMOSPIKE - generates SPIKE test data set with a choice of several  
SUNMO - NMO for an arbitrary velocity function of time and CDP  
SUNORMALIZE - Trace balancing by rms, max, or median ",  
SUNULL - create null (all zeroes) traces  
SUOEXT - smaller Offset EXTrapolation via Offset Continuation  
SUOLDTONEW - convert existing su data to xdr format  
SUOP2 - do a binary operation on two data sets  
SUOP - do unary arithmetic operation on segys  
SUPACK1 - pack segy trace data into chars  
SUPACK2 - pack segy trace data into 2 byte shorts  
SUPASTE - paste existing SEG Y headers on existing data  
SUPEF - Wiener predictive error filtering  
SUPERMUTE - permute or transpose a 3d datacube  
SUPGC - Programmed Gain Control--apply agc like function  
SUPICKAMP - pick amplitudes within user defined and resampled window  
SUPLANE - create common offset data file with up to 3 planes  
SUPOFILT - Polarization FILTer for three-component data  
SUPOLAR - POLarization analysis of three-component data  
SUPUT - Connect SU program to file descriptor for output stream.  
SUPWS - Phase stack or phase-weighted stack (PWS) of adjacent traces  
SUQUANTILE - display some quantiles or ranks of a data set  
SURADON - compute forward or reverse Radon transform or remove multiples  
SURAMP - Linearly taper the start and/or end of traces to zero.  
SURANDSPIKE - make a small data set of RANDom SPIKEs  
SURANDSTAT - Add RANDom time shifts STATIC errors to seismic traces  
SURANGE - get max and min values for non-zero header entries  
SURECIP - sum opposing offsets in prepared data (see below)  
SUREDUCE - convert traces to display in reduced time ",

SUREFCON - Convolution of user-supplied Forward and Reverse  
 SURELANAN - REsidual-moveout semblance ANalysis for ANisotropic media  
 SURELAN - compute residual-moveout semblance for cdp gathers based  
 SURESAMP - Resample in time  
 SURESSTAT - Surface consistent source and receiver statics calculation  
 SUSEHW - Set the value the Header Word denoting trace number within  
 SUSHAPE - Wiener shaping filter  
 SUSHIFT - shifted/windowed traces in time  
 SUSHW - Set one or more Header Words using trace number, mod and  
 SUSORT - sort on any segy header keywords  
 SUSORTY - make a small 2-D common shot off-end  
 SUSPECFK - F-K Fourier SPEcTrum of data set  
 SUSPECFX - Fourier SPEcTrum (T -> F) of traces  
 SUSPECK1K2 - 2D (K1,K2) Fourier SPEcTrum of (x1,x2) data set  
 SUSPIKE - make a small spike data set  
 SUSPLIT - Split traces into different output files by keyword value  
 SUSTACK - stack adjacent traces having the same key header word  
 SUSTATIC - Elevation static corrections, apply corrections from  
 SUSTATICRRS - Elevation STATIC corrections, apply corrections from  
 SUSTKVEL - convert constant dip layer interval velocity model to the  
 SUSTOLT - Stolt migration for stacked data or common-offset gathers  
 SUSTRIP - remove the SEGy headers from the traces  
 SUSWAPBYTES - SWAP the BYTES in SU data to convert data from big endian  
 SUSYN CZ - SYNthetic seismograms for piecewise constant V(Z) function  
 SUSYNLV - SYNthetic seismograms for Linear Velocity function  
 SUSYNLV CW - SYNthetic seismograms for Linear Velocity function  
 SUSYNLVFTI - SYNthetic seismograms for Linear Velocity function in a  
 SUSYNVXZ - SYNthetic seismograms of common offset V(X,Z) media via  
 SUSYNVXZCS - SYNthetic seismograms of common shot in V(X,Z) media via  
 SUTAB - print non zero header values and data for non-graphic terminals  
 SUTAPER - Taper the edge traces of a data panel to zero.  
 SUTAUP - forwarded and inverse T-X and F-K global slant stacks  
 SUTIFOWLER VTI constant velocity prestack time migration  
 SUTIHAI LEMO - TI Hale Dip MoveOut (based on Hale's PhD thesis)  
 SUTIVEL - SU Transversely Isotropic velocity table builder  
 SUTSQ -- time axis time-squared stretch of seismic traces  
 SUTTOZ - resample from time to depth  
 SUTVBAND - time-variant bandpass filter (sine-squared taper)  
 SUTXTAPER - TAPER in (X,T) the edges of a data panel to zero.  
 SUUNPACK1 - unpack segy trace data from chars to floats  
 SUUNPACK2 - unpack segy trace data from shorts to floats  
 SUUTM - UTM projection of longitude and latitude in SU trace headers  
 SUVCAT - append one data set to another, with or without an ",

SUVEL2DF - compute stacking VELOCITY semblance for a single time in  
SUVELAN - compute stacking velocity semblance for cdp gathers  
SUVELAN\_NCCS - compute stacking VELOCITY panel for cdp gathers  
SUVELAN\_NSEL - compute stacking VELOCITY panel for cdp gathers  
SUVELAN\_UCCS - compute stacking VELOCITY panel for cdp gathers  
SUVELAN\_USEL - compute stacking velocity panel for cdp gathers  
SUVIBRO - Generates a Vibroseis sweep (linear, linear-segment,  
SUVLENGTH - Adjust variable length traces to common length  
SUWAVEFORM - generate a seismic wavelet  
SUWEIGHT - weight traces by header parameter, such as offset  
SUWELLRF - convert WELL log depth, velocity, density data into a  
SUWIND - window traces by key word  
SUWINDPOLY - WINDOW data to extract traces on or within a respective  
SUXCOR - correlation with user-supplied filter  
SUXEDIT - examine segy diskfiles and edit headers  
SUZERO -- zero-out (or set constant) data within a time window  
SUZTOT - resample from depth to time

In CWPROOT/src/su/graphics/psplot:

SUPSCONTOUR - PostScript CONTOUR plot of a segy data set  
SUPSCUBE - PostScript CUBE plot of a segy data set  
SUPSCUBECONTOUR - PostScript CUBE plot of a segy data set  
SUPSGRAPH - PostScript GRAPH plot of a segy data set  
SUPSIMAGE - PostScript IMAGE plot of a segy data set  
SUPSMAX - PostScript of the MAX, min, or absolute max value on each trace  
SUPSMOVIE - PostScript MOVIE plot of a segy data set  
SUPSWIGB - PostScript Bit-mapped WIGgle plot of a segy data set  
SUPSWIGP - PostScript Polygon-filled WIGgle plot of a segy data set

In CWPROOT/src/su/graphics/xplot:

SUXCONTOUR - X CONTOUR plot of Seismic UNIX tracefile via vector plot call  
SUXGRAPH - X-windows GRAPH plot of a segy data set  
SUXIMAGE - X-windows IMAGE plot of a segy data set  
SUXMAX - X-windows graph of the MAX, min, or absolute max value on  
SUXMOVIE - X MOVIE plot of a 2D or 3D segy data set  
SUXPICKER - X-windows WIGgle plot PICKER of a segy data set  
SUXWIGB - X-windows Bit-mapped WIGgle plot of a segy data set

In CWPROOT/src/tri/main:

GBBEAM - Gaussian beam synthetic seismograms for a sloth model  
NORMRAY - dynamic ray tracing for normal incidence rays in a sloth model  
TRI2UNI - convert a TRIangulated model to UNIformly sampled model  
TRIMODEL - make a triangulated sloth ( $1/\text{velocity}^2$ ) model

TRIRAY - dynamic RAY tracing for a TRIangulated sloth model  
TRISEIS - Gaussian beam synthetic seismograms for a sloth model  
UNI2TRI - convert UNIformly sampled model to a TRIangulated model

In CWROOT/src/xtri:

SXPLOT - X Window plot a triangulated sloth function  $s(x_1, x_2)$

In CWROOT/src/tri/graphics/psplot:

SPSPLOT - plot a triangulated sloth function  $s(x, z)$  via PostScript

In CWROOT/src/comp/dct/main:

DCTCOMP - Compression by Discrete Cosine Transform

DCTUNCOMP - Discrete Cosine Transform Uncompression

ENTROPY - compute the ENTROPY of a signal

WPTCOMP - Compression by Wavelet Packet Compression

WPTUNCOMP - Uncompress WPT compressed data

WTCOMP - Compression by Wavelet Transform

WTUNCOMP - UNCOMPRESS of WT compressed data

In CWROOT/src/comp/dwpt/1d/main:

WPC1COMP2 --- COMPRESS a 2D seismic section trace-by-trace using

WPC1UNCOMP2 --- UNCOMPRESS a 2D seismic section, which has been

In CWROOT/src/comp/dwpt/2d/main:

WPCCOMPRESS --- COMPRESS a 2D section using Wavelet Packets

WPCUNCOMPRESS --- UNCOMPRESS a 2D section

Shells:

In CWROOT/src/cwp/shell:

# ARGV - give examples of dereferencing char \*\*argv

# COPYRIGHT - insert CSM COPYRIGHT lines at top of files in working directory

# CPALL , RCPALL - for local and remote directory tree/file transfer

# CWPFind - look for files with patterns in CWROOT/src/cwp/lib

# DIRTREE - show DIRectory TREE

# FILETYPE - list all files of given type

# Grep - recursively call egrep in pwd

# NEWCASE - Changes the case of all the filenames in a directory, dir

# OVERWRITE - copy stdin to stdout after EOF

# PRECEDENCE - give table of C precedences from Kernighan and Ritchie

# REPLACE - REPLACE string1 with string2 in files

# THIS\_YEAR - print the current year

# TIME\_NOW - prints time in ZULU format with no spaces

```
# TODAYS_DATE - prints today's date in ZULU format with no spaces
# USERNAMES - get list of all login names
# VARLIST - list variables used in a Fortran program
# WEEKDAY - prints today's WEEKDAY designation
# ZAP - kill processes by name
```

In CWPROOT/src/par/shell:

```
# GENDOCS - generate complete list of selfdocs in latex form
# STRIPTOTXT - put files from $CWPROOT/src/doc/Stripped into a new
# UPDATEDOCALL - put self-docs in ../doc/Stripped
# UPDATEDOC - put self-docs in ../doc/Stripped and ../doc/Headers
# UPDATEHEAD - update ../doc/Headers/Headers.all
```

In CWPROOT/src/psplot/shell:

```
# MERGE2 - put 2 standard size PostScript figures on one page
# MERGE4 - put 4 standard size PostScript plots on one page
```

In CWPROOT/src/su/shell:

```
# LOOKPAR - show getpar lines in SU code with defines evaluated
# MAXDIFF - find absolute maximum difference in two segy data sets
# RECIP - sum opposing (reciprocal) offsets in cdp sorted data
# RMAXDIFF - find percentage maximum difference in two segy data sets
# SUAGC - perform agc on SU data
# SUBAND - Trapezoid-like Sin squared tapered Bandpass filter via SUFILTER
# SUDIFF, SUSUM, SUPROD, SUQUO, SUPTDIFF, SUPTSUM,
# SUDOC - get DOC listing for code
# SUENV - Instantaneous amplitude, frequency, and phase via: SUATTRIBUTES
# SUFIND - get info from self-docs
# SUFIND - get info from self-docs
# SUGENDOCS - generate complete list of selfdocs in latex form
# SUHELP - list the CWP/SU programs and shells
# SUKEYWORD -- guide to SU keywords in segy.h
# SUNAME - get name line from self-docs
# UNGLITCH - zonk outliers in data
```

Libs:

In CWPROOT/src/cwp/lib:

```
ABEL - Functions to compute the discrete ABEL transform:
AIRY - Approximate the Airy functions  $A_i(x)$ ,  $B_i(x)$  and their respective
ALLOC - Allocate and free multi-dimensional arrays
ANTIALIAS - Butterworth anti-aliasing filter
AXB - Functions to solve a linear system of equations  $Ax=b$  by LU
```

BIGMATRIX - Functions to manipulate 2-dimensional matrices that are too big  
 BUTTERWORTH - Functions to design and apply Butterworth filters:  
 COMPLEX - Functions to manipulate complex numbers  
 COMPLEXD - Functions to manipulate double-precision complex numbers  
 COMPLEXF - Subroutines to perform operations on complex numbers.  
 COMPLEXFD - Subroutines to perform operations on double complex numbers.  
 CONVOLUTION - Compute  $z = x$  convolved with  $y$   
 CUBICSPLINE - Functions to compute CUBIC SPLINE interpolation coefficients  
 DBLAS - Double precision Basic Linear Algebra subroutines  
 DGE - Double precision Gaussian Elimination matrix subroutines adapted  
 PFAFFT - Functions to perform Prime Factor (PFA) FFT's, in place  
 \*CWP\_Exit - exit subroutine for CWP/SU codes  
 FRANNOR - functions to generate a pseudo-random float normally distributed  
 FRANUNI - Functions to generate a pseudo-random float uniformly distributed  
 HANKEL - Functions to compute discrete Hankel transforms  
 HILBERT - Compute Hilbert transform  $y$  of  $x$   
 HOLBERG1D - Compute coefficients of Holberg's 1st derivative filter  
 INTCUB - evaluate  $y(x)$ ,  $y'(x)$ ,  $y''(x)$ , ... via piecewise cubic interpolation  
 INTL2B - bilinear interpolation of a 2-D array of bytes  
 INTLIN - evaluate  $y(x)$  via linear interpolation of  $y(x[0])$ ,  $y(x[1])$ , ...  
 INTLINC - evaluate complex  $y(x)$  via linear interpolation of  $y(x[0])$ ,  $y(x[1])$ , ...  
 INTSINC8 - Functions to interpolate uniformly-sampled data via 8-coeff. sinc  
 INTTABLE8 - Interpolation of a uniformly-sampled complex function  $y(x)$   
 LINEAR\_REGRESSION - Compute linear regression of  $(y_1, y_2, \dots, y_n)$  against  
 MKDIFF - Make an  $n$ -th order DIFFerentiator via Taylor's series method.  
 MKHDIFF - Compute filter approximating the bandlimited Half-DIFFerentiator.  
 MKSINC - Compute least-squares optimal sinc interpolation coefficients.  
 MNEWT - Solve non-linear system of equations  $f(x) = 0$  via Newton's method  
 PFAFFT - Functions to perform Prime Factor (PFA) FFT's, in place  
 POLAR - Functions to map data in rectangular coordinates to polar and vice versa  
 PRINTERPLOT - Functions to make a printer plot of a 1-dimensional array  
 QUEST - Functions to ESTimate Quantiles:  
 RESSINC8 - Functions to resample uniformly-sampled data via 8-coefficient sinc  
 RFWTVA - Rasterize a Float array as Wiggle-Trace-Variable-Area.  
 RFWTVAINT - Rasterize a Float array as Wiggle-Trace-Variable-Area, with  
 SBLAS - Single precision Basic Linear Algebra Subroutines  
 SCAXIS - compute a readable scale for use in plotting axes  
 SGA - Single precision general matrix functions adapted from LINPACK FORTRAN:  
 SHFS8R - Shift a uniformly-sampled real-valued function  $y(x)$  via  
 SINC - Return SINC( $x$ ) for as floats or as doubles  
 SORT - Functions to sort arrays of data or arrays of indices  
 SQR - Single precision QR decomposition functions adapted from LINPACK FORTRAN:  
 STOEP - Functions to solve a symmetric Toeplitz linear system of equations

STRSTUFF -- STRing manipulation subs  
SWAPBYTE - Functions to SWAP the BYTE order of binary data  
SYMEIGEN - Functions solving the eigenvalue problem for symmetric matrices  
TEMPORARY\_FILENAME - Creates a file name in a user-specified directory.  
TRIDIAGONAL - Functions to solve tridiagonal systems of equations  $Tu=r$  for  $u$ .  
VANDERMONDE - Functions to solve Vandermonde system of equations  $Vx=b$   
WAVEFORMS Subroutines to define some wavelets for modeling of seismic  
XCOR - Compute  $z = x$  cross-correlated with  $y$   
XINDEX - determine index of  $x$  with respect to an array of  $x$  values  
YCLIP - Clip a function  $y(x)$  defined by linear interpolation of the  
YXTOXY - Compute a regularly-sampled, monotonically increasing function  $x(y)$   
ZASC - routine to translate  $n$ characters from ebcdic to ascii  
ZEBC - routine to translate  $n$ characters from ascii to ebcdic

In CWPROOT/src/par/lib:

ATOPKGE - convert ascii to arithmetic and with error checking  
DOCPKGE - Function to implement the CWP self-documentation facility  
EALLOC - Allocate and free multi-dimensional arrays with error reports.  
ERRPKGE - routines for reporting errors  
FILESTAT - Functions to determine and output the type of a file from file  
GETPARS - Functions to GET PARAMeterS from the command line. Numeric  
LINCOEFF - subroutines to create linearized reflection coefficients  
MINFUNC - routines to MINimize FUNCtions  
MODELING - Seismic Modeling Subroutines for SUSYNLV and clones  
REFANISO - Reflection coefficients for Anisotropic media  
RKE - integrate a system of  $n$ -first order ordinary differential equations  
SMOOTH - Functions to compute smoothing of 1-D or 2-D input data  
SUBCALLS - routines for system functions with error checking  
SYSCALLS - routines for SYSTEM CALLs with error checking  
TAUP - Functions to perform forward and inverse taup transforms (radon or  
UPWEIK - Upwind Finite Difference Eikonal Solver  
VND - large out-of-core multidimensional block matrix transpose  
WTLIB - Functions for wavelet transforms

In CWPROOT/src/su/lib:

fgethdr - get segy tape identification headers from the file by file pointer  
FGETTR - Routines to get an SU trace from a file  
FPUTTR - Routines to put an SU trace to a file  
HDRPKGE - routines to access the SEGy header via the hdr structure.  
TABPLOT - TABPLOT selected sample points on selected trace  
VALPKGE - routines to handle variables of type Value

In CWPROOT/src/psplot/lib:

BASIC - Basic C function interface to PostScript  
PSAXESBOX3 - Functions draw an axes box via PostScript, estimate bounding box  
PSAXESBOX - Functions to draw PostScript axes and estimate bounding box  
PSCAXESBOX - Draw an axes box for cube via PostScript  
PSCONTOUR - draw contour of a two-dimensional array via PostScript  
PSDRAWCURVE - Functions to draw a curve from a set of points  
PSLEGENDBOX - Functions to draw PostScript axes and estimate bounding box  
PSWIGGLE - draw wiggle-trace with (optional) area-fill via PostScript

In CWPROOT/src/xplot/lib:

AXESBOX - Functions to draw axes in X-windows graphics  
COLORMAP - Functions to manipulate X colormaps:  
DRAWCURVE - Functions to draw a curve from a set of points  
IMAGE - Function for making the image in an X-windows image plot  
LEGENDBOX - draw a labeled axes box for a legend (i.e. colorscale)  
RUBBERBOX - Function to draw a rubberband box in X-windows plots  
WINDOW - Function to create a window in X-windows graphics  
XCONTOUR - draw contour of a two-dimensional array via X vectorplot calls

In CWPROOT/src/Xtcwp/lib:

AXES - the Axes Widget  
COLORMAP - Functions to manipulate X colormaps:  
FX - Functions to support floating point coordinates in X  
MISC - Miscellaneous X-Toolkit functions  
RESCONV - general purpose resource type converters  
RUBBERBOX - Function to draw a rubberband box in X-windows plots

In CWPROOT/src/Xmcpw/lib:

RADIOBUTTONS - convenience functions creating and using radio buttons  
SAMPLES - Motif-based Graphics Functions

In CWPROOT/src/tri/lib:

CHECK - CHECK triangulated models  
CIRCUM - define CIRCUMcircles for Delaunay triangulation  
COLINEAR - determine if edges or vertecies are COLINEAR in triangulated  
CREATE - create model, boundary edge triangles, edge face, edge vertex, add  
DELETE - DELETE vertex, model, edge, or boundary edge from triangulated model  
DTE - Distance to Edge  
FIXEDGES - FIX or unFIX EDGES between verticies  
INSIDE - Is a vertex or point inside a circum circle, etc. of a triangulated  
NEAREST - NEAREST edge or vertex in triangulated model  
PROJECT - project to edge in triangulated model  
READWRITE - READ or WRITE a triangulated model

In CWPROOT/src/cwputils:

CPUSEC - return cpu time (UNIX user time) in seconds

CPUTIME - return cpu time (UNIX user time) in seconds using ANSI C built-ins

WALLSEC - Functions to time processes

WALLTIME - Function to show time a process takes to run

In CWPROOT/src/comp/dct/lib:

BUFFALLOC - routines to ALLOCate/initialize and free BUFFers

DCT1 - 1D Discreet Cosine Transform Routines

DCT2 - 2D Discrete Cosine Transform Routines

DCTALLOC - ALLOCate space for transform tables for 1D DCT

GETFILTER - GET wavelet FILTER type

HUFFMAN - Routines for in memory Huffman coding/decoding

LCT1 - functions used to perform the 1D Local Cosine Transform (LCT)

LPRED - Lateral Prediction of Several Plane Waves

PENCODING - Routines to en/decode the quantized integers for lossless

QUANT - QUANTization routines

RLE - routines for in memory silence en/decoding

WAVEPACK1 - 1D wavelet packet transform

WAVEPACK2 - 2D Wavelet PACKet transform

WAVEPACK1 - 1D wavelet packet transform

WAVETRANS2 - 2D wavelet transform by tensor-product of two 1D transforms

In CWPROOT/src/comp/dct/libutil:

In CWPROOT/src/comp/dwpt/1d/lib:

WBUFFALLOC - routines to allocate/initialize and free buffers in wavelet

WPC1 - routines for compress a single seismic trace using wavelet packets

WPC1CODING - routines for encoding the integer symbols in 1D WPC

wpc1Quant - quantize

WPC1TRANS - routines to perform a 1D wavelet packet transform

In CWPROOT/src/comp/dwpt/2d/lib:

WPCBUFFAL - routines to allocate/initialize and free buffers

WPC - routines for compress a 2D seismic section using wavelet packets

WPCCODING - Routines for in memory coding of the quantized coeffieicients

WPCENDEC - Wavelet Packet Coding, Encoding and Decoding routines

WPCHUFF -Routines for in memory Huffman coding/decoding

WPCPACK2 - routine to perform a 2D wavelet packet transform

WPCQUANT - quantization routines for WPC

WPCSILENCE - routines for in memory silence en/decoding

To search on a program name fragment, type:  
suname name\_fragment <CR>

For more information type: program\_name <CR>

Items labeled with an asterisk (\*) are C programs that may  
or may not have this self documentation feature.

Items labeled with a pound sign (#) are shell scripts that may,  
or may not have the self documentation feature.

## Self Documentations

Mains:

-----  
CTRLSTRIP - Strip non-graphic characters

ctrlstrip <dirtyfile >cleanfile

-----  
DOWNFORT - change Fortran programs to lower case, preserving strings

Usage: downfort < infile.f > outfile.f

Credits:

Brian Sumner c. 1984

-----  
FCAT - fast cat with 1 read per file

Usage: fcat file1 file2 ... > file3

Credits:

Shuki

This program belongs to the Center for Wave Phenomena  
Colorado School of Mines

/

-----  
ISATTY - pass on return from isatty(2)

Usage: isatty filedes

See: man isatty for further information

Credits:  
CWP: Shuki

This program belongs to the Center for Wave Phenomena  
Colorado School of Mines

-----  
MAXINTS - Compute maximum and minimum sizes for integer types  
(quick and dirty)

Usage: maxints

Note: These results will be in limits.h on most systems

Credits:  
CWP: Jack K. Cohen

This program belongs to the Center for Wave Phenomena  
Colorado School of Mines

-----  
PAUSE - prompt and wait for user signal to continue

Usage: pause [optional arguments]

Note:  
Default prompt is "press return key to continue" which is \*evoked  
by calling pause with no arguments. The word,  
"continue", is replaced by any optional arguments handed to pause.  
Thus, the command "pause do plot" will evoke the prompt,  
"press return key to do plot".

-----  
T - time and date for non-military types

Usage: t

Credit: Jack

-----  
UPFORT - change Fortran programs to upper case, preserving strings

Usage: upfort < infile.f > outfile.f

Reverse of: downfort

A2B - convert ascii floats to binary

```
a2b <stdin >stdout outpar=/dev/null
```

Required parameters:

none

Optional parameters:

n1=2 floats per line in input file

outpar=/dev/null output parameter file, contains the number of lines (n=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Credits:

CWP: Jack K. Cohen, Dave Hale

Hans Ecke 2002: Replaced line-wise file reading via gets() with float-wise reading via fscanf(). This makes it much more robust: it does not impose a specific structure on the input file.

B2A - convert binary floats to ascii

b2a <stdin >stdout

Required parameters:

none

Optional parameters:

n1=2 floats per line in output file

outpar=/dev/tty output parameter file, contains the  
number of lines (n=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Credits:

CWP: Jack K. Cohen

## CELLAUTO - Two-dimensional CELLular AUTOmata

```
cellauto > stdout [optional params]
```

### Optional Parameters:

n1=500 output dimensions of image (n1 x n1 pixels)

rule=30 CA rule (Wolfram classification)

Others: 54,60,62,90,94,102,110,122,126

150,158,182,188,190,220,222,225,226,250

fill=0 Don't fill image (=1 fill image)

f0=330 fill zero values with f0

f1=3000 fill non-zero values with f1

ic=1 initial condition for centered unit value at t=0

= 2 for multiple random units

nc=20 number of random units (if ic=2)

tc=1 random initial units at t=0 (if ic=2)

= 2 for initial units at random (t,x)

verbose=0 silent operation

= 1 echos 'porosity' of the CA in bottom half of image

seed=from\_clock random number seed (integer)

### Notes:

This program generates a select set of Wolframs fundamental cellular automata. This may be useful for constructing rough, vuggy wavespeed profiles. The numbering scheme follows Stephen Wolfram's.

### Example:

```
cellauto rule=110 ic=2 nc=100 fill=1 f1=3000 | ximage n1=500 nx=500 &
```

Here we simulate a complex near surface with air-filled vugs in hard country rock, with smoothing applied via smooth2

```
cellauto rule=110 ic=2 nc=100 fill=1 f1=3000 n1=500 |  
smooth2 n1=500 n2=500 r1=5 r2=5 > vfile.bin
```

### Credits:

UHouston: Chris Liner

Trace header fields accessed: ns

Trace header fields modified: ns and delrt

CSHOTPLOT - convert CSHOT data to files for CWP graphers

cshotplot <cshot1plot [optional parameter file]

Required parameters:

none

Optional parameter:

outpar=/dev/tty output parameter file, contains:  
number of plots (n2=)  
points in each plot (n1=)  
colors for plots (linecolor=)

DZDV - determine depth derivative with respect to the velocity ", parameter,  $dz/dv$ , by ratios of migrated data with the primary amplitude and those with the extra amplitude

dzdv <infile afile=afile dfile=dfile>outfile [parameters]

Required Parameters:

infile= input of common image gathers with primary amplitude  
afile= input of common image gathers with extra amplitude  
dfile= output of imaged depths in common image gathers  
outfile= output of  $dz/dv$  at the imaged points  
nx= number of migrated traces  
nz= number of points in migrated traces  
dx= horizontal spacing of migrated trace  
dz= vertical spacing of output trace  
fx= x-coordinate of first migrated trace  
fz= z-coordinate of first point in migrated trace  
off0= first offset in common image gathers  
noff= number of offsets in common image gathers  
doff= offset increment in common image gathers  
cip=x1,z1,r1,..., cip=xn,zn,rn description of input CIGS  
x x-value of a common image point  
z z-value of a common image point at zero offset  
r r-parameter in a common image gather

Optional Parameters:

nxw, nzw=0 window widths along x- and z-directions in which points are contributed in solving  $dz/dv$ .

Notes:

This program is used as part of the velocity analysis technique developed by Zhenyue Liu, CWP:1995.

Author: CWP: Zhenyue Liu, 1995

Reference:

Liu, Z. 1995, "Migration Velocity Analysis", Ph.D. Thesis, Colorado School of Mines, CWP report #168.

FARITH - File ARITHmetic -- perform simple arithmetic with binary files

farith <infile >outfile [optional parameters]

Optional Parameters:

in=stdin input file

out=stdout output file

in2= second input file (required for binary operations)

if it can't be opened as a file, it might be a scalar

n=size\_of\_in, fastest dimension (used only for op=cartprod is set)

isig= index at which signum function acts (used only for

op=signum)

scale= value to scale in by, used only for op=scale)

bias= value to bias in by, used only for op=bias)

op=noop noop for out = in

neg for out = -in

abs for out = abs(in)

scale for out = in \*scale

bias for out = in + bias

exp for out = exp(in)

sin for out = sin(in)

cos for out = cos(in)

log for out = log(in)

sqrt for out = (signed) sqrt(in)

sqr for out = in\*in

degrad for out = in\*PI/180

raddeg for out = in\*180/PI

pinv for out = (punctuated) 1 / in

pinvsqr for out = (punctuated) 1 /in\*in

pinvsqrt for out = (punctuated signed) 1 /sqrt(in)

add for out = in + in2

sub for out = in - in2

mul for out = in \* in2

div for out = in / in2

cartprod for out = in x in2

requires: n=size\_of\_in, fastest dimension in output

signum for out[i] = in[i] for i< isig and

= -in[i] for i>= isig

requires: isig=point where signum function acts

Seismic operations:

slowp for out = 1/in - 1/in2 Slowness perturbation

slothp for out = 1/in^2 - 1/in2^2 Sloth perturbation

Notes:

op=sqrt takes  $\sqrt{x}$  for  $x \geq 0$  and  $-\sqrt{\text{ABS}(x)}$  for  $x < 0$  (signed sqrt)

op=pinv takes  $y=1/x$  for  $x \neq 0$ , if  $x=0$  then  $y=0$ . (punctuated inverse)

The seismic operations assume that in and in2 are wavespeed profiles. "Slowness" is  $1/\text{wavespeed}$  and "sloth" is  $1/\text{wavespeed}^2$ . Use "suop" and "suop2" to perform unary and binary operations on data in the SU (SEG Y trace) format.

The options "pinvsq" and "pinvsqrt" are also useful for seismic computations involving converting velocity to sloth and vice versa.

The option "cartprod" (cartesian product) requires also that the parameter n=size\_of\_in be set. This will be the fastest dimension of the rectangular array that is output.

The option "signum" causes a flip in sign for all values with index greater than "isig" (really  $-1 * \text{signum}(\text{index})$ ).

For file operations on SU format files, please use: suop, suop2

AUTHOR: Dave Hale, Colorado School of Mines, 07/07/89  
Zhaobo Meng added scale and cartprod, 10/01/96  
Zhaobo Meng added signum, 9 May 1997  
Tony Kocurko added scalar operations, August 1997  
John Stockwell added bias option 4 August 2004

FTNSTRIP - convert a file of binary data plus record delimiters created  
via Fortran to a file containing only binary values (as created via C)

```
ftnstrip <ftn_data >c_data
```

Caveat: this code assumes the conventional Fortran format of header  
and trailer integer containing the number of byte in the  
record. This is overwhelmingly common, but not universal.

Credits:

CWP: Jack K. Cohen

FTNUNSTRIP - convert C binary floats to Fortran style floats

ftnunstrip <stdin >stdout

Required parameters:

none

Optional parameters:

n1=1 floats per line in output file

outpar=/dev/tty output parameter file, contains the  
number of lines (n=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Notes: This program assumes that the record length is constant  
throughout the input and output files.

In fortran code reading these floats, the following implied  
do loop syntax would be used:

```
DO i=1,n2
    READ (10) (someARRAY(j), j=1,n1)
END DO
```

Here n1 is the number of samples per record, n2 is the number  
of records, 10 is some default file (fort.10, for example), and  
someArray(j) is an array dimensioned to size n1

Credits:

CWP: John Stockwell, Feb 1998,

based on ftnstrip by: Jack K. Cohen

GRM - Generalized Reciprocal refraction analysis for a single layer

grm <stdin >stdout [parameters]

Required parameters:

nt= Number of arrival time pairs

dx= Geophone spacing (m)

v0= Velocity in weathering layer (m/s)

abtime= If set to 0, use last time as a-b, else give time (ms)

Optional parameters:

XY= Value of XY if you want to override the optimum XY algorithm in the program. If it is not an integer multiple of dx, then it will be converted to the closest one.

XYmax Maximum offset distance allowed when searching for optimum XY (m) (Default is 2\*dx\*10)

depthres Size of increment in x during vertical depth search(m) (Default is 0.5m)

Input file:

4 column ASCII - x,y, forward time, reverse time

Output file:

1) XYoptimum

2) apparent refractor velocity

3) x, y, z(x,y), y-z(x,y)

z(x,y) = calculated (GRM) depth below (x y)

y-z(x,y) = GRM depth subtracted from y - absolute depth

.....

4) x, y, d(x,y), y-d(x,y), (error)

d(x,y) = dip corrected depth estimate below (x,y)

y-d(x,y) = dip corrected absolute depth

error = estimated error in depth due only to the inexact matching of tangents to arcs in dip estimate.

If the XY calculation is bypassed and XY specified, the values used will precede 1) above. XYoptimum will still be calculated and displayed for reference.

Notes:

Uses average refractor velocity along interface.

Credits:

CWP: Steven D. Sheaffer

D. Palmer, "The Generalized Reciprocal Method of Seismic Refraction Interpretation", SEG, 1982.

H2B - convert 8 bit hexadecimal floats to binary

```
h2b <stdin >stdout outpar=/dev/tty
```

Required parameters:

none

Optional parameters:

outpar=/dev/tty output parameter file, contains the  
number of lines (n=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Note: this code may be used to recover binary data from PostScript  
bitmaps. To do this, strip away all parts of the PSfile that  
are not the actual hexadecimal bitmap and run through h2b.

Note: that the binary file may need to be transposed using  
"transp" to appear to be the same as input data.

Note: output will be floats with the values 0-255

HTI2STIFF - convert HTI parameters alpha, beta, d(V), e(V), gamma into stiffness tensor

hti2stiff [optional parameter] (output is to outpar)

Optional Parameters

alpha=2 isotropy-plane p-wave velocity  
beta=1 fast isotropy-plan s-wave velocity  
ev=0 e(V)  
dv=0 d(V)  
gamma=0 shear-wave splitting parameter  
rho=1 density  
sign sign of c13+c55 ( for most materials sign=1)  
outpar=/dev/tty output parameter file

Output:

c\_ijkl stiffness components for x1=symmetry axis  
x3= vertical

Credits: Andreas Rueger, CWP Aug 01, 1996

Reference: Andreas Rueger, P-wave reflection coefficients for transverse isotropy with vertical and horizontal axis of symmetry, GEOPHYSICS

HUDSON - compute effective parameters of anisotropic solids  
using Hudson's crack theory.

Required paramters: <none>

Optional parameters

vp=4.5            p-wave velocity uncracked solid  
vs=2.53          s-wave velocity uncracked solid  
rho=2.8          density  
cdens=0 crack density  
aspect=0         aspect ratio  
fill=0           gas filled cracks  
                 =1 water filled  
outpar            =/dev/tty     output file

Notes:

The cracks are assumed to be vertically aligned, penny-shaped and the matrix is isotropic. The resulting anisotropic solid is of HTI symmetry.

Output:

Computes(a) stiffness elements  
          (b) density normalized stiffness components  
          (c) generic Thomsen parameters (vp0,vs0,eps,delta,gamma)  
          (d) equivalent VTI parameters (alpha,beta,ev,dv,gv)

AUTHOR:: Andreas Rueger, Colorado School of Mines, 10/10/96

Additional notes:

The routine can be easily modified to allow for any  
filling adding attenuation is not trivial

Technical Reference:

Hudson's theory: Hudson, 1981: Wave speed and attenuation of elastic  
                 waves in material containing cracks.  
                 Geophys. J. R. astr. Soc 64, 133-150  
Crampin, 1984: Effective anisotropic elastic constants  
                 for waves propagating through cracked  
                 solids:

Geophys. J. R. astr. Soc 76, 135-145

Equivalent VTI : Rueger, 1996: Reflection coefficients in transversely isotropic media with vertical and horizontal axis of symmetry: Geophysics

KAPERTURE - generate the k domain of a line scatterer for a seismic array

```
kaperture [optional parameters] >stdout
```

Optional parameters

```
x0=1000 point scatterer location
z0=1000 point scatterer location
nshot=1 number of shots
sxmin=0 first shot location
szmin=0 first shot location
dsx=100 x-steps in shot location
dsz=0 z-steps in shot location
ngeo=1 number of receivers
gxmin=0 first receiver location
gzmin=0 first receiver location
dgx=100 x-steps in receiver location
dgz=0 z-steps in receiver location
fnyq=125 Nyquist frequency (Hz)
fmax=125 maximum frequency (Hz)
fmin=5 minimum frequency (Hz)
nfreq=2 number of frequencies
both=0 = 1 gives negative freqs too
nstep=60 points on Nyquist circle
c=5000 speed
outpar=/dev/tty output parameter file, contains:
xmin, xmax, ymin, ymax
and npairs (needed for psgraph or xgraph)
other choices for outpar are: /dev/tty,
/dev/stderr, or a name of a disk file
```

Notes:

```
    nfreq=1 produces fmin
    nstep=0 suppresses the Nyquist circle
    and npairs
```

Examples:

Default case: both=0 nfreq=2

```
kaperture nshot=NSHOT ngeo=NGEO nstep=NSTEP |
psgraph n=NPAIRS,NSTEP mark=1,0 marksize=1,0 linewidth=0,1 |...
WHERE: NPAIRS=NSHOT*NGEO
```

Other cases:

```
both=0 nfreq=NFREQ > 2
  kaperture both=0 nfreq=NFREQ nshot=NSHOT ngeo=NGEO nstep=NSTEP |
  psgraph n=NPAIRS,NSTEP mark=1,0 marksize=1,0 linewidth=0,1 |...
  WHERE: NPAIRS=NFREQ*NSHOT*NGEO
```

```
both=1 nfreq=NFREQ > 2
  kaperture both=1 nfreq=NFREQ nshot=NSHOT ngeo=NGEO nstep=NSTEP |
  psgraph n=NPAIRS,NSTEP mark=1,0 marksize=1,0 linewidth=0,1 |...
  WHERE: NPAIRS=NFREQ*NSHOT*NGEO*2
```

When in doubt to the size of NPAIRS, redirect output of kaperture to /dev/tty the first time to get npairs=:

```
kaperture [optional parameters] > /dev/tty
```

LINRORT - linearized P-P, P-S1 and P-S2 reflection coefficients for a horizontal interface separating two of any of the following halfspaces: ISOTROPIC, VTI, HTI and ORTHORHOMBIC.

linrort [optional parameters]

hspace1=ISO medium type of the incidence halfspace:

=ISO ... isotropic

=VTI ... VTI anisotropy

=HTI ... HTI anisotropy

=ORT ... ORTHORHOMBIC anisotropy

for ISO:

vp1=2 P-wave velocity, halfspace1

vs1=1 S-wave velocity, halfspace1

rho1=2.7 density, halfspace1

for VTI:

vp1=2 P-wave vertical velocity (V33), halfspace1

vs1=1 S-wave vertical velocity (V44=V55), halfspace1

rho1=2.7 density, halfspace1

eps1=0 Thomsen's generic epsilon, halfspace1

delta1=0 Thomsen's generic delta, halfspace1

gamma1=0 Thomsen's generic gamma, halfspace1 ",

for HTI:

vp1=2 P-wave vertical velocity (V33), halfspace1

vs1=1 "fast" S-wave vertical velocity (V44), halfspace1

rho1=2.7 density, halfspace1

eps1\_v=0 Tsvankin's "vertical" epsilon, halfspace1

delta1\_v=0 Tsvankin's "vertical" delta, halfspace1

gamma1\_v=0 Tsvankin's "vertical" gamma, halfspace1 ",

for ORT:

vp1=2 P-wave vertical velocity (V33), halfspace1

vs1=1 x2-polarized S-wave vertical velocity (V44), halfspace1

rho1=2.7 density, halfspace1

eps1\_1=0 Tsvankin's epsilon in [x2,x3] plane, halfspace1

delta1\_1=0 Tsvankin's delta in [x2,x3] plane, halfspace1

gamma1\_1=0 Tsvankin's gamma in [x2,x3] plane, halfspace1

eps1\_2=0 Tsvankin's epsilon in [x1,x3] plane, halfspace1

delta1\_2=0 Tsvankin's delta in [x1,x3] plane, halfspace1

gamma1\_2=0 Tsvankin's gamma in [x1,x3] plane, halfspace1

delta1\_3=0 Tsvankin's delta in [x1,x2] plane, halfspace1

hspace2=ISO medium type of the reflecting halfspace (the same convention as above)

medium parameters of the 2nd halfspace follow the same convention as above:

```
vp2=2.5  vs2=1.2  rho2=3.0
eps2=0   delta2=0
eps2_v=0 delta2_v=0 gamma2_v=0
eps2_1=0 delta2_1=0 gamma2_1=0
eps2_2=0 delta2_2=0 gamma2_2=0
delta2_3=0
```

(note you do not need "gamma2" parameter for evaluation of weak-anisotropy reflection coefficients)

a\_file=-1 the string '-1' ... incidence and azimuth angles are generated automatically using the setup values below  
a\_file=file\_name ... incidence and azimuth angles are read from a file "file\_name"; the program expects a file of two columns [inc. angle, azimuth]

in the case of a\_file=-1:  
fangle=0 first incidence phase angle  
langle=30 last incidence angle  
dangle=1 incidence angle increment  
fazim=0 first azimuth (in deg)  
lazim=0 last azimuth (in deg)  
dazim=1 azimuth increment (in deg)

kappa=0. azimuthal rotation of the lower halfspace2 (e.t. a symmetry axis plane for HTI, or a symmetry plane for ORTHORHOMBIC) with respect to the x1-axis

out\_inf=info.out information output file  
out\_P=Rpp.out file with Rpp reflection coefficients  
out\_S=Rps.out file with Rps reflection coefficients  
out\_SVSH=Rsvsh.out file with SV and SH projections of reflection coefficients  
out\_Error=error.out file containing error estimates evaluated during the computation of the reflection coefficients;

Output:

out\_P:

inc. phase angle, azimuth, reflection coefficient; for a\_file=-1, the inc. angle is the fast dimension

out\_S:

inc. phase angle, azimuth, Rps1, Rps2, cos(PHI), sin(PHI); for a\_file=-1, the inc. angle is the fast dimension ",

out\_SVSH:

inc. phase angle, azimuth, Rsv, Rsh, cos(PHI), sin(PHI); for a\_file=-1, the inc. angle is the fast dimension

out\_Error:

error estimates of Rpp, Rpsv and RpsH approximations; global error is analysed as well as partial contributions to the error due to the isotropic velocity contrasts, and due to anisotropic upper and lower halfspaces. The error file is self-explanatory, see also descriptions of subroutines P\_err\_2nd\_order, SV\_err\_2nd\_order and SH\_err\_2nd\_order.

Adopted Convention:

The right-hand Cartesian coordinate system with the x3-axis pointing upward has been chosen. The upper halfspace (halfspace1) contains the incident P-wave. Incidence angles can vary from  $\langle 0, \pi/2 \rangle$ , azimuths are unlimited, +azimuth sense counted from x1->x2 axes (azimuth=0 corresponds to the direction of x1-axis). In the current version, the coordinate system is attached to the halfspace1 (e.t. the symmetry axis plane of HTI halfspace1, or one of symmetry planes of ORTHORHOMBIC halfspace1, is aligned with the x1-axis), however, the halfspace2 can be arbitrarily rotated along the x3-axis with respect to the halfspace1. The positive weak-anisotropy polarization of the reflected P-P wave (e.t. positive P-P reflection coefficient) is close to the direction of isotropic slowness vector of the wave (pointing outward the interface). Similarly, weak-anisotropy S-wave reflection coefficients are described in terms of "SV" and "SH" isotropic polarizations, "SV" and "SH" being unit vectors in the plane perpendicular to the isotropic slowness vector. Then, the positive "SV" polarization vector lies in the incidence plane and points towards the interface, and positive "SH" polarization vector is perpendicular to the incidence plane, aligned with the positive x2-axis, if azimuth=0. Rotation angle "PHI", characterizing a rotation of "the best projection" of the S1-wave polarization vector in the isotropic SV-SH plane in the incidence halfspace1, is

counted in the positive sense from "SV" axis ( $\text{PHI}=0$ ) towards the "SH" axis ( $\text{PHI}=\text{PI}/2$ ). Of course, S2 is perpendicular to S1, and the projection of S1 and S2 polarizations onto the SV-SH plane coincides with SV and SH directions, respectively, for  $\text{PHI}=0$ .

The units for velocities are km/s, angles I/O are in degrees

Additional Notes:

The coefficients are computed as functions of phase incidence angle and azimuth (determined by the incidence slowness vector). Vertical symmetry planes of the HTI and ORTHORHOMBIC halfspaces can be arbitrarily rotated along the x3-axis. The linearization is based on the assumption of weak contrast in elastic medium parameters across the interface, and the assumption of weak anisotropy in both halfspaces. See the "Adopted Convention" paragraph below for a proper input.

Author: Petr Jilek, CSM-CWP, December 1999.

LORENZ - compute the LORENZ attractor

```
lorenz > [stdout]
```

Required Parameters: none

Optional Parameters:

rho=28.0 parameter for lorenz equations

sigma=10.0 parameter for lorenz equations

eta=1.6666667 parameter for lorenz equations

y0=1.0 initial value of y[0]

y1=-1.0 initial value of y[1]

y2=1.0 initial value of y[2]

h=.01 increment in time

tol=1.e-08 error tolerance

stepmax=500 maximum number of steps to compute

mode=xy xy-pairs, =yz yz-pairs, =xz xz-pairs,

=xyz xyz-triplet, =x only, =y only, =z only

Notes:

This program is really just a demo showing how to use the differential equation solver rke\_solve written by Francois Pinard, based on a modified form of the 4th order Runge-Kutta method, which employs the error checking method of R. England 1969.

The output consists of unformatted C-style binary floats, of either pairs or triplets as specified by the "mode" parameter.

Examples:

```
lorenz stepmax=1000 mode=xy | xgraph n=1000 &
```

```
lorenz stepmax=1000 mode=yz | xgraph n=1000 &
```

```
lorenz stepmax=1000 mode=xz | xgraph n=1000 &
```

```
lorenz stepmax=1000 mode=x | suaddhead ns=1000 | suxwigg &
```

```
lorenz stepmax=1000 mode=y | suaddhead ns=1000 | suxwigg &
```

```
lorenz stepmax=1000 mode=z | suaddhead ns=1000 | suxwigg &
```

The lorenz equations describe a simplified model of a convection cell, and are given by the autonomous system of ODE's

$$x'(t) = \sigma * (y - x)$$

$$y'(t) = x * (rho - z) - y$$

$$z'(t) = x * y - \text{eta} * z$$

Author: CWP: Aug 2004: John Stockwell

MAKEVEL - MAKE a VELOCITY function  $v(x,y,z)$

makevel > outfile nx= nz= [optional parameters]

Required Parameters:

nx= number of x samples (3rd dimension)  
nz= number of z samples (1st dimension)

Optional Parameters:

ny=1 number of y samples (2nd dimension)  
dx=1.0 x sampling interval  
fx=0.0 first x sample  
dy=1.0 y sampling interval  
fy=0.0 first y sample  
dz=1.0 z sampling interval  
fz=0.0 first z sample  
v000=2.0 velocity at  $(x=0,y=0,z=0)$   
dvdx=0.0 velocity gradient with respect to x  
dvdy=0.0 velocity gradient with respect to y  
dvdz=0.0 velocity gradient with respect to z  
vlens=0.0 velocity perturbation in parabolic lens  
tlens=0.0 thickness of parabolic lens  
dlens=0.0 diameter of parabolic lens  
xlens= x coordinate of center of parabolic lens  
ylens= y coordinate of center of parabolic lens  
zlens= z coordinate of center of parabolic lens  
vran=0.0 standard deviation of random perturbation  
vzfile= file containing  $v(z)$  profile  
vzran=0.0 standard deviation of random perturbation to  $v(z)$   
vzc=0.0  $v(z)$  chirp amplitude  
z1c=fz z at which to begin chirp  
z2c=fz+(nz-1)\*dz z at which to end chirp  
l1c=dz wavelength at beginning of chirp  
l2c=dz wavelength at end of chirp  
exc=1.0 exponent of chirp

MKPARFILE - convert ascii to par file format

```
mkparfile <stdin >stdout
```

Optional parameters:

```
string1="par1" first par string  
string2="par2" second par string
```

This is a tool to convert values written line by line to parameter vectors in the form expected by getpar. For example, if the input file looks like:

```
t0 v0  
t1 v1
```

...

then

```
mkparfile <input >output string1=tnmo string2=vnmo
```

yields:

```
tnmo=t0,t1,...
```

```
vnmo=v0,v1,...
```

MRAFXZWT - Multi-Resolution Analysis of a function F(X,Z) by Wavelet Transform. Modified to perform different levels of resolution analysis for each dimension and also to allow to transform back only the lower level of resolution.

```
mrafxzwt [parameters] < infile > mrafile
```

Required Parameters:

n1= size of first (fast) dimension

n2= size of second (slow) dimension

Optional Parameters:

p1= maximum integer such that  $2^{p1} \leq n1$

p2= maximum integer such that  $2^{p2} \leq n2$

order=6 order of Daubechies wavelet used (even,  $4 \leq \text{order} \leq 20$ )

mrlevel1=3 maximum multi-resolution analysis level in dimension 1

mrlevel2=3 maximum multi-resolution analysis level in dimension 2

trunc=0.0 truncation level (percentage) of the reconstruction

verbose=0 =1 to print some useful information

reconfile= reconstructed data file to write

reconmrafile= reconstructed data file in MRA domain to write

dfile= difference between infile and reconfile to write

dmrafile= difference between mrafile and reconmrafile to write

dconly=0 =1 keep only dc component of MRA

verbose=0 =1 to print some useful information

if (n1 or n2 is not integer powers of 2) specify the following:

nc1=n1/2 center of trimmed image in the 1st dimension

nc2=n2/2 center of trimmed image in the 2nd dimension

trimfile= if given, output the trimmed file

Notes:

This program performs multi-resolution analysis of an input function  $f(x,z)$  via the wavelet transform method. Daubechies's least asymmetric wavelets are used. The smallest wavelet coefficient retained is given by trunc times the absolute maximum size coefficient in the MRA.

The input dimensions of the data must be expressed by (p1,p2) which

Author: Zhaobo Meng, 11/25/95, Colorado School of Mines \*

Modified: Carlos E. Theodoro, 06/25/97, Colorado School of Mines \*

Included options for: \*

- different level of resolutionf or each dimension; \*

- transform back the lower level of resolution, only. \*

\*

Reference: \*

Daubechies, I., 1988, Orthonormal Bases of Compactly Supported \*  
Wavelets, Communications on Pure and Applied Mathematics, Vol. XLI, \*  
909-996. \*

PDFHISTOGRAM - generate a HISTOGRAM of the Probability Density function

```
pdfhistogram < stdin > sdtout [Required params] (Optional params)
```

Required parameters:

ix= column containing X variable

iy= column containing Y variable

min\_x= minimum X bin

max\_x= maximum X bin

min\_y= minimum Y bin

max\_y= maximum Y bin

logx=0 =1 use logarithmic scale for X axis

logy=0 =1 use logarithmic scale for Y axis

norm= selected normalization type

sqrt - bin / sqrt( xnct\*ycnt)

avg\_cnt - 0.5\* bin / (xcnt + ycnt)

avg\_sum - (bin / xcnt + bin / ycnt ) / 2

xcnt - bin / xcnt

ycnt - bin / ycnt

log - log(bin)

total - bin / total

Optional parameters:

nx=100 - number of X bins

ny=100 - number of Y bins

ir= - column containing reject variable

rmin= - reject values below rmin

rmax= - reject values above rmax

NOTE: only one, rmin or rmax, may be used

Notes:

PDFHISTOGRAM creates a 2D histogram representing the probability density function of the input data. The output is in the form of a binary array that can then be plotted via ximage.

Commandline options allow selecting any of several normalizations to apply to the distributions.

Credits:

Reginald H. Beardsley rhb@acm.org

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PRPLOT - PRinter PLOT of 1-D arrays  $f(x_1)$  from a 2-D function  $f(x_1, x_2)$

prplot <infile >outfile [optional parameters]

Optional Parameters:

n1=all	number of samples in 1st dimension
d1=1.0	sampling interval in 1st dimension
f1=d1	first sample in 1st dimension
n2=all	number of samples in 2nd dimension
d2=1.0	sampling interval in 2nd dimension
f2=d2	first sample in 2nd dimension
label2=Trace	label for 2nd dimension

RANDVEL3D - Add a random velocity layer (RVL) to a gridded  
v(x,y,z) velocity model

randvel3d <infile n1= n2= >outfile [parameters]

Required Parameters:

n1= number of samples along 1st dimension

n2= number of samples along 2nd dimension

Optional Parameters:

n3=1            number of samples along 3rd dimension

mode=1            add single layer populated with random vels

                  =2 add nrvl layers of random thickness and vel

seed=from\_clock    random number seed (integer)

---->New layer geometry info

i1beg=1            1st dimension beginning sample

i1end=n1/5        1st dimension ending sample

i2beg=1            2nd dimension beginning sample

i2end=n2           2nd dimension ending sample

i3beg=1            3rd dimension beginning sample

i3end=n3           3rd dimension ending sample

---->New layer velocity info

vlstd=v/3         range (std dev) of random velocity in layer,  
                  where v=v(0,0,i1) and i1=(i1beg+i1end)/2

add=1             add random vel to original vel (v\_orig) at that point

                  =0 replace vel at that point with (v\_orig+v\_rand)

how=0             random vels can be higher or lower than v\_orig

                  =1 random vels are always lower than v\_orig

                  =2 random vels are always higher than v\_orig

cvel=2000         layer filled with constant velocity cvel  
                  (overrides vlstd,add,how params)

---->Smoothing parameters (0 = no smoothing)

r1=0.0            1st dimension operator length in samples

r2=0.0            2nd dimension operator length in samples

r3=0.0            3rd dimension operator length in samples

slowness=0        =1 smoothing on slowness; =0 smoothing on velocity

nrvl=n1/10        number of const velocity layers to add

pdv=10.           percentage velocity deviation (max) from input model

Notes:

1. Smoothing radii usually fall in the range of [0,20].
2. Smoothing radii can be used to set aspect ratio of random velocity anomalies in the new layer. For example (r1=5,r2=0,r3=0) will result in vertical vel streaks that mimick vertical fracturing.
3. Smoothing on slowness works better to preserve traveltimes relative to the unsmoothed case.
4. Default case is a random velocity (+/-30%) near surface layer whose thickness is 20% of the total 2D model thickness.
5. Each layer vel is a random perturbation on input model at that level.
6. The depth dimension is assumed to be along axis 1.

Example:

1. 2D RVL with no smoothing  
makevel nz=250 nx=200 | randvel3d n1=250 n2=200 | ximage n1=250
2. 3D RVL with no smoothing  
makevel nz=250 nx=200 ny=220 |  
randvel3d n1=250 n2=200 n3=220 |  
xmovie n1=250 n2=200

Author: Saudi Aramco: Chris Liner Jan/Feb 2005  
Based on smooth3d (CWP: Zhenyue Liu March 1995)

RAYT2DAN -- P- and SV-wave raytracing in 2D anisotropic media

rayt2dan > ttime parameterfiles= nt= nx= nz= [optional parameters]

Required Parameters:

VPOfile= name of file containing VPO(x,z)  
nt= number of time samples for each ray  
nx= number of samples (x) for the parameter fields  
nz= number of samples (z) for the parameter fields

Optional Parameters:

SV=0 for P-waves, SV=1 for Shear waves

Parameters defining the velocity field

dt=0.008 time sampling interval "  
fx=0 first lateral sample (x) in parameter field  
fz=0 first lateral sample (z) in parameter field  
dx=100.0 sample spacing (x) for the parameter fields  
dz=100.0 sample spacing (z) for the parameter fields

Parameters defining the takeoff angle of a ray at a source position "

fa=-60 first take-off angle of rays (degrees)  
na=61 number of rays "  
da=2 increment of take-off angle  
amin=0 minimum emergence angle; must be > -90 degrees  
amax=90 maximum emergence angle; must be < 90 degrees

Parameters defining the output travelttime table

fxo=fx first lateral sample in travelttime table  
nxo=nx number of later samples in travelttime table  
dxo=dx lateral interval in travelttime table  
fzo=fz first depth sample in travelttime table  
nzo=nz number of depth samples in travelttime table  
dzo=dz depth interval in travelttime table  
fac=0.01 factor to determine the radius of extrap.

Parameters defining the source positions

fsx=fx x-coordinate of first source  
nsx=1 number of sources  
dsx=2\*dxo x-coordinate increment of sources  
aperx=0.5\*nx\*dx ray tracing aperature in x-direction

Files for general anisotropic parameters confined to a vertical plane:

a1111file name of file containing a1111(x,z)  
a1133file name of file containing a1133(x,z)  
VS0file name of file containing VS0(x,z)  
a1113file name of file containing a1113(x,z)  
a3313file name of file containing a3313(x,z)

For transversely isotropic media Thomsen's parameters could be used:  
deltafile name of file containing delta(x,z)  
epsilonfile name of file containing epsilon(x,z)

if anisotropy parameters are not given the program considers "  
isotropic media. ",

Credits:

Debashish Sarkar

Technical Reference:

Cerveny, V., 1972, Seismic rays and ray intensities  
in inhomogeneous anisotropic media:  
Geophys. J. R. Astr. Soc., 29, 1--13.

Hangya, A., 1986, Gaussian beams in anisotropic elastic media:  
Geophys. J. R. Astr. Soc., 85, 473--563.

Gajewski, D. and Psencik, I., 1987, Computation of high frequency  
seismic wavefields in 3-D laterally inhomogeneous anisotropic  
media: Geophys. J. R. Astr. Soc., 91, 383-411.

RAYT2D - travelttime Tables calculated by 2D paraxial RAY tracing

rayt2d vfile= tfile= [optional parameters]

Required parameters:

vfile=stdin file containning velocity v[nx][nz]

tfile=stdout file containning travelttime tables

t[nxs][nxo][nzo]

Optional parameters

dt=0.008 time sample interval in ray tracing

nt=401 number of time samples in ray tracing

fz=0 first depth sample in velocity

nz=101 number of depth samples in velocity

dz=100 depth interval in velocity

fx=0 first lateral sample in velocity

nx=101 number of lateral samples in velocity

dx=100 lateral interval in velocity

fzo=fz first depth sample in travelttime table

nzo=nz number of depth samples in travelttime table

dzo=dz depth interval in travelttime table

fxo=fx first lateral sample in travelttime table

nxo=nx number of lateral samples in travelttime table

dxo=dx lateral interval in travelttime table

surf="0,0;99999,0" Recording surface "x1,z1;x2,z2;x3,z3;...

fxs=fx x-coordinate of first source

nxs=1 number of sources

dxs=2\*dxo x-coordinate increment of sources

aperx=0.5\*nx\*dx ray tracing aperature in x-direction

fa=-60 first take-off angle of rays (degrees)

na=61 number of rays

da=2 increment of take-off angle

amin=0 minimum emergence angle

amax=90 maximum emergence angle

fac=0.01 factor to determine radius for extrapolation

ek=1 flag of implementing eikonal in shadow zones

ms=10 print verbal information at every ms sources

restart=n job is restarted (=y yes; =n no)

npv=0 flag of computing quantities for velocity analysis  
if npv>0 specify the following three files  
pvfile=pvfile input file of velocity variation pv[nxo][nzo]  
tvfile=tvfile output file of traveltime variation tables  
tv[nxs][nxo][nzo]  
csfile=csfile output file of cosine tables cs[nxs][nxo][nzo]

Notes:

1. Each traveltime table is calculated by paraxial ray tracing; then traveltimes in shadow zones are compensated by solving eikonal equation.
2. Input velocity is uniformly sampled and smooth one preferred.
3. Traveltime table and source ranges must be within velocity model.
4. Ray tracing aperature can be chosen as sum of migration aperature plus half of maximum offset.
5. Memory requirement for this program is about  
[nx\*nz+4\*mx\*nz+3\*nxo\*nzo+na\*(nx\*nz+mx\*nz+3\*nxo\*nzo)]\*4 bytes  
where mx = min(nx, 2\*(1+aperx/dx)).

Author: Zhenyue Liu, 10/11/94, Colorado School of Mines

Trino Salinas, 01/01/96 included the option to handle nonflat reference surfaces.

Subroutines from Dave Hale's modeling library were adapted in this code to define topography using cubic splines.

References:

Beydoun, W. B., and Keho, T. H., 1987, The paraxial ray method: Geophysics, vol. 52, 1639-1653.

Cerveny, V., 1985, The application of ray tracing to the numerical modeling of seismic wavefields in complex structures, in Dohr, G., ED., Seismic shear waves (part A: Theory): Geophysical Press, Number 15 in Handbook of Geophysical Exploration, 1-124.

RECAST - RECAST data type (convert from one data type to another)

```
recast <stdin [optional parameters] >stdout
```

Required parameters:

none

Optional parameters:

in=float input type (float)

=double (double)

=int (int)

=char (char)

=uchar (unsigned char)

=short (short)

=long (long)

=ulong (unsigned long)

out=double output type (double)

=float (float)

=int (int)

=char (char)

=uchar (unsigned char)

=short (short)

=long (long)

=ulong (unsigned long)

outpar=/dev/tty output parameter file, contains the  
number of values (n1=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Notes: Converting bigger types to smaller is hazardous. For float  
or double conversions to integer types, the results are  
rounded to the nearest integer.

Credits:

CWP: John Stockwell, Jack K. Cohen

REFREALAZIHTI - REAL AZimuthal REFL/transm coeff for HTI media

refRealAziHTI [optional parameters] >coeff.data

Optional parameters:

vp1=2 p-wave velocity medium 1 (with respect to symm.axes)  
vs1=1 s-wave velocity medium 1 (with respect to symm.axes)  
eps1=0 epsilon medium1  
delta1=0 delta medium 1  
gamma1=0 gamma medium 1  
rho1=2.7 density medium 1  
vp2=2 p-wave velocity medium 2 (with respect to symm.axes)  
vs2=1 s-wave velocity medium 2 (with respect to symm.axes)  
eps2=0 epsilon medium 2  
delta2=0 delta medium 2  
gamma2=0 gamma medium 2  
rho2=2.7 density medium 2  
modei=0 incident mode is qP  
=1 incident mode is qSV  
=2 incident mode is SP  
modet=0 scattered mode  
rort=1 reflection(1) or transmission (0)  
azimuth=0 azimuth with respect to x1-axis (clockwise)  
fangle=0 first incidence angle  
langle=45 last incidence angle  
dangle=1 angle increment  
iscale=0 default: angle in degrees  
=1 angle-axis in rad  
=2 axis horizontal slowness  
=3 sin<sup>2</sup> of incidence angle  
ibin=1 binary output  
=0 Ascci output  
outparfile =outpar parameter file for plotting  
coefffile =coeff.data coefficient-output file  
test=1 activate testing routines in code  
info=0 output intermediate results

Notes:

Axes of symmetry have to coincide in both media. This code computes all 6 REAL reflection/transmissions coefficients on the fly. However, the set-up is such Real reflection/transmission coefficients in HTI-media with coinciding symmetry axes. However, the set-up is such that currently only one coefficient is

dumped into the output. This is easily changed. The solution of the scattering problem is obtained numerically and involves the Gaussian elimination of a 6X6 matrix. ",

AUTHOR:: Andreas Rueger, Colorado School of Mines, 02/10/95  
original name of code <graebnerTIH.c>  
modified, extended version of this code <refTIH3D>

Technical references:

Sebastian Geoltrain: Asymptotic solutions to direct and inverse scattering in anisotropic elastic media; CWP 082.

Graebner, M.; Geophysics, Vol 57, No 11:  
Plane-wave reflection and transmission coefficients for a transversely isotropic solid.

Cerveny, V., 1972, Seismic rays and ray intensities in inhomogeneous anisotropic media: Geophys. J. R. astr. Soc., 29, 1-13.

.. and some derivations by Andreas Rueger.

If propagation is perpendicular or parallel to the symmetry axis, the solution is analytic (see graebner2D.c and rtRealIso.c

REFREALVTI - REAL REFL/transm coeff for VTI media and symmetry-axis  
planes of HTI media

refRealVTI [Optional parameters]

Optional parameters:

vp1=2 p-wave velocity medium 1 (along symm.axes)  
vs1=1 s-wave velocity medium 1 (along symm.axes)  
eps1=0 Thomsen's epsilon medium 1  
delta1=0 Thomsen's delta medium 1  
rho1=2.7 density medium 1  
axis1=0 medium 1 is VTI  
=1 medium 1 is HTI  
vp2=2.5 p-wave velocity medium 2 (along symm.axes)  
vs2=1.2 s-wave velocity medium 2 (along symm.axes)  
eps2=0 epsilon medium2  
delta2=0 delta medium 2  
rho2=3.0 density medium 2  
axis2=0 medium 2 is VTI  
=2 medium 2 is HTI  
modei=0 incident mode is qP  
=1 incident mode is qSV  
modet=0 scattered mode  
rort=1 reflection(1) or transmission (0)  
fangle=0 first angle  
langle=45 last angle  
dangle=1 angle increment  
iscale=0 =1 angle-axis in rad  
=2 axis horizontal slowness  
=3 sin<sup>2</sup> of incidence angle  
ibin=1 binary output  
=0 Ascci output  
outparfile =outpar parameter file for plotting  
coefffile =coeff.data coefficient-output file

Notes:

Coefficients are based on Graebner's 1992 Geophysics paper. Note the mistype in the equation for K1. The algorithm can be used for VTI and HTI media on the incidence and scattering side.

AUTHOR:: Andreas Rueger, Colorado School of Mines, 01/20/95

original name of algorithm: graebner1.c

Technical reference: Graebner, M.; Geophysics, Vol 57, No 11:  
Plane-wave reflection and transmission coefficients  
for a transversely isotropic solid.

Rueger, A.; Geophysics 1996 (accepted):  
P-wave reflection coefficients ...

REGRID3 - REwrite a [ni3][ni2][ni1] GRID to a [no3][no2][no1] 3-D grid

```
regrid3 < oldgrid > newgrid [parameters]
```

Optional parameters:

ni1=1 fastest (3rd) dimension in input grid

ni2=1 second fastest (2nd) dimension in input grid

ni3=1 slowest (1st) dimension in input grid

no1=1 fastest (3rd) dimension in output grid

no2=1 second fastest (2nd) dimension in output grid

no3=1 slowest (1st) dimension in output grid

",

Optional Parameters:

verbose=0 =1 print some useful information

Notes:

REGRID3 can be used to span a 1-D grid to a 2-D grid, or a 2-D grid to a 3-D grid; or to change grid parameters within the dimensions.

Together with MUL and UNIF3, most 3-D velocity model can be

Credits:

CWP: Zhaobo Meng, 1996, Colorado School of Mines

RESAMP - RESAMPle the 1st dimension of a 2-dimensional function  $f(x_1, x_2)$

resamp <infile >outfile [optional parameters]

Required Parameters:

Optional Parameters:

n1=all	number of samples in 1st (fast) dimension
n2=all	number of samples in 2nd (slow) dimension
d1=1.0	sampling interval in 1st dimension
f1=d1	first sample in 1st dimension
n1r=n1	number of samples in 1st dimension after resampling
d1r=d1	sampling interval in 1st dimension after resampling
f1r=f1	first sample in 1st dimension after resampling

NOTE: resamp currently performs NO ANTI-ALIAS FILTERING before resampling!

SMOOTH2 --- SMOOTH a uniformly sampled 2d array of data, within a user-defined window, via a damped least squares technique

```
smooth2 < stdin n1= n2= [optional parameters ] > stdout
```

Required Parameters:

n1= number of samples in the 1st (fast) dimension  
n2= number of samples in the 2nd (slow) dimension

Optional Parameters:

r1=0 smoothing parameter in the 1 direction  
r2=0 smoothing parameter in the 2 direction  
win=0,n1,0,n2 array for window range  
rw=0 smoothing parameter for window function  
efile= =efilename if set write relative error(x1) to  
efilename

Notes:

Larger r1 and r2 result in a smoother data. Recommended ranges of r1 ", and r2 are from 1 to 20.

The file verror gives the relative error between the original velocity and the smoothed one, as a function of depth. If the error is between 0.01 and 0.1, the smoothing parameters are suitable. Otherwise, consider increasing or decreasing the smoothing parameter values.

Smoothing can be implemented in a selected window. The range of 1st dimension for window is from win[0] to win[1]; the range of 2nd dimension is from win[2] to win[3].

Smoothing the window function (i.e. blurring the edges of the window) may be done by setting a nonzero value for rw, otherwise the edges of the window will be sharp.

Credits:

CWP: Zhen-yue Liu,  
adapted for par/main by John Stockwell 1 Oct 92  
Windowing feature added by Zliu on 16 Nov 1992

SMOOTH3D - 3D grid velocity SMOOTHing by the damped least squares

smooth3d <infile >outfile [parameters]

Required Parameters:

n1= number of samples along 1st dimension

n2= number of samples along 2nd dimension

n3= number of samples along 3rd dimension

Optional Parameters:

Smoothing parameters (0 = no smoothing)

r1=0.0 operator length in 1st dimension

r2=0.0 operator length in 2nd dimension

r3=0.0 operator length in 3rd dimension

Sample intervals:

d1=1.0 1st dimension

d2=1.0 2nd dimension

d3=1.0 3rd dimension

iter=2 number of iteration used

time=0 which dimension the time axis is (0 = no time axis)

depth=1 which dimension the depth axis is (ignored when time>0)

mu=1 the relative weight at maximum depth (or time)

verbose=0 =1 for printing minimum wavelengths

slowness=0 =1 smoothing on slowness; =0 smoothing on velocity

vminc=0 velocity values below it are clipped before smoothing

vmaxc=99999 velocity values above it are clipped before smoothing

Notes:

1. The larger the smoothing parameters, the smoother the output velocity. These parameters are lengths of smoothing operators in each dimension.
2. iter controls the orders of derivatives to be smoothed in the output velocity. e.g., iter=2 means derivatives until 2nd order smoothed.
3. mu is the multiplier of smoothing parameters at the bottom compared to those at the surface.
4. Minimum wavelengths of each dimension and the total may be printed for the resulting output velocity is. To compute these parameters for the input velocity, use r1=r2=r3=0.
5. Smoothing directly on slowness works better to preserve traveltimes. So the program optionally converts the input velocity into slowness, and smooths the slowness, then converts back into velocity.

Author: CWP: Zhenyue Liu March 1995

Reference:

Liu, Z., 1994, "A velocity smoothing technique based on damped least squares in Project Reveiw, May 10, 1994, Consortium Project on Seismic Inverse Methods for Complex Stuctures.

SMOOTHINT2 --- SMOOTH non-uniformly sampled INTERfaces, via the damped least-squares technique

```
smoothint2 <input ninf= >output [optional parameters]
```

Required Parameters:

```
<input          file containing original interfaces
>output        file containing smoothed interfaces
```

Optional Parameters:

```
ninf=5          number of interfaces
r=100 smoothing parameter
npmax=101 maximum number of points in interfaces
```

Notes:

The input file is an ASCII file. Each interface is represented by pairs (non-uniform sampling) of x and z values, with one pair of values on each line, separated by spaces or tabs. Each interface is separated with an entry with a large negative z value for example: 1.0 -9999. There is no entry for the surface. The surface is assumed to be flat with z=0.

This is similar to a CSHOT model file without a surface entry and without comments.

The smoothing method is analogous to a moving window averaging process (but not the same) with the parameter "r" being analogous to the "width of the window. Thus, the size of "r" must be chosen to be compatible with the scale (wavelengths) of the variations of the interfaces in the model being smoothed.

Example using the test data set generated by unif2:

```
unif2 tfile=tfilename
```

Compare the unsmoothed interface model:

```
unif2 < tfilename method=interpolation_method |
  psimage n1=100 n2=100 d1=10 d2=10 | ...
```

To the smoothed interface model:

```
smoothint2 r=100 < tfilename | unif2 method=interpolation_method | ",
psimage n1=100 n2=100 d1=10 d2=10 | ...
```

Credits:

CWP: Zhenyue Liu, Jan 1994

Reference:

Liu, Zhenyue, 1994, Velocity smoothing: theory and implementation,  
Project Review, 1994, Consortium Project on Seismic Inverse Methods  
for Complex Structures (in review)

STIFF2VEL - Transforms 2D elastic stiffnesses to (vp,vs,epsilon,delta)

stiff2vel nx= nz= [optional parameters]

Required parameters:

nx= number of x samples (2nd dimension)

nz= number of z samples (1st dimension)

rho\_file='rho.bin' input file containing rho(x,z)

c11\_file='c11.bin' input file containing c11(x,z)

c13\_file='c13.bin' input file containing c13(x,z)

c33\_file='c33.bin' input file containing c33(x,z)

c44\_file='c44.bin' input file containing c44(x,z)

Optional Parameters:

vp\_file='vp.bin' output file containing P-wave velocities

vs\_file='vs.bin' output file containing S-wave velocities

rho\_file='rho.bin' output file containing densities

eps\_file='eps.bin' output file containing Thomsen epsilon

delta\_file='delta.bin' output file containing Thomsen delta

Notes:

1. All quantities in MKS units
2. Isotropy implied by  $c11(x,z)=c33(x,z)=0$
3. Vertical symmetry axis is assumed.

Coded:

Aramco: Chris Liner 9/25/2005  
(based on vel2stiff.c)

SUBSET - select a SUBSET of the samples from a 3-dimensional file

subset <infile >outfile [optional parameters]

Optional Parameters:

n1=nfloats	number of samples in 1st dimension
n2=nfloats/n1	number of samples in 2nd dimension
n3=nfloats/(n1*n2)	number of samples in 3rd dimension
id1s=1	increment in samples selected in 1st dimension
if1s=0	index of first sample selected in 1st dimension
n1s=1+(n1-if1s-1)/id1s	number of samples selected in 1st dimension
ix1s=if1s,if1s+id1s,...	indices of samples selected in 1st dimension
id2s=1	increment in samples selected in 2nd dimension
if2s=0	index of first sample selected in 2nd dimension
n2s=1+(n2-if2s-1)/id2s	number of samples selected in 2nd dimension
ix2s=if2s,if2s+id2s,...	indices of samples selected in 2nd dimension
id3s=1	increment in samples selected in 3rd dimension
if3s=0	index of first sample selected in 3rd dimension
n3s=1+(n3-if3s-1)/id3s	number of samples selected in 3rd dimension
ix3s=if3s,if3s+id3s,...	indices of samples selected in 3rd dimension

For the 1st dimension, output is selected from input as follows:

output[i1s] = input[ix1s[i1s]], for i1s = 0 to n1s-1

Likewise for the 2nd and 3rd dimensions.

AUTHOR: Dave Hale, Colorado School of Mines, 07/07/89

SWAPBYTES - SWAP the BYTES of various data types

swapbytes <stdin [optional parameters] >stdout

Required parameters:

none

Optional parameters:

in=float input type (float)

=double (double)

=short (short)

=ushort (unsigned short)

=long (long)

=ulong (unsigned long)

=int (int)

outpar=/dev/tty output parameter file, contains the number of values (n1=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Notes:

The byte order of the mantissa of binary data values on PC's and DEC's is the reverse of so called "big endian" machines (IBM RS6000, SUN,etc.) hence the need for byte-swapping capability. The subroutines in this code have been tested for swapping between PCs and big endian machines, but have not been tested for DEC products.

Caveat:

2 byte short, 4 byte long, 4 byte float, 4 byte int,  
and 8 bit double assumed.

Credits:

CWP: John Stockwell (Jan 1994)

Institut fur Geophysik, Hamburg: Jens Hartmann supplied byte swapping subroutines

THOM2HTI - Convert Thompson parameters  $V_{p0}$ ,  $V_{s0}$ ,  $\epsilon$ ,  $\gamma$ ,  
to the HTI parameters  $\alpha$ ,  $\beta$ ,  $\epsilon(V)$ ,  $\delta(V)$ ,  
 $\gamma$

thom2hti [optional parameter]

vp=2            symm.axis p-wave velocity  
vs=1            symm.axis s-wave velocity  
eps=0           Thomsen's (generic) epsilon  
gamma=0          Thomsen's generic gamma  
weak=1          compute weak approximation  
outpar=/dev/tty output parameter file

Outputs:

$\alpha$ ,  $\beta$ ,  $\epsilon(V)$ ,  $\delta(V)$ ,  $\gamma$

Notes:

Output is dumped to the screen and, if selected to outpar

Code can be used to find models that satisfy the constraints  
that are imposed on HTI models caused by vertically fractured  
layers. For definition and use of the HTI parameter set see CWP-235.

Credits: Andreas Rueger, CWP

For definition and use of the HTI parameter set see CWP-235.

THOM2STIFF - convert Thomsen's parameters into (density normalized)  
stiffness components for transversely isotropic  
material with in-plane-tilted axis of symmetry

thom2stiff [optional parameter]

vp=2            symm.axis p-wave velocity  
vs=1            symm.axis s-wave velocity  
eps=0           Thomsen's (generic) epsilon  
delta=0          Thomsen's (generic) delta  
gamma=0          Thomsen's (generic) gamma  
rho=1           density  
phi=0           angle(DEG) vertical --> symmetry axes (clockwise)  
sign=1           sign of c11+c44 (generally sign=1)  
outpar=/dev/tty output parameter file

Output:

aijkl,cijkl (density normalized) stiffness components

Author: CWP: Andreas Rueger 1995

TRANSP - TRANSPOSE an n1 by n2 element matrix

transp <infile >outfile n1= [optional parameters]

Required Parameters:

n1                            number of elements in 1st (fast) dimension of matrix

Optional Parameters:

n2=all                        number of elements in 2nd (slow) dimension of matrix

nbpe=sizeof(float)          number of bytes per matrix element

verbose=0                    =1 for diagnostic information

TVNMOQC - Check tnmo-vnmo pairs; create t-v column files

```
tvnmoqc [parameters] cdp=... tnmo=... vnmo=...
```

Example:

```
tvnmoqc mode=1 \<\  
cdp=15,35 \<\  
tnmo=0.0091,0.2501,0.5001,0.7501,0.9941 \<\  
vnmo=1497.0,2000.0,2500.0,3000.0,3500.0 \<\  
tnmo=0.0082,0.2402,0.4902,0.7402,0.9842 \<\  
vnmo=1495.0,1900.0,2400.0,2900.0,3400.0
```

Required Parameter:

```
prefix=          Prefix of output t-v file(s)  
                  Required only for mode=2
```

Optional Parameter:

```
mode=1          1=qc: check that tnmo values increase  
                2=qc and output t-v files
```

mode=1

TVNMOQC checks that there is a tnmo and vnmo series for each CDP and it checks that each tnmo series increases in time.

mode=2

TVNMOQC does mode=1 checking, plus ...

TVNMOQC converts par (MKPARFILE) values written as:

```
cdp=15,35,...,95 \<\  
tnmo=t151,t152,...,t15n \<\  
vnmo=v151,v152,...,v15n \<\  
tnmo=t351,t352,...,t35n \<\  
vnmo=v351,v352,...,v35n \<\  
tnmo=... \<\  
vnmo=... \<\  
tnmo=t951,t952,...,t95n \<\  
vnmo=v951,v952,...,v95n \<\  

```

to column format. The format of each output file is:

```
t1 v1  
t2 v2
```

...  
tn vn

One file is output for each input pair of tnmo-vnmo series.

A CDP VALUE MUST BE SUPPLIED FOR EACH TNMO-VNMO ROW PAIR.

Prefix of each output file is the user-supplied value of  
parameter PREFIX.

Suffix of each output file is the cdp value.

For the example above, output files names are:

PREFIX.15 PREFIX.35 ... PREFIX.95

Credits:

MTU: David Forel (adapted from SUNMO)

UNIF2ANISO - generate a 2-D UNIFormly sampled profile of elastic constants from a layered model.

unif2aniso < infile [Parameters]

Required Parameters:

none

Optional Parameters:

ninf=5 number of interfaces

nx=100 number of x samples (2nd dimension)

nz=100 number of z samples (1st dimension)

dx=10 x sampling interval

dz=10 z sampling interval

npmax=201 maximum number of points on interfaces

fx=0.0 first x sample

fz=0.0 first z sample

x0=0.0,0.0,..., distance x at which vp00 and vs00 are specified

z0=0.0,0.0,..., depth z at which vp00 and vs00 are specified

vp00=1500,2000,..., P-velocity at each x0,z0 (m/sec)

vs00=866,1155..., S-velocity at each x0,z0 (m/sec)

rho00=1000,1100,..., density at each x0,z0 (kg/m<sup>3</sup>)

q00=110,120,130,..., attenuation Q, at each x0,z0 (kg/m<sup>3</sup>)

eps00=0,0,0..., Thomsen or Sayers epsilon

delta00=0,0,0..., Thomsen or Sayers delta

gamma00=0,0,0..., Thomsen or Sayers gamma

dqdx=0.0,0.0,..., x-derivative of Q (d q/dx)

dqdz=0.0,0.0,..., z-derivative of Q (d q/dz)

drdx=0.0,0.0,..., x-derivative of density (d rho/dx)

drdz=0.0,0.0,..., z-derivative of density (d rho/dz)

dvpdx=0.0,0.0,..., x-derivative of P-velocity (dvp/dx)

dvpdz=0.0,0.0,..., z-derivative of P-velocity (dvs/dz)

dvsdx=0.0,0.0,..., x-derivative of S-velocity (dvs/dx)

dvsdz=0.0,0.0,..., z-derivative of S-velocity (dvs/dz)

dedx=0.0,0.0,..., x-derivative of epsilon (de/dx)

dedz=0.0,0.0,..., z-derivative of epsilon with depth z (de/dz)

dddx=0.0,0.0,..., x-derivative of delta (dd/dx)

dddz=0.0,0.0,..., z-derivative of delta (dd/dz)

dgdz=0.0,0.0,..., x-derivative of gamma (dg/dz)

dgdx=0.0,0.0,..., z-derivative of gamma (dg/dx)

phi00=0,0,..., rotation angle(s) in each layer

...output filenames

c11\_file=c11\_file output filename for c11 values

c13\_file=c13\_file output filename for c13 values

c15\_file=c15\_file output filename for c15 values

c33\_file=c33\_file output filename for c33 values

c35\_file=c35\_file output filename for c35 values

c44\_file=c44\_file output filename for c44 values

c55\_file=c55\_file output filename for c55 values

c66\_file=c66\_file output filename for c66 values

rho\_file=rho\_file output filename for density values

q\_file=q\_file output filename for Q values

paramtype=1 =1 Thomsen parameters, =0 Sayers parameters(see below)

method=linear for linear interpolation of interface

=mono for monotonic cubic interpolation of interface

=akima for Akima's cubic interpolation of interface

=spline for cubic spline interpolation of interface

tfile= =testfilename if set, a sample input dataset is  
output to "testfilename".

Notes:

The input file is an ASCII file containing x z values representing a piecewise continuous velocity model with a flat surface on top.

The surface and each successive boundary between media is represented by a list of selected x z pairs written column form. The first and last x values must be the same for all boundaries. Use the entry 1.0 -99999 to separate the entries for successive boundaries. No

boundary may cross another. Note that the choice of the method of interpolation may cause boundaries to cross that do not appear to cross in the input data file.

The number of interfaces is specified by the parameter "ninf". This number does not include the top surface of the model. The input data format is the same as a CSHOT model file with all comments removed.

The algorithm works by transforming the P-wavespeed, S-wavespeed, density and the Thomsen or Sayers parameters epsilon, delta, and gamma into elastic stiffness coefficients. Furthermore, the user can specify rotations, phi, to the elasticity tensor in each layer.

Common ranges of Thomsen parameters are

```
epsilon: 0.0 -> 0.5
delta:   -0.2 -> 0.4
gamma:   0.0 -> 0.4
```

If only P-wave, S-wave velocities and density is given as input, the model is, by definition, isotropic.

If files containing Thomsen/Sayers parameters are given, the model will be assumed to have VTI symmetry.

Example using test input file generating feature:

```
unif2aniso tfile=testfilename produces a 5 interface demonstration model
```

```
unif2aniso < testfilename
ximage < c11_file n1=100 n2=100
ximage < c13_file n1=100 n2=100
ximage < c15_file n1=100 n2=100
ximage < c33_file n1=100 n2=100
ximage < c35_file n1=100 n2=100
ximage < c44_file n1=100 n2=100
ximage < c55_file n1=100 n2=100
ximage < c66_file n1=100 n2=100
ximage < rho_file n1=100 n2=100
ximage < q_file   n1=100 n2=100
```

Credits:

CWP: John Stockwell, April 2005.

CWP: based on program unif2 by Zhenyue Liu, 1994



UNIF2 - generate a 2-D UNIFormly sampled velocity profile from a layered model. In each layer, velocity is a linear function of position.

```
unif2 < infile > outfile [parameters]
```

Required parameters:

none

Optional Parameters:

ninf=5 number of interfaces

nx=100 number of x samples (2nd dimension)

nz=100 number of z samples (1st dimension)

dx=10 x sampling interval

dz=10 z sampling interval

npmax=201 maximum number of points on interfaces

fx=0.0 first x sample

fz=0.0 first z sample

x0=0.0,0.0,..., distance x at which v00 is specified

z0=0.0,0.0,..., depth z at which v00 is specified

v00=1500,2000,2500..., velocity at each x0,z0 (m/sec)

dvdx=0.0,0.0,..., derivative of velocity with distance x (dv/dx)

dvdz=0.0,0.0,..., derivative of velocity with depth z (dv/dz)

method=linear for linear interpolation of interface

=mono for monotonic cubic interpolation of interface

=akima for Akima's cubic interpolation of interface

=spline for cubic spline interpolation of interface

tfile= =testfilename if set, a sample input dataset is  
output to "testfilename".

Notes:

The input file is an ASCII file containing x z values representing a piecewise continuous velocity model with a flat surface on top. The surface and each successive boundary between media are represented by a list of selected x z pairs written column form. The first and last x values must be the same for all boundaries. Use the entry 1.0 -99999 to separate entries for successive boundaries. No boundary may cross another. Note that the choice of the method of interpolation may cause boundaries to cross that do not appear to cross in the input data file.

The number of interfaces is specified by the parameter "ninf". This number does not include the top surface of the model. The input data format is the same as a CSHOT model file with all comments removed.

Example using test input file generating feature:

```
unif2 tfile=testfilename      produces a 5 interface demonstration model
unif2 < testfilename | psimage n1=100 n2=100 d1=10 d2=10 | ...
```

Credits:

CWP: Zhenyue Liu, 1994

CWP: John Stockwell, 1994, added demonstration model stuff.

UNISAM2 - UNiformly SAMple a 2-D function f(x1,x2)

unisam2 [optional parameters] <inputfile >outputfile

Required Parameters:

none

Optional Parameters:

x1=                array of x1 values at which input f(x1,x2) is sampled  
... Or specify a uniform linear set of values for x1 via:  
nx1=1             number of input samples in 1st dimension  
dx1=1             input sampling interval in 1st dimension  
fx1=0             first input sample in 1st dimension  
...  
n1=1              number of output samples in 1st dimension  
d1=                output sampling interval in 1st dimension  
f1=                first output sample in 1st dimension  
x2=                array of x2 values at which input f(x1,x2) is sampled  
... Or specify a uniform linear set of values for x2 via:  
nx2=1             number of input samples in 2nd dimension  
dx2=1             input sampling interval in 2nd dimension  
fx2=0             first input sample in 2nd dimension  
...  
n2=1              number of output samples in 2nd dimension  
d2=                output sampling interval in 2nd dimension  
f2=                first output sample in 2nd dimension  
...  
method1=linear    =linear for linear interpolation  
                  =mono for monotonic bicubic interpolation  
                  =akima for Akima bicubic interpolation  
                  =spline for bicubic spline interpolation  
method2=linear    =linear for linear interpolation  
                  =mono for monotonic bicubic interpolation  
                  =akima for Akima bicubic interpolation  
                  =spline for bicubic spline interpolation

NOTES:

The number of input samples is the number of x1 values times the number of x2 values. The number of output samples is n1 times n2. The output sampling intervals (d1 and d2) and first samples (f1 and f2) default to span the range of input x1 and x2 values. In other words,  $d1=(x1_{max}-x1_{min})/(n1-1)$  and  $f1=x1_{min}$ ; likewise for d2 and f2.

Interpolation is first performed along the 2nd dimension for each

value of  $x_1$  specified. Interpolation is then performed along the 1st dimension.

AUTHOR: Dave Hale, Colorado School of Mines, 01/12/91\n"

UNISAM - UNiformly SAMple a function  $y(x)$  specified as  $x,y$  pairs

```
unisam xin= yin= nout= [optional parameters] >binaryfile
... or ...
unisam xfile= yfile= npairs= nout= [optional parameters] >binaryfile
... or ...
unisam xyfile= npairs= nout= [optional parameters] >binaryfile
```

Required Parameters:

```
xin=,,, array of x values (number of xin = number of yin)
yin=,,, array of y values (number of yin = number of xin)
... or
xfile= binary file of x values
yfile= binary file of y values
... or
xyfile= binary file of x,y pairs
npairs= number of pairs input (active only if xfile= and yfile=
or xyfile= are set)
```

```
nout= number of y values output to binary file
```

Optional Parameters:

```
dxout=1.0 output x sampling interval
fxout=0.0 output first x
method=linear =linear for linear interpolation (continuous y)
=mono for monotonic cubic interpolation (continuous y')
=akima for Akima's cubic interpolation (continuous y')
=spline for cubic spline interpolation (continuous y'')
isint=,,, where these sine interpolations to apply
amp=,,, amplitude of sine interpolations
phase0=,,, starting phase (defaults: 0,0,0,...,0)
totalphase=,,, total phase (default pi,pi,pi,...,pi.)
nwidth=0 apply window smoothing if nwidth>0
```

AUTHOR: Dave Hale, Colorado School of Mines, 07/07/89  
Zhaobo Meng, Colorado School of Mines,  
added sine interpolation and window smoothing, 09/16/96  
CWP: John Stockwell, added file input options, 24 Nov 1997

Remarks: In interpolation, suppose you need 2 pieces of  
sine interpolation before index 3 to 4, and index 20 to 21  
then set: isint=3,20. The sine interpolations use a sine

function with starting phase being phase0, total phase being totalphase (i.e. ending phase being phase0+totalphase for each interpolation).

UTMCONV - CONVert longitude and latitude to UTM, and vice versa

utmconv <stdin >stdout [optional parameters]

Optional parameters:

idx=23	reference ellipsoid index (default is WGS 1984)
format=%.3f	output number format (printf style for one float)
a=(from idx)	user-specified semimajor axis of ellipsoid
f=(from idx)	user-specified flattening of ellipsoid
letter=0	=1: use UTM letter designator for latitude/Northing
invert=0	=0: convert latitude and longitude to UTM =1: convert UTM to latitude and longitude
verbose=0	=1: echo parameters and number of converted coords
lon0=	central meridian for TM projection in degrees (default uses the 60 standard UTM longitude zones)
xoff=500000	false Easting (default: UTM)
ysoff=10000000	false Northing, southern hemisphere (default: UTM)
ynoff=0	false Northing, northern hemisphere (default: UTM)

Notes:

Universal Transverse Mercator (UTM) coordinates are defined between latitudes 80S (-80) and 84N (84). Longitude values must be between -180 degrees (west) and 179.999... degrees (east).

Input and output is in ASCII format. For a conversion from lon/lat to UTM (invert=0), input is a two-column table of longitude and latitude in decimal degrees. Output is a three-column table of UTM Easting, UTM Northing, and UTM zone. The zone is given either by the zone number only (default, negative on southern hemisphere) or by the positive zone number plus a letter designator (letter=1).

Example:

Convert 40.822N, 14.125E to UTM with zone number and letter, output values rounded to nearest integer:  
echo 14.125 40.822 | utmconv letter=1 format=%.0f  
The output is "426213 4519366 33T" (Easting, Northing, UTM zone).

Reference ellipsoids:

An ellipsoid may be specified by its semimajor axis *a* and its flattening *f*, or one of the following ellipsoids may be selected by its index *idx* (semimajor axes in meters):

0 Sphere with radius of 6371000 m

- 1 Airy 1830
- 2 Australian National 1965
- 3 Bessel 1841 (Ethiopia, Indonesia, Japan, Korea)
- 4 Bessel 1841 (Namibia)
- 5 Clarke 1866
- 6 Clarke 1880
- 7 Everest (Brunei, E. Malaysia)
- 8 Everest (India 1830)
- 9 Everest (India 1956)
- 10 Everest (Pakistan)
- 11 Everest (W. Malaysia, Singapore 1948)
- 12 Everest (W. Malaysia 1969)
- 13 Geodetic Reference System 1980 (GRS 1980)
- 14 Helmert 1906
- 15 Hough 1960
- 16 Indonesian 1974
- 17 International 1924 / Hayford 1909
- 18 Krassovsky 1940
- 19 Modified Airy
- 20 Modified Fischer 1960
- 21 South American 1969
- 22 World Geodetic System 1972 (WGS 1972)
- 23 World Geodetic System 1984 (WGS 1984) / NAD 1983

UTM grid:

The Universal Transverse Mercator (UTM) system is a world wide coordinate system defined between 80S and 84N. It divides the Earth into 60 six-degree zones. Zone number 1 has its central meridian at 177W (-177 degrees), and numbers increase eastward.

Within each zone, an Easting of 500,000 m is assigned to its central meridian to avoid negative coordinates. On the northern hemisphere, Northings start at 0 m at the equator and increase northward. On the southern hemisphere a false Northing of 10,000,000 m is applied, i.e. Northings start at 10,000,000 m at the equator and decrease southward. Letters are sometimes used to identify different zones of latitude. The letters C-M indicate zones on the southern and the letters N-X zones on the northern hemisphere.

Author:

Nils Maercklin, RISSC, University of Naples, Italy, March 2007

References:

- NIMA (2000). Department of Defense World Geodetic System 1984 - its definition and relationships with local geodetic systems. Technical Report TR8350.2. National Imagery and Mapping Agency, Geodesy and Geophysics Department, St. Louis, MO. 3rd edition.
- J. P. Snyder (1987). Map Projections - A Working Manual. U.S. Geological Survey Professional Paper 1395, 383 pages. U.S. Government Printing Office.

VEL2STIFF - Transforms VELOCities, densities, and Thomsen or Sayers parameters to elastic STIFFnesses

```
vel2stiff [Required parameters] [Optional Parameters] > stdout
```

Required parameters:

vpfile= file with P-wave velocities

vsfile= file with S-wave velocities

rhofile= file with densities

Optional Parameters:

epsfile= file with Thomsen/Sayers epsilon

deltafile= file with Thomsen/Sayers delta

gammafile= file with Thomsen/Sayers gamma

phi\_file= angle of axis of symmetry from vertical (radians)

c11\_file=c11\_file output filename for c11 values

c13\_file=c13\_file output filename for c13 values

c15\_file=c15\_file output filename for c15 values

c33\_file=c33\_file output filename for c33 values

c35\_file=c35\_file output filename for c35 values

c44\_file=c44\_file output filename for c44 values

c55\_file=c55\_file output filename for c55 values

c66\_file=c66\_file output filename for c66 values

paramtype=1 (1) Thomsen parameters, (0) Sayers parameters(see below)

nx=101 number of x samples 2nd (slow) dimension

nz=101 number of z samples 1st (fast) dimension

Notes:

Transforms velocities, density and Thomsen/Sayers parameters epsilon, delta, and gamma into elastic stiffness coefficients.

If only P-wave, S-wave velocities and density is given as input, the model is assumed to be isotropic.

If files containing Thomsen/Sayers parameters are given, the model will be assumed to have VTI symmetry.

All input files vpfile, vsfile, rhofile etc. are assumed to consist only of C style binary floating point numbers representing the corresponding material values of vp, vs, rho etc. Similarly, the output

files consist of the corresponding stiffnesses as C style binary floats. If the output files are to be used as input for a modeling program, such as suea2df, then further, the contents are assumed be arrays of floating point numbers of the form of `Array[n2][n1]`, where the fast dimension, dimension 1, represents depth.

Author:

CWP: Sverre Brandsberg-Dahl 1999

Extended:

CWP: Stig-Kyrre Foss 2001

- to include the option to use the parameters by Sayers (1995) instead of the Thomsen parameters

Technical reference:

Sayers, C. M.: Simplified anisotropy parameters for transversely isotropic sedimentary rocks. *Geophysics* 1995, pages 1933-1935.

## VELCONV - VELOCITY CONVERSION

velconv <infile >outfile intype= outtype= [optional parameters]

### Required Parameters:

intype=                   input data type (see valid types below)  
outtype=                   output data type (see valid types below)

### Valid types for input and output data are:

vintt                   interval velocity as a function of time  
vrmst                   RMS velocity as a function of time  
vintz                   velocity as a function of depth  
zt                      depth as a function of time  
tz                      time as a function of depth

### Optional Parameters:

nt=all                   number of time samples  
dt=1.0                   time sampling interval  
ft=0.0                   first time  
nz=all                   number of depth samples  
dz=1.0                   depth sampling interval  
fz=0.0                   first depth  
nx=all                   number of traces

Example: "intype=vintz outtype=vrmst" converts an interval velocity function of depth to an RMS velocity function of time.

Notes: nt, dt, and ft are used only for input and output functions of time; you need specify these only for vintt, vrmst, orzt. Likewise, nz, dz, and fz are used only for input and output functions of depth.

The input and output data formats are C-style binary floats.

AUTHOR: Dave Hale, Colorado School of Mines, 07/07/89

VELPERTAN - Velocity PERTurbation analysis in ANisotropic media to  
determine the model update required to flatten image gathers",

velpertan boundary= par=cig.par refl1= refl2= npicks1=  
npicks2= cdp1= cdp2= vfile= efile= dfile= nx= dx= fx=  
ncdp= dcdp= fcdp= off0= noff= doff= >outfile [parameters]

Required Parameters:

refl1= file with picks on the 1st reflector  
refl2= file with picks on the 2nd reflector  
vfile= file defining VPO at all grid points from prev. iter. "  
efile= file defining eps at all grid points from prev. iter. "  
dfile= file defining del at all grid points from prev. iter. "  
boundary= file defining the boundary above which  
parameters are known; update is done below this "  
boundary "  
npicks1= number of picks on the 1st reflector  
npicks2= number of picks on the 2nd reflector  
ncdp= number of cdp's  
dcdp= cdp spacing  
fcdp= first cdp  
off0= first offset in common image gathers  
noff= number of offsets in common image gathers  
doff= offset increment in common image gathers  
cip1=x1,r1,r2,..., cip=xn,r1n,r2n description of input CIGS  
cip2=x2,r1,r2,..., cip=xn,r1n,r2n description of input CIGS  
x x-value of a common image point  
r1 hyperbolic component of the residual moveout  
r2 non-hyperbolic component of residual moveout

Optional Parameters:

method=akima for linear interpolation of the interface  
=mono for monotonic cubic interpolation of interface  
=akima for Akima's cubic interpolation of interface  
=spline for cubic spline interpolation of interface  
VPO=2000 Starting value for vertical velocity at a point in the  
target layer  
x00=0.0 x-coordinate at which VPO is defined  
z00=0.0 z-coordinate at which VPO is defined  
eps=0.0 Starting value for Thomsen's parameter epsilon  
del=0.0 Starting value for Thomsen's parameter delta  
kz=0.0 Starting value for the vertical gradient in VPO  
kx=0.0 Starting value for the lateral gradient in VPO  
nx=100 number of nodes in the horizontal direction for the

velocity grid  
nz=100 number of nodes in the vertical direction for the  
velocity grid  
dx=10 horizontal grid increment  
dz=10 vertical grid increment  
fx=0 first horizontal grid point  
fz=0 first vertical grid point  
dt=0.008 traveltime increment  
nt=500 no. of points on the ray  
amax=360 max. angle of emergence  
amin=0 min. angle of emergence

Smoothing parameters:

r1=0 smoothing parameter in the 1 direction  
r2=0 smoothing parameter in the 2 direction  
win=0,n1,0,n2 array for window range  
rw=0 smoothing parameter for window function  
nbound=2 number of points picked on the boundary  
tol=0.1 tolerance in computing the offset (m)

Notes:

This program is used as part of the velocity analysis technique developed by Debashish Sarkar, CWP:2003.

Notes:

The output par file contains the coefficients describing the residual moveout. This program is used in conjunction with surelanan.

Author: CSM: Debashish Sarkar, December 2003  
based on program: velpert.c written by Zhenuye Liu.

VELPERT - estimate velocity parameter perturbation from covariance of imaged depths in common image gathers (CIGs)

```
verpert <dfile dzfile=dzfile >outfile [parameters]
```

Required Parameters:

dfile input of imaged depths in CIGs

dzfile=dzfile input of dz/dv at the imaged depths in CIGs

outfile output of the estimated parameter

noff number of offsets

ncip number of common image gathers

Optional Parameters:

moff=noff number of first offsets used in velocity estimation

Notes:

1. This program is part of Zhenyue Liu's velocity analysis technique. The input dzdv values are computed using the program dzdv.
2. For given depths, using moff smaller than noff may avoid poor values of dz/dv at far offsets. However, a too small moff used will the sensitivity of velocity error to the imaged depth.
3. Outfile contains three parts:
  - dlambda correction of the velocity parameter. dlambda plus the initial parameter (used in migration) will be the updated one.
  - deviation to measure how close imaged depths are to each other in CIGs. Old deviation corresponds to the initial parameter; new deviation corresponds to the updated one.
  - sensitivity to predict how sensitive the error in the estimated parameter is to an error in the measurement of imaged depths.

error of parameter  $\leq$  sensitivity \* error of depth.

Author: Zhenyue Liu, 12/29/93, Colorado School of Mines

Reference:

Liu, Z. 1995, "Migration Velocity Analysis", Ph.D. Thesis, Colorado School of Mines, CWP report #168.

VTLVZ -- Velocity as function of Time for Linear V(Z);  
writes out a vector of velocity =  $v_0 \exp(a t/2)$

vtlvz > velfile nt= dt= v0= a=

Required parameters

nt= number of time samples

dt= time sampling interval

v0= velocity at the surface

a= velocity gradient

WKBJ - Compute WKBJ ray theoretic parameters, via finite differencing

wkbj <vfile >tfile nx= nz= xs= zs= [optional parameters]

Required Parameters:

<vfile file containing velocities v[nx] [nz]

nx= number of x samples (2nd dimension)

nz= number of z samples (1st dimension)

xs= x coordinate of source

zs= z coordinate of source

Optional Parameters:

dx=1.0 x sampling interval

fx=0.0 first x sample

dz=1.0 z sampling interval

fz=0.0 first z sample

sfile=sfile file containing sigmas sg[nx] [nz]

bfile=bfile file containing incident angles bet[nx] [nz]

afile=afile file containing propagation angles a[nx] [nz]

Notes:

Traveltimes, propagation angles, sigmas, and incident angles in WKBJ by finite differences in polar coordinates. Traveltimes are calculated by upwind scheme; sigmas and incident angles by a Crank-Nicolson scheme.

Credits:

CWP: Zhenyue Liu, Dave Hale, pre 1992.

XY2Z - converts (X,Y)-pairs to spike Z values on a uniform grid

```
xy2z < stdin npairs= [optional parameters] >stdout
```

Required parameter:

npairs= number of pairs input

Optional parameter:

scale=1.0 value to scale spikes by

nx1=100 dimension of first (fast) dimension of output array

nx2=100 dimension of second (slow) dimension of output array

x1pad=2 zero padding in x1 dimension

x2pad=2 zero padding in x2 dimension

yx=0 assume (x,y) pairs

=1 assume (y,x) pairs

Notes:

Converts ordered (x,y) pairs to spike x1values, of height=scale on a uniform grid.

Credits:

CWP: John Stockwell, Nov 1995

Z2XYZ - convert binary floats representing Z-values to ascii form in X Y Z ordered triples

```
z2xyz <stdin >stdout
```

Required parameters:

n1= number of floats in 1st (fast) dimension

Optional parameters:

outpar=/dev/tty output parameter file

Notes: This program is useful for converting panels of float data (representing evenly spaced z values) to the x y z ordered triples required for certain 3D plotting packages.

Example of NXplot3d usage on a NeXT:

```
suplane | sufilter | z2xyz n1=64 > junk.ascii
```

Now open junk.ascii as a mesh data file with NXplot3d.

(NXplot3d is a NeXTStep-only utility for viewing 3d data sets

Credits:

CWP: John Stockwell based on "b2a" by Jack Cohen

BHEDTOPAR - convert a Binary tape HEaDer file to PAR file format

```
bhedtopar < stdin outpar=parfile
```

Required parameter:

none

Optional parameters:

swap=0 =1 to swap bytes

outpar=/dev/tty =parfile name of output param file

Notes:

This program dumps the contents of a SEG Y binary tape header file, as would be produced by segyread and segyhdrs to a file in "parfile" format. A "parfile" is an ASCII file containing entries of the form param=value. Here "param" is the keyword for the binary tape header field and "value" is the value of that field. The parfile may be edited as any ASCII file. The edited parfile may then be made into a new binary tape header file via the program setbhed.

See sudoc setbhed for examples

Credits:

CWP: John Stockwell 11 Nov 1994

DT1TOSU - Convert ground-penetrating radar data in the Sensors & Software  
X.dt1 GPR format to SU format.

```
dt1tosu < gpr_data_in_dt1_format > stdout
```

Optional parameters:

```
ns=from header number of samples per trace
dt=.8 time sample interval (see below)
swap=1 perform byte swapping (big endian machines)
=0 don't swap bytes (little endian machines)
verbose=0 silent
=1 S & S header values from first trace
sent to outpar
=2 S & S header values from all traces
sent to outpar
outpar=/dev/tty output parameter file
list=0 silent
=1 list explaining labels used in verbose
is printed to stderr
```

Caution: An incorrect ns field will munge subsequent processing.

Notes:

```
For compatibility with SEGY header, apparent dt is set to
.8 ms (800 microsecs). Actual dt is .8 nanosecs.
Using TRUE DISTANCES, this scales velocity
and frequency by a factor of 1 million.
Example: v_air = 9.83X10^8 ft/s (real)
v_air = 983 ft/s (apparent for su)
Example: fnyquist = 625 MHz (real)
fnyquist = 625 Hz (apparent for su)
```

IBM RS6000, NeXT, SUN are examples of big endian machines  
PC's and DEC are examples of little endian machines

Caveat:

This program has not been tested on DEC, some modification of the  
byte swapping routines may be required.

Credits:

```
CWP: John Stockwell, Jan 1994 Based on a code "sugpr" by
UTULSA: Chris Liner & Bill Underwood (Dec93)
```

modifications permit S & S dt1 header information to be transferred directly to SU header

Trace header fields set: ns, tracl, tracr, dt, delrt, trid,  
hour, minute, second

LAS2SU - convert las2 format well log curves to su traces

```
las2su <stdin nskip= ncurve= >stdout [optional params]
```

Required parameters:

none

Optional parameters:

ncurve=automatic number of log curves in the las file

dz=0.5 input depth sampling (ft)

m=0 output (d1,f1) in feet

=1 output (d1,f1) in meters

ss=0 do not subsample (unless nz > 32767 )

=1 pass every other sample

verbose=0 =1 to echo las header lines to screen

outhdr=las\_header.asc name of file for las headers

Notes:

1. It is recommended to run LAS\_CERTIFY available from CWLS at <http://cwls.org>.
2. First log curve MUST BE depth.
3. If number of depth levels > 32767 (segy NT limit) then input is subsampled by factor of 2 or 4 as needed
4. Logs may be isolated using tracl header word (1,2,...,ncurve)  
tracl=1 is depth

Credits:

\* Chris Liner based on code by Ferhan Ahmed and a2b.c (June 2005)

\* CWP: John Stockwell 31 Oct 2006, combining lasstrip and

\* CENPET: lasstrip 2006 by Werner Heigl

\*

\* Ideas for improvement:

\* add option to chop off part of logs (often shallow

\* portions are not of interest

\* cross check sampling interval from header against

\* values found from first log curve (=depth)

\*

SEGYCLEAN - zero out unassigned portion of header

```
segyclean <stdin >stdout
```

Since "foreign" SEG-Y tapes may use the unassigned portion of the trace headers and since SU now uses it too, this program zeros out the fields meaningful to SU.

Example:

```
segypread trmax=200 | segyclean | suximage
```

Credits:

CWP: Jack Cohen

SEGYHDRMOD - replace the text header on a SEGY file

```
segyhdrmod text=file data=file
```

Required parameters:

text= name of file containing new 3200 byte text header

data= name of file containing SEGY data set

====\*\

sgyhdrmod - replace the text header on a SEGY data file in place

This program only reads and writes 3200 bytes

Reginald H. Beardsley

rhb@acm.org

\\*====\*/

SEGYHDRS - make SEG-Y ascii and binary headers for segywrite

segyhdrs [ < sudata ] [optional parameters] [ > copy of sudata ]

Required parameters:

ns= if no input trace header

dt= if no input trace header

Optional parameters:

ns=tr.ns from header number of samples on input traces

dt=tr.dt from header sample rate (microseconds) from traces

bfile=binary name of file containing binary block

hfile=header name of file containing ascii block

Some binary header fields are set:

jobid=1 job id field

lino=1 line number (only one line per reel)

reno=1 reel number

format=1 data format

All other fields are set to 0, by default.

To set any binary header field, use sukeyword to find out the appropriate keyword, then use the getpar form:

keyword=value to set keyword to value

The header file is created as ascii and is translated to ebcdic by segywrite before being written to tape. Its contents are formal but can be edited after creation as long as the forty line format is maintained.

Caveat: This program has not been tested under XDR for machines not having a 2 byte unsigned short integral data type.

Credits:

CWP: Jack K. Cohen, John Stockwell

MOBIL: Stew Levin

SEGYREAD - read an SEG-Y tape

```
segyread > stdout tape=
```

or

```
SEG-Y data stream ... | segyread tape=- > stdout
```

Required parameter:

tape= input tape device or seg-y filename (see notes)

Optional parameters:

buff=1 for buffered device (9-track reel tape drive)  
=0 possibly useful for 8mm EXABYTE drives  
verbose=0 silent operation  
=1 ; echo every 'vblock' traces  
vblock=50 echo every 'vblock' traces under verbose option  
hfile=header file to store ebcdic block (as ascii)  
bfile=binary file to store binary block  
xfile=xhdrs file to store extended text block  
over=0 quit if bhed format not equal 1, 2, 3, 5, or 8  
= 1 ; override and attempt conversion  
format=bh.format if over=1 try to convert assuming format value  
conv=1 convert data to native format  
= 0 ; assume data is in native format  
ns=bh.hns number of samples (use if bhed ns wrong)  
trcwt=1 apply trace weighting factor (bytes 169-170)  
=0, do not apply. (Default is 0 for formats 1 and 5)  
trmin=1 first trace to read  
trmax=INT\_MAX last trace to read  
endian=1 set =0 for little-endian machines(PC's,DEC,etc.)  
errmax=0 allowable number of consecutive tape IO errors  
remap=...,... remap key(s)  
byte=...,... formats to use for header remapping

Notes:

Traditionally tape=/dev/rmt0. However, in the modern world tape device names are much less uniform. The magic name can often be deduced by "ls /dev". Likely man pages with the names of the tape devices are: "mt", "sd" "st". Also try "man -k scsi", " man mt", etc. Sometimes "mt status" will tell the device name.

For a SEG-Y diskfile use tape=filename.

The xfile argument will only be used if the file contains extended text headers.

Remark: a SEG-Y file is not the same as an su file. A SEG-Y file consists of three parts: an ebcdic header, a binary reel header, and the traces. The traces are (usually) in 32 bit IBM floating point format. An SU file consists only of the trace portion written in the native binary floats.

Formats supported:

- 1: IBM floating point, 4 byte (32 bits)
- 2: two's complement integer, 4 byte (32 bits)
- 3: two's complement integer, 2 byte (16 bits)
- 5: IEEE floating point, 4 byte (32 bits)
- 8: two's complement integer, 1 byte (8 bits)

tape=- read from standard input. Caveat, under Solaris, you will need to use the buff=1 option, as well.

Header remap:

The value of header word remap is mapped from the values of byte

Map a float at location 221 to sample spacing d1:

```
segypread <data >outdata remap=d1 byte=221f
```

Map a long at location 225 to source location sx:

```
segypread <data >outdata remap=sx byte=225l
```

Map a short at location 229 to gain constant igc:

```
segypread <data >outdata remap=igc byte=229s
```

Or all combined:

```
segypread <data >outdata remap=d1,sx,igc byte=221f,225l,229s
```

Segy header words are accessed as Xt where X denotes the byte number starting at 1 in correspondance with the SEG-Y standard (1975)

Known types include: f float (4 bytes)

l long int (4 bytes)

s short int (2 bytes)

b byte (1 bytes)

type: sudoc segypread for further information

Note:

If you have a tape with multiple sequences of ebcdic header, binary header, traces, use the device that invokes the no-rewind option and issue multiple segyread commands (making an appropriate shell script if you want to save all the headers). Consider using >> if you want a single trace file in the end. Similar considerations apply for multiple reels of tapes, but use the standard rewind on end of file.

Note: For buff=1 (default) tape is accessed with 'read', for buff=0 tape is accessed with fread. We suggest that you try buff=1 even with EXABYTE tapes.

Caveat: may be slow on an 8mm streaming (EXABYTE) tapedrive

Warning: segyread or segywrite to 8mm tape is fragile. Allow sufficient time between successive reads and writes.

Warning: may return the error message "efclose: fclose failed" intermittently when segyreading/segypwriting to 8mm (EXABYTE) tape even if actual segyread/segypwrite is successful. However, this error message may be returned if your tape drive has a fixed block size set.

Caution: When reading or writing SEG-Y tapes, the tape drive should be set to be able to read variable block length tape files.

Credits:

SEP: Einar Kjartansson

CWP: Jack K. Cohen, Brian Sumner, Chris Liner

: John Stockwell (added 8mm tape stuff)

conv parameter added by:

Tony Kocurko

Department of Earth Sciences

Memorial University of Newfoundland

St. John's, Newfoundland

read from stdin via tape=- added by Tony Kocurko

bhed format = 2,3 conversion by:

Remco Romijn (Applied Geophysics, TU Delft)

J.W. de Bruijn (Applied Geophysics, TU Delft)

bhed format = 8 conversion by: John Stockwell

header remap feature added by:  
Matthias Imhof, Virginia Tech

-----

Additional Notes:

Brian's subroutine, `ibm_to_float`, which converts IBM floating point to IEEE floating point is NOT portable and must be altered for non-IEEE machines. See the subroutine notes below.

A direct read by `dd` would suck up the entire tape; hence the dancing around with buffers and files.

SEGYWRITE - write an SEG-Y tape

segypwrite <stdin tape=

Required parameters:

tape= tape device to use (see sudoc segypread)

Optional parameter:

verbose=0 silent operation

=1 ; echo every 'vblock' traces

vblock=50 echo every 'vblock' traces under verbose option

buff=1 for buffered device (9-track reel tape drive)

=0 possibly useful for 8mm EXABYTE drive

conv=1 =0 don't convert to IBM format

hfile=header ebcdic card image header file

bfile=binary binary header file

trmin=1 first trace to write

trmax=INT\_MAX last trace to write

endian=1 =0 for little-endian machines (PC's, DEC,etc...)

errmax=0 allowable number of consecutive tape IO errors

format= override value of format in binary header file

Note: The header files may be created with 'segyphdrs'.

Note: For buff=1 (default) tape is accessed with 'write', for buff=0 tape is accessed with fwrite. Try the default setting of buff=1 for all tape types.

Caveat: may be slow on an 8mm streaming (EXABYTE) tapedrive

Warning: segypread or segypwrite to 8mm tape is fragile. Allow time between successive reads and writes.

Precaution: make sure tapedrive is set to read/write variable blocksize tapefiles.

For more information, type: sudoc <segypwrite>

Warning: may return the error message "efclose: fclose failed" intermittently when segypreading/segypwriting to 8mm EXABYTE tape, even if actual segypread/segypwrite is successful. However, this may indicate that your tape drive has been set to a fixed block size. Tape drives should be set to variable block size before reading

or writing tapes in the SEG-Y format.

Credits:

SEP: Einar Kjartansson

CWP: Jack, Brian, Chris

: John Stockwell (added EXABYTE functionality)

Notes:

Brian's subroutine, float\_to\_ibm, for converting IEEE floating point to IBM floating point is NOT portable and must be altered for non-IEEE machines. See the subroutine notes below.

On machines where shorts are not 2 bytes and/or ints are not 4 bytes, routines to convert SEG-Y 16 bit and 32 bit integers will be required.

The program, segyhdrs, can be used to make the ascii and binary files required by this code.

SETBHED - SET the fields in a SEG-Y Binary tape HEaDer file, as would be produced by segyread and segyhdrs

setbhed par= [optional parameters]

Required parameter:

none

Optional parameters:

bfile=binary output binary tape header file

par= =parfile

Set field by field, if desired:

jobid= job id field

lino= line number (only one line per reel)

reno= reel number

format= data format

... etc....

To set any binary header field, use sukeyword to find out

the appropriate keyword, then use the getpar form:

keyword=value to set keyword to value

Notes:

As with all other programs in the CWP/SU package that use getpars, (GET PARAmeters from the command line) a file filled with such statments may be included via option par=parfile. In particular, a parfile created by "bhedtopar" may be used as input for the program "setbhed".

Caveat: This program breaks if a "short" isn't 2 bytes since the SEG-Y standard demands a 2 byte integer for ns.

Credits:

CWP: John Stockwell 11 Nov 1994

SU3DCHART - plot x-midpoints vs. y-midpoints for 3-D data

```
su3dchart <stdin >stdout
```

Optional parameters:

outpar=null name of parameter file

degree=0 =1 convert seconds of arc to degrees

The output is the (x, y) pairs of binary floats

Example:

```
su3dchart <segy_data outpar=pfile >plot_data  
psgraph <plot_data par=pfile \<\  
linewidth=0 marksize=2 mark=8 | ...  
rm plot_data
```

```
su3dchart <segy_data | psgraph n=1024 d1=.004 \<\  
linewidth=0 marksize=2 mark=8 | ...
```

Note: sx, etc., are declared double because float has only 7 significant numbers, that's not enough, for example, when tr.scalco=100 and coordinates are in second of arc and located near 30 degree latitude and 59 degree longitude

Credits:

CWP: Shuki Ronen

Toralf Foerster

Trace header fields accessed: sx, sy, gx, gy, counit, scalco.

SUABSHW - replace header key word by its absolute value

suabshw <stdin >stdout key=offset

Required parameters:

none

Optional parameter:

key=offset header key word

Credits:

CWP: Jack K. Cohen

SUACOR - auto-correlation

suacor <stdin >stdout [optional parms]

Optional Parameters:

ntout=101 odd number of time samples output

norm=1 if non-zero, normalize maximum absolute output to 1

sym=1 if non-zero, produce a symmetric output from

lag  $-(ntout-1)/2$  to lag  $+(ntout-1)/2$

Credits:

CWP: Dave Hale

Trace header fields accessed: ns

Trace header fields modified: ns and delrt

SUADDEVENT - add a linear or hyperbolic moveout event to seismic data

suaddevent <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

type=nmo       =lmo for linear event  
t0=1.0         zero-offset intercept time IN SECONDS  
vel=3000.      moveout velocity in m/s  
amp=1.         amplitude  
dt=            must provide if 0 in headers (seconds)

Typical usage:

```
sunull nt=500 dt=0.004 ntr=100 | sushw key=offset a=-1000 b=20 \\  
| suaddevent v=1000 t0=0.05 type=lmo | suaddevent v=1800 t0=0.8 \  
| sufiler f=8,12,75,90 | suxwigb clip=1 &
```

Credits:

Gary Billings, Talisman Energy, May 1996, Apr 2000, June 2001

Note: code is inefficient in that to add a single "spike", with sinc interpolation, an entire trace is generated and added to the input trace. In fact, only a few points needed be created and added, but the current coding avoids the bookkeeping re which are the relevant points!

SUADDHEAD - put headers on bare traces and set the tracl and ns fields

```
suaddhead <stdin >stdout ns= ftn=0
```

Required parameter:

ns=the number of samples per trace

Optional parameter:

```
ifdef SU_LINE_HEADER
```

```
head=          file to read headers in
                not supplied -- will generate headers
                given          -- will read in headers and attach
                                floating point arrays to form
                                traces ",
                                (head can be created via sustrip program)
```

```
endif
```

ftn=0 Fortran flag

0 = data written unformatted from C

1 = data written unformatted from Fortran

tsort=3 trace sorting code:

1 = as recorded (no sorting)

2 = CDP ensemble

3 = single fold continuous profile

4 = horizontally stacked ",

ntrpr=1 number of data traces per record

if tsort=2, this is the number of traces per cdp",

Trace header fields set: ns, tracl

Use sushw/suchw to set other needed fields.

Caution: An incorrect ns field will munge subsequent processing.

Note: n1 and nt are acceptable aliases for ns.

Example:

```
suaddhead ns=1024 <bare_traces | sushw key=dt a=4000 >segy_traces
```

This command line adds headers with ns=1024 samples. The second part of the pipe sets the trace header field dt to 4 ms.

SUADDNOISE - add noise to traces

```
suaddnoise <stdin >stdout sn=20 noise=gauss seed=from_clock
```

Required parameters:

if any of  $f=f_1, f_2, \dots$  and  $\text{amp}=a_1, a_2, \dots$  are specified by the user and if  $dt$  is not set in header, then  $dt$  is mandatory

Optional parameters:

$sn=20$  signal to noise ratio  
 $noise=gauss$  noise probability distribution  
=flat for uniform; default Gaussian  
 $seed=from\_clock$  random number seed (integer)  
 $f=f_1, f_2, \dots$  array of filter frequencies (as in `sufilter`)  
 $\text{amps}=a_1, a_2, \dots$  array of filter amplitudes  
 $dt=$  (from header) time sampling interval (sec)  
 $verbose=0$  =1 for echoing useful information

$tmpdir=$  if non-empty, use the value as a directory path prefix for storing temporary files; else if the `CWP_TMPDIR` environment variable is set use its value for the path; else use `tmpfile()`

Notes:

Output = Signal + scale \* Noise

$$\text{scale} = (1/sn) * (\text{absmax\_signal}/\sqrt{2})/\sqrt{\text{energy\_per\_sample}}$$

If the signal is already band-limited,  $f=f_1, f_2, \dots$  and  $\text{amps}=a_1, a_2, \dots$  can be used, as in `sufilter`, to bandlimit the noise traces to match the signal band prior to computing the scale defined above.

Examples of noise bandlimiting:

```
low frequency:    suaddnoise < data f=40,50 amps=1,0 | ...
high frequency:   suaddnoise < data f=40,50 amps=0,1 | ...
near monochromatic: suaddnoise < data f=30,40,50 amps=0,1,0 | ...
with a notch:     suaddnoise < data f=30,40,50 amps=1,0,1 | ...
bandlimited:      suaddnoise < data f=20,30,40,50 amps=0,1,1,0 | ...
```

Credits:

CWP: Jack Cohen, Brian Sumner, Ken Lerner  
John Stockwell (fixed filtered noise option)

Notes:

At  $S/N = 2$ , the strongest reflector is well delineated, so to see something  $1/n$ th as strong as this dominant reflector requires  $S/N = 2*n$ .

Trace header field accessed: ns

SUADDSTATICS - ADD random STATICS on seismic data

suaddstatics required parameters [optional parameters] > stdout

Required parameters:

shift= the static shift will be generated  
randomly in the interval [+shift,-shif] (ms)  
sources= number of source locations  
receivers= number of receiver locations  
cmps= number of common mid point locations  
maxfold= maximum fold of input data  
datafile= name and COMPLETE path of the input file

Optional parameters:

dt=tr.dt time sampling interval (ms)  
seed=getpid() seed for random number generator  
verbose=0 =1 print useful information

Notes:

SUADDSTATICS applies static time shifts in a surface consistent way on seismic data sets. SUADDSTATICS writes the static time shifts in the header field TSTAT. To perform the actual shifts the user should use the program SUSTATIC after SUADDSTATICS. SUADDSTATICS outputs the corrupted data set to stdout.

Header field used by SUADDSTATICS: cdp, sx, gx, tstat, dt.

Credits: CWP Wences Gouveia, 11/07/94, Colorado School of Mines

SUALFORD - trace by trace Alford Rotation of shear wave data volumes

```
sualford inS11=file1 inS22=file2 inS12=file3 inS21=file4
outS11=file5 outS22=file6 outS12=file7 outS21=file8 [optional
parameters]
```

Required Parameters:

```
inS11= input data volume for the 11 component
inS12= input data volume for the 12 component
inS21= input data volume for the 21 component
inS22= input data volume for the 22 component
outS11= output data volume for the 11 component
outS12= output data volume for the 11 component
outS21= output data volume for the 11 component
outS22= output data volume for the 11 component
```

Optional parameters:

```
angle_inc=          sets the increment to the angle by which
                    the data sets are rotated. The minimum is
                    set to be 1 degree and default is 5.
Az_key=             to set the header field storing the azimuths
                    for the fast shear wave on the output volumes
Q_key=              to set the header field storing the quality
                    factors of performed optimum rotations
lag_key=            to set the header field storing the lag in
                    miliseconds the fast and slow shear components
xcorr_key=          to set the header field containing the maxi-
                    mum normalized cross-correlation between the
                    and slow shear waves.
taper= 2*taper+1 is the length of the sample overlap
                    between the unrotated data with the rotated
                    data on the traces. The boundary between them
                    is defined by time windowing.
taper = -1, for no-overlap
taper = 0, for overlap of one sample
taper =>1, for use of cosine scale to
                    to interpolate between the
                    unrotated and rotated parts
                    of the traces
taperwin=           another taper used to taper the data within
                    the window of analysis to diminish the effect
                    of data near the window edges. In this way one
```

can focus on a given reflector. Also given in  
number of samples

maxlag= maximum limit in ms for the lag between fast  
and slow shear waves. If this threshold is  
attained or surpassed, the quality factor for  
the rotation is zeroed as well as all the  
parameters found for that certain rotation

ntraces= number of traces to be used per computation  
ntraces=3 will use three adjacent traces to  
compute the angle of rotation "

Notes:

The Alford Rotation is a method to rotate the four components  
of a shear wave survey into its natural coordinate system, where  
the fast and slow shear correspond to the inline to inline shear (S11)  
and xline to xline (S22) volumes, respectively.

This Alford Rotation code tries to maximize the energy in the  
diagonal volumes, i.e., S11 and S22, while minimizing the energy  
in the off-diagonals, i.e., in volumes S12 and S21, in a trace by  
trace manner. It then returns the new rotated volumes, saving the  
the quality factor for the rotation and azimuth angle of the fast  
shear wave direction for each trace headers of the new rotated S11  
volume.

The fields in the header containing the Azimuth and Quality factor  
and the sample lag between fast and slow shear are otrav, grnolf and  
grnofr, respectively, by default. The values are multiplied by ten in  
the case of the angles and by a thousand for quality factors. To  
change this defaults use the optional parameters Az\_key, Q\_key and  
lag\_key

modified header fields:

the ones specified by Az\_key, Q\_key, lag\_key and xcorr\_key. By default  
these are otrav, grnlof, tstat and grnors, respectively.

Credits:

CWP: Rodrigo Felicio Fuck

Code translated and adapted from original version in Fortran  
by Ted Schuck (1993)

Schuck, E. L. , 1993, Multicomponent, three dimensional seismic  
characterization of a fractured coalbed methane reservoir,  
Cedar Hill Field, San Juan County, New Mexico, Ph.D. Thesis,  
Colorado School of Mines

SUAMP - output amp, phase, real or imag trace from  
(frequency, x) domain data

```
suamp <stdin >stdout mode=amp
```

Required parameters:

none

Optional parameter:

mode=amp output flag

amp = output amplitude traces

phase = output phase traces

real = output real parts

imag = output imag parts

Note:

The trace returned is half length from 0 to Nyquist.

Example:

```
sufft <data | suamp >amp_traces
```

Example:

```
sufft < data > complex_traces
```

```
suamp < complex_traces mode=real > real_traces
```

```
suamp < complex_traces mode=imag > imag_traces
```

Note: the inverse of the above operation is:

```
suop2 real_traces imag_traces op=zipper > complex_traces
```

Credits:

CWP: Shuki, Jack

Notes:

If efficiency becomes important consider inverting main loop  
and repeating extraction code within the branches of the switch.

Trace header fields accessed: ns, trid

Trace header fields modified: ns, trid

SUASCII - print non zero header values and data in various formats

```
suascii <stdin >ascii_file
```

Optional parameter:

```
bare=0    print headers and data
  =1      print only data
  =2      print headers only
  =3      print data in print data in .csv format, e.g. for Excel
  =4      print data as tab delimited .txt file, e.g. for GnuPlot
  =5      print data as .xyz file, e.g. for plotting with GMT

ntr=50    maximum number of output traces (bare=3 or bare=4 only)
index=0   don't include time/depth index in ascii file (bare=4)
  =1      include time/depth index in ascii file

key=      if set, name of keyword containing x-value
          in .xyz output (bare=5 only)
sep=      if set, string separating traces in .xyz output
          (bare=5; default is no separation)

verbose=0 =1 for detailed information
```

Notes:

The programs suwind and suresamp provide trace selection and subsampling, respectively.

With bare=0 and bare=1 traces are separated by a blank line.

With bare=3 a maximum of ntr traces are output in .csv format ("comma-separated value"), e.g. for import into spreadsheet applications like Excel.

With bare=4 a maximum of ntr traces are output in as tab delimited columns. Use bare=4 for plotting in GnuPlot.

With bare=5 traces are written as "x y z" triples as required by certain plotting programs such as the Generic Mapping Tools (GMT). If sep= is set, traces are separated by a line containing the string provided, e.g. sep=">" for GMT multisegment files.

"option=" is an acceptable alias for "bare=".

Related programs: sugethw, sudumptrace

Credits:

CWP: Jack K. Cohen c. 1989

CENPET: Werner M. Heigl 2006 - bug fixes & extensions

RISSC: Nils Maercklin 2006

Trace header field accessed: ns, dt, delrt, d1, f1, trid

SUATTRIBUTES - instantaneous trace ATTRIBUTES

```
suattributes <stdin >stdout mode=amp
```

Required parameters:

none

Optional parameter:

```
mode=amp output flag
      =amp envelope traces
      =phase phase traces
      =freq frequency traces
=freqw Frequency Weighted Envelope
=thin Thin-Bed (inst. freq - average freq)
=bandwith Instantaneous bandwidth
=normamp Normalized Phase (Cosine Phase)
      =fdenv 1st envelope traces derivative
      =sdenv 2nd envelope traces derivative
      =q Ins. Q Factor
unwrap= default unwrap=0 for mode=phase
      default unwrap=1 for mode=freq
      dphase_min=PI/unwrap
wint= windowing for freqw
windowing for thin
default=1
  o-----o-----o
  data-1 data data+1
```

Notes:

This program performs complex trace attribute analysis. The first three attributes, amp,phase,freq are the classical Taner, Kohler, and Sheriff, 1979.

The unwrap parameter is active only for mode=freq and mode=phase. The quantity dphase\_min is the minimum change in the phase angle taken to be the result of phase wrapping, rather than natural phase variation in the data. Setting unwrap=0 turns off phase-unwrapping altogether. Choosing unwrap > 1 makes the unwrapping function more sensitive to phase changes. Setting unwrap > 1 may be necessary to resolve higher frequencies in data (or sample data more finely). The phase unwrapping is crude. The differentiation needed to compute the instantaneous frequency

freq(t)= d(phase)/dt is a simple centered difference.

Examples:

```
suviro f1=10 f2=50 t1=0 t2=0 tv=1 | suattributes2 mode=amp | ...
suviro f1=10 f2=50 t1=0 t2=0 tv=1 | suattributes2 mode=phase | ...
suviro f1=10 f2=50 t1=0 t2=0 tv=1 | suattributes2 mode=freq | ...
suplane | suattributes mode=... | supswigb |...
```

Credits:

CWP: Jack Cohen

CWP: John Stockwell (added freq and unwrap features)

UGM (Geophysics Students): Agung Wiyono

email:aakanjas@gmail.com (others)

Algorithm:

$c(t) = \text{hilbert\_transform\_kernel}(t)$  convolved with  $\text{data}(t)$

$\text{amp}(t) = \sqrt{c.\text{re}^2(t) + c.\text{im}^2(t)}$

$\text{phase}(t) = \arctan(c.\text{im}(t)/c.\text{re}(t))$

$\text{freq}(t) = d(\text{phase})/dt$

Reference: Taner, M. T., Koehler, A. F., and Sheriff R. E.

"Complex seismic trace analysis", Geophysics, vol.44, p. 1041-1063, 1979

Trace header fields accessed: ns, trid

Trace header fields modified: d1, trid

SUAZIMUTH - compute trace AZIMUTH, offset, and midpoint coordinates  
and set user-specified header fields to these values

suazimuth <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

key=otrav header field to store computed azimuths in  
scale=1.0 value(key) = scale \* azimuth  
az=0 azimuth convention flag  
0: 0-179.999 deg, reciprocity assumed  
1: 0-359.999 deg, points from receiver to source  
-1: 0-359.999 deg, points from source to receiver  
sector=1.0 if set, defines output in sectors of size  
sector=degrees\_per\_sector, the default mode is  
the full range of angles specified by az  
offset=0 if offset=1 then set offset header field  
offkey=offset header field to store computed offsets in  
cmp=0 if cmp=1, then compute midpoint coordinates and  
set header fields for (cmpx, cmpy)  
mxkey=ep header field to store computed cmpx in  
mykey=cdp header field to store computed cmpy in

Notes:

All values are computed from the values in the coordinate fields  
sx,sy (source) and gx,gy (receiver).

The output field "otrav" for the azimuth was chosen arbitrarily as  
an example of a little-used header field, however, the user may  
choose any field that is convenient for his or her application.

Setting the sector=number\_of\_degrees\_per\_sector sets key field to  
sector number rather than an angle in degrees.

For az=0, azimuths are measured from the North, however, reciprocity  
is assumed, so azimuths go from 0 to 179.9999 degrees. If sector  
option is set, then the range is from 0 to 180/sector.

For az=1, azimuths are measured from the North, with the assumption  
that the direction vector points from the receiver to the source.

For az=-1, the direction vector points from the source to the receiver. No reciprocity is assumed in these cases, so the angles go from 0 to 359.999 degrees.

If the sector option is set, then the range is from 0 to 360/sector.

Caveat:

This program honors the value of scalco in scaling the values of sx,sy,gx,gy. Type "sukeyword scalco" for more information.

Type "sukeyword -o" to see the keywords and descriptions of all header fields.

To plot midpoints, use: su3dchart

Credits:

based on suchw, su3dchart

CWP: John Stockwell and UTulsa: Chris Liner, Oct. 1998

UTulsa: Chris Liner added offset option, Feb. 2002

c11: fixed offset option and added cmp option, May 2003

RISSC: Nils Maercklin added key options for offset and midpoints, and added azimuth direction option, Sep. 2006

Algorithms:

offset = osign \* sqrt( (gx-sx)\*(gx-sx) + (gy-sy)\*(gy-sy) )  
with osign = sgn( min((sx-gx),(sy-gy)) )

midpoint x value xm = (sx + gx)/2

midpoint y value ym = (sy + gy)/2

Azimuth will be defined as the angle, measured in degrees, turned from North, of a vector pointing to the source from the midpoint, or from the midpoint to the source. Azimuths go from 0-179.000 degrees or from 0-180.0 degrees.

value(key) = scale\*[90.0 - (180.0/PI)\*(atan((sy - ym)/(sx - xm))) ]

or

value(key) = scale\*[180.0 - (180.0/PI)\*(atan2((ym - sy),(xm - sx)) ) ]

Trace header fields accessed: sx, sy, gx, gy, scalco.

Trace header fields modified: (user-specified keys)

SUBFILT - apply Butterworth bandpass filter

subfilt <stdin >stdout [optional parameters]

Required parameters:

if dt is not set in header, then dt is mandatory

Optional parameters: (nyquist calculated internally)

zerophase=1 =0 for minimum phase filter

locut=1 =0 for no low cut filter

hicut=1 =0 for no high cut filter

fstoplo=0.10\*(nyq) freq(Hz) in low cut stop band

astoplo=0.05 upper bound on amp at fstoplo

fpasslo=0.15\*(nyq) freq(Hz) in low cut pass band

apasslo=0.95 lower bound on amp at fpasslo

fpasshi=0.40\*(nyq) freq(Hz) in high cut pass band

apasshi=0.95 lower bound on amp at fpasshi

fstophi=0.55\*(nyq) freq(Hz) in high cut stop band

astophi=0.05 upper bound on amp at fstophi

verbose=0 =1 for filter design info

dt = (from header) time sampling interval (sec)

Credits:

CWP: Dave for bf.c subs and test drivers

CWP: Jack for su wrapper

Caveat: zerophase will not do good if trace has a spike near the end. One could make a try at getting the "effective" length of the causal filter, but padding the traces seems painful in an already expensive algorithm.

Trace header fields accessed: ns, dt, trid

SUCCWT - Complex continuous wavelet transform of seismic traces

succwt < tdata.su > tfdata.su [optional parameters]

Required Parameters:

None

Optional Parameters:

noct=5 Number of octaves (int)  
nv=10 Number of voices per octave (int)  
fmax=Nyq Highest frequency in transform  
p=-0.5 Power of scale value normalizing CWT  
=0 for amp-preserved spec. decomp.  
c=1/(2\*fmax) Time-domain inverse gaussian damping parameter  
(bigger c means more wavelet oscillations,  
default gives minimal oscillations)  
k=1 Use complex Morlet as wavelet transform kernel  
=2 use Fourier kernel ...  $\text{Exp}[i 2 \pi f t]$   
fs=1 Use dyadic freq sampling (CWT standard, honors  
noct, nv)  
=2 use linear freq sampling (Fourier standard)  
df=1 Frequency sample interval in Hz (used only for fs=2)  
NOTE: not yet implimented (hardwired to df=1)  
dt=(from tr.dt) Sample interval override (in secs, if time data)  
verbose=0 Run silent, except echo c value. (=1 for more info)

Examples:

This generates amplitude spec of the CWT impulse response (IR).

suspiketrace ntr=1 ix1=1 nt=125 | succwt | suamp | suximage &

Real part of Fourier IR with linear freq sampling:

suspiketrace ntr=1 ix1=1 nt=125 | succwt k=2 fs=2 | suamp mode=real | suximage &

Real part of Fourier IR with dyadic freq sampling:

suspiketrace ntr=1 ix1=1 nt=125 | succwt k=2 | suamp mode=real | suximage &

Inverse CWT: (within a constant scale factor)

... | succwt p=-1 | suamp mode=real | sustack key=cdp > inv.su

Notes:

1. Total number of scales: nscale = noct\*nv
2. Each input trace spawns nscale complex output traces
3. Lowest frequency in the transform is fmax/(  $2^{(noct-1/nv)}$  )
4. Header field (cdp) used as cwt spectrum counter
5. Header field (cdpt) used as scale counter within cwt spectrum

6. Header field (gut) holds number of cwt scales 'na'
7. Header field (unscale) holds CWT scale 'a'

Header fields set: tracl, cdp, cdpt, unscale, gut

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Author: UTulsa: Chris Liner, SEP: Bob Clapp

todo:

fix fs=2 case to allow df not equal to 1

History:

6/18/04

major overhaul by Clapp, including fourier implementation.

Speedup ~ 41 times (4100 %)

2/20/04

made p=-0.5 default

2/16/04

added p option to experiment with CWT normalization

2/12/04

replace fb (bandwidth parameter) with c (t-domain gaussian damping const.)

2/10/04 --- in sync with EAS paper in prep

changed morlet scaling (c = 1) to preserve time-domain peak amplitude

changed morlet exp sign to std CWT definition (conjugate) and

mathematica result that only gives positive freq gaussian with neg exp

1/26/04

added linear frequency sampling option

1/23/04

figured out fb and made it a getpar

key: Look at real ccwt output and determine fb by number of

oscillations desired: Default gives -+--+--

1/20/04

beefed up verbose output

dimension wavelet to length 2\*nt and change correlation call

... this is done to avoid conv edge effects

1/19/04

added fourier wavlet option for comparison with Fourier Transform action

1/17/04

complex morlet amp scaling now set to preserve first scale amp with IR

1/16/04

added dt getpar to handle depth input properly

preserves first tracl so tracl is ok after spice  
11/11/03  
initial version

Trace header fields set: tracl, cdp, cdpt, unscale, gut

SUCDDECON - DECONvolution with user-supplied filter by straightforward  
Complex Division in the frequency domain

sucddecon <stdin >stdout [optional parameters]

Required parameters:

filter= ascii filter values separated by commas

...or...

sufile= file containing SU traces to use as filter

(must have same number of traces as input data

for panel=1)

Optional parameters:

panel=0 use only the first trace of sufile as filter

=1 decon trace by trace an entire gather

pnoise=0.001 white noise factor for stabilizing results

(see below)

centered=0 not centered, =1 center the output on each trace

verbose=0 silent, =1 chatty

Notes:

For given time-domain input data  $I(t)$  (stdin) and deconvolution  
filter  $F(t)$ , the frequency-domain deconvolved trace can be written as:

$I(f) = I(f) * \text{complex\_conjugate}[F(f)]$

$D(f) = \text{-----} \implies D(f) = \text{-----}$

$F(f) |F(f)|^2 + \delta$

The real scalar delta is introduced to prevent the resulting deconvolved trace to be dominated by frequencies at which the filter power is close to zero. As described above, delta is set to some fraction (pnoise) of the mean of the filter power spectra. Time sampling rate must be the same in the input data and filter traces. If panel=1 the two input files must have the same number of traces. Data and filter traces don't need to necessarily have the same number of samples, but the filter trace length length be always equal or shorter than the data traces.

Trace header fields accessed: ns, dt

Trace header fields modified: none

Credits:

CWP: Ivan Vasconcelos

some changes by John Stockwell

CAVEATS:

In the option, panel=1 the number of traces in the sufile must be the same as the number of traces on the input.

Trace header fields accessed: ns,dt

Trace header fields modified: none

SUCENTSAMP - CENTROID SAMPLE seismic traces

```
sucentsamp <stdin [optional parameters] >sdout
```

Required parameters:

none

Optional parameters:

dt=from header sampling interval

verbose=1 =0 to stop advisory messages

Notes:

This program takes seismic traces as input, and returns traces consisting of spikes of height equal to the area of each lobe of each oscillation, located at the centroid of the lobe in question. The height of each spike equal to the area of the corresponding lobe.

Caveat: No check is made that the data are real time traces!

Credits:

Providence Technologies: Tom Morgan

Trace header fields accessed: ns, dt

SUCHART - prepare data for x vs. y plot

```
suchart <stdin >stdout key1=sx key2=gx
```

Required parameters:

none

Optional parameters:

key1=sx abscissa

key2=gx ordinate

outpar=null name of parameter file

The output is the (x, y) pairs of binary floats

Examples:

```
suchart < sudata outpar=pfile >plot_data
psgraph <plot_data par=pfile title="CMG" \\
linewidth=0 marksize=2 mark=8 | ...
rm plot_data
```

```
suchart < sudata | psgraph n=1024 d1=.004 \\
linewidth=0 marksize=2 mark=8 | ...
```

fold chart:

```
suchart < stacked_data key1=cdp key2=nhs |
          psgraph n=NUMBER_OF_TRACES d1=.004 \\
linewidth=0 marksize=2 mark=8 > chart.ps
```

Credits:

SEP: Einar Kjartansson

CWP: Jack K. Cohen

Notes:

The vtof routine from valpkge converts values to floats.

SUCHW - Change Header Word using one or two header word fields

```
suchw <stdin >stdout [optional parameters]
```

Required parameters:

none

Optional parameters:

key1=cdp,... output key(s)

key2=cdp,... input key(s)

key3=cdp,... input key(s)

a=0,... overall shift(s)

b=1,... scale(s) on first input key(s)

c=0,... scale on second input key(s)

d=1,... overall scale(s)

e=1,... exponent on first input key(s)

f=1,... exponent on second input key(s)

The value of header word key1 is computed from the values of key2 and key3 by:

$$\text{val}(\text{key1}) = (a + b * \text{val}(\text{key2})^e + c * \text{val}(\text{key3})^f) / d$$

Examples:

Shift cdp numbers by -1:

```
suchw <data >outdata a=-1
```

Add 1000 to tracr value:

```
suchw key1=tracr key2=tracr a=1000 <infile >outfile
```

We set the receiver point (gx) field by summing the offset and shot point (sx) fields and then we set the cdp field by averaging the sx and gx fields (we choose to use the actual locations for the cdp fields instead of the conventional 1, 2, 3, ... enumeration):

```
suchw <indata key1=gx key2=offset key3=sx b=1 c=1 |  
suchw key1=cdp key2=gx key3=sx b=1 c=1 d=2 >outdata
```

Do both operations in one call:

```
suchw<indata key1=gx,cdp key2=offset,gx key3=sx,sx b=1,1 c=1,1 d=1,2 >outdata
```

Credits:

SEP: Einar Kjartansson

CWP: Jack K. Cohen

CWP: John Stockwell, 7 July 1995, added array of keys feature

Delphi: Alexander Koek, 6 November 1995, changed calculation so  
headers of different types can be expressed in each other

SUCLIPHEAD - Clip header values

sucliphead <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

key=cdp,... header key word(s) to clip

min=0,... minimum value to clip

max=ULONG\_MAX,ULONG\_MAX,... maximum value to clip

Credits:

Geocon: Garry Perratt

SUCMP - CoMPare two seismic data sets, returns 0 to the shell ",  
if the same and 1 if different

```
sucmp file_A file_B
```

Required parameters:

none

Optional parameters:

limit=1.0e-4 normalized difference threshold value

Notes:

This program is the seismic equivalent of the Unix cmp(1) command. However, unlike cmp(1), it understands seismic data and will consider files which have only small numerical differences to be the same.

Sucmp first checks that the number of traces and number of samples are the same. It then compares the trace headers bit for bit. Finally it checks that the fractional difference of A & B is less than limit.

This program is intended as an aid in regression testing changes to seismic processing programs.

Expected usage is in shell scripts or Makefiles, e.g.

```
#!/bin/sh
#-----
# Run a test data set and verify the result is correct
# If the data doesn't match show the data on the screen.
#-----

./fubar par=tst1.par
sucmp tst1.su ref/tst1.su
if [ $? ]
then
suxwigb <tst1.su &
suxwigb <ref/tst1.su & "
fi
```

Author: Reginald H. Beardsley

rhb@acm.org

sucmp - compare two seismic files in CWP/SU format to see if they are the same within the user specified limit.

Algorithm:

Loop over both input files comparing data values. To be considered the same files must have:

- same number of traces
- same number of samples per trace
- trace values within limits of each other

Note that the program exits as soon as the files fail to match.

For readability, explicit temporary variables are used which the compiler will optimize away. Braces are used on all conditionals so that a breakpoint can be set to stop the debugger only if the condition is true.

Because of the overloading of trace header fields in CWP/SU, the headers are compared bit for bit.

SUCOMMAND - pipe traces having the same key header word to command

```
sucommand <stdin >stdout [Optional parameters]
```

Required parameters:

none

Optional parameters:

verbose=0 wordy output

key=cdp header key word to pipe on

command="suop nop" command piped into

dir=0 0: change of header key

-1: break in monotonic decrease of header key

+1: break in monotonic increase of header key

Notes:

This program permits limited parallel processing capability by opening pipes for processes, signaled by a change in key header word value.

Credits:

VT: Matthias Imhof

Note:

The "valxxx" subroutines are in su/lib/valpkge.c. In particular,

"valcmp" shares the annoying attribute of "strcmp" that

```
if (valcmp(type, val, valnew) {
```

```
...
```

```
}
```

will be performed when val and valnew are different.

SUCONV - convolution with user-supplied filter

```
suconv <stdin >stdout filter= [optional parameters]
```

Required parameters: ONE of  
sufile= file containing SU trace to use as filter  
filter= user-supplied convolution filter (ascii)

Optional parameters:  
none

Trace header fields accessed: ns  
Trace header fields modified: ns

Notes: It is quietly assumed that the time sampling interval on the single trace and the output traces is the same as that on the traces in the input file. The sufile may actually have more than one trace, but only the first trace is used.

Examples:

```
suplane | suwind min=12 max=12 >TRACE  
suconv<DATA sufile=TRACE | ...
```

Here, the su data file, "DATA", is convolved trace by trace with the the single su trace, "TRACE".

```
suconv<DATA filter=1,2,1 | ...
```

Here, the su data file, "DATA", is convolved trace by trace with the the filter shown.

Credits:

CWP: Jack K. Cohen, Michel Dietrich

CAVEATS: no space-variable or time-variable capacity.

The more than one trace allowed in sufile is the beginning of a hook to handle the spatially variant case.

Modification:

CWP: Huub Douma (HD), 14/01/2005

Implemented correct use of delrt

Trace header fields accessed: ns  
Trace header fields modified: ns



SUCOUNTKEY - COUNT the number of unique values for a given KEYword.

```
sucountkey < input.su key=[sx,gx,cdp,...]
```

Required parameter:

key= array of SU header keywords being counted

Optional parameters:

verbose=1 chatty, =0 just print keyword number

Example:

```
suplane | sucountkey key=tracl,tracr,offset
```

Credits: Baoniu Han, bhan@mines.edu, Nov, 2000

SUCVS4FOWLER --compute constant velocity stacks for input to Fowler codes

Required Parameter:

ncdps= number of input cdp gathers

Optional Parameters:

vminstack=1500. minimum velocity panel in m/s to output

nvstack=180 number of stacking velocity panels to compute

( Let offmax be the maximum offset, fmax be the maximum freq to preserve, and tmute be the starting mute time in sec on offmax, then the recommended value for nvstack would be  $nvstack = 4 + (\text{offmax} * \text{offmax} * \text{fmax}) / (0.6 * \text{vmin} * \text{vmin} * \text{tmute})$

---you may want to make do with less---

lmute=24 length of mute taper in ms

nonhyp=1 1 if do mute at  $2 * \text{offset} / \text{vhyp}$  to avoid non-hyperbolic moveout, 0 otherwise

vhyp=2500. velocity to use for non-hyperbolic moveout mute

lbtaper=0 length of bottom taper in ms

lstaper=0 length of side taper in traces

dtout=1.5\*dt output sample rate in s,

note: typically  $\text{fmax} = \text{salias} * 0.5 / \text{dtout}$

mxfold=120 maximum number of offsets/input cmp

salias=0.8 fraction of output frequencies to force within sloth antialias limit. This controls muting by offset of the input data prior to computing the cv stacks for values of choose=1 or choose=2.

Required trace header words on input are ns, dt, cdp, offset.

Author: (Visitor to CSM from Mobil): John E. Anderson, Spring 1994

References:

Fowler, P., 1988, Ph.D. Thesis, Stanford University.

Anderson, J.E., Alkhalifah, T., and Tsvankin, I., 1994, Fowler DMO and time migration for transversely isotropic media, 1994 CWP project review

SUCWT - generates Continuous Wavelet Transform amplitude, regularity analysis in the wavelet basis

```
sucwt < stdin [Optional parameters ] > stdout
```

Required Parameters:

none

Optional Parameters:

base=10 Base value for wavelet transform scales

first=-1 First exponent value for wavelet transform scales

expinc=0.01 Exponent increment for wavelet transform scales

last=1.5 Last exponent value for wavelet transform scales

Wavelet Parameters:

wtype=0 2nd derivative of Gaussian (Mexican hat)

=1 4th derivative of Gaussian (witch's hat)

=2 6th derivative of Gaussian (wizard's hat)

nwavelet=1024 number of samples in the wavelet

xmin=-20 minimum x value wavelet is computed

xcenter=0 center x value wavelet is computed

xmax=20 maximum x value wavelet is computed

sigma=1 sharpness parameter ( sigma > 1 sharper)

verbose=0 silent, =1 chatty

holder=0 =1 compute Holder regularity estimate

divisor=1.0 a floating point number >= 1.0 (see notes)

Notes:

This is the CWT version of the time frequency analysis notion that is applied in sugabor.

The parameter base is the base of the power that is applied to scale the wavelet. Some mathematical literature assume base 2. Base 10 works well here.

Default option yields an output similar to that of sugabor. With the parameter holder=1 an estimate of the instantaneous Holder regularity (the Holder exponent) is output for each input data value. The result is a Holder exponent trace for each corresponding input data trace.

The strict definition of the Holder exponent is the maximum slope of the rise of the spectrum in the log(amplitude) versus log(scale) domain:

divisor=1.0 means the exponent is computed simply by fitting a line through all of the values in the transform. A value of divisor>1.0 indicates that the Holder exponent is determined as the max of slopes found in (total scales)/divisor length segments.

Some experimentation with the parameters nwavelet, first, last, and expinc may be necessary before a desirable output is obtained. The most effective way to proceed is to perform a number of tests with holder=0 to determine the range of first, last, and expinc that best represents the data in the wavelet domain. Then experimentation with holder=1 and values of divisor>=1.0 may proceed.

Credits:

CWP: John Stockwell, Nov 2004

inspired in part by "bhpcwt" in the BHP\_SU package, code written by BHP: Michael Glinsky, c. 2002, based loosely on a Matlab CWT function

References:

Li C.H., (2004), Information passage from acoustic impedance to seismogram: Perspectives from wavelet-based multiscale analysis, Journal of Geophysical Research, vol. 109, B07301, p.1-10.

Mallat, S. and W. L. Hwang, (1992), Singularity detection and processing with wavelets, IEEE Transactions on information, v 38, March 1992, p.617 - 643.

SUDATUMFD - 2D zero-offset Finite Difference acoustic wave-equation  
DATUMing

sudatumfd <stdin > stdout [optional parameters]

Required parameters:

nt= number of time samples on each trace  
nx= number of receivers per shot gather  
nsx= number of shot gathers  
nz= number of downward continuation depth steps  
dz= depth sampling interval (in meters)  
mx= number of horizontal samples in the velocity model  
mz= number of vertical samples in the velocity model  
vfile1= velocity file used for thin-lens term  
vfile2= velocity file used for diffraction term  
dx= horizontal sampling interval (in meters)

Optional parameters:

dt=.004 time sampling interval (in seconds)  
buff=5 number of zero traces added to each side of each  
shot gather as a pad  
tap\_len=5 taper length (in number of traces)  
x\_0=0.0 x coordinate of leftmost position in velocity model

Notes:

The algorithm is a 45-degree implicit-finite-difference scheme based on the one-way wave equation. It works on poststack (zero-offset) data only. The two velocity files, vfile1 and vfile2, are binary files containing floats with the format v[ix][iz]. There are two potentially different velocity files for the thin-lens and diffraction terms to allow for the use of a zero-velocity layer which allows for datuming from an irregular surface.

Source and receiver locations must be set in the header values in order for the datuming to work properly. The leftmost position of the velocity models given in vfile1 and vfile2 must also be given.

Author: Chris Robinson, 10/16/00, CWP, Colorado School of Mines

References:

Beasley, C., and Lynn, W., 1992, The zero-velocity layer: migration from irregular surfaces: *Geophysics*, 57, 1435-1443.

Claerbout, J. F., 1985, *Imaging the earth's interior*: Blackwell Scientific Publications.

SUDATUMK2DR - Kirchhoff datuming of receivers for 2D prestack data  
(shot gathers are the input)

```
sudatumk2dr infile= outfile= [parameters]
```

Required parameters:

infile=stdin file for input seismic traces

outfile=stdout file for common offset migration output

ttfile= file for input travelttime tables

The following 9 parameters describe travelttime tables:

fzt= first depth sample in travelttime table

nzt= number of depth samples in travelttime table

dzt= depth interval in travelttime table

fxt= first lateral sample in travelttime table

nxt= number of lateral samples in travelttime table

dxt= lateral interval in travelttime table

fs= x-coordinate of first source

ns= number of sources

ds= x-coordinate increment of sources

fxi= x-coordinate of the first surface location

dxi= horizontal spacing on surface

nxi= number of input surface locations

sgn= Sign of the datuming process (up=-1 or down=1)

Optional Parameters:

dt= or from header (dt) time sampling interval of input data

ft= or from header (ft) first time sample of input data

surf="0,0;99999,0" The first surface defined the recording surface  
surf="0,0;99999,0" and the second one, the new datum.

"x1,z1;x2,z2;x3,z3;..."

fzo=fzt z-coordinate of first point in output trace

dzo=0.2\*dzt vertical spacing of output trace

nzo=5\*(nzt-1)+1 number of points in output trace "

fxso=fxt x-coordinate of first shot

dxso=0.5\*dxt shot horizontal spacing

nxso=2\*(nxt-1)+1 number of shots

fxgo=fxt x-coordinate of first receiver

dxgo=0.5\*dxt receiver horizontal spacing

nxgo=nxso number of receivers per shot

fmax=0.25/dt frequency-highcut for input traces

offmax=99999 maximum absolute offset allowed in migration

aperx=nxt\*dxt/2 migration lateral aperature

angmax=60 migration angle aperture from vertical  
v0=1500(m/s) reference velocity value at surface  
dvz=0.0 reference velocity vertical gradient  
antiali=1 Antialias filter (no-filter = 0)  
jpfile=stderr job print file name  
mtr=100 print verbal information at every mtr traces  
ntr=100000 maximum number of input traces to be migrated

verbose=0 silent, =1 chatty

Notes:

1. Traveltime tables were generated by program rayt2d (or other ones) on relatively coarse grids, with dimension ns\*nxt\*nzt. In the datuming process, traveltimes are interpolated into shot/geophone positions and output grids.
2. Input traces must be SU format and organized in common rec. gathers
3. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
4. Amplitudes are computed using the reference velocity profile,  $v(z)$ , specified by the parameters  $v0=$  and  $dvz=$ .
5. Input traces must specify source and receiver positions via the header fields tr.sx and tr.gx. Offset is computed automatically.

Author: Trino Salinas, 05/01/96, Colorado School of Mines

This code is based on sukzmig2d.c written by Zhenyue Liu, 03/01/95. Subroutines from Dave Hale's modeling library were adapted in this code to define topography using cubic splines.

This code implements a Kirchhoff extrapolation operator that allows to transfer data from one reference surface to another. The formula used in this application is a far field approximation of the Berryhill's original formula (Berryhill, 1979). This equation is the result of a stationary phase analysis to get an analog asymptotic expansion for the two-and-one half dimensional extrapolation formula (Bleistein, 1984).

The extrapolation formula permits the downward continuation of upgoing waves and upward continuation of downgoing waves. For upward continuation of upgoing waves and downward continuation of downgoing waves, the conjugate transpose of the equation is used (Bevc, 1993).

References :

Berryhill, J.R., 1979, Wave equation datuming: Geophysics, 44, 1329--1344.

-----, 1984, Wave equation datuming before stack (short note) : Geophysics, 49, 2064--2067.

Bevc, D., 1993, Data parallel wave equation datuming with irregular acquisition topography : 63rd Ann. Internat. Mtg., SEG, Expanded Abstracts, 197--200.

Bleistein, N., 1984, Mathematical methods for wave phenomena, Academic Press Inc. (Harcourt Brace Jovanovich Publishers), New York.

SUDATUMK2DS - Kirchhoff datuming of sources for 2D prestack data  
(input data are receiver gathers)

```
sudatumk2ds infile= outfile= [parameters]
```

Required parameters:

infile=stdin file for input seismic traces

outfile=stdout file for common offset migration output

tfile= file for input travelttime tables

The following 9 parameters describe travelttime tables:

fzt= first depth sample in travelttime table

nzt= number of depth samples in travelttime table

dzt= depth interval in travelttime table

fxt= first lateral sample in travelttime table

nxt= number of lateral samples in travelttime table

dxt= lateral interval in travelttime table

fs= x-coordinate of first source

ns= number of sources

ds= x-coordinate increment of sources

fxi= x-coordinate of the first surface location

dxi= horizontal spacing on surface

nxix= number of input surface locations

sgn= Sign of the datuming process (up=-1 or down=1)

Optional Parameters:

dt= or from header (dt) time sampling interval of input data

ft= or from header (ft) first time sample of input data

surf="0,0;99999,0" The first surface defined the recording surface  
surf="0,0;99999,0" and the second one, the new datum.

"x1,z1;x2,z2;x3,z3;...

fzo=fzt z-coordinate of first point in output trace

dzo=0.2\*dzt vertical spacing of output trace

nzo=5\*(nzt-1)+1 number of points in output trace "

fxso=fxt x-coordinate of first shot

dxso=0.5\*dxt shot horizontal spacing

nxso=2\*(nxt-1)+1 number of shots

fxgo=fxt x-coordinate of first receiver

exgo=fxgo+(nxgo-1)\*dxgo x-coordinate of the last receiver

dxgo=0.5\*dxt receiver horizontal spacing

nxgo=nxso number of receivers per shot

fmax=0.25/dt frequency-highcut for input traces

offmax=99999 maximum absolute offset allowed in migration

aperx=nxt\*dxt/2 migration lateral aperature  
angmax=60 migration angle aperature from vertical  
v0=1500(m/s) reference velocity value at surface  
dvz=0.0 reference velocity vertical gradient  
antiali=1 Antialias filter (no-filter = 0)  
jpfiler=stderr job print file name  
mtr=100 print verbal information at every mtr traces  
ntr=100000 maximum number of input traces to be migrated

Notes:

1. Traveltime tables were generated by program rayt2d (or other ones) on relatively coarse grids, with dimension ns\*nxt\*nzt. In the migration process, traveltimes are interpolated into shot/geophone positions and output grids.
2. Input traces must be SU format and organized in common shot gathers
3. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
4. Amplitudes are computed using the reference velocity profile,  $v(z)$ , specified by the parameters  $v0=$  and  $dvz=$ .
5. Input traces must specify source and receiver positions via the header fields tr.sx and tr.gx. Offset is computed automatically.

Author: Trino Salinas, 05/01/96, Colorado School of Mines

This code is based on sukzmig2d.c written by Zhenyue Liu, 03/01/95. Subroutines from Dave Hale's modeling library were adapted in this code to define topography using cubic splines.

This code implements a Kirchhoff extrapolation operator that allows to transfer data from one reference surface to another. The formula used in this application is a far field approximation of the Berryhill's original formula (Berryhill, 1979). This equation is the result of a stationary phase analysis to get an analog asymptotic expansion for the two-and-one half dimensional extrapolation formula (Bleistein, 1984).

The extrapolation formula permits the downward continuation of upgoing waves and upward continuation of downgoing waves. For upward continuation of upgoing waves and downward continuation of downgoing waves, the conjugate transpose of the equation is used (Bevc, 1993).

References :

Berryhill, J.R., 1979, Wave equation datuming: Geophysics,  
44, 1329--1344.

-----, 1984, Wave equation datuming before stack  
(short note) : Geophysics, 49, 2064--2067.

Bevc, D., 1993, Data parallel wave equation datuming with  
irregular acquisition topography : 63rd Ann. Internat.  
Mtg., SEG, Expanded Abstracts, 197--200.

Bleistein, N., 1984, Mathematical methods for wave phenomena,  
Academic Press Inc. (Harcourt Brace Jovanovich Publishers),  
New York.

SUDIPDIVCOR - Dip-dependent Divergence (spreading) correction

sudipdivcor <stdin >stdout [optional parms]

Required Parameters:

dxcdp distance between successive cdps in meters

Optional Parameters:

np=50 number of slopes

tmig=0.0 times corresponding to interval velocities in vmig

vmig=1500.0 interval velocities corresponding to times in tmig

vfile=binary (non-ascii) file containing velocities vmig(t)

conv=0 =1 to apply the conventional divergence correction

trans=0 =1 to include transmission factors

verbose=0 =1 for diagnostic print

Notes:

The tmig, vmig arrays specify an interval velocity function of time. Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in tmig must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If vfile is specified, then the tmig and vmig arrays are ignored.

The time of the first sample is assumed to be constant, and is taken as the value of the first trace header field delrt.

Whereas the conventional divergence correction (sudivcor) is valid only for horizontal reflectors, which have zero reflection slope, the dip-dependent divergence correction is valid for any reflector dip or reflection slope. Only the conventional correction will be applied to the data if conv=1 is specified. Note that the conventional correction over-amplifies reflections from dipping beds

The transmission factor should be applied when the divergence corrected data is to be migrated with a reverse time migration based on the constant density wave equation.

Trace header fields accessed: ns, dt, delrt

SUDIPFILT - DIP--or better--SLOPE Filter in f-k domain

sudipfilt <infile >outfile [optional parameters]

Required Parameters:

dt=(from header) if not set in header then mandatory

dx=(from header, d1) if not set in header then mandatory

Optional parameters:

slopes=0.0 monotonically increasing slopes

amps=1.0 amplitudes corresponding to slopes

bias=0.0 slope made horizontal before filtering

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes:

d2 is an acceptable alias for dx in the getpar

Slopes are defined by  $\Delta t / \Delta x$ , where  $\Delta$  means change. Units of  $\Delta t$  and  $\Delta x$  are the same as dt and dx. It is sometimes useful to fool the program with dx=1 dt=1, thus avoiding units and small slope values.

Linear interpolation and constant extrapolation are used to determine amplitudes for slopes that are not specified. Linear moveout is removed before slope filtering to make slopes equal to bias appear horizontal. This linear moveout is restored after filtering. The bias parameter may be useful for spatially aliased data. The slopes parameter is compensated for bias, so you need not change slopes when you change bias.

Credits:

CWP: Dave (algorithm--originally called slopef)  
Jack (reformatting for SU)

Trace header fields accessed: ns, dt, d2

SUDIVCOR - Divergence (spreading) correction

sudivcor <stdin >stdout [optional parms]

Required Parameters:

none

Optional Parameters:

trms=0.0 times corresponding to rms velocities in vrms

vrms=1500.0 interval velocities corresponding to times in trms

vfile= binary (non-ascii) file containing velocities vrms(t)

Notes:

The trms, vrms arrays specify an rms velocity function of time. Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in trms must increase monotonically.

Alternatively, rms velocities may be stored in a binary file containing one velocity for every time sample. If vfile is specified, then the trms and vrms arrays are ignored.

The time of the first sample is assumed to be constant, and is taken as the value of the first trace header field delrt.

Credits:

CWP: Jack K. Cohen, Francesca Fazarri

Trace header fields accessed: ns, dt, delrt



Embree, P.,1968, Diversity seismic record stacking method and system:  
U.S. patent 3,398,396.

Gimlin, D. R., and Smith, J. W., 1980, A comparison of seismic trace  
summing techniques: Geophysics, vol. 45, pages 1017-1041.

Trace header fields accessed: ns, dt, key=keyword

Trace header fields modified: tracl

SUDMOFKCW - converted-wave DMO via F-K domain (log-stretch) method for common-offset gathers

```
sudmofkcw <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [...]
```

Required Parameters:

cdpmin minimum cdp (integer number) for which to apply DMO  
cdpmax maximum cdp (integer number) for which to apply DMO  
dxcdp distance between adjacent cdp bins (m)  
noffmix number of offsets to mix (see notes)

Optional Parameters:

tdmo=0.0 times corresponding to rms velocities in vdm0 (s)  
vdm0=1500.0 rms velocities corresponding to times in tdmo (m/s)  
gamma=0.5 velocity ratio, upgoing/downgoing  
ntable=1000 number of tabulated z/h and b/h (see notes)  
sdmo=1.0 DMO stretch factor; try 0.6 for typical v(z)  
flip=0 =1 for negative shifts and exchanging s1 and s2  
(see notes below)  
fmax=0.5/dt maximum frequency in input traces (Hz)  
verbose=0 =1 for diagnostic print

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

The tdmo and vdm0 arrays specify a velocity function of time that is used to implement a first-order correction for depth-variable velocity. The times in tdmo must be monotonically increasing. The velocity function is assumed to have been gotten by traditional NMO.

For each offset, the minimum time at which a non-zero sample exists is used to determine a mute time. Output samples for times earlier than this mute time will be zeroed. Computation time may be significantly reduced

if the input traces are zeroed (muted) for early times at large offsets.

$z/h$  is horizontal-reflector depth normalized to half source-recvier offset  $h$ . Normalized shift of conversion point is  $b/h$ . The code now does not support signed offsets, therefore it is recommended that only end-on data, not split-spread, be used as input (of course after being sorted into common-offset gathers).  $z/h$  vs  $b/h$  depends on  $\gamma$  (see Alfaraj's Ph.D. thesis, 1993).

Flip factor = 1 implies positive shift of traces (in the increasing CDP bin number direction). When processing split-spread data, for example, if one side of the spread is processed with  $flip=0$ , then the other side of the spread should be processed with  $flip=1$ . The flip factor also determines the actions of the factors  $s1$  and  $s2$ , i.e., stretching or squeezing.

Trace header fields accessed:  $nt$ ,  $dt$ ,  $delrt$ ,  $offset$ ,  $cdp$ .

Credits:

CWP: Mohamed Alfaraj

Dave Hale

Technical Reference:

Transformation to zero offset for mode-converted waves

Mohammed Alfaraj, Ph.D. thesis, 1993, Colorado School of Mines

Dip-Moveout Processing - SEG Course Notes

Dave Hale, 1988

SUDMOFK - DMO via F-K domain (log-stretch) method for common-offset gathers

```
sudmofk <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [...]
```

Required Parameters:

cdpmin minimum cdp (integer number) for which to apply DMO  
cdpmax maximum cdp (integer number) for which to apply DMO  
dxcdp distance between adjacent cdp bins (m)  
noffmix number of offsets to mix (see notes)

Optional Parameters:

tdmo=0.0 times corresponding to rms velocities in vdm0 (s)  
vdm0=1500.0 rms velocities corresponding to times in tdmo (m/s)  
sdmo=1.0 DMO stretch factor; try 0.6 for typical v(z)  
fmax=0.5/dt maximum frequency in input traces (Hz)  
verbose=0 =1 for diagnostic print  
tmpdir= if non-empty, use the value as a directory path prefix  
for storing temporary files; else if the CWP\_TMPDIR  
environment variable is set use its value for the path;  
else use tmpfile()

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

The tdmo and vdm0 arrays specify a velocity function of time that is used to implement a first-order correction for depth-variable velocity. The times in tdmo must be monotonically increasing.

For each offset, the minimum time at which a non-zero sample exists is used to determine a mute time. Output samples for times earlier than this", mute time will be zeroed. Computation time may be significantly reduced if the input traces are zeroed (muted) for early times at large offsets.

Credits:  
CWP: Dave

Technical Reference:  
Dip-Moveout Processing - SEG Course Notes  
Dave Hale, 1988

Trace header fields accessed: ns, dt, delrt, offset, cdp.

SUDMOTIVZ - DMO for Transeversely Isotropic V(Z) media for common-offset gathers

```
sudmotivz <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [...]
```

Required Parameters:

cdpmin	minimum cdp (integer number) for which to apply DMO
cdpmax	maximum cdp (integer number) for which to apply DMO
dxcdp	distance between adjacent cdp bins (m)
noffmix	number of offsets to mix (see notes)

Optional Parameters:

vnfile=	binary (non-ascii) file containing NMO interval velocities (m/s)
vfile=	binary (non-ascii) file containing interval velocities (m/s)
etafile=	binary (non-ascii) file containing eta interval values (m/s)
tdmo=0.0	times corresponding to interval velocities in vdmo (s)
vndmo=1500.0	NMO interval velocities corresponding to times in tdmo (m/s)
vdmo=vdmo	interval velocities corresponding to times in tdmo (m/s)
etadmo=1500.0	eta interval values corresponding to times in tdmo (m/s)
fmax=0.5/dt	maximum frequency in input traces (Hz)
smute=1.5	stretch mute used for NMO correction
speed=1.0	twist this knob for speed (and aliasing)
verbose=0	=1 for diagnostic print

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

vnfile, vfile and etafile should contain the regularly sampled interval values of NMO velocity, velocity and eta respectively as a function of time. If, for example, vfile is not supplied, the interval velocity function is defined by linear interpolation of the values in the tdmo and vdmo arrays. The times in tdmo must be monotonically increasing.

If vfile or vdm0 are not given it will be equated to vnfile or vndm0.

For each offset, the minimum time to process is determined using the smute parameter. The DMO correction is not computed for samples that have experienced greater stretch during NMO.

Trace header fields accessed: nt, dt, delrt, offset, cdp.

SUDMOTX - DMO via T-X domain (Kirchhoff) method for common-offset gathers

sudmotx <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [optional parms]

Required Parameters:

cdpmin	minimum cdp (integer number) for which to apply DMO
cdpmax	maximum cdp (integer number) for which to apply DMO
dxcdp	distance between successive cdps
noffmix	number of offsets to mix (see notes)

Optional Parameters:

offmax=3000.0	maximum offset
tmute=2.0	mute time at maximum offset offmax
vrms=1500.0	RMS velocity at mute time tmute
verbose=0	=1 for diagnostic print
tmpdir=	if non-empty, use the value as a directory path prefix for storing temporary files; else if the CWP_TMPDIR environment variable is set use its value for the path; else use tmpfile()

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

The defaults for offmax and vrms are appropriate only for metric units. If distances are measured in feet, then these parameters should be specified explicitly.

offmax, tmute, and vrms need not be specified precisely. If these values are unknown, then one should overestimate offmax and underestimate tmute and vrms.

No muting is actually performed. The tmute parameter is used only to

determine parameters required to perform DMO.

Credits:

CWP: Dave Hale

Technical Reference:

A non-aliased integral method for dip-moveout  
Dave Hale  
submitted to Geophysics, June, 1990

Trace header fields accessed: ns, dt, delrt, offset, cdp.

SUDMOVZ - DMO for V(Z) media for common-offset gathers

sudmovz <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [...]

Required Parameters:

cdpmin            minimum cdp (integer number) for which to apply DMO  
cdpmax            maximum cdp (integer number) for which to apply DMO  
dxcdp             distance between adjacent cdp bins (m)  
noffmix           number of offsets to mix (see notes)

Optional Parameters:

vfile=            binary (non-ascii) file containing interval velocities (m/s)  
tdmo=0.0          times corresponding to interval velocities in vdm0 (s)  
vdm0=1500.0       interval velocities corresponding to times in tdm0 (m/s)  
fmax=0.5/dt       maximum frequency in input traces (Hz)  
smute=1.5          stretch mute used for NMO correction  
speed=1.0          twist this knob for speed (and aliasing)  
verbose=0          =1 for diagnostic print

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

vfile should contain the regularly sampled interval velocities as a function of time. If vfile is not supplied, the interval velocity function is defined by linear interpolation of the values in the tdm0 and vdm0 arrays. The times in tdm0 must be monotonically increasing.

For each offset, the minimum time to process is determined using the smute parameter. The DMO correction is not computed for samples that have experienced greater stretch during NMO.

Trace header fields accessed: nt, dt, delrt, offset, cdp.

SUDUMPTRACE - print selected header values and data.  
Print first num traces.  
Use SUWIND to skip traces.

sudumptrace < stdin [> ascii\_file]

Optional parameters:

num=4	number of traces to dump
key=key1,key2,...	key(s) to print above trace values
hpf=0	header print format is float
	=1 print format is exponential

Examples:

```
sudumptrace < inseis.su          PRINTS: 4 traces, no headers
sudumptrace < inseis.su key=tracf,offset
sudumptrace < inseis.su num=7 key=tracf,offset > info.txt
sudumptrace < inseis.su num=7 key=tracf,offset hpf=1 > info.txt
```

Related programs: suascii, sugethw

Credits:

MTU: David Forel, Jan 2005

Trace header field accessed: nt, dt, delrt

SUEA2DF - SU version of (an)elastic anisotropic 2D finite difference forward modeling

```
suea2df > outfile c11file= c55file [optional parameters]
```

Required Parameters:

```
c11file=c11_file c11 voigt elasticity parameter filename  
c55file=c55_file c55 voigt elasticity parameter filename
```

Optional Parameters:

```
rhofile=rho_file density filename
```

(if rhofile is not set, rho=1000 is assumed)

Anisotropy parameters:

```
aniso=0 =1 - include anisotropy parameters
```

```
mode=0 =0 output particle velocity, =1 output stresses
```

(snapshots only)

... the next 3 parameters become active only when aniso=1....

```
c13file=c13_file c13 voigt elasticity parameter filename
```

```
c33file=c33_file c33 voigt elasticity parameter filename
```

```
c15file=c15_file c15 voigt elasticity parameter filename
```

```
c35file=c35_file c35 voigt elasticity parameter filename
```

Attenuation parameters:

```
qsw=0 switch to include attenuation =1 - include
```

... the next parameter becomes active only when qsw=1....

```
qfile=Q_file Q parameter filename
```

```
dt=0.001 time sampling interval (s)
```

```
ft=0.0 first time (s)
```

```
lt=1.0 last time (s)
```

```
nx=200 number of values in slow (x-direction)
```

```
dx=10.0 spatial sampling interval (m) x-coor
```

```
fx=-1000 first x coor (m)
```

```
nz=100 number of values in fast (z)-dimension
```

```
dz=dx spatial sampling interval (m) z-coor
```

```
fz=0 firstz coor (m)
```

Source parameters:

```
sx=0 source x position (m)
```

sz=500 source location (m)  
stype='p' source type  
  p: P-wave  
  v: velocity  
pw: P plane-wave  
sang=0 for stype='pw': plane wave angle  
wtype='dg' wave type  
  dg: Gaussian derivative  
  ga: Gaussian  
  ri: Ricker  
  sp: spike, sp2: double spike  
ts=0.05 source duration (s)  
favg=50 source average frequency

Attenuation parameters:

qsw=0 switch to include attenuation =1 - include

Boundary condition parameters:

bc=10,10,10,10 Top,left,bottom,right boundary condition  
=0 none  
=1 symmetry  
=2 free surface (top only)  
>2 absorbing (value indicates width of absorbing

layer

bc\_a=0.95; bc initial taper value for absorbing boundary  
bc\_r=0.; bc exponential factor for absorbing boundary  
variables are scaled by  $bc_a * \text{pow}(i, -bc_r)$

Optional output parameters:

sofile= name of source file  
snfile= name of file containing for snapshots  
snptime= times of snapshots i.e. snptime=0.1,0.2,0.3

vsx= x coordinate of vertical line of seismograms  
hsz= z coordinate of horizontal line of seismograms  
vrslfile="vsp.su" output file for vertical line of seismograms[nz] [nt]  
hsfile="hs.su" output file for horizontal line of seismograms[nx] [nt]  
tsw=0 switch to use shear stress only in non-fluid  
media - may help reduce dispersion tsw=1. If  
tsw=0 then standard calculation  
verbose=0 =1 to print progress on screen

Notes:

- 1) The outfile contains information generated by the input parameters, such as memory allocation, stability, etc. If your input file does not work, check this file first.

The model is specified as binary files of stiffness parameters and densities. These may be created any way the user desires. The program `unif2` or `makevel` may be used to generate densities, and the program `unif2anis` may be used to generate the stiffnesses. You will need to transpose these files, as the input format for `suea2df` assumes that the fast dimension is the horizontal or the x-dimension. You may do this via

```
transp n1=nz < c11_file > transp_c11_file
```

If `anis=1` then the program will expect the additional stiffnesss files.

If `qsw=1` `unif2anis` can be used to generate the Q values on a grid. These value also need to be transposed, as with the stiffnesses.

Output files (always generated)

```
hsfile  
vrslfile  
hsfile.chd - header for hsfile  
vrslfile.chd - header for vrslfile  
hsfile.mod - model file
```

Output files (if requested)

```
sofile - ascii source file  
snfile - su format snapshots file
```

Credits: UU GEOPHY Chris Juhlin 15 May 1999

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Parts of program use Seismic Unix Package - CSM

Changes - C. Juhlin

1. Fixed upgrading of stresses. There was an error in the coding for the Tzz term, c15 was being used instead of c35. This only caused problems for dipping anisotropic layers

2. Added some header information for hutput of snapshots.

3. 2001-01-30: Added option to set absorbing bc constants bc\_a and bc\_r
4. 2001-02-23: Corrected bug in outputting model boundaries to standard output in routine get\_econst
5. 2001-04-26: Added option for updating velocities to only use shear stress if material is non-fluid, this appears to reduce dispersion at near grazing angles for fluid-solid boundary. Set tsw=1 to invoke
6. 2001-05-14: Changed loop in free-surface boundary condition for velocities Thanks goes to Mike Holzrichter for pointing out this problem and the wrong scaling factor in the updating.
7. 2001-05-16: Changed set\_layers function to avoid negative indexing. Thanks goes to Mike Holzrichter for pointing out this problem
8. 2001-05-17: Modified make\_seis to take into account VSP geometry correctly and not store unnecessary data.
9. 2001-08-21: Fixed set\_layers so mode fills properly in depth. Earlier versions were accessing incorrect array locations at last defined depth.
10. 2003-04-21: Fixed boundary conditions.
11. 2003-05-02: Extended the model area by half the grid spacing on the RHS. This makes the model area symmetric allowing a plane wave source to be introduced into the model (stype=pw). The w, txx and tzz grids contain now one more column than the u and txz grids.
12. 2003-05-02: Added routines to allow plane waves to be introduced at a specified angle (sang) into the model with functions add\_pw\_source\_V and add\_pw\_source\_S.
13. 15 Oct 2005 -- tossed all the model building stuff. Read models from binary files made by unif2aniso (CWP:John Stockwell)
14. 25 Feb 2008 -- Fixed attenuation option (qsw=1) so that Q values are from binary files made by makevel or similar program

Algorithm based on Juhlin (1995, Geophys. Prosp.)  
and Levander (1988, Geophysics)

Attenuation included as in Graves (1996, BSSA)

SUEDIT - examine segy diskfiles and edit headers

```
suedit diskfile (open for possible header modification if writable)
suedit <diskfile (open read only)
```

The following commands are recognized:

```
number read in that trace and print nonzero header words
<CR> go to trace one step away (step is initially -1)
+ read in next trace (step is set to +1)
- read in previous trace (step is set to -1)
dN advance N traces (step is set to N)
% print some percentiles of the trace data
r print some ranks (rank[j] = jth smallest datum)
p [n1 [n2]] tab plot sample n1 to n2 on current trace
g [tr1 tr2] ximage plot the trace [traces tr1 to tr2]
w [tr1 tr2] xwigg plot the trace [traces tr1 to tr2]
f [tr1 tr2] ximage plot the amplitude spectra of the trace
u [tr1 tr2] apply user pipeline to specified traces
! key=val change a value in a field (e.g. ! tracr=101)
? print help file
q quit
```

NOTE: sample numbers are 1-based (first sample is 1).

```
'u 1000000 1000100 suwind >subset.su' will quickly extract a few
traces from the middle of a large dataset
```

Credits:

SEP: Einar Kjartansson, Shuki Ronen, Stew Levin

CWP: Jack K. Cohen

Unocal: Reg Beardsley

Trace header fields accessed: ns

Trace header fields modified: ntr (only for internal plotting)

SUEIPOFI - Eigenimage (SVD) based Polarization Filter for  
three-component data

sueipofi <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

dt=(from header)	time sampling intervall in seconds
wl=0.1	SVD time window length in seconds
pwr=1.0	exponent of filter weights
interp=cubic	interpolation between initially calculated weights, choose "cubic" or "linear"
verbose=0	1 = echo additional information
file=polar	base name for additional output file(s) of filter weights (see flags below)
rl1=0	1 = rectilinearity along first principal axis
rl2=0	1 = rectilinearity along second principal axis
pln=0	1 = planarity

Notes:

Three adjacent traces are considered as one three-component dataset.

The filter is the sum of the first two eigenimages of the singular value decomposition (SVD) of the signal matrix (time window). Weighting functions depending on linearity and planarity of the signal are applied, additionally. To avoid edge effects, these are interpolated linearly or via cubic splines between initially calculated values of non-overlapping time windows. The algorithm is based on the assumption that the particle motion trajectory is essentially 2D (elliptical polarization).

Caveat:

Cubic spline interpolation may result in filter weights exceeding the set of values of initial weights. Weights outside the valid interval [0.0, 1.0] are clipped.

Author: Nils Maercklin,  
GeoForschungsZentrum (GFZ) Potsdam, Germany, 2001.  
E-mail: nils@gfz-potsdam.de

References:

- Franco, R. de, and Musacchio, G., 2000: Polarization Filter with Singular Value Decomposition, submitted to Geophysics and published electronically in Geophysics online ([www.geo-online.org](http://www.geo-online.org)).
- Jurkevics, A., 1988: Polarization analysis of three-component array data, Bulletin of the Seismological Society of America, vol. 78, no. 5.
- Press, W. H., Teukolsky, S. A., Vetterling, W. T., and Flannery, B. P. 1996: Numerical Recipes in C - The Art of Scientific Computing, Cambridge University Press, Cambridge.

Trace header fields accessed: ns, dt

Trace header fields modified: none

SUFCTANISMOD - Flux-Corrected Transport correction applied to the 2D elastic wave equation for finite difference modeling in anisotropic media

sufctanismod > outfile [optional parameters]  
outfile is the wavefield snapshot x-component  
x-component of wavefield snapshot is in snapshotx.data  
y-component of wavefield snapshot is in snapshoty.data  
z-component of wavefield snapshot is in snapshotz.data

Optional Output Files:

reflxfile= reflection seismogram file name for x-component  
no output produced if no name specified  
reflyfile= reflection seismogram file name for y-component  
no output produced if no name specified  
reflzfile= reflection seismogram file name for z-component  
no output produced if no name specified  
vspxfile= VSP seismogram file name for x-component  
no output produced if no name specified  
vspyfile= VSP seismogram file name for y-component  
no output produced if no name specified  
vspzfile= VSP seismogram file name for z-component  
no output produced if no name specified

suhead=1        To get SU-header output seismograms (else suhead=0)

New parameter:

receiverdepth=0    depth of horizontal receivers (in gridpoints)

Optional Parameters:

dofct=1    1 do the FCT correction  
0 do not do the FCT correction  
FCT Related parameters:  
eta0=0.03 diffusion coefficient  
typical values ranging from 0.008 to 0.06  
about 0.03 for the second-order method  
about 0.012 for the fourth-order method  
eta=0.04 anti-diffusion coefficient  
typical values ranging from 0.008 to 0.06  
about 0.04 for the second-order method  
about 0.015 for the fourth-order method  
fctxbeg=0    x coordinate to begin applying the FCT correction

fctzbeg=0 z coordinate to begin applying the FCT correction  
fctxend=nx x coordinate to stop applying the FCT correction  
fctzend=nz z coordinate to stop applying the FCT correction

deta0dx=0.0 gradient of eta0 in x-direction d(eta0)/dx  
deta0dz=0.0 gradient of eta0 in z-direction d(eta0)/dz  
detadx=0.0 gradient of eta in x-direction d(eta)/dx  
detadz=0.0 gradient of eta in z-direction d(eta)/dz

General Parameters:

order=2 2 second-order finite-difference  
4 fourth-order finite-difference

nt=200 number of time steps  
dt=0.004 time step

nx=100 number of grid points in x-direction  
nz=100 number of grid points in z-direction

dx=0.02 spatial step in x-direction  
dz=0.02 spatial step in z-direction

sx=nx/2 source x-coordinate (in gridpoints)  
sy=nz/2 source z-coordinate (in gridpoints)

fpeak=20 peak frequency of the wavelet

wavelet=1 1 AKB wavelet  
2 Ricker wavelet  
3 impulse  
4 unity

isurf=2 1 absorbing surface condition  
2 free surface condition  
3 zero surface condition

source=1 1 point source  
2 sources are located on a given refelector ",  
(two horizontal and one dipping reflectors)  
3 sources are located on a given dipping refelector ",

sfile= the name of input source file, if no name specified then  
use default source location. (source=1 or 2)

Density and Elastic Parameters:

dfile= the name of input density file,  
if no name specified then  
assume a linear density profile with ...  
rho00=2.0 density at (0, 0)  
drhodx=0.0 density gradient in x-direction  $d(\rho)/dx$   
drhodz=0.0 density gradient in z-direction  $d(\rho)/dz$

afile= name of input elastic param. (c11) aa file, if no name  
specified then, assume a linear profile with ...  
aa00=2.0 elastic parameter at (0, 0)  
daadx=0.0 parameter gradient in x-direction  $d(aa)/dx$   
daadz=0.0 parameter gradient in z-direction  $d(aa)/dz$

cfile= name of input elastic param. (c33) cc file, if no name  
specified then, assume a linear profile with ...  
cc00=2.0 elastic parameter at (0, 0)  
dccdx=0.0 parameter gradient in x-direction  $d(cc)/dx$   
dccdz=0.0 parameter gradient in z-direction  $d(cc)/dz$

ffile= name of input elastic param. (c13) ff file, if no name  
specified then, assume a linear profile with ...  
ff00=2.0 elastic parameter at (0, 0)  
dffdx=0.0 parameter gradient in x-direction  $d(ff)/dx$   
dffdz=0.0 parameter gradient in z-direction  $d(ff)/dz$

lfile= name of input elastic param. (c44) ll file, if no name  
specified then, assume a linear profile with ...  
ll00=2.0 elastic parameter at (0, 0)  
dlldx=0.0 parameter gradient in x-direction  $d(ll)/dx$   
llddz=0.0 parameter gradient in z-direction  $d(ll)/dz$

nfile= name of input elastic param. (c66) nn file, if no name  
specified then, assume a linear profile with ...  
nn00=2.0 elastic parameter at (0, 0)  
dnndx=0.0 parameter gradient in x-direction  $d(nn)/dx$   
dnndz=0.0 parameter gradient in z-direction  $d(nn)/dz$

Optimizations:

The moving boundary option permits the user to restrict the computations of the wavefield to be confined to a specific range of spatial coordinates. The boundary of this restricted area moves with the wavefield

movebc=0 0 do not use moving boundary optimization  
1 use moving boundaries  
If movebc=1 then specify:  
mbx1=0 initial left side of moving boundary  
mbz1=0 initial top of moving boundary  
mbx2=nx initial right side of moving boundary  
mbz2=nz initial bottom of moving boundary

Author: Tong Fei, Center for Wave Phenomena,  
Colorado School of Mines, Dec 1993  
Some additional features by: Stig-Kyrre Foss, CWP  
Colorado School of Mines, Oct 2001

New features (Oct 2001):  
- setting receiver depth  
- outputfiles with SU-headers  
- additional commentary

Notes:

This program performs seismic modeling for elastic anisotropic media with vertical axis of symmetry.

The finite-difference method with the FCT correction is used.

Stability condition:  $v_{max} * dt / (\sqrt{2} * \min(dx, dz)) < 1$

Two major stages are used in the algorithm:

- (1) conventional finite-difference wave extrapolation
- (2) followed by an FCT correction

References:

The detailed algorithm description is given in the article "Elimination of dispersion in finite-difference modeling and migration" in CWP-137, project review, page 155-174.

Original reference to the FCT method:

Boris, J., and Book, D., 1973, Flux-corrected transport. I. SHASTA, a fluid transport algorithm that works: Journal of Computational Physics, vol. 11, p. 38-69.

/

SUFDMOD1 - Finite difference modelling (1-D 1st order) for the acoustic wave equation "

sufdmod1 <vfile >sfile nz= tmax= sz= [optional parameters]

Required parameters :

<vfile or vfile= binary file containing velocities[nz]

>sfile or sfile= SU file containing seismogram[nt]

nz= number of z samples

tmax= maximum propagation time

sz= z coordinate of source

Optional parameters :

dz=1 z sampling interval

fz=0.0 first depth sample

rz=1 coordinate of receiver

sz=1 coordinate of source

dfile= binary input file containing density[nz]

wfile= output file for wave field (snapshots in a SU trace panel)

abs=0,1 absorbing conditions on top and bottom

styp=0 source type (0: gauss, 1: ricker 1, 2: ricker 2)

freq=15.0 approximate source center frequency (Hz)

nt=1+tmax/dt number of time samples (dt determined for numerical stability)

zt=1 trace undersampling factor for trace and snapshots

zd=1 depth undersampling factor for snapshots

press=1 to record the pressure field; 0 records the particle velocity

verbose=0 =1 for diagnostic messages

Notes :

This program uses a first order explicit velocity/pressure finite difference equation.

The source function is applied on the pressure component.

If no density file is given, constant density is assumed

Wavefield can be easily viewed with suximage, user must provide f2=0 to the ximage program in order to get correct time labelling

Seismic trace is shifted in order to get a zero phase source

Source begins and stop when it's amplitude is  $10^{-4}$  its maximum

Time and depth undersampling only modify the output trace and snapshots.

These parameters are useful for keeping snapshot file small and the number of samples under SU\_NFLTS.

```

NULL  };

float source (float t, int styp, float dt, float dz, float t0, float alpha);

int main (int argc, char **argv)
{
float *rv; /* array of rock velocity from cfile
float *rd; /* array of rock density from dfile on p knots
float *rd1_5; /* array of rock density from dfile on v knots
float *p; /* pressure
float *v; /* particle velocity
float tmax, dt, t0; /* maximum time , time step, */
/* time delay for near causal source */
float vmax; /* maximum rock velocity */
int verbose; /* is verbose? */
int nz, nt; /* number of z samples, time samples */
float fz, dz; /* first sample depth spatial depth */
float sz; /* source coordinate */
int abs[2]; /* array of absorbing conditions */
int isz; /* source location index */
float rz; /* receiver depth
int irz; /* zcoordinate (in samples) of the source
int iz, it, itsis; /* counter
int ies; /* end of source index
int press; /* to choose between pressure or particle
/* velocity
float t; /* time
int td, zd; /* time and depth decimation
segy snapsh, sismo; /* recording of the seismic field,
/* seismogram
char *dfile=""; /* density file name
char *wfile=""; /* seismogram file name
char *velfile=""; /* velocity file name
char *sfile=""; /* velocity file name
float freq=0.0; /* source center freq
float alpha=0.0; /* source exp */
float epst0=0.0; /* source first amp ratio
int styp; /* source type

FILE *seisfp=stdout; /* pointer to seismic trace output file
FILE *wavefp=NULL; /* pointer to wave field output file
FILE *velocityfp=stdin; /* pointer to input velocity file
FILE *densityfp=NULL; /* pointer to input density file

```

```

/* hook up getpar to handle the parameters
initargs (argc, argv);
requestdoc(0);

/* verbose
if (!getparint ("verbose",&verbose)) verbose=0;

/* get required parameters
if (!getparint ("nz",&nz)) err("must specify nz ! ");
if (verbose) warn("nz= %d", nz);

if (!getparfloat ("tmax",&tmax)) err("must specify tmax ! ");
if (verbose) warn("tmax= %f", tmax);

if (!getparfloat("sz", &sz)) err ("must specify sz ! ");
if (verbose) warn("sz= %f", sz);

/* get optional parameters
if (!getparint ("nt", &nt)) nt=0;
if (verbose) warn("nt= %d", nt);
if (!getparint ("styp", &styp)) styp=0;
if (verbose) warn("styp= %d ", styp);
if (!getparfloat ("dz", &dz)) dz=1;
if (!getparfloat ("fz", &fz)) fz=0.0;

/* source coordinates to samples
isz=NINT((sz-fz)/dz);
if (verbose) warn( "source on knot number %d ", isz);

if (!getparfloat("rz", &rz)) rz=0.0;
irz = NINT ((rz-fz)/dz);
if (verbose) warn("receiver depth : %f on knot # %d ", rz, irz);

if (!getparfloat("freq", &freq)) freq=15.0;
if (verbose) warn("frequency : %f Hz",freq);

getparstring ("velfile", &velfile);
if (verbose) {

```

```

if (*velfile != '\0' ) warn("Velocity file : %s ",velfile);
else warn("Velocity file supplied via stdin");
}

getparstring ("sfile", &sfile);
if (verbose) {
if (*sfile != '\0' ) warn("Output trace file : %s ",sfile);
else warn("Output trace via stdout");
}

getparstring ("dfile", &dfile);
if (verbose) {
if (*dfile != '\0' ) warn("Density file : %s ",dfile);
else warn("No density file supplied ");
}

getparstring ("wfile", &wfile);
if (verbose) {
if (*wfile != '\0' ) warn("Wave file : %s ",wfile);
else warn("No wave file requested ");
}

if ( NINT((float) nz/((float) zd)) + 1 >SU_NFLTS) {
warn ("Too many depth points : impossible to output wave field. Increase zd ?");
*wfile='\0';
}

/* get absorbing conditions
if (!getparint("abs",&abs)) { abs[0]=0; abs[1]=1; }
if (verbose) {
if (abs[0]==1) warn("absorbing condition on top ");
if (abs[1]==1) warn("absorbing condition on bottom ");
}
/* get decimation coefficients
if (!getparint("td",&td)) td=1 ;
if (verbose) warn("time decimation ccoefficient: %d ",td);
if (!getparint("zd",&zd)) zd=1 ;
if (verbose) warn("depth decimation ccoefficient: %d ",zd);

/* choose pressure or particle velocity
if (!getparint("press", &press)) press=1 ;
if ((press != 0) && (press != 1)) err ("press must equal 0 or 1");

```

```

if (verbose) {
if (press==1) warn( "program will output pressure values");
else if (press==0) warn( "program will output particle velocity values");
}

/* allocate space
p=alloc1float(nz);
v=alloc1float(nz);
rv=alloc1float(nz);
rd=alloc1float(nz);
rd1_5=alloc1float(nz);

/* read velocity file
if (*velfile != '\0' ) {
if ((velocityfp=fopen(velfile,"r"))=='\0') err("cannot open velfile=%s ",velfile);
}
if (efread (rv, sizeof(float), nz, velocityfp)!=nz)
err("cannot read %d velocity values ", nz);

/* read density file and linearly inderpolate on corrrct location
if (*dfile != '\0') {
if ((densityfp=fopen(dfile,"r"))=='\0') err("cannot open dfile=%s ",dfile);
if (fread(rd,sizeof(float), nz, densityfp)!=nz) err("error reading dfile %s",dfile);
fclose(densityfp);
}
else for (iz=0; iz<nz; iz++) rd[iz]=2500;
for (iz=0; iz<nz-1; iz++) rd1_5[iz]=(rd[iz]+rd[iz+1])/2;
rd1_5[nz-1]=rd[nz-1];

/* time step computation
vmax=0;
for (iz=0; iz<nz; iz++) if (rv[iz]>vmax) vmax=rv[iz];if (verbose) warn( "vmax= %f ", vmax);
dt=dz/1.414/vmax/2; if (verbose) warn( "time step dt= %f ", dt);

/* maximum number of iterations
if (nt==0) nt=1+tmax/dt;
if (verbose) warn( "number of time steps nt= %d ", nt);
if (NINT( (float) nt/((float)td))+1>SU_NFLTS) err("too many time steps. Increase td ?");

/* source parameter computation
alpha=2*9.8696*freq*freq;

```

```

/* time shift to get a t0 centered source

if ((styp==0) || (styp == 2)) epst0=fabs(source (0, styp, dt, dz, 0, alpha) / 1e4);
else if (styp==1) epst0=fabs(source (1/sqrt(2*alpha), styp, dt, dz, 0, alpha)) / 1e4;
if (verbose) warn( "epst0 = %f ", epst0);

t=tmax+dt;
do t=t-dt; while (fabs(source(t, styp, dt, dz, 0, alpha))<epst0);
t0=t;
ies=2*t/dt;

if (verbose) warn("time shift t0 = %f s", t0);

array initialization
for (iz=0; iz<nz; iz++) { v[iz]=0; p[iz]=0; }

if (*wfile != '\0') {
wavefp=fopen (wfile,"w");
snapsh.d1=dz*zd; snapsh.f1=fz ; snapsh.ns=nz/zd+1; snapsh.d2=dt*td; snapsh.f2=0;
/* snapsh.f2=0 is useless since 0 is the "no value" code for SU headers
}
/* propagation computation
itsis=0;
for (it=0; it<=nt; it++) {
t=it*dt;
if (abs[0]==1) p[0]=(p[0]*(1-rv[0]*dt/dz)+2*rd[0]*rv[0]*rv[0]*dt/dz*v[0])/(1+rv[0]*dt/dz);
else p[0]=0;
for (iz=1; iz<nz; iz++) p[iz]=p[iz]+rd[iz]*rv[iz]*rv[iz]*dt/dz*(v[iz]-v[iz-1]);
if (abs[1]!=1) p[nz-1]=0;
if (it<ies) {
p[isz]=p[isz]+source(t, styp, dt, dz, t0, alpha);
}

for (iz=0; iz<nz-1; iz++) v[iz]=v[iz]+dt/rd1_5[iz]/dz*(p[iz+1]-p[iz]);

if (abs[1] != 1) v[nz-1]=0;
else
v[nz-1]=((rd1_5[nz-1]*dz-dt*rd[nz-1]*rv[nz-1])*v[nz-1]-2*dt*p[nz-1])/(rd1_5[nz-1]*dz+dt);

if (it % td == 0) {
if (press==1)
sismo.data[itsis]=p[irz];
else

```

```

sismo.data[itsis]=v[irz];
    itsis++;
}

if ((*wfile!='\0') && (it % td == 0)) {
if (press==1)
for (iz=0; iz<nz/zd; ++iz) snapsh.data[iz]=p[iz*zd];
else
for (iz=0; iz<nz/zd; ++iz) snapsh.data[iz]=v[iz*zd];

    fputtr(wavefp, &snapsh);
}

}

if (*wfile!='\0') fclose (wavefp);

sismo.dt=td*dt*1e6; sismo.ns=itsis; sismo.delrt=-t0*1000; sismo.trid=1; sismo.tracl=1;

if (*sfile != '\0') seisfp=efopen(sfile,"w");
fputtr (seisfp, &sismo);

return(CWP_Exit());
}

float source (float t, int styp, float dt, float dz, float t0, float alpha)
{
float x=0.0, sou=0.0;
x=-alpha*(t-t0)*(t-t0);
if (x>-40) {
    if (styp==0) sou=exp(x);
    else if (styp==1) sou=-2*alpha*(t-t0)*exp(x);
    else if (styp==2) sou=2*alpha*(1+2*x)*exp(x);
}
else sou=0;
return sou/dz*dt*1e8;
}

```

SUFDMOD2\_PML - Finite-Difference MODELing (2nd order) for acoustic wave equation with PML absorbing boundary conditions.  
Caveat: experimental PML absorbing boundary condition version, may be buggy!

```
sufdmod2_pml <vfile >wfile nx= nz= tmax= xs= zs= [optional parameters]
```

Required Parameters:

```
<vfile file containing velocity[nx][nz]
>wfile file containing waves[nx][nz] for time steps
nx= number of x samples (2nd dimension)
nz= number of z samples (1st dimension)
xs= x coordinates of source
zs= z coordinates of source
tmax= maximum time
```

Optional Parameters:

```
nt=1+tmax/dt number of time samples (dt determined for stability)
mt=1 number of time steps (dt) per output time step
```

```
dx=1.0 x sampling interval
fx=0.0 first x sample
dz=1.0 z sampling interval
fz=0.0 first z sample
```

```
fmax = vmin/(10.0*h) maximum frequency in source wavelet
fpeak=0.5*fmax peak frequency in ricker wavelet
```

```
dfile= input file containing density[nx][nz]
vsx= x coordinate of vertical line of seismograms
hsz= z coordinate of horizontal line of seismograms
vsfile= output file for vertical line of seismograms[nz][nt]
hsfile= output file for horizontal line of seismograms[nx][nt]
ssfile= output file for source point seismograms[nt]
verbose=0 =1 for diagnostic messages, =2 for more
```

```
abs=1,1,1,1 Absorbing boundary conditions on top,left,bottom,right
sides of the model.
=0,1,1,1 for free surface condition on the top
```

...PML parameters....

```
pml_max=1000.0          PML absorption parameter
pml_thick=0             half-thickness of pml layer (0 = do not use PML)
```

Notes:

This program uses the traditional explicit second order differencing method.

Two different absorbing boundary condition schemes are available. The first is a traditional absorbing boundary condition scheme created by Hale, 1990. The second is based on the perfectly matched layer (PML) method of Berenger, 1995.

Authors: CWP:Dave Hale

CWP:modified for SU by John Stockwell, 1993.

CWP:added frequency specification of wavelet: Craig Artley, 1993

TAMU:added PML absorbing boundary condition:

Michael Holzrichter, 1998

CWP/WesternGeco:corrected PML code to handle density variations:  
Greg Wimpey, 2006

References: (Hale's absorbing boundary conditions)

Clayton, R. W., and Engquist, B., 1977, Absorbing boundary conditions for acoustic and elastic wave equations, Bull. Seism. Soc. Am., 6, 1529-1540.

Clayton, R. W., and Engquist, B., 1980, Absorbing boundary conditions for wave equation migration, Geophysics, 45, 895-904.

Hale, D., 1990, Adaptive absorbing boundaries for finite-difference modeling of the wave equation migration, unpublished report from the Center for Wave Phenomena, Colorado School of Mines.

Richtmyer, R. D., and Morton, K. W., 1967, Difference methods for initial-value problems, John Wiley & Sons, Inc, New York.

Thomee, V., 1962, A stable difference scheme for the mixed boundary problem for a hyperbolic, first-order system in two dimensions, J. Soc. Indust. Appl. Math., 10, 229-245.

Toldi, J. L., and Hale, D., 1982, Data-dependent absorbing side boundaries, Stanford Exploration Project Report SEP-30, 111-121.

References: (PML boundary conditions)

Jean-Pierre Berenger, ‘‘A Perfectly Matched Layer for the Absorption of Electromagnetic Waves,’’ Journal of Computational Physics, vol. 114, pp. 185-200.

Hastings, Schneider, and Broschat, ‘‘Application of the perfectly matched layer (PML) absorbing boundary condition to elastic wave propagation,’’ Journal of the Acoustical Society of America, November, 1996.

Allen Taflove, ‘‘Electromagnetic Modeling: Finite Difference Time Domain Methods’’, Baltimore, Maryland: Johns Hopkins University Press, 1995, chap. 7, pp. 181-195.

Trace header fields set: ns, delrt, tracl, tracr, offset, d1, d2,  
sdepth, trid

SUFDMOD2 - Finite-Difference MODeling (2nd order) for acoustic wave equation

sufdmod2 <vfile >wfile nx= nz= tmax= xs= zs= [optional parameters]

Required Parameters:

<vfile file containing velocity[nx] [nz]

>wfile file containing waves[nx] [nz] for time steps

nx= number of x samples (2nd dimension)

nz= number of z samples (1st dimension)

xs= x coordinates of source, or, alternatively, the name of a file that contains the x- and z-coordinates, with the number of pairs as the first record and the actual pairs of (x,z) locations following.

zs= z coordinates of source

sstrength=1.0 strength of source

tmax= maximum time

Optional Parameters:

nt=1+tmax/dt number of time samples (dt determined for stability)

mt=1 number of time steps (dt) per output time step

dx=1.0 x sampling interval

fx=0.0 first x sample

dz=1.0 z sampling interval

fz=0.0 first z sample

fmax = vmin/(10.0\*h) maximum frequency in source wavelet

fpeak=0.5\*fmax peak frequency in ricker wavelet

dfile= input file containing density[nx] [nz]

vsx= x coordinate of vertical line of seismograms

hsz= z coordinate of horizontal line of seismograms

vsfile= output file for vertical line of seismograms[nz] [nt]

hsfile= output file for horizontal line of seismograms[nx] [nt]

ssfile= output file for source point seismograms[nt]

verbose=0 =1 for diagnostic messages, =2 for more

abs=1,1,1,1 Absorbing boundary conditions on top,left,bottom,right sides of the model.

=0,1,1,1 for free surface condition on the top

Notes:

This program uses the traditional explicit second order differencing method.

The input velocity and density files contain C-style binary floating numbers with the z-direction being the fast dimension in the file. Here  $v[ix][iz]$  means that this is a  $v(z,x)$  velocity function.

Authors: CWP:Dave Hale  
CWP:modified for SU by John Stockwell, 1993.

Trace header fields set:  $sx, gx, ns, delrt, tracl, tracr, offset, d1, d2,$   
 $sdepth, trid$

Modifications: Tony Kocurko (TK:)  
Memorial University in Newfoundland and Labrador  
- Allow user to supply the name of a file containing shot point locations, rather than supplying them as values to the  $xs=$  and  $zs=$  command line arguments.  
- Correct the calculation of  $izs[is]$ .

SUFFT - fft real time traces to complex frequency traces

```
suftt <stdin >sdout sign=1
```

Required parameters:

none

Optional parameters:

sign=1 sign in exponent of fft

dt=from header sampling interval

verbose=1 =0 to stop advisory messages

Notes: To facilitate further processing, the sampling interval in frequency and first frequency (0) are set in the output header.

suftt | suifft is not quite a no-op since the trace length will usually be longer due to fft padding.

Caveats:

No check is made that the data IS real time traces!

Output is type complex. To view amplitude, phase or real, imaginary parts, use suamp

Examples:

```
suftt < stdin | suamp mode=amp | ....
```

```
suftt < stdin | suamp mode=phase | ....
```

```
suftt < stdin | suamp mode=real | ....
```

```
suftt < stdin | suamp mode=imag | ....
```

Credits:

CWP: Shuki Ronen, Chris Liner, Jack K. Cohen

CENPET: Werner M. Heigl - added well log support

Note: leave dt set for later inversion

Trace header fields accessed: ns, dt, d1, f1

Trace header fields modified: ns, d1, f1, trid

SUFILTER - applies a zero-phase, sine-squared tapered filter

sufilter <stdin >stdout [optional parameters]

Required parameters:

if dt is not set in header, then dt is mandatory

Optional parameters:

f=f1,f2,... array of filter frequencies(HZ)

amps=a1,a2,... array of filter amplitudes

dt = (from header) time sampling interval (sec)

verbose=0 =1 for advisory messages

Defaults:f=.10\*(nyquist),.15\*(nyquist),.45\*(nyquist),.50\*(nyquist)  
(nyquist calculated internally)

amps=0.,1.,...,1.,0. trapezoid-like bandpass filter

Examples of filters:

Bandpass: sufilter <data f=10,20,40,50 | ...

Bandreject: sufilter <data f=10,20,30,40 amps=1.,0.,0.,1. | ..

Lowpass: sufilter <data f=10,20,40,50 amps=1.,1.,0.,0. | ...

Highpass: sufilter <data f=10,20,40,50 amps=0.,0.,1.,1. | ...

Notch: sufilter <data f=10,12.5,35,50,60 amps=1.,.5,0.,.5,1. |..

Credits:

CWP: John Stockwell, Jack Cohen

CENPET: Werner M. Heigl - added well log support

Possible optimization: Do assignments instead of crmuls where  
filter is 0.0.

Trace header fields accessed: ns, dt, d1

SUFLIP - flip a data set in various ways

```
suflip <data1 >data2 flip=1 verbose=0
```

Required parameters:

none

Optional parameters:

flip=1 rotational sense of flip

+1 = flip 90 deg clockwise

-1 = flip 90 deg counter-clockwise

0 = transpose data

2 = flip right-to-left

3 = flip top-to-bottom

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

verbose=0 verbose = 1 echoes flip info

NOTE: tr.dt header field is lost if flip=-1,+1. It can be  
reset using sushw.

EXAMPLE PROCESSING SEQUENCES:

1. suflip flip=-1 <data1 | sushw key=dt a=4000 >data2

2. suflip flip=2 <data1 | suflip flip=2 >data1\_again

3. suflip tmpdir=/scratch <data1 | ...

Caveat: may fail on large files.

Credits:

CWP: Chris Liner, Jack K. Cohen, John Stockwell

Caveat:

right-left flip (flip = 2) and top-bottom flip (flip = 3)  
don't require the matrix approach. We sacrificed efficiency  
for uniform coding.

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt, tracl



SUFNZERO - get Time of First Non-ZERO sample by trace

sufnzero <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

mode=first    Output time of first non-zero sample  
              =last for last non-zero sample  
              =both for both first & last non-zero samples

min=0        Threshold value for considering as zero

Any abs(sample)<min is considered to be zero

key=key1,... Keyword(s) to print

Credits:

    Geocon : Garry Perratt

based on surms by the same, itself based on sugain & sumax by:

CWP : John Stockwell

SUFRAC -- take general (fractional) time derivative or integral of data, plus a phase shift. Input is CAUSAL time-indexed or depth-indexed data.

suffrac power= [optional parameters] <indata >outdata

Optional parameters:

power=0 exponent of (-i\*omega)

=0 ==> phase shift only

>0 ==> differentiation

<0 ==> integration

sign=-1 sign in front of i \* omega

dt=(from header) time sample interval (in seconds)

phasefac=0 phase shift by phase=phasefac\*PI

verbose=0 =1 for advisory messages

Examples:

preprocess to correct 3D data for 2.5D migration

suffrac < sudata power=.5 sign=1 | ...

preprocess to correct susynlv, susynvxz, etc. (2D data) for 2D migration

suffrac < sudata phasefac=.25 | ...

The filter is applied in frequency domain.

if dt is not set in header, then dt is mandatory

Algorithm:

$g(t) = \text{Re}[\text{INVFTT}\{ ( (\text{sign}) iw)^{\text{power}} \text{FFT}(f) \}]$

Caveat:

Large amplitude errors will result if the data set has too few points.

Good numerical integration routine needed!

For example, see Gnu Scientific Library.

Credits:

CWP: Chris Liner, Jack K. Cohen, Dave Hale (pfas)

CWP: Zhenyue Liu and John Stockwell added phase shift option

CENPET: Werner M. Heigl - added well log support

Trace header fields accessed: ns, dt, trid, d1

/

SUFXDECON - random noise attenuation by FX-DECONvolution

sufxdecon <stdin >stdout [...]

Required Parameters:

Optional Parameters:

taper=.1 length of taper  
fmin=6. minimum frequency to process in Hz (accord to twlen)  
fmax=.6/(2\*dt) maximum frequency to process in Hz  
twlen=entire trace time window length (minimum .3 for lower freqs)  
ntrw=10 number of traces in window  
ntrf=4 number of traces for filter (smaller than ntrw)  
verbose=0 =1 for diagnostic print  
tmpdir= if non-empty, use the value as a directory path prefix  
for storing temporary files; else, if the CWP\_TMPDIR  
environment variable is set, use its value for the path;  
else use tmpfile()

Notes: Each trace is transformed to the frequency domain.

For each frequency, Wiener filtering, with unity prediction in  
space, is used to predict the next sample.

At the end of the process, data is mapped back to t-x domain. ",

Credits:

CWP: Carlos E. Theodoro (10/07/97)

References:

Canales(1984):'Random noise reduction' 54th. SEG

Gulunay(1986):'FXDECON and complex Wiener Prediction  
filter' 56th. SEG

Galbraith(1991):'Random noise attenuation by F-X  
prediction: a tutorial' 61th. SEG

Algorithm:

- read data
- loop over time windows
- select data
- FFT (t -> f)
- loop over space windows

- select data
- loop over frequencies
- autocorelation
- matrix problem
- construct filter
- filter data
- loop along space window
- FFT (f -> t)
- reconstruct data
  - output data

Trace header fields accessed: ns, dt, d1

Trace header fields modified:

SUGABOR - Outputs a time-frequency representation of seismic data via the Gabor transform-like multifilter analysis technique presented by Dziewonski, Bloch and Landisman, 1969.

```
sugabor <stdin >stdout [optional parameters]
```

Required parameters:

if dt is not set in header, then dt is mandatory

Optional parameters:

```
dt=(from header) time sampling interval (sec)
fmin=0 minimum frequency of filter array (hz)
fmax=NYQUIST maximum frequency of filter array (hz)
beta=3.0 ln[filter peak amp/filter endpoint amp]
band=.05*NYQUIST filter bandwidth (hz)
alpha=beta/band^2 filter width parameter
verbose=0 =1 supply additional info
holder=0 =1 output Holder regularity estimate
=2 output linear regularity estimate
```

Notes: This program produces a multifilter (as opposed to moving window) representation of the instantaneous amplitude of seismic data in the time-frequency domain. (With Gaussian filters, moving window and multifilter analysis can be shown to be equivalent.)

An input trace is passed through a collection of Gaussian filters to produce a collection of traces, each representing a discrete frequency range in the input data. For each of these narrow bandwidth traces, a quadrature trace is computed via the Hilbert transform. Treating the narrow bandwidth trace and its quadrature trace as the real and imaginary parts of a "complex" trace permits the "instantaneous" amplitude of each narrow bandwidth trace to be computed. The output is thus a representation of instantaneous amplitude as a function of time and frequency.

Some experimentation with the "band" parameter may be necessary to produce the desired time-frequency resolution. A good rule of thumb is to run sugabor with the default value for band and view the image. If band is too big, then the t-f plot will consist of stripes parallel to the frequency axis. Conversely, if band is too small, then the stripes will be parallel to the time axis.

Caveat:

The Gabor transform is not a wavelet transform, but rather are sharp

frame basis. However, it is nearly a Morlet continuous wavelet transform so the concept of Holder regularity may have some meaning. If you are computing Holder regularity of, say, a migrated seismic section, then set band to 1/3 of the frequency band of your data.

Examples:

```
suviBro | sugabor | suximage
suviBro | sugabor | suxmovie n1= n2= n3=
    (because suxmovie scales it's amplitudes off of the first panel,
    may have to experiment with the wclip and bclip parameters
suviBro | sugabor | supsimage | ... ( your local PostScript utility)
```

Credits:

CWP: John Stockwell, Oct 1994

CWP: John Stockwell Oct 2004, added holder=1 option

Algorithm:

This programs takes an input seismic trace and passes it through a collection of truncated Gaussian filters in the frequency domain.

The bandwidth of each filter is given by the parameter "band". The decay of these filters is given by "alpha", and the number of filters is given by  $n_{filt} = (f_{max} - f_{min})/band$ . The result, upon inverse Fourier transforming, is that  $n_{filt}$  traces are created, with each trace representing a different frequency band in the original data.

For each of the resulting bandlimited traces, a quadrature (i.e.  $\pi/2$  phase shifted) trace is computed via the Hilbert transform. The bandlimited trace constitutes a "complex trace", with the bandlimited trace being the "real part" and the quadrature trace being the "imaginary part". The instantaneous amplitude of each bandlimited trace is then computed by computing the modulus of each complex trace. (See Taner, Koehler, and Sheriff, 1979, for a discussion of complex trace analysis.

The final output for a given input trace is a map of instantaneous amplitude as a function of time and frequency.

This is not a wavelet transform, but rather a redundant frame representation.

References: Dziewonski, Bloch, and Landisman, 1969, A technique for the analysis of transient seismic signals, Bull. Seism. Soc. Am., 1969, vol. 59, no.1, pp.427-444.

Taner, M., T., Koehler, F., and Sheriff, R., E., 1979, Complex seismic trace analysis, Geophysics, vol. 44, pp.1041-1063.

Chui, C., K., 1992, Introduction to Wavelets, Academic Press, New York.

Trace header fields accessed: ns, dt, trid, ntr

Trace header fields modified: tracl, tracr, d1, f2, d2, trid, ntr

SUGAIN - apply various types of gain to display traces

sugain <stdin >stdout [optional parameters]

Required parameters:

none (no-op)

Optional parameters:

panel=0	=1 gain whole data set (vs. trace by trace)
tpow=0.0	multiply data by $t^{tpow}$
epow=0.0	multiply data by $\exp(epow*t)$
gpow=1.0	take signed growth power of scaled data
agc=0	flag; 1 = do automatic gain control
gagc=0	flag; 1 = ... with gaussian taper
wagc=0.5	agc window in seconds (use if agc=1 or gagc=1)
trap=none	zero any value whose magnitude exceeds trapval
clip=none	clip any value whose magnitude exceeds clipval
pclip=none	clip any value greater than clipval
nclip=none	clip any value less than clipval
qclip=1.0	clip by quantile on absolute values on trace
qbal=0	flag; 1 = balance traces by qclip and scale
pbal=0	flag; 1 = bal traces by dividing by rms value
mbal=0	flag; 1 = bal traces by subtracting the mean
maxbal=0	flag; 1 = balance traces by subtracting the max
scale=1.0	multiply data by overall scale factor
norm=0.0	divide data by overall scale factor
bias=0.0	bias data by adding an overall bias value
jon=0	flag; 1 means $tpow=2$ , $gpow=.5$ , $qclip=.95$
verbose=0	verbose = 1 echoes info
mark=0	apply gain only to traces with $tr.mark=0$ =1 apply gain only to traces with $tr.mark!=0$

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Operation order:

if (norm) scale/norm

$out(t) = scale * BAL\{CLIP[AGC\{[t^{tpow} * \exp(epow * t) * (in(t)-bias)]^{gpow}\}]\}$

Notes:

The jon flag selects the parameter choices discussed in Claerbout's Imaging the Earth, pp 233-236.

Extremely large/small values may be lost during agc. Windowing these off and applying a scale in a preliminary pass through sugain may help.

Sugain only applies gain to traces with tr.mark=0. Use sushw, suchw, suedit, or suxedit to mark traces you do not want gained. See the selfdocs of sushw, suchw, suedit, and suxedit for more information about setting header fields. Use "sukeyword mark for more information about the mark header field.

Credits:

SEP: Jon Claerbout

CWP: Jack K. Cohen, Brian Sumner, Dave Hale

Note: Have assumed tr.deltr  $\geq$  0 in tpow routine.

Technical Reference:

Jon's second book, pages 233-236.  
for the rationale for jon=1

Trace header fields accessed: ns, dt, delrt, mark

SUGAUSSTAPER - Multiply traces with gaussian taper

sugausstaper < stdin > stdout [optional parameters]

Required Parameters:

<none>

Optional parameters:

key=offset      keyword of header field to weight traces by

x0=300          centre of gaussian window

xw=50           width of gaussian window

Traces are multiplied with a symmetrical gaussian taper

$w(t)=\exp(-((key-x0)/xw)**2)$

Credits:

Thomas Bohlen, 04.01.2002

Trace header fields accessed: ns

SUGAZMIGQ - SU version of Jenő GAZDAG's phase-shift migration  
for zero-offset data, with attenuation Q.

```
sugazmig <infile >outfile vfile= [optional parameters]
```

Optional Parameters:

dt=from header(dt) or .004 time sampling interval  
dx=from header(dx) or 1.0 midpoint sampling interval  
ft=0.0 first time sample  
ntau=nt(from data) number of migrated time samples  
dtau=dt(from header) migrated time sampling interval  
ftau=ft first migrated time sample  
tmig=0.0 times corresponding to interval velocities in vmig  
vmig=1500.0 interval velocities corresponding to times in tmig  
vfile= name of file containing velocities  
Q=1e6 quality factor  
ceil=1e6 gain ceiling beyond which migration ceases

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note: ray bending effects not accounted for in this version.

The tmig and vmig arrays specify an interval velocity function of time.  
Linear interpolation and constant extrapolation is used to determine  
interval velocities at times not specified. Values specified in tmig  
must increase monotonically.

Alternatively, interval velocities may be stored in a binary file  
containing one velocity for every time sample in the data that is to be  
migrated. If vfile is specified, then the tmig and vmig arrays are ignored.

Caveat: Adding Q is a first attempt to address GPR issues.

Credits:

Constant Q attenuation correction by Chuck Oden 5 May 2004  
CWP John Stockwell 12 Oct 1992  
Based on a constant v version by Dave Hale.

Trace header fields accessed: ns, dt, delrt, d2  
Trace header fields modified: ns, dt, delrt

SUGETHW - sugethw writes the values of the selected key words

```
sugethw key=key1,... [output=] <infile [>outfile]
```

Required parameters:

key=key1,... At least one key word.

Optional parameters:

output=ascii output written as ascii for display

=binary for output as binary floats

=geom ascii output for geometry setting

verbose=0 quiet

=1 chatty

Output is written in the order of the keys on the command line for each trace in the data set.

Example:

```
sugethw <stdin key=sx,gx
```

writes sx, gx values as ascii trace by trace to the terminal.

Comment:

Users wishing to edit one or more header field (as in geometry setting) may do this via the following sequence:

```
sugethw < sudata output=geom key=key1,key2,... > hdrfile
```

Now edit the ASCII file hdrfile with any editor, setting the fields appropriately. Convert hdrfile to a binary format via:

```
a2b < hdrfile n1=nfields > binary_file
```

Then set the header fields via:

```
sushw < sudata infile=binary_file key=key1,key2,... > sudata.edited
```

Credits:

SEP: Shuki Ronen

CWP: Jack K. Cohen

CWP: John Stockwell, added geom stuff, and getparstringarray

SUGET - Connect SU program to file descriptor for input stream.

```
suget fd=$1 | next_su_module
```

This program is for interfacing " outside processing systems with SU. Typically, an outside system would execute the su command file and a file descriptor would be passed by an outside system to the su command file so that output data from the outside system could be piped into the su programs executing inside the command file.

Example: suget fd=\$1 | next\_su\_module

```
fd=-1      file_descriptor_for_input_stream
verbose=0  minimal listing
           =1 asks for message with each trace processed.
```

Author: John Anderson (visiting scholar from Mobil) July 1994

SUGOUPILLAUDPO - calculate Primaries-Only impulse response of a lossless  
GOUPILLAUD medium for plane waves at normal incidence

sugoupillaudpo < stdin > stdout [optional parameters]

Required parameters:

none

Optional parameters:

l=1 source layer number; 1 <= l <= tr.ns  
Source is located at the top of layer l.  
k=1 receiver layer number; 1 <= k  
Receiver is located at the top of layer k.  
tmax number of output time-samples;  
default: long enough to capture all primaries  
pV=1 flag for vector field seismogram  
(displacement, velocity, acceleration);  
=-1 for pressure seismogram.  
verbose=0 silent operation, =1 list warnings

Input: Reflection coefficient series:

$$r[i] = \frac{\text{impedance}[i] - \text{impedance}[i+1]}{\text{impedance}[i] + \text{impedance}[i+1]}$$

r[0]= surface refl. coef. (as seen from above)

r[n]= refl. coef. of the deepest interface

Input file is to be in SU format, i.e., binary floats with a SU header.

Remarks:

1. For vector fields, a buried source produces a spike of amplitude 1 propagating downwards and a spike of amplitude -1 propagating upwards. A buried pressure source produces spikes of amplitude 1 both in the up- and downward directions.

A surface source induces only a downgoing spike of amplitude 1 at the top of the first layer (both for vector and pressure fields).

2. The sampling interval dt in the header of the input reflectivity file is interpreted as a two-way traveltime thickness of the layers. The sampling interval of the output seismogram is the same as that of the input file.

Credits:  
CWP: Albena Mateeva, April 2001.

SUGOUPILLAUD - calculate 1D impulse response of  
non-absorbing Goupillaud medium

sugoupillaud < stdin > stdout [optional parameters]

Required parameters:

none

Optional parameters:

l=1 source layer number; 1 <= l <= tr.ns  
Source is located at the top of layer l.  
k=1 receiver layer number; 1 <= k  
Receiver is located at the top of layer k.  
tmax number of output time-samples; default:  
tmax=NINT((2\*tr.ns-(l-1)-(k-1))/2) if k < tr.ns  
tmax=k if k >=tr.ns  
pV=1 flag for vector field seismogram  
(displacement, velocity, acceleration);  
=-1 for pressure seismogram.  
verbose=0 silent operation, =1 list warnings

Input: Reflection coefficient series:

$$r[i] = \frac{\text{impedance}[i] - \text{impedance}[i+1]}{\text{impedance}[i] + \text{impedance}[i+1]}$$

r[0]= surface refl. coef. (as seen from above)

r[n]= refl. coef. of the deepest interface

Input file is to be in SU format, i.e., binary floats with a SU header.

Remarks:

1. For vector fields, a buried source produces a spike of amplitude 1 propagating downwards and a spike of amplitude -1 propagating upwards. A buried pressure source produces spikes of amplitude 1 both in the up- and downward directions.

A surface source induces only a downgoing spike of amplitude 1 at the top of the first layer (both for vector and pressure fields).

2. The sampling interval dt in the header of the input reflectivity file is interpreted as a two-way traveltime thickness of the layers. The sampling interval of the output seismogram is the same as that of the input file.

Credits:

CWP: Albenia Mateeva, May 2000, a summer project at Western Geophysical

ANOTATION used in the code comments [arises from the use of z-transforms]:

Z-sampled: sampling interval equal to the TWO-way  
traveltime of the layers;

z-sampled: sampling interval equal to the ONE-way  
traveltime of the layers;

REFERENCES:

1. Ganley, D. C., 1981, A method for calculating synthetic seismograms which include the effects of absorption and dispersion. Geophysics, Vol.46, No. 8, p. 1100-1107.

The burial of the source is based on the Appendix of that article.

2. Robinson, E. A., Multichannel Time Series Analysis with Digital Computer Programs: 1983 Goose Pond Press, 2nd edition.

The recursive polynomials Q, P used in this code are described in Chapter 3 of the book: Wave Propagation in Layered Media.

My polynomial multiplication and division functions "prod" and "pratio" are based on Robinson's Fortran subroutines in Chapter 1.

4. Clearbout, J. F., Fundamentals of Geophysical Data Processing with Applications to Petroleum Prospecting: 1985 Blackwell Scientific Publications.

Chapter 8, Section 3: Introduces recursive polynomials F, G in a more intuitive way than Robinson.

The connection between the Robinson's  $P_k$ ,  $Q_k$  and Clearbout's  $F_k$ ,  $G_k$  is:

$$P_k(Z) = F_k(Z)$$

$$Q_k(Z) = - Z^{(k)} G_k(1/Z)$$

SUHARLAN - signal-noise separation by the invertible linear transformation method of Harlan, 1984

susnlinsep <infile >outfile [optional parameters]

Required Parameters:

<none>

Optional Parameters:

FLAGS:

niter=1 number of requested iterations  
anenv=1 =1 for positive analytic envelopes  
=0 for no analytic envelopes (not recommended)  
scl=0 =1 to scale output traces (not recommended)  
plot=3 =0 for no plots. =1 for 1-D plots only  
=2 for 2-D plots only. =3 for all plots  
norm=1 =0 not to normalize reliability values  
verbose=1 =0 not to print processing information  
rgt=2 =1 for uniform random generator  
=2 for gaussian random generator  
sts=1 =0 for no smoothing (not recommended)

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

General Parameters:

dx=20 offset sampling interval (m)  
fx=0 offset on first trace (m)  
dt=0.004 time sampling interval (s)

Tau-P Transform Parameters:

gopt=1 =1 for parabolic transform. =2 for Foster/Mosher  
=3 for linear. =4 for absolute value of linear  
pmin1=-400 minimum moveout at farthest offset for fwd transf(ms)  
pmax1=400 maximum moveout at farthest offset for fwd transf(ms)  
pmin2=pmin1 minimum moveout at farthest offset for inv transf(ms)  
pmax2=pmax1 maximum moveout at farthest offset for inv transf(ms)  
np=100 number of p-values for taup transform  
prewhite=0.01 prewhitening value (suggested between 0.1 and 0,01)  
offref=2000 reference offset for p-values (m)  
depthref=500 reference depth for Foster/Mosher taup (if gopt=4)

pmula=pmax1 maximum p-value preserved in the data (ms)  
pmulb=pmax1 minimum p-value muted on the data (ms)  
ninterp=0 number of traces to interpolate in input data

Extraction Parameters:

nintlh=50 number of intervals (bins) in histograms  
sditer=5 number of steepest descent iterations to compute ps  
c=0.04 maximum noise allowed in a sample of signal(%)  
rel1=0.5 reliability value for first pass of the extraction  
rel2=0.75 reliability value for second pass of the extraction

Smoothing Parameters: ",

r1=10 number of points for damped lsq vertical smoothing  
r2=2 number of points for damped lsq horizontal smoothing

Output Files:

signal=out\_signal name of output file for extracted signal  
noise=out\_noise name of output file for extracted noise

Notes:

The signal-noise separation algorithm was developed by Dr. Bill Harlan in 1984. It can be used to separate events that can be focused by a linear transformation (signal) from events that can't (noise). The linear transform is whatever is well suited for the application at hand. Here, only the discrete Radon transform is used, so the program is capable of separating events focused by that transform (linear, parabolic or time-invariantly hyperbolic). Should other transform be required, the changes to the program will be relatively straightforward.

The reliability parameter is the most critical one to determine what to extract as signal and what to reject as noise. It should be tested for every dataset. The way to test it is to start with a small value, say 0.1 or 0.01. If too much noise is present in the extracted noise, it is too low. If too much signal was extracted, that is, part of the signal was lost, it is too big. All other parameters have good default values and should perhaps not be changed in a first encounter with the program. The transform parameters are also critical. They should be chosen such that no aliasing is present and such that the range of interesting slopes is spanned by the transform but not much more. The program suradon.c has more documentation on the transform parameters.

Credits:

Gabriel Alvarez CWP (1995)

Some subroutines are direct translations to C from Fortran versions written by Dr. Bill Harlan (1984)

References:

Harlan, S., Claerbout, J., and Roca, F. (1984), Signal/noise separation and velocity estimation, *Geophysics*, v. 49, no. 11, p 1869-1880.

Harlan, S. (1988), Separation of signal and noise applied to vertical seismic profiles, *Geophysics*, v. 53, no. 7, p 932-946.

Alvarez, G. (1995), Comparison of moveout-based approaches to ground roll and multiple suppression, MSc., Department of Geophysics, Colorado School of Mines, (Chapter 3 deals exclusively with this method).

SUHILB - Hilbert transform

suhilb <stdin >sdout

Note: the transform is computed in the direct (time) domain

Credits:

CWP: Jack Cohen

CWP: John Stockwell, modified to use Dave Hale's hilbert() subroutine

Trace header fields accessed: ns, trid

```
char *sdoc[] = {
```

SUHISTOGRAM - create histogram of input amplitudes

```
    suhistogram <in.su >out.dat
```

Required parameters:

min= minimum bin

max= maximum bin

bins= number of bins

Optional parameters

trend=0 =0 1-D histogram

          =1 2-D histogram picks on cumulate

          =2 2-D histogram in trace format

clip=      threshold value to drop outliers

dt= sample rate in feet or milliseconds. Defaults to  
      tr.dt\*1e-3

datum= header key to get datum shift if desired (e.g. to  
        hang from water bottom)

Notes:

trend=0 produces a two column ASCII output for use w/ gnuplot.  
Extreme values are counted in the end bins.

trend=1 produces a 6 column ASCII output for use w/ gnuplot  
The columns are time/depth and picks on the cumulate  
at 2.28%, 15.87%, 50%, 84.13% & 97.72% of the total points  
corresponding to the median and +- 1 or 2 standard deviations  
for a Gaussian distribution.

trend=2 produces an SU trace panel w/ one trace per bin that  
can be displayed w/ suximage, etc.

Example for plotting with xgraph:

```
suhistogram < data.su min=MIN max=MAX bins=BINS |  
a2b n1=2 | xgraph n=BINS nplot=1
```

Author: Reginald H. Beardsley 2006 rhb@acm.org



SUHROT - Horizontal ROTation of three-component data

suhrot <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

angle=rad unit of angles, choose "rad", "deg", or "gon

inv=0 1 = inverse rotation (counter-clockwise)

verbose=0 1 = echo angle for each 3-C station

a=... array of user-supplied rotation angles

x=0.0,... array of corresponding header value(s)

key=tracf header word defining 3-C station ("x")

... or input angles from files:

n=0 number of x and a values in input files

xfile=... file containing the x values as specified by the  
"key" parameter

afile=... file containing the a values

Notes:

Three adjacent traces are considered as one three-component dataset.

By default, the data will be rotated from the Z-North-East (Z,N,E) coordinate system into Z-Radial-Transverse (Z,R,T).

If one of the parameters "a=" or "afile=" is set, the data are rotated by these user-supplied angles. Specified x values must be monotonically increasing or decreasing, and afile and xfile are files of binary (C-style) floats.

Author: Nils Maercklin,

Geophysics, Kiel University, Germany, 1999.

Trace header fields accessed: ns, sx, sy, gx, gy, key=keyword

Trace header fields modified: trid

SUHTMATH - do unary arithmetic operation on segy traces with headers values

suhtmath <stdin >stdout

Required parameters:

none

Optional parameter:

key=tracl header word to use

op=nop operation flag

nop : no operation

add : add header to trace

mult : multiply trace with header

div : divide trace by header

scale=1.0 scalar multiplier for header value

const=0.0 additive constant for header value

Operation order: ",

op=add:  $out(t) = in(t) + (scale * key + const)$

op=mult:  $out(t) = in(t) * (scale * key + const)$

op=div:  $out(t) = in(t) / (scale * key + const)$

Credits:

Matthias Imhof, Virginia Tech, Fri Dec 27 09:17:29 EST 2002

SUIFFT - fft complex frequency traces to real time traces

```
suiFFT <stdin >sdout sign=-1
```

Required parameters:

none

Optional parameter:

sign=-1 sign in exponent of inverse fft

Output traces are normalized by  $1/N$  where  $N$  is the fft size.

Note: `sufft | suiFFT` is not quite a no-op since the trace length will usually be longer due to fft padding.

Credits:

CWP: Shuki, Chris, Jack

Trace header fields accessed: ns, trid

Trace header fields modified: ns, trid

SUILOG -- time axis inverse log-stretch of seismic traces

```
sulog nt= ntmin= <stdin >stdout
```

Required parameters:

nt= nt output from sulog prog

ntmin= ntmin output from sulog prog

dt= dt output from sulog prog

Optional parameters:

none

NOTE: Parameters needed by sulog to reconstruct the original data may be input via a parameter file.

EXAMPLE PROCESSING SEQUENCE:

```
sulog outpar=logpar <data1 >data2
```

```
sulog par=logpar <data2 >data3
```

where logpar is the parameter file

Credits:

CWP: Shuki Ronen, Chris Liner

Caveats:

amplitudes are not well preserved

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt

SUIMP2D - generate shot records for a line scatterer  
embedded in three dimensions using the Born  
integral equation ",

```
suimp2d [optional parameters] >stdout
```

Optional parameters

nshot=1 number of shots  
nrec=1 number of receivers  
c=5000 speed  
dt=.004 sampling rate  
nt=256 number of samples  
x0=1000 point scatterer location  
z0=1000 point scatterer location  
sxmin=0 first shot location  
szmin=0 first shot location  
gxmin=0 first receiver location  
gzmin=0 first receiver location  
dsx=100 x-step in shot location  
dsz=0 z-step in shot location  
dgx=100 x-step in receiver location  
dgz=0 z-step in receiver location

Example:

```
suimp2d nrec=32 | sufilter | supswigp | ...
```

Credits:

CWP: Norm Bleistein, Jack K. Cohen

Theory: Use the 3D Born integral equation (e.g., Geophysics,  
v51, n8, p1554(7)). Use 2-D delta function for alpha and do  
remaining y-integral by stationary phase.

Note: Setting a 2D offset in a single offset field beats the  
hell out of us. We did `_something_`.

Trace header fields set: ns, dt, tracl, tracr, fldr, sx, selev,  
gx, gelev, offset

SUIMP3D - generate inplane shot records for a point scatterer embedded in three dimensions using the Born integral equation ",

suimp3d [optional parameters] >stdout

Optional parameters

nshot=1 number of shots

nrec=1 number of receivers

c=5000 speed

dt=.004 sampling rate

nt=256 number of samples

x0=1000 point scatterer location

y0=0 point scatterer location

z0=1000 point scatterer location

sxmin=0 first shot location

symin=0 first shot location

szmin=0 first shot location

gxmin=0 first receiver location

gymin=0 first receiver location

gzmin=0 first receiver location

dsx=100 x-step in shot location

dsy=0 y-step in shot location

dsz=0 z-step in shot location

dgx=100 x-step in receiver location

dgy=0 y-step in receiver location

dgz=0 z-step in receiver location

Example:

```
suimp3d nrec=32 | sufilter | supswigp | ...
```

Credits:

CWP: Norm Bleistein, Jack K. Cohen

Theory: Use the 3D Born integral equation (e.g., Geophysics, v51, n8, p1554(7)). Use 3-D delta function for alpha.

Note: Setting a 3D offset in a single offset field beats the hell out of us. We did `_something_`.

Trace header fields set: ns, dt, tracl, tracr, fldr, tracf,  
sx, sy, selev, gx, gy, gelev, offset

SUIMPEDANCE - Convert reflection coefficients to impedances.

suimpedance <stdin >stdout [optional parameters]

Optional Parameters:

v0=1500.        Velocity at first sample (m/sec)

rho0=1.0e6     Density at first sample (g/m<sup>3</sup>)

Notes:

Implements recursion  $[1-R(k)]Z(k) = [1+R(k)]Z(k-1)$ .

Credits:

SEP: Stew Levin

Trace header fields accessed: ns

SUINTERPFOWLER - interpolate output image from constant velocity panels  
built by SUTIFOWLER or CVS

These parameters should be specified the same as in SUTIFOWLER:

vmin=1500. minimum velocity  
vmax=2500. maximum velocity  
nv=21 number of velocity panels  
etamin=0.10 minimum eta value  
etamax=0.25 maximum eta value  
neta=11 number of eta values  
ncdps=1130 number of cdp points

If these parameters are specified so that nvstack>5, then the input  
data are assumed to come from CVS and the SUTIFOWLER parameters are ignored.

nvstack=0 number of constant velocity stack panels output by CVS  
vminstack=1450 minimum velocity specified for CVS  
vscale=1.0 scale factor for velocity functions

These parameters specify the desired output (time,velocity,eta) model  
at each cdp location. The sequential cdp numbers should be specified in  
increasing order from 0 to 'ncdps-1' at from 1 to 'ncdps' control point  
locations. (Time values are in seconds.)

cdp=0 cdp number for (t,v,eta) triplets (specify more than  
once if needed)  
t=0. array of times for (t,v,eta) triplets (specify more  
than once if needed)  
v=1500. array of velocities for (t,v,eta) triplets (specify  
more than once if needed)  
eta=0. array of etas for (t,v,eta) triplets (specify more  
than once if needed)

Note: This is a simple research code based on linear interpolation.  
There are no protections against aliasing built into the code beyond  
suggesting that this program have a knowledgeable user. A final version  
should do a better job taking care of endpoint conditions.

Author: (Visitor from Mobil) John E. Anderson, Spring 1994

SUINTERP - interpolate traces using automatic event picking

suinterp < stdin > stdout

ninterp=1     number of traces to output between each pair of input traces  
nxmax=500     maximum number of input traces  
freq1=4.       starting corner frequency of unaliased range  
freq2=20.      ending corner frequency of unaliased range  
deriv=0        =1 means take vertical derivative on pick section  
                  (useful if interpolating velocities instead of seismic)  
linear=0        =0 means use 8 point sinc temporal interpolation  
                  =1 means use linear temporal interpolation  
                  (useful if interpolating velocities instead of seismic)  
lent=5         number of time samples to smooth for dip estimate  
lenx=1         number of traces to smooth for dip estimate  
lagc=400        number of ms agc for dip estimate  
xopt=0          0 compute spatial derivative via FFT  
                  (assumes input traces regularly spaced and relatively  
                  noise-free)  
                  1 compute spatial derivative via differences  
                  (will work on irregularly spaced data)  
iopt=0          0 = interpolate  
                  1 = output low-pass model: useful for QC if interpolator failing  
                  2 = output dip picks in units of samples/trace  
  
verbose=0     verbose = 1 echoes information

tmpdir=     if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
            the CWP\_TMPDIR environment variable is set use  
            its value for the path; else use tmpfile()

Notes:

This program outputs 'ninterp' interpolated traces between each pair of input traces. The values for lagc, freq1, and freq2 are only used for event tracking. The output data will be full bandwidth with no agc. The default parameters typically will do a satisfactory job of interpolation for dips up to about 12 ms/trace. Using a larger value for freq2 causes the algorithm to do a better job on the shallow dips, but to fail on the steep dips. Only one dip is assumed at each time sample between each pair of input traces.

The key assumption used here is that the low frequency data are unaliased

and can be used for event tracking. Those dip picks are used to interpolate the original full-bandwidth data, giving some measure of interpolation at higher frequencies which otherwise would be aliased. Using `iopt equal` to 1 allows you to visually check whether the low-pass picking model is aliased.

Trace headers for interpolated traces are not updated correctly. The output header for an interpolated traces equals that for the preceding trace in the original input data. The original input traces are passed through this module without modification.

The place this code is most likely to fail is on the first breaks.

Example run: `suplane | suinterp | suxwigb &`

Credit: John Anderson (visiting scholar from Mobil) July 1994

Trace header fields accessed: `ns, dt`

SUINVEL - convert stacking velocity model to interval velocity model

```
suintvel vs= t0= outpar=/dev/tty
```

Required parameters:

vs= stacking velocities

t0= normal incidence times

Optional parameters:

outpar=/dev/tty output parameter file in the form:

h=layer thicknesses vector

v=interval velocities vector

Examples:

```
suintvel vs=5000,5523,6339,7264 t0=.4,.8,1.125,1.425 outpar=intpar
```

```
suintvel par=stkpar outpar=intpar
```

If the file, stkpar, contains:

```
vs=5000,5523,6339,7264
```

```
t0=.4,.8,1.125,1.425
```

then the two examples are equivalent.

Note: suintvel does not have standard su syntax since it does not operate on seismic data. Hence stdin and stdout are not used.

Note: may go away in favor of par program, velconv, by Dave

Credits:

CWP: Jack

Technical Reference:

The Common Depth Point Stack

William A. Schneider

Proc. IEEE, v. 72, n. 10, p. 1238-1254

1984

Formulas:

Note: All sums on i are from 1 to k

From Schneider:

Let  $h[i]$  be the  $i$ th layer thickness measured at the  $cmp$  and

$v[i]$  the  $i$ th interval velocity.

Set:

$$t[i] = h[i]/v[i]$$

Define:

$$t0by2[k] = 0.5 * t0[k] = \text{Sum } h[i]/v[i]$$

$$vh[k] = vs[k]*vs[k]*t0by2[k] = \text{Sum } v[i]*h[i]$$

Then:

$$dt[i] = h[i]/v[i] = t0by2[i] - t0by2[i-1]$$

$$dvh[i] = h[i]*v[i] = vh[i] - vh[i-1]$$

$$h[i] = \text{sqrt}(dvh[i] * dt[i])$$

$$v[i] = \text{sqrt}(dvh[i] / dt[i])$$

SUINVXZCO - Seismic INVersion of Common Offset data for a smooth velocity function  $V(X,Z)$  plus a slowness perturbation  $vp(x,z)$

suinvvxzco <infile >outfile [optional parameters]

Required Parameters:

vfile file containing velocity array  $v[nx][nz]$   
nx= number of x samples (2nd dimension) in velocity  
nz= number of z samples (1st dimension) in velocity  
nxm= number of midpoints of input traces

Optional Parameters:

dt= or from header (dt) time sampling interval of input data  
offs= or from header (offset) source-receiver offset  
dxm= or from header (d2) sampling interval of midpoints  
fxm=0 first midpoint in input trace  
nxd=5 skipped number of midpoints (see note)  
dx=50.0 x sampling interval of velocity  
fx=0.0 first x sample of velocity  
dz=50.0 z sampling interval of velocity  
nxb=nx/2 band centered at midpoints (see note)  
nxc=0 hozizontal range in which velocity is changed  
nzc=0 vertical range in which velocity is changed  
fxo=0.0 x-coordinate of first output trace  
dxo=15.0 horizontal spacing of output trace  
nxo=101 number of output traces ",  
fzo=0.0 z-coordinate of first point in output trace  
dzo=15.0 vertical spacing of output trace  
nzo=101 number of points in output trace ",  
fmax=0.25/dt Maximum frequency set for operator antialiasing  
ang=180 Maximum dip angle allowed in the image  
ls=0 =1 for line source; =0 for point source  
pert=0 =1 calculate time correction from  $v_p[nx][nz]$   
vpfile file containing slowness perturbation array  $v_p[nx][nz]$   
verbose=1 =1 to print some useful information

Notes:

Traveltime and amplitude are calculated by finite difference which is done only in one of every NXD midpoints; in the skipped midpoint, interpolation is used to calculate traveltime and amplitude. ",  
For each midpoint, traveltime and amplitude are calculated in the horizontal range of  $(xm-nxb*dx, xm+nxb*dx)$ . Velocity is changed by constant extropolation in two upper trianglar corners whose width is

$n_{xc} \cdot dx$  and height is  $n_{zc} \cdot dz$ .

Eikonal equation will fail to solve if there is a polar turned ray. In this case, the program shows the related geometric information. There are three ways to remove the turned ray: smoothing velocity, reducing  $n_{xb}$ , and increasing  $n_{xc}$  and  $n_{zc}$  (if the turned ray occurs in the shallow areas). To prevent traveltime distortion from a over smoothed velocity, traveltime is corrected based on the slowness perturbation.

Offsets are signed - may be positive or negative.

Author: Zhenyue Liu, 08/28/93, Colorado School of Mines

Reference:

Bleistein, N., Cohen, J. K., and Hagin, F., 1987,  
Two-and-one-half dimensional Born inversion with an arbitrary reference  
Geophysics Vol. 52, no.1, 26-36.

SUINVZCO3D - Seismic INVersion of Common Offset data with V(Z) velocity  
function in 3D

suinvzco3d <infile >outfile [optional parameters]

Required Parameters:

vfile file containing velocity array v[nz]  
nz= number of z samples (1st dimension) in velocity  
nxm= number of midpoints of input traces  
ny= number of lines

Optional Parameters:

dt= or from header (dt) time sampling interval of input data  
offs= or from header (offset) source-receiver offset  
dxm= or from header (d2) sampling interval of midpoints  
fxm=0 first midpoint in input trace  
nxd=5 skipped number of midpoints (see note)  
dx=50.0 x sampling interval of velocity  
fx=0.0 first x sample of velocity  
dz=50.0 z sampling interval of velocity  
nxb=nx/2 band centered at midpoints (see note)  
fxo=0.0 x-coordinate of first output trace  
dxo=15.0 horizontal spacing of output trace  
nxo=101 number of output traces ",  
fyo=0.0 y-coordinate of first output trace  
dyo=15.0 y-coordinate spacing of output trace  
nyo=101 number of output traces in y-direction  
fzo=0.0 z-coordinate of first point in output trace  
dzo=15.0 vertical spacing of output trace  
nzo=101 number of points in output trace ",  
fmax=0.25/dt Maximum frequency set for operator antialiasing  
ang=180 Maximum dip angle allowed in the image  
verbose=1 =1 to print some useful information

Notes:

This algorithm is based on formula (50) in Geophysics Vol. 51,  
1552-1558, by Cohen, J., Hagin, F., and Bleistein, N.

Traveltime and amplitude are calculated by ray tracing.  
Interpolation is used to calculate traveltime and amplitude. ",  
For each midpoint, traveltime and amplitude are calculated in the  
horizontal range of (xm-nxb\*dx, xm+nxb\*dx). Velocity is changed by

linear interpolation in two upper triangular corners whose width is  $nxc*dx$  and height is  $nzc*dz$ . ",

Eikonal equation will fail to solve if there is a polar turned ray. In this case, the program shows the related geometric information.

Offsets are signed - may be positive or negative. ",

SUK1K2FILTER - symmetric box-like K-domain filter defined by the cartesian product of two  $\sin^2$ -tapered polygonal filters defined in k1 and k2

suk1k2filter <infile >outfile [optional parameters]

Optional parameters:

k1=val1,val2,... array of K1 filter wavenumbers  
k2=val1,val2,... array of K2 filter wavenumbers  
amps1=a1,a2,... array of K1 filter amplitudes  
amps2=a1,a2,... array of K2 filter amplitudes  
d1=tr.d1 or 1.0 sampling interval in first (fast) dimension  
d2=tr.d1 or 1.0 sampling interval in second (slow) dimension  
quad=0 =0 all four quadrants  
=1 (quadrants 1 and 4)  
=2 (quadrants 2 and 3)

Defaults:

k1=.10\*(nyq1),.15\*(nyq1),.45\*(nyq1),.50\*(nyq1)  
k2=.10\*(nyq2),.15\*(nyq2),.45\*(nyq2),.50\*(nyq2)  
amps1=0.,1.,...,1.,0. trapezoid-like bandpass filter  
amps2=0.,1.,...,1.,0. trapezoid-like bandpass filter

The nyquist wavenumbers, nyq1 and nyq2, are computed internally.

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes:

The filter is assumed to be symmetric, to yield real output

Because the data are assumed to be purely spatial (i.e. non-seismic), the data are assumed to have trace id (30), corresponding to (z,x) data

The relation:  $w = 2 \pi F$  is well known for frequency, but there doesn't seem to be a commonly used letter corresponding to F for the spatial conjugate transform variables. We use K1 and K2 for this. More specifically we assume a phase:  
 $-i(k_1 x_1 + k_2 x_2) = -2 \pi i(K_1 x_1 + K_2 x_2)$ .

and  $K_1$ ,  $K_2$  define our respective wavenumbers.

Credits:

CWP: John Stockwell, November 1995.

Trace header fields accessed: ns, d1, d2

## SUKDMIG2D - Kirchhoff Depth Migration of 2D poststack/prestack data

```
sukdmig2d infile= outfile= ttfile= [parameters]
```

### Required parameters:

```
infile=stdin file for input seismic traces  
outfile=stdout file for common offset migration output  
ttfile= file for input travelttime tables
```

... The following 9 parameters describe travelttime tables:

```
fzt= first depth sample in travelttime table  
nzt= number of depth samples in travelttime table  
dzt= depth interval in travelttime table  
fxt= first lateral sample in travelttime table  
nxt= number of lateral samples in travelttime table  
dxt= lateral interval in travelttime table  
fs= x-coordinate of first source  
ns= number of sources  
ds= x-coordinate increment of sources
```

### Optional Parameters:

```
dt= or from header (dt) time sampling interval of input data  
ft= or from header (ft) first time sample of input data  
dxm= or from header (d2) sampling interval of midpoints  
fzo=fzt z-coordinate of first point in output trace  
dzo=0.2*dzt vertical spacing of output trace  
nzo=5*(nzt-1)+1 number of points in output trace "  
fxo=fxt x-coordinate of first output trace  
dxo=0.5*dxt horizontal spacing of output trace  
nxo=2*(nxt-1)+1 number of output traces "  
off0=0 first offest in output  
doff=99999 offset increment in output  
noff=1 number of offsets in output "  
absoff=0 flag for using absolute offsets of input traces  
=0 means use offset=gx-sx  
=1 means use abs(gx-sx)  
limoff=0 flag for only using input traces that fall within the range  
of defined output offset bins (off0,doff,noff)  
=0 means use all input traces  
=1 means limit traces used by offset  
fmax=0.25/dt frequency-highcut for input traces  
offmax=99999 maximum absolute offset allowed in migration  
aperx=nxt*dxt/2 migration lateral aperature
```

angmax=60 migration angle aperture from vertical  
v0=1500(m/s) reference velocity value at surface "  
dvz=0.0 reference velocity vertical gradient

ls=1 flag for line source  
jpfile=stderr job print file name

mtr=100 print verbal information at every mtr traces  
ntr=100000 maximum number of input traces to be migrated  
npv=0 flag of computing quantities for velocity analysis  
rscale=1000.0 scaling for roundoff error suppression

...if npv>0 specify the following three files:  
tvfile=tvfile input file of traveltime variation tables  
tv[ns] [nxt] [nzt]  
csfile=csfile input file of cosine tables cs[ns] [nxt] [nzt]  
outfile1=outfile1 file containning additional migration output  
with extra amplitude

Notes:

1. Traveltime tables were generated by program rayt2d (or other ones) on relatively coarse grids, with dimension ns\*nxt\*nzt. In the migration process, traveltimes are interpolated into shot/geophone positions and output grids.
2. Input seismic traces must be SU format and can be any type of gathers (common shot, common offset, common CDP, and so on). "
3. Migrated traces are output in CDP gathers if velocity analysis is required, with dimension nxo\*noff\*nzo. "
4. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
5. Memory requirement for this program is about  
 $[ns*nxt*nzt+noff*nxo*nzo+4*nr*nzt+5*nxt*nzt+npa*(2*ns*nxt*nzt+noff*nxo*nzo+4*nxt*nzt)]*4$  bytes  
where  $nr = 1+\min(nxt*dxt, 0.5*offmax+aperx)/dxo$ .
6. Amplitudes are computed using the reference velocity profile,  $v(z)$ , specified by the parameters v0= and dvz=.
7. Input traces must specify source and receiver positions via the header fields tr.sx and tr.gx. Offset is computed automatically.
8. if limoff=0, input traces from outside the range defined by off0, doff, noff, will get migrated into the extremal offset bins/planes. E.g. if absoff=0 and limoff=0, all traces with  $gx<sx$  will get migrated into the off0 bin.

Author: Zhenyue Liu, 03/01/95, Colorado School of Mines

Modifications:

Gary Billings, Talisman Energy, Sept 2005: added absoff, limoff.

Trace header fields accessed: ns, dt, delrt, d2

Trace header fields modified: sx, gx

## SUKDMIG3D - Kirchhoff Depth Migration of 3D poststack/prestack data

```
sukdmig3d datain= dataout= [parameters]
```

Required parameters:

```
ttfile file for input tttables
```

Optional Parameters:

```
datain=stdin file for input seismic traces
```

```
dataout=stdout file for common offset migration output
```

```
crfile=NULL file for cos theta and ray paths
```

The following 17 parameters describe tttables: (from ttfile header)

```
fxgd= or from header (f1) first x-sample in tttable
```

```
nxt= or from header (ns) number of x-samples in tttable
```

```
dxgd= or from header (d1) x-interval in tttable
```

```
fygd= or from header (f2) first y-sample in tttable
```

```
nyt= or from header (ntr) number of y-samples in tttable
```

```
dygd= or from header (d2) y-interval in tttable
```

```
ixsf= or from header (sdel) x in dxgd of first source
```

```
nxs= or from header (nhs) number of sources in x
```

```
ixsr= or from header (swdep) ratio of source & gd spacing
```

```
iysf= or from header (gdel) y in dygd of first source
```

```
nys= or from header (nvs) number of sources in y
```

```
iysr= or from header (gwdep) ratio of source & gd spacing
```

```
fzs= or from header (sdepth/1000) first depth sample in tttable
```

```
nzs= or from header (duse) number of depth samples in tttable
```

```
dzs= or from header (ep/1000) depth interval in tttable
```

```
nxgd= or from header (selev) x size of the travelttime region
```

```
nygd= or from header (gelev) y size of the travelttime region
```

```
multit= or from header (scale1) number of multivalued travelttime
```

The following two parameters are from data header

```
dt= or from header (dt) time sampling interval of input data
```

```
ft= or from header (ft) first time sample of input data
```

```
dxm= or from header (d2) mid point spacing of input data
```

Default: output is 5 times finer in depth and 2 times finer in lateral

```
fzo=fzs z-coordinate of first point in output trace
```

```
dzo=0.2*dzs vertical spacing of output trace (5 times finer)
```

```
nzo=5*(nzs-1)+1 number of points in output trace (5 times finer) "
```

```
fxo=fxgd x-coordinate of first output trace
```

dxo=0.5\*dxgd horizontal spacing of output trace (2 times finer)  
nxo=2\*(nxgd-1)+1 number of output traces (2 times finer)  
fyo=fygd y-coordinate of first output trace  
dyo=0.5\*dygd horizontal spacing of output trace (2 times finer)  
nyo=2\*(nygd-1)+1 number of output traces (2 times finer)

Default: poststack migration "  
fxoffset=0 first offset in output in x  
fyoffset=0 first offset in output in y  
dxoffset=99999 offset increment in output in x  
dyoffset=99999 offset increment in output in y  
nxoffset=1 number of offsets in output in x  
nyoffset=1 number of offsets in output in y "  
xoffsetmax=99999 x-maximum absolute offset allowed in migration  
yoffsetmax=99999 y-maximum absolute offset allowed in migration  
xaper=nxt\*dxgd/2.5 migration lateral aperture in x  
yaper=nyt\*dygd/2.5 migration lateral aperture in y  
angmax=60 max angle to handle  
fmax=0.25/dt max frequency in the data  
jpptr=stderr job print file name  
pptr=100 print verbal information at every pptr traces  
ntrmax=100000 maximum number of input traces to be migrated  
ls=0 point =0 line source =1

Notes:

1. Traveltime tables were generated by program SUTETRARAY (or other ones) on very sparse tetrahedral model, with dimension nys\*nxs\*nzs\*nyt\*nxt.
2. Input seismic traces must be SU format and can be any type of gathers (common shot, common offset, common CDP, and so on). "
3. Migrated traces are output in CDP gathers if velocity analysis is required, with dimension nyoffset\*nxoffset\*nyo\*nxo\*nzo. "
4. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
5. Memory requirement for this program is about  
[nys\*nxs\*nzs\*nyt\*nxt+nyoffset\*nxoffset\*nxo\*nyo\*nzo+  
nys\*nxo\*nzo\*nyt\*nxt]
6. Input traces must specify source and receiver positions via header fields tr.sx and tr.gx, as well as tr.sy and tr.gy. Offset is computed automatically.

Disclaimer:

This is a research code that will take considerable work to get into

the form of a a production level 3D migration code. The code is offered as is, along with tetramod and sutetrray, to provide a starting point for researchers who wish to write their own 3D migration codes.

Author: Zhaobo Meng, 01/10/97, Colorado School of Mines

Trace header fields accessed: ns, dt, delrt, d2

Trace header fields modified: sx, gx

SUKDSYN2D - Kirchhoff Depth SYNthesis of 2D seismic data from a  
migrated seismic section

```
sukdsyn2d infile outfile [parameters]
```

Required parameters:

infile=stdin input migrated section  
outfile=stdout file for output seismic traces  
ttfile file for input travelttime tables

The following 9 parameters describe travelttime tables:

fzt= first depth sample  
nzt= number of depth samples  
dzt= depth interval  
fxt= first lateral sample  
nxt= number of lateral samples  
dxt= lateral interval  
fs= x-coordinate of first source  
ns= number of sources  
ds= x-coordinate increment of sources

The following 6 parameters describe the migration section:

fz= first z-coordinate in migrated section  
dz= vertical spacing of migrated section  
nz= number of depth points in migrated section  
fx= first x-coordinate of migrated section  
dx= horizontal spacing of migrated section  
nx= number of lateral points in migrated section

Optional Parameters:

nt=501 number of time samples  
dt=0.004 time sampling interval (sec)  
ft=0.0 first time (sec)  
nxo=1 number of source-receiver offsets  
dxo=25 offset sampling interval  
fxo=0.0 first offset  
nxs=101 number of shotpoints  
dxs=25 shotpoint sampling interval  
fxs=0.0 first shotpoint  
fmax=1/(4\*dt) maximum frequency in migration section (Hz)  
aperx=nxt\*dxt/2 modeling lateral aperature  
angmax=60 modeling angle aperature from vertical  
v0=1500(m/s) reference velocity value at surface

dvz=0.0 reference velocity vertical gradient  
ls=1 flag for line source  
jpfile=stderr job print file name  
mtr=100 print verbal information at every mtr traces

Notes:

This program takes a migrated seismic section and a set of travel time tables generated using rayt2d for a specific background velocity model and generates synthetic seismic data in the form of common shot gathers. (Common offset gathers may be generated by using nxo=1.) (Demigration.)

This program is a tool which may be used for the migration residual statics estimation technique of Tjan, Audebert, and Larner 1994.

1. The traveltimes tables are generated by program rayt2d (or other ones) on relatively coarse grids, with dimension ns\*nxt\*nzt. In the modeling process, traveltimes are interpolated into shot/geophone positions and migration section grids.
2. The input migration section must be an array of binary floats (no SU headers). "
3. The synthesized traces are output in common-shot gathers in SU format.
4. The memory requirement for this program is about  
 $(ns*nxt*nzt+nx*nz+4*nr*nzt+3*nxt*nzt)*4$  bytes  
where  $nr = 1+\min(nxt*dxt,0.5*offmax+aperx)/dxo$ .

Author: CWP: Zhenyue Liu, 07/24/95, Colorado School of Mines

References:

Tjan, T., F. Audebert, and K. Larner, 1994,  
Prestack migration for residual statics estimation in complex media  
(Appeared in 1994 Project Review, CWP-153.)

Tjan, T., 1995, Residual statics estimation for data from structurally complex areas using prestack depth migration: M.Sc. thesis, Colorado School of Mines. (In progress.)

Larner, K., and Tjan, T., 1995, Simultaneous statics and velocity estimation for data from structurally complex areas.  
(Appeared in 1995 Project Review, CWP-185.)

Trace header fields set: ns, dt, delrt, tracl, tracr, fldr, tracf  
offset, sx, gx, trid, counit

SUKEYCOUNT - sukeycount writes a count of a selected key

```
sukeycount key=keyword < infile [> outfile]
```

Required parameters:

```
key=keyword      One key word.
```

Optional parameters:

```
verbose=0 quiet  
          =1 chatty
```

Writes the key and the count to the terminal or a text file when a change of key occurs. This does not provide a unique key count (see SUCOUNTKEY for that).

Note that for key values 1 2 3 4 2 5 value 2 is counted once per occurrence since this program only recognizes a change of key, not total occurrence.

Examples:

```
sukeycount < stdin key=fldr  
sukeycount < stdin key=fldr > out.txt
```

Credits:

MTU: David Forel, Jan 2005

SUKFILTER - radially symmetric K-domain,  $\sin^2$ -tapered, polygonal filter

sukfilter <infile >outfile [optional parameters]

Optional parameters:

k=val1,val2,... array of K filter wavenumbers

amps=a1,a2,... array of K filter amplitudes

d1=tr.d1 or 1.0 sampling interval in first (fast) dimension

d2=tr.d1 or 1.0 sampling interval in second (slow) dimension

Defaults:

k=.10\*(nyq),.15\*(nyq),.45\*(nyq),.50\*(nyq)

amps=0.,1.,...,1.,0. trapezoid-like bandpass filter

The nyquist wavenumbers,  $nyq = \sqrt{nyq1^2 + nyq2^2}$  is computed internally.

Notes:

The filter is assumed to be symmetric, to yield real output.

Because the data are assumed to be purely spatial (i.e. non-seismic), the data are assumed to have trace id (30), corresponding to (z,x) data

The relation:  $w = 2 \pi F$  is well known for frequency, but there doesn't seem to be a commonly used letter corresponding to F for the spatial conjugate transform variables. We use K1 and K2 for this.

More specifically we assume a phase:

$$-i(k_1 x_1 + k_2 x_2) = -2 \pi i(K_1 x_1 + K_2 x_2).$$

and K1, K2 define our respective wavenumbers.

Credits:

CWP: John Stockwell, June 1997.

Trace header fields accessed: ns, d1, d2

SUKFRAC - apply FRACTIONAL powers of  $i|k|$  to data, with phase shift

```
sukfrac <infile >outfile [optional parameters]
```

Optional parameters:

```
power=0 exponent of  $(i*\sqrt{k1^2 + k2^2})^{\text{power}}$   
=0 ==> phase shift only  
>0 ==> differentiation  
<0 ==> integration  
sign=1 sign on transform exponent  
d1=1.0 x1 sampling interval  
d2=1.0 x2 sampling interval  
phasefac=0 phase shift by  $\text{phase}=\text{phasefac}*\text{PI}$ 
```

Notes:

The relation:  $w = 2 \pi F$  is well known for frequency, but there doesn't seem to be a commonly used letter corresponding to F for the spatial conjugate transform variables. We use K1 and K2 for this.

More specifically we assume a phase:

$-i(k1 x1 + k2 x2) = -2 \pi i(K1 x1 + K2 x2)$ .

and K1, K2 define our respective wavenumbers.

Algorithm:

```
 $g(x1,x2)=\text{Re}[2\text{DINVERSEFFT}\{ ( (\text{sign}) i |k|)^{\text{power}} 2\text{DFFT}(f)\}e^{i(\text{phase})}]$ 
```

Caveat:

Large amplitude errors will result if the data set has too few points.

Examples:

Edge sharpening:

Laplacian :

```
sukfrac < image_data power=2 phasefac=-1 | ...
```

Image enhancement:

Derivative filter:

```
sukfrac < image_data power=1 phasefac=-.5 | ...
```

Image enhancement:

Half derivative (this one is the best for photographs):

```
sukfrac < image_data power=.5 phasefac=-.25 | ...
```

Credits:

CWP: John Stockwell, June 1997, based on sufrac.

Trace header fields accessed: ns, d1, d2

SUKILL - zero out traces

```
sukill <stdin >stdout min= count=1
```

Required parameters

min= first trace to kill (one-based)

Optional parameters

count= 1 number of traces to kill

Credits:

CWP: Chris Liner, Jack K. Cohen

Trace header fields accessed: ns

SUKTMIG2D - prestack time migration of a common-offset section with the double-square root (DSR) operator

```
suktmig2d < infile vfile= [parameters] > outfile
```

Required Parameters:

vfile= rms velocity file (units/s)  $v(t,x)$  as a function of time  
dx= distance (units) between consecutive traces

Optional parameters:

fcdpdata=tr.cdp first cdp in data  
firstcdp=fcdpdata first cdp number in velocity file  
lastcdp=from header last cdp number in velocity file  
dcdp=from header number of cdps between consecutive traces  
angmax=40 maximum aperture angle for migration (degrees)  
hoffset=.5\*tr.offset half offset (m)  
nfc=16 number of Fourier-coefficients to approximate low-pass filters. The larger nfc the narrower the filter  
fwidth=5 high-end frequency increment for the low-pass filters in Hz. The lower this number the more the number of lowpass filters to be calculated for each input trace.

Notes:

Data must be preprocessed with sufrac to correct for the wave-shaping factor using phasefac=.25 for 2D migration.

Input traces must be sorted into offset and cdp number. The velocity file consists of rms velocities for all CMPs as a function of vertical time and horizontal position  $v(t,z)$  in C-style binary floating point numbers. It's easiest to supply  $v(t,z)$  that has the same dimensions as the input data to be migrated.

The units may be feet or meters, as long as these are consistent for Antialias filter is performed using (Gray,1992, Geoph. Prosp), using nc low- pass filtered copies of the data. The cutoff frequencies are calculated as fractions of the Nyquist frequency.

The maximum allowed angle is 80 degrees(a 10 degree taper is applied to the end of the aperture)

```
define LOOKFAC 2          /* Look ahead factor for npfaro  
define PFA_MAX 720720    /* Largest allowed nfft
```

```

    Prototype of functions used internally
void lpfilt(int nfc, int nfft, float dt, float fhi, float *filter);

segy intrace; /* input traces
segy outrace; /* migrated output traces

int
main(int argc, char **argv)
{
int i,k,imp,iip,it,ix,ifc; /* counters
int ntr,nt; /* x,t

int verbose; /* is verbose? */
int nc; /* number of low-pass filtered versions */
/* of the data for antialiasing */
int nfft,nf; /* number of frequencies */
int nfc; /* number of Fourier coefficients for low-pass filter
int fwidth; /* high-end frequency increment for the low-pass
/* filters */
int firstcdp=0; /* first cdp in velocity file */
int lastcdp=0; /* last cdp in velocity file */
int oldcdp=0; /* temporary storage */
int fcdpdata=0; /* first cdp in the data */
int olddeltacdp=0;
int deltacdp;
int ncdp=0; /* number of cdps in the velocity file */
int dcdp=0; /* number of cdps between consecutive traces

float dx=0.0; /* cdp sample interval
float hoffset=0.0; /* half receiver-source
float p=0.0; /* horizontal slowness of the migration operator
float pmin=0.0; /* maximum horizontal slowness for which there's
/* no aliasing of the operator
float dt; /* t sample interval
float h; /* offset
float x; /* aperture distance
float xmax=0.0; /* maximum aperture distance

float obliq; /* obliquity factor
float geoms; /* geometrical spreading factor
float angmax; /* maximum aperture angle

```

```

float mp,ip; /* mid-point and image-point coordinates
float t; /* time
float t0; /* vertical travelttime
float tmax; /* maximum time

float fnyq; /* Nyquist frequency
float ang; /* aperture angle
float angtaper=0.0; /* aperture-angle taper
float v; /* velocity

float *fc=NULL; /* cut-frequencies for low-pass filters
float *filter=NULL; /* array of low-pass filter values

float **vel=NULL; /* array of velocity values from vfile
float **data=NULL; /* input data array*/
float **lowpass=NULL; /* low-pass filtered version of the trace
float **mig=NULL; /* output migrated data array

register float *rtin=NULL,*rtout=NULL; /* real traces
register complex *ct=NULL; /* complex trace

/* file names
char *vfile=""; /* name of velocity file
FILE *vfp=NULL;
FILE *tracefp=NULL; /* temp file to hold traces*/
FILE *hfp=NULL; /* temp file to hold trace headers

float datalo[8], datahi[8];
int itb, ite;
float firstt, amplo, amphi;

cwp_Bool check_cdp=cwp_false; /* check cdp in velocity file */

/* Hook up getpar to handle the parameters
initargs(argc,argv);
requestdoc(0);

/* Get info from first trace
if (!gettr(&intrace)) err("can't get first trace");
nt=intrace.ns;
dt=(float)intrace.dt/1000000;
tmax=(nt-1)*dt;

```

```

MUSTGETPARFLOAT("dx",&dx);
MUSTGETPARSTRING("vfile",&vfile);
if (!getparfloat("angmax",&angmax)) angmax=40;
if (!getparint("firstcdp",&firstcdp)) firstcdp=intrace.cdp;
if (!getparint("fcdpdata",&fcdpdata)) fcdpdata=intrace.cdp;
if (!getparfloat("hoffset",&hoffset)) hoffset=.5*intrace.offset;
if (!getparint("nfc",&nfc)) nfc=16;
if (!getparint("fwidth",&fwidth)) fwidth=5;
if (!getparint("verbose",&verbose)) verbose=0;

h=hoffset;

/* Store traces in tmpfile while getting a count of number of traces
tracefp = etmpfile();
hfp = etmpfile();
ntr = 0;
do {
++ntr;

/* get new deltacdp value
deltacdp=intrace.cdp-oldcdp;

/* read headers and data
efwrite(&intrace,HDRBYTES, 1, hfp);
efwrite(intrace.data, FSIZE, nt, tracefp);

/* error trappings.
/* ...did cdp value interval change?
if ((ntr>3) && (olddeltacdp!=deltacdp)) {

if (verbose) {
warn("cdp interval changed in data");
warn("ntr=%d olddeltacdp=%d deltacdp=%d"
,ntr,olddeltacdp,deltacdp);
    check_cdp=cwp_true;
}
}

/* save cdp and deltacdp values
oldcdp=intrace.cdp;
olddeltacdp=deltacdp;

} while (gettr(&intrace));

```

```

/* get last cdp and dcdp
if (!getparint("lastcdp",&lastcdp)) lastcdp=intrace.cdp;
if (!getparint("dcdp",&dcdp)) dcdp=deltacd - 1;

/* error trappings
if ( (firstcdp==lastcdp)
|| (dcdp==0)
|| (check_cdp==cwp_true) ) warn("Check cdp values in data!");

/* rewind trace file pointer and header file pointer
erewind(tracefp);
erewind(hfp);

/* total number of cdp's in data
ncdp=lastcdp-firstcdp+1;

/* Set up FFT parameters
nfft = npfaro(nt, LOOKFAC*nt);
if(nfft>= SU_NFLTS || nfft >= PFA_MAX)
    err("Padded nt=%d -- too big",nfft);
nf = nfft/2 + 1;

/* Determine number of filters for antialiasing
fnyq= 1.0/(2*dt);
nc=ceil(fnyq/fwidth);
if (verbose)
warn(" The number of filters for antialiasing is nc= %d",nc);

/* Allocate space
data = alloc2float(nt,ntr);
lowpass=alloc2float(nt,nc+1);
mig=    alloc2float(nt,ntr);
vel=    alloc2float(nt,ncdp);
fc = alloc1float(nc+1);
rtin= ealloc1float(nfft);
rtout= ealloc1float(nfft);
ct= ealloc1complex(nf);
filter= alloc1float(nf);

/* Read data from temporal array
for (ix=0; ix<ntr; ++ix){

```

```

efread(data[ix],FSIZE,nt,tracefp);
}

/* read velocities
vfp=efopen(vfile,"r");
efread(vel[0],FSIZE,nt*ncdp,vfp);
efclose(vfp);

/* Zero all arrays
memset((void *) mig[0], 0,nt*ntr*FSIZE);
memset((void *) rtin, 0, nfft*FSIZE);
memset((void *) filter, 0, nf*FSIZE);
memset((void *) lowpass[0], 0,nt*(nc+1)*FSIZE);

/* Calculate cut frequencies for low-pass filters
for(i=1; i<nc+1; ++i){
fc[i]= fnyq*i/nc;
}

/* Start the migration process
/* Loop over input mid-points first
if (verbose) warn("Starting migration process...\n");
for(imp=0; imp<ntr; ++imp){
float perc;

mp=imp*dx;
perc=imp*100.0/(ntr-1);
if(fmod(imp*100,ntr-1)==0 && verbose)
warn("migrated %g\n ",perc);

/* Calculate low-pass filtered versions
/* of the data to be used for antialiasing
for(it=0; it<nt; ++it){
rtin[it]=data[imp][it];
}
for(ifc=1; ifc<nc+1; ++ifc){
memset((void *) rtout, 0, nfft*FSIZE);
memset((void *) ct, 0, nf*FSIZE);
lpfilt(nfc,nfft,dt,fc[ifc],filter);
pfarc(1,nfft,rtin,ct);

for(it=0; it<nf; ++it){
ct[it] = crmul(ct[it],filter[it]);

```

```

}
pfacr(-1,nfft,ct,rtout);
for(it=0; it<nt; ++it){
lowpass[ifc][it]= rtout[it];
}
}

/* Loop over vertical traveltimes
for(it=0; it<nt; ++it){
int lx,ux;

t0=it*dt;
v=vel[imp*dcdp+fcdpdata-1][it];
xmax=tan((angmax+10.0)*PI/180.0)*v*t0;
lx=MAX(0,imp - ceil(xmax/dx));
ux=MIN(ntr,imp + ceil(xmax/dx));

/* loop over output image-points to the left of the midpoint
for(iip=imp; iip>lx; --iip){
float ts,tr;
int fplo=0, fphi=0;
float ref,wlo,whi;

ip=iip*dx;
x=ip-mp;
ts=sqrt( pow(t0/2,2) + pow((x+h)/v,2) );
tr=sqrt( pow(t0/2,2) + pow((h-x)/v,2) );
t= ts + tr;
if(t>=tmax) break;
geoms=sqrt(1/(t*v));
  obliq=sqrt(.5*(1 + (t0*t0/(4*ts*tr))
- (1/(ts*tr))*sqrt(ts*ts - t0*t0/4)*sqrt(tr*tr - t0*t0/4)));
  ang=180.0*fabs(acos(t0/t))/PI;
  if(ang<=angmax) angtaper=1.0;
  if(ang>angmax) angtaper=cos((ang-angmax)*PI/20);
  /* Evaluate migration operator slowness p to determine
/* the low-pass filtered trace for antialiasing
pmin=1/(2*dx*fnyq);
p=fabs((x+h)/(pow(v,2)*ts) + (x-h)/(pow(v,2)*tr));
if(p>0){fplo=floor(nc*pmin/p);}
if(p==0){fplo=nc;}
ref=fmod(nc*pmin,p);
wlo=1-ref;

```

```

fphi=++fplo;
whi=ref;
itb=MAX(ceil(t/dt)-3,0);
ite=MIN(itb+8,nt);
firstt=(itb-1)*dt;
/* Move energy from CMP to CIP
if(fplo>=nc){
for(k=itb; k<ite; ++k){
datalo[k-itb]=lowpass[nc][k];
}
ints8r(8,dt,firstt,datalo,0.0,0.0,1,&t,&amplo);
mig[iip][it] +=geoms*obliq*angtaper*amplo;
} else if(fplo<nc){
for(k=itb; k<ite; ++k){
datalo[k-itb]=lowpass[fplo][k];
datahi[k-itb]=lowpass[fphi][k];
}
ints8r(8,dt,firstt,datalo,0.0,0.0,1,&t,&amplo);
ints8r(8,dt,firstt,datahi,0.0,0.0,1,&t,&amphi);
mig[iip][it] += geoms*obliq*angtaper*(wlo*amplo + whi*amphi);
}
}

/* loop over output image-points to the right of the midpoint
for(iip=imp+1; iip<ux; ++iip){
float ts,tr;
int fplo=0, fphi;
float ref,wlo,whi;

ip=iip*dx;
x=ip-mp;
t0=it*dt;
ts=sqrt( pow(t0/2,2) + pow((x+h)/v,2) );
tr=sqrt( pow(t0/2,2) + pow((h-x)/v,2) );
t= ts + tr;
if(t>=tmax) break;
geoms=sqrt(1/(t*v));
obliq=sqrt(.5*(1 + (t0*t0/(4*ts*tr))
- (1/(ts*tr))*sqrt(ts*ts
- t0*t0/4)*sqrt(tr*tr
- t0*t0/4)));
ang=180.0*fabs(acos(t0/t))/PI;
if(ang<=angmax) angtaper=1.0;

```

```

if(ang>angmax) angtaper=cos((ang-angmax)*PI/20.0);

/* Evaluate migration operator slowness p to determine the
/* low-pass filtered trace for antialiasing
pmin=1/(2*dx*fnyq);
p=fabs((x+h)/(pow(v,2)*ts) + (x-h)/(pow(v,2)*tr));
if(p>0){
fplo=floor(nc*pmin/p);
}
if(p==0){
fplo=nc;
}

ref=fmod(nc*pmin,p);
wlo=1-ref;
fphi=fplo+1;
whi=ref;
itb=MAX(ceil(t/dt)-3,0);
ite=MIN(itb+8,nt);
firstt=(itb-1)*dt;

/* Move energy from CMP to CIP
if(fplo>=nc){
for(k=itb; k<ite; ++k){
datalo[k-itb]=lowpass[nc][k];
}
ints8r(8,dt,firstt,datalo,0.0,0.0,1,&t,&amplo);
mig[iip][it] +=geoms*obliq*angtaper*amplo;
} else if(fplo<nc){
for(k=itb; k<ite; ++k){
datalo[k-itb]=lowpass[fplo][k];
datahi[k-itb]=lowpass[fphi][k];
}
ints8r(8,dt,firstt,datalo,0.0,0.0,1,&t,&amplo);
ints8r(8,dt,firstt,datahi,0.0,0.0,1,&t,&amphi);
mig[iip][it] += geoms*obliq*angtaper*(wlo*amplo + whi*amphi);
}
}

/* Output migrated data

```

```

erewind(hfp);
for (ix=0; ix<ntr; ++ix) {
efread(&outtrace, HDRBYTES, 1, hfp);
for (it=0; it<nt; ++it) {
outtrace.data[it] = mig[ix][it];
}
puttr(&outtrace);
}

efclose(hfp);

return(CWP_Exit());
}

void
lpfilt(int nfc, int nfft, float dt, float fhi, float *filter)
lpfilt -- low-pass filter using Lanczos Smoothing
(R.W. Hamming:"Digital Filtering",1977)
Input:
nfc number of Fourier coefficients to approximate ideal filter
nfft number of points in the fft
dt time sampling interval
fhi cut-frequency

Output:
filter array[nf] of filter values
Notes: Filter is to be applied in the frequency domain
Author: CWP: Carlos Pacheco 2006
{
int i,j; /* counters
int nf; /* Number of frequencies (including Nyquist)
float onfft; /* reciprocal of nfft
float fn; /* Nyquist frequency
float df; /* frequency interval
float dw; /* frequency interval in radians
float whi; /* cut-frequency in radians
float w; /* radian frequency

nf= nfft/2 + 1;
onfft=1.0/nfft;
fn=1.0/(2*dt);
df=onfft/dt;
whi=fhi*PI/fn;

```

```
dw=df*PI/fn;

for(i=0; i<nf; ++i){
filter[i]= whi/PI;
w=i*dw;

for(j=1; j<nfc; ++j){
float c= sin(whi*j)*sin(PI*j/nfc)*2*nfc/(PI*PI*j*j);
filter[i] +=c*cos(j*w);
}
}
}
```

SULOG -- time axis log-stretch of seismic traces

sulog [optional parameters] <stdin >stdout

Required parameters:

none

Optional parameters:

ntmin= .1\*nt minimum time sample of interest  
outpar=/dev/tty output parameter file, contains:  
number of samples (nt=)  
minimum time sample (ntmin=)  
output number of samples (ntau=)  
m=3 length of stretched data  
is set according to  
ntau = nextpow(m\*nt)  
ntau= pow of 2 override for length of stretched  
data (useful for padding zeros  
to avoid aliasing)

NOTES:

ntmin is required to avoid taking log of zero and to  
keep number of outsamples (ntau) from becoming enormous.

Data above ntmin is zeroed out.

The output parameters will be needed by suilog to  
reconstruct the original data.

EXAMPLE PROCESSING SEQUENCE:

sulog outpar=logpar <data1 >data2  
suilog par=logpar <data2 >data3

Credits:

CWP: Shuki, Chris

Caveats:

Amplitudes are not well preserved.

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt

```
char *sdoc[] = {
```

```
SUMAX - get trace by trace local/global maxima, minima, or absolute maximum
```

```
sumax <stdin >stdout [optional parameters]
```

```
Required parameters:
```

```
none
```

```
Optional parameters:
```

```
output=ascii write ascii data to outpar
```

```
=binary for binary floats to stdout
```

```
=segy for SEGY traces to stdout
```

```
mode=maxmin output both minima and maxima
```

```
=max maxima only
```

```
=min minima only
```

```
=abs absolute maxima only
```

```
=rms RMS
```

```
=thd search first max above threshold
```

```
threshamp=0 threshold amplitude value
```

```
threshtime=0 tmin to start search for threshold
```

```
verbose=0 writes global quantities to outpar
```

```
=1 trace number, values, sample location
```

```
=2 key1 & key2 instead of trace number
```

```
key1=fldr key for verbose=2
```

```
key2=ep key for verbose=2
```

```
outpar=/dev/tty output parameter file; contains output
```

```
from verbose
```

```
Examples:
```

```
For global max and min values: sumax < segy_data
```

```
For local and global max and min values: sumax < segy_data verbose=1
```

```
To plot values specified by mode:
```

```
sumax < segy_data output=binary mode=modeval | xgraph n=npairs
```

```
To plot seismic data with the only values nonzero being those specified
```

```
by mode=modeval:
```

```
sumax < segy_data output=segy mode=modeval | suxwigb
```

```
Note: while traces are counted from 1, sample values are counted from 0.
```

Also, if multiple min, max, or abs max values exist on a trace,  
only the first one is captured.

See also: suxmax, supsmx

Credits:

CWP : John Stockwell (total rewrite)

Geocon : Garry Perratt (all ASCII output changed from %e to %e)  
(added mode=rms).

ESCI: Reginald Beardsley (added header key option)

based on an original program by:

SEP: Shuki Ronen

CWP: Jack K. Cohen

IFM-GEOMAR: Gerald Klein (added threshold option)

Trace header fields accessed: ns dt & user specified keys

SUMEAN - get the mean values of data traces ",

sumean < stdin > stdout [optional parameters]

Required parameters:

power = 2.0 mean to the power

(e.g. = 1.0 mean amplitude, = 2.0 mean energy)

Optional parameters:

verbose = 0 writes mean value of section to outpar

= 1 writes mean value of each trace / section to

outpar

outpar=/dev/tty output parameter file

abs = 1 average absolute value

= 0 preserve sign if power=1.0

Notes:

Each sample is raised to the requested power, and the sum of all those values is averaged for each trace (verbose=1) and the section.

The values power=1.0 and power=2.0 are physical, however other powers represent other mathematical L-p norms and may be of use, as well.

Credits:

Bjoern E. Rommel, IKU, Petroleumsforskning / October 1997

bjorn.rommel@iku.sintef.no

SUMEDIAN - MEDIAN filter about a user-defined polygonal curve with the distance along the curve specified by key header word

sumedian <stdin >stdout xshift= tshift= [optional parameters]

Required parameters:

xshift= array of position values as specified by the 'key' parameter  
tshift= array of corresponding time values (sec)  
... or input via files:  
nshift= number of x,t values defining median times  
xfile= file containing position values as specified by the 'key' parameter  
tfile= file containing corresponding time values (sec)

Optional parameters:

key=tracl Key header word specifying trace number  
=offset use trace offset instead  
  
mix=.6,1,1,1,.6 array of weights for mix (weighted moving average)  
median=0 =0 for mix  
=1 for median filter  
nmed=5 odd no. of traces to median filter  
sign=-1 =-1 for upward shift  
=+1 for downward shift  
subtract=1 =1 subtract filtered data from input  
=0 don't subtract  
verbose=0 =1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes:

-----

Median filtering is a process for suppressing a particular moveout on seismic sections. Its advantage over traditional dip filtering is that events with arbitrary moveout may be suppressed. Median filtering is commonly used in up/down wavefield separation of VSP data.

The process generally consists of 3 steps:

1. A copy of the data panel is shifted such that the polygon in x,t

specifying moveout is flattened to horizontal. The x,t pairs are specified either by the vector xshift,tshift or by the values in the datafiles xfile,tfile. For fractional shift, the shifted data is interpolated.

2. Then a mix (weighted moving average) is performed over the shifted panel to emphasize events with the specified moveout and suppress events with other moveouts.
3. The panel is then shifted back (and interpolated) to its original moveout, and subtracted from the original data. Thus all events with the user-specified moveout are removed.

For VSP data the following modifications are provided:

1. The moveout polygon in x,t is usually the first break times for each trace. The parameter sign allows for downward shift in order align upgoing events.
2. Alternative to a mix, a median filter can be applied by setting the parameter median=1 and nmed= to the number of traces filtered.
3. By setting subtract=0 the filtered panel is only shifted back but not subtracted from the original data.

The values of tshift are linearly interpolated for traces falling between given xshift values. The tshift interpolant is extrapolated to the left by the smallest time sample on the trace and to the right by the last value given in the tshift array.

The files tfile and xfile are files of binary (C-style) floats.

The number of values defined by mix=val1,val2,... determines the number of traces to be averaged, the values determine the weights.

Caveat:

The median filter may perform poorly on the edges of a section. Choosing larger beginning and ending mix values may help, but may also introduce additional artifacts.

Examples:

Credits:

CWP: John Stockwell, based in part on sumute, sureduce, sumix  
CENPET: Werner M. Heigl - fixed various errors, added VSP functionality

ideas for improvement:

- \* a versatile median filter needs to do:
  - shift traces by fractional amounts -> needs sinc interpolation
  - positive and negative shifts similar to SUSTATIC
  - make subtraction of filtered events a user choice
  - provide a median stack as well as a weighted average stack

Trace header fields accessed: ns, dt, delrt, key=keyword

SUMIGFD - 45-90 degree Finite difference depth migration for zero-offset data.

```
sumigfd <infile >outfile vfile= [optional parameters]
```

Required Parameters:

nz= number of depth samples

dz= depth sampling interval

vfile= name of file containing velocities

(see Notes below concerning format of this file)

Optional Parameters:

dt=from header(dt) or .004 time sampling interval

dx=from header(dx) or 1.0 midpoint sampling interval

dip=45,65,79,80,87,89,90 Maximum angle of dip reflector

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes: ",

The computation cost by dip angle is 45=65=79<80<87<89<90

The input velocity file \'vfile\' consists of C-style binary floats. ",  
The structure of this file is vfile[iz][ix]. Note that this means that  
the x-direction is the fastest direction instead of z-direction! Such a  
structure is more convenient for the downward continuation type  
migration algorithm than using z as fastest dimension as in other SU  
programs. (In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]  
denotes a v(z,x) array, the opposite of what Matlab and Fortran  
programmers may expect.) ",

Because most of the tools in the SU package (such as unif2, unisam2,  
and makevel) produce output with the structure vfile[ix][iz], you will  
need to transpose the velocity files created by these programs. You may  
use the SU program \'transp\' in SU to transpose such files into the  
required vfile[iz][ix] structure.

Credits: CWP Baoniu Han, April 20th, 1998

Trace header fields accessed: ns, dt, delrt, d2  
Trace header fields modified: ns, dt, delrt

SUMIGFFD - Fourier finite difference depth migration for zero-offset data. This method is a hybrid migration which combines the advantages of phase shift and finite difference", migrations.

```
sumigffd <infile >outfile vfile= [optional parameters]
```

Required Parameters:

```
nz=    number of depth samples    ",  
dz=    depth sampling interval  
vfile= name of file containing velocities
```

Optional Parameters:

```
dt=from header(dt) or .004    time sampling interval  
dx=from header(d2) or 1.0    midpoint sampling interval  
ft=0.0 first time sample  
fz=0.0 first depth sample
```

tmpdir= if non-empty, use the value as a directory path prefix for storing temporary files; else if the the CWP\_TMPDIR environment variable is set use its value for the path; else use tmpfile()

The input velocity file \'vfile\' consists of C-style binary floats. ",  
The structure of this file is vfile[iz][ix]. Note that this means that the x-direction is the fastest direction instead of z-direction! Such a structure is more convenient for the downward continuation type migration algorithm than using z as fastest dimension as in other SU ",  
programs. (In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz] denotes a v(z,x) array, the opposite of what Matlab and Fortran programmers may expect.) ",

Because most of the tools in the SU package (such as unif2, unisam2, ",  
and makevel) produce output with the structure vfile[ix][iz], you will need to transpose the velocity files created by these programs. You may use the SU program \'transp\' in SU to transpose such files into the required vfile[iz][ix] structure.

Credits: CWP Baoniu Han, July 21th, 1997

Trace header fields accessed: ns, dt, delrt, d2  
Trace header fields modified: ns, dt, delrt

SUMIGGBZOAN - MIGration via Gaussian beams ANisotropic media (P-wave)

sumiggbzoan <infile >outfile vfile= nt= nx= nz= [optional parameters]

Required Parameters:

a3333file= name of file containing a3333(x,z)  
nx= number of inline samples (traces)  
nz= number of depth samples

Optional Parameters:

dt=tr.dt time sampling interval  
dx=tr.d2 inline sampling interval (trace spacing)  
dz=1.0 depth sampling interval  
fmin=0.025/dt minimum frequency  
fmax=10\*fmin maximum frequency  
amin=-amax minimum emergence angle; must be > -90 degrees  
amax=60 maximum emergence angle; must be < 90 degrees  
bwh=0.5\*vavg/fmin beam half-width; vavg denotes average velocity  
verbose=0 silent, =1 chatty

Files for general anisotropic parameters confined to a vertical plane:

a1111file= name of file containing a1111(x,z)  
a1133file= name of file containing a1133(x,z)  
a1313file= name of file containing a1313(x,z)  
a1113file= name of file containing a1113(x,z)  
a3313file= name of file containing a3313(x,z)

For transversely isotropic media Thomsen's parameters could be used:

deltafile= name of file containing delta(x,z)  
epsilonfile= name of file containing epsilon(x,z)  
a1313file= name of file containing a1313(x,z)

if anisotropy parameters are not given the program considers "  
the medium to be isotropic.

Credits:

CWP: Tariq Alkhalifah, based on MIGGBZO by Dave Hale  
CWP: repackaged as an SU program by John Stockwell, April 2006

Technical Reference:

Alkhailfah, T., 1993, Gaussian beam migration for

anisotropic media: submitted to Geophysics.

Cerveny, V., 1972, Seismic rays and ray intensities  
in inhomogeneous anisotropic media:  
Geophys. J. R. Astr. Soc., 29, 1--13.

Hale, D., 1992, Migration by the Kirchhoff,  
slant stack, and Gaussian beam methods:  
CWP,1992 Report 121, Colorado School of Mines.

Hale, D., 1992, Computational Aspects of Gaussian  
Beam migration:  
CWP,1992 Report 121, Colorado School of Mines.

SUMIGGBZO - MIGration via Gaussian Beams of Zero-Offset SU data

sumiggbzo <infile >outfile vfile= nz= [optional parameters]

Required Parameters:

vfile= name of file containing v(z,x)

nz= number of depth samples

Optional Parameters:

dt=from header time sampling interval

dx=from header(d2) or 1.0 spatial sampling interval

dz=1.0 depth sampling interval

fmin=0.025/dt minimum frequency

fmax=10\*fmin maximum frequency

amin=-amax minimum emergence angle; must be > -90 degrees

amax=60 maximum emergence angle; must be < 90 degrees

bwh=0.5\*vavg/fmin beam half-width; vavg denotes average velocity

verbose=0 =0 silent; =1 chatty

Note: spatial units of v(z,x) must be the same as those on dx.

v(z,x) is represented numerically in C-style binary floats v[x][z],

where the depth direction is the fast direction in the data. Such

models can be created with unif2 or makevel.

(In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]

denotes a v(z,x) array, the opposite of what Matlab and Fortran

programmers may expect.) ",

Credits:

CWP: Dave Hale (algorithm), Jack K. Cohen, and John Stockwell

(reformatting for SU)

SUMIGPREFD --- The 2-D prestack common-shot 45-90 degree finite-difference depth migration.

```
sumigprefd <indata >outfile [parameters] ",
```

Required Parameters: ",

nxo= number of total horizontal output samples

nxshot= number of shot gathers to be migrated

nz= number of depth samples

dx= horizontal sampling interval ",

dz= depth sampling interval

vfile= velocity profile, it must be binary format (see Notes)

Optional Parameters:

dip=79 the maximum dip to migrate, possible values are:

45,65,79,80,87,89,90 degrees

The computation cost is 45=65=79<80<87<89<90

fmax=25 peak frequency of Ricker wavelet used as source wavelet

f1=5,f2=10,f3=40,f4=50 frequencies to build a Hamming window

lpad=9999, rpad=9999 number of zero traces padded on both

sides of depth section to determine the

migration aperture, the default values

are using the full aperture.

verbose=0 silent, =1 additional runtime information

Notes:

The input velocity file \'vfile\' consists of C-style binary floats.

The structure of this file is vfile[iz][ix]. Note that this means that the x-direction is the fastest direction instead of z-direction! Such a structure is more convenient for the downward continuation type migration algorithm than using z as fastest dimension as in other SU programs.

Because most of the tools in the SU package (such as unif2, unisam2, ", and makevel) produce output with the structure vfile[ix][iz], you will need to transpose the velocity files created by these programs. You may use the SU program \'transp\' in SU to transpose such files into the required vfile[iz][ix] structure.

(In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]

denotes a v(z,x) array, the opposite of what Matlab and Fortran programmers may expect.) ",

Also, sx must be monotonically increasing throughout the dataset, and gx must be monotonically increasing within a shot. You may resort your data with `\susort\`, accordingly.

The scalco header field is honored so this field must be set correctly. See selfdocs of `\susort\`, `\suchw\`. Also: `sukeyword scalco`

Credits: CWP, Baoniu Han, bhan@dix.mines.edu, April 19th, 1998  
Modified: Chris Stolk, 11 Dec 2005, - changed data input  
to remove erroneous time delay.  
Modified: CWP, John Stockwell 26 Sept 2006 - replaced Han's  
"goto-loop" in two places with "do { }while loops".  
Fixed it so that sx, gx, and scalco are honored.

Trace header fields accessed: ns, dt, delrt, d2, sx, gx,  
Trace header fields modified: ns, dt, delrt

SUMIGPREFFD - The 2-D prestack common-shot Fourier finite-difference depth migration.

```
sumigpreffd <indata >outfile [parameters] ",
```

Required Parameters: ",

nxo= number of total horizontal output samples

nxshot= number of shot gathers to be migrated

nz= number of depth samples

dx= horizontal sampling interval

dz= depth sampling interval

vfile= velocity profile, it must be binary format.

Optional Parameters:

fmax=25 the peak frequency of Ricker wavelet used as source wavelet

f1=5,f2=10,f3=40,f4=50 frequencies to build a Hamming window

lpad=9999, rpad=9999 number of zero traces padded on both sides of depth section to determine the migration aperture, the default

values are using the full aperture.

verbose=0 silent, =1 additional runtime information

Notes:

The input velocity file consists of C-style binary floats. ",

The structure of this file is vfile[iz][ix]. Note that this means that the x-direction is the fastest direction instead of z-direction! Such a structure is more convenient for the downward continuation type migration algorithm than using z as fastest dimension as in other SU ", programs.

Because most of the tools in the SU package (such as unif2, unisam2, ", and makevel) produce output with the structure vfile[ix][iz], you will need to transpose the velocity files created by these programs. You may use the SU program \'transp\' in SU to transpose such files into the required vfile[iz][ix] structure.

(In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]

denotes a v(z,x) array, the opposite of what Matlab and Fortran programmers may expect.) ",

Also, sx must be monotonically increasing throughout the dataset, and gx must be monotonically increasing within a shot. You may resort your data with \'susort\' , accordingly.

The scalco header field is honored so this field must be set correctly.  
See selfdocs of \'susort\', \'suchw\'. Also: sukeyword scalco

Credits: CWP, Baoniu Han, bhan@dix.mines.edu, April 19th, 1998

Modified: Chris Stolk, 11 Dec 2005, - changed data input  
to remove erroneous time delay.

Modified: CWP, John Stockwell 26 Sept 2006 - replaced Han's  
"goto-loop" with "do { }while loops".

Fixed it so that sx, gx, and scalco are honored.

Trace header fields accessed: ns, dt, delrt, d2

Trace header fields modified: ns, dt, delrt

SUMIGPREPSPI --- The 2-D PREstack commom-shot Phase-Shift-Plus interpolation depth MIGration.

```
sumigprepspi <indata >outfile [parameters] ",
```

Required Parameters:

nxo= number of total horizontal output samples  
nxshot= number of shot gathers to be migrated  
nz= number of depth sapmls  
dx= horizontal sampling interval ",  
dz= depth sampling interval  
vfile= velocity profile, it must be binary format.

Optional Parameters:

fmax=25 the peak frequency of Ricker wavelet used as source wavelet  
f1=5,f2=10,f3=40,f4=50 frequencies to build a Hamming window  
lpad=9999,ypad=9999 number of zero traces padded on both  
sides of depth section to determine the  
migration aperature, the default values  
are using the full aperature.  
verbose=0 silent, =1 additional runtime information

Notes:

The input velocity file `\`vfile\`` consists of C-style binary floats. ",  
The structure of this file is `vfile[iz][ix]`. Note that this means that  
the x-direction is the fastest direction instead of z-direction! Such a  
structure is more convenient for the downward continuation type  
migration algorithm than using z as fastest dimension as in other SU ",  
programs.

Because most of the tools in the SU package (such as `unif2`, `unisam2`, ",  
and `makevel`) produce output with the structure `vfile[ix][iz]`, you will  
need to transpose the velocity files created by these programs. You may  
use the SU program `\`transp\`` in SU to transpose such files into the  
required `vfile[iz][ix]` structure.

(In C `v[iz][ix]` denotes a  $v(x,z)$  array, whereas `v[ix][iz]`  
denotes a  $v(z,x)$  array, the opposite of what Matlab and Fortran  
programmers may expect.) ",

Also, `sx` must be monotonically increasing throughout the dataset, and  
and `gx` must be monotonically increasing within a shot. You may resort

your data with `\susort\`, accordingly.

The scalco header field is honored so this field must be set correctly.  
See selfdocs of `\susort\`, `\suchw\`. Also: `sukeyword scalco`

Credits: CWP, Baoniu Han, bhan@dix.mines.edu, April 19th, 1998

Modified: Chris Stolk, 11 Dec 2005, - changed data input  
to remove erroneous time delay.

Modified: CWP, John Stockwell 26 Sept 2006 - replaced Han's  
"goto-loop" in two places with "do { }while loops".

Fixed it so that `sx`, `gx`, and `scalco` are honored.

Trace header fields accessed: `ns`, `dt`, `delrt`, `d2`

Trace header fields modified: `ns`, `dt`, `delrt`

SUMIGPRESP - The 2-D prestack common-shot split-step Fourier ",  
migration

sumigpresp <indata >outfile [parameters] ",

Required Parameters:

nxo= number of total horizontal output samples  
nxshot= number of shot gathers to be migrated  
nz= number of depth samples  
dx= horizontal sampling interval  
dz= depth sampling interval  
vfile= velocity profile, it must be binary format.

Optional Parameters:

fmax=25 The peak frequency of Ricker wavelet used as source wavelet  
f1=5,f2=10,f3=40,f4=50 frequencies to build a Hamming window  
lpad=9999, rpad=9999 number of zero traces padded on both  
sides of depth section to determine the  
migration aperture, the default values  
are using the full aperture.  
verbose=0 silent, =1 additional runtime information

Notes:

The input velocity file consists of C-style binary floats.  
The structure of this file is vfile[iz][ix]. Note that this means that  
the x-direction is the fastest direction instead of z-direction! Such a  
structure is more convenient for the downward continuation type  
migration algorithm than using z as fastest dimension as in other SU  
programs.

Because most of the tools in the SU package (such as unif2, unisam2, ",  
and makevel) produce output with the structure vfile[ix][iz], you will  
need to transpose the velocity files created by these programs. You may  
use the SU program \'transp\' in SU to transpose such files into the  
required vfile[iz][ix] structure.

(In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]  
denotes a v(z,x) array, the opposite of what Matlab and Fortran  
programmers may expect.) ",

Also, sx must be monotonically increasing throughout the dataset, and  
and gx must be monotonically increasing within a shot. You may resort  
your data with \'susort\' , accordingly.

The scalco header field is honored so this field must be set correctly.  
See selfdocs of \'susort\', \'suchw\'. Also: sukeyword scalco

Credits: CWP, Baoniu Han, bhan@dix.mines.edu, April 19th, 1998  
Modified: Chris Stolk, 11 Dec 2005, - changed data input  
to remove erroneous time delay.  
Modified: CWP, John Stockwell 26 Sept 2006 - replaced Han's  
"goto-loop" in two places with "do { }while loops".  
Fixed it so that sx, gx, and scalco are honored.

Trace header fields accessed: ns, dt, delrt, d2, sx, gx, scalco  
Trace header fields modified: ns, dt, delrt

SUMIGPSPI - Gazdag's phase-shift plus interpolation depth migration for zero-offset data, which can handle the lateral velocity variation.

sumigpspi <infile >outfile vfile= [optional parameters]

Required Parameters:

nz= number of depth samples

dz= depth sampling interval

vfile= name of file containing velocities

(Please see Notes below concerning the format of vfile)

Optional Parameters:

dt=from header(dt) or .004      time sampling interval

dx=from header(d2) or 1.0      midpoint sampling interval

tmpdir=            if non-empty, use the value as a directory path prefix for storing temporary files; else if the the CWP\_TMPDIR environment variable is set use its value for the path; else use tmpfile()

Notes:

The input velocity file \'vfile\' consists of C-style binary floats. The structure of this file is vfile[iz][ix]. Note that this means that the x-direction is the fastest direction instead of z-direction! Such a structure is more convenient for the downward continuation type migration algorithm than using z as fastest dimension as in other SU programs.

Because most of the tools in the SU package (such as unif2, unisam2, and makevel) produce output with the structure vfile[ix][iz], you will need to transpose the velocity files created by these programs. You may use the SU program \'transp\' in SU to transpose such files into the required vfile[iz][ix] structure.

Credits: CWP, Baoniu Han, April 20th, 1998

Trace header fields accessed: ns, dt, delrt, d2

Trace header fields modified: ns, dt, delrt

SUMIGPS - MIGration by Phase Shift with turning rays

sumigps <stdin >stdout [optional parms]

Required Parameters:

None

Optional Parameters:

dt=from header(dt) or .004 time sampling interval  
dx=from header(d2) or 1.0 distance between successive cdp's  
ffil=0,0,0.5/dt,0.5/dt trapezoidal window of frequencies to migrate  
tmig=0.0 times corresponding to interval velocities in vmig  
vmig=1500.0 interval velocities corresponding to times in tmig  
vfile= binary (non-ascii) file containing velocities v(t)  
nxpad=0 number of cdp's to pad with zeros before FFT  
ltaper=0 length of linear taper for left and right edges",  
verbose=0 =1 for diagnostic print

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes:

Input traces must be sorted by either increasing or decreasing cdp.

The tmig and vmig arrays specify an interval velocity function of time. Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in tmig must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If vfile is specified, then the tmig and vmig arrays are ignored.

The time of first sample is assumed to be zero, regardless of the value of the trace header field delrt.

Credits:

CWP: Dave Hale (originally called supsmig.c)

Trace header fields accessed: ns, dt, d2



SUMIGPSTI - MIGration by Phase Shift for TI media with turning rays

sumigpsti <stdin >stdout [optional parms]

Required Parameters:

None

Optional Parameters:

dt=from header(dt) or .004 time sampling interval  
dx=from header(d2) or 1.0 distance between successive cdp's  
ffil=0,0,0.5/dt,0.5/dt trapezoidal window of frequencies to migrate  
tmig=0.0 times corresponding to interval velocities in vmig  
vnmig=1500.0 interval NMO velocities corresponding to times in tmig  
vmig=1500.0 interval velocities corresponding to times in tmig  
etamig=0.0 interval eta values corresponding to times in tmig  
vnfile= binary (non-ascii) file containing NMO velocities vn(t)  
vfile= binary (non-ascii) file containing velocities v(t)  
etafile= binary (non-ascii) file containing eta values eta(t)  
nxpad=0 number of cdps to pad with zeros before FFT  
ltaper=0 length of linear taper for left and right edges "  
verbose=0 =1 for diagnostic print

Notes:

Input traces must be sorted by either increasing or decreasing cdp.

The tmig, vnmig, vmig and etamig arrays specify an interval values function of time. Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in tmig must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If vnfile is specified, then the tmig and vnmig arrays are ignored.

The time of first sample is assumed to be zero, regardless of the value of the trace header field delrt.

Trace header fields accessed: ns and dt

SUMIGSPLIT - Split-step depth migration for zero-offset data.

```
sumigsplit <infile >outfile vfile= [optional parameters]
```

Required Parameters:

```
nz=          number of depth samples
dz=          depth sampling interval
vfile=       name of file containing velocities
```

Optional Parameters:

```
dt=from header(dt) or .004  time sampling interval
dx=from header(d2) or 1.0    midpoint sampling interval
ft=0.0                    first time sample
fz=                        first depth sample
```

```
tmpdir=       if non-empty, use the value as a directory path
               prefix for storing temporary files; else if the
               the CWP_TMPDIR environment variable is set use
               its value for the path; else use tmpfile()
```

Notes:

The input velocity file `\'vfile\'` consists of C-style binary floats. The structure of this file is `vfile[iz][ix]`. Note that this means that the x-direction is the fastest direction instead of z-direction! Such a structure is more convenient for the downward continuation type migration algorithm than using z as fastest dimension as in other SU programs.

Because most of the tools in the SU package (such as `unif2`, `unisam2`, and `makevel`) produce output with the structure `vfile[ix][iz]`, you will need to transpose the velocity files created by these programs. You may use the SU program `\'transp\'` in SU to transpose such files into the required `vfile[iz][ix]` structure.

(In C `v[iz][ix]` denotes a `v(x,z)` array, whereas `v[ix][iz]` denotes a `v(z,x)` array, the opposite of what Matlab and Fortran programmers may expect.) "

Credits: CWP Baoniu Han, July 21th, 1997

Reference:

Stoffa, P. L. and Fokkema, J. T. and Freire, R. M. and Kessinger, W. P.,  
1990, Split-step Fourier migration, Geophysics, 55, 410-421.

Trace header fields accessed: ns, dt, delrt, d2

Trace header fields modified: ns, dt, delrt

SUMIGTK - MIGration via T-K domain method for common-midpoint stacked data

sumigtk <stdin >stdout dxcdp= [optional parms]

Required Parameters:

dxcdp                    distance between successive cdps

Optional Parameters:

fmax=Nyquist            maximum frequency  
tmig=0.0                times corresponding to interval velocities in vmig  
vmig=1500.0            interval velocities corresponding to times in tmig  
vfile=                 binary (non-ascii) file containing velocities v(t)  
nxpad=0                number of cdps to pad with zeros before FFT  
ltaper=0               length of linear taper for left and right edges",  
verbose=0              =1 for diagnostic print

tmpdir=    if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
          the CWP\_TMPDIR environment variable is set use  
          its value for the path; else use tmpfile()

Notes:

Input traces must be sorted by either increasing or decreasing cdp.

The tmig and vmig arrays specify an interval velocity function of time. Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in tmig must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If vfile is specified, then the tmig and vmig arrays are ignored.

The time of first sample is assumed to be zero, regardless of the value of the trace header field delrt.

The migration is a reverse time migration in the (t,k) domain. In the first step, the data  $g(t,x)$  are Fourier transformed  $x \rightarrow k$  into the ", the time-wavenumber domain  $g(t,k)$ .

Then looping over wavenumbers, the data are then reverse-time finite-difference migrated, wavenumber by wavenumber. The resulting migrated data  $m(\tau,k)$ , now in the  $\tau$  (migrated time) and  $k$  domain,

are inverse fourier transformed back into (tau,x) and written out.

Credits:

CWP: Dave Hale

Trace header fields accessed: ns and dt

SUMIGTOP02D - Kirchhoff Depth Migration of 2D poststack/prestack data  
from the (variable topography) recording surface

```
sumigtopo2d infile= outfile= [parameters]
```

Required parameters:

infile=stdin file for input seismic traces

outfile=stdout file for common offset migration output

tfile file for input traveltimes tables

The following 9 parameters describe traveltimes tables:

fzt first depth sample in traveltimes table

nzt number of depth samples in traveltimes table

dzt depth interval in traveltimes table

fxt first lateral sample in traveltimes table

nxt number of lateral samples in traveltimes table

dxt lateral interval in traveltimes table

fs x-coordinate of first source

ns number of sources

ds x-coordinate increment of sources

fxi x-coordinate of the first input trace

dxi horizontal spacing of input data

nxix number of input trace locations in surface

Optional Parameters:

dt= or from header (dt) time sampling interval of input data

ft= or from header (ft) first time sample of input data

dxm= or from header (d2) sampling interval of midpoints

surf="0,0;99999,0" Recording surface "x1,z1;x2,z2;x3,z3;...

fzo=fzt z-coordinate of first point in output trace

dzo=0.2\*dzt vertical spacing of output trace

nzo=5\*(nzt-1)+1 number of points in output trace "

fxo=fxt x-coordinate of first output trace

dxo=0.5\*dxt horizontal spacing of output trace

nxo=2\*(nxt-1)+1 number of output traces "

off0=0 first offset in output

doff=99999 offset increment in output

noff=1 number of offsets in output "

fmax=0.25/dt frequency-highcut for input traces

offmax=99999 maximum absolute offset allowed in migration

aperx=nxt\*dxt/2 migration lateral aperture

angmax=60 migration angle aperture from vertical

v0=1500(m/s) reference velocity value at surface "

dvz=0.0 reference velocity vertical gradient  
ls=1 flag for line source  
jpfile=stderr job print file name  
mtr=100 print verbal information at every mtr traces  
ntr=100000 maximum number of input traces to be migrated

Notes:

1. Traveltime tables were generated by program rayt2dtopo (or any other one that considers topography) on relatively coarse grids, with dimension ns\*nxt\*nzt. In the migration process, traveltimes are interpolated into shot/geophone positions and output grids.
2. Input seismic traces must be SU format and can be any type of gathers (common shot, common offset, common CDP, and so on). "
3. Migrated traces are output in CDP gathers if velocity analysis is required, with dimension nxo\*noff\*nzo. "
4. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
5. Amplitudes are computed using the reference velocity profile,  $v(z)$ , specified by the parameters  $v0=$  and  $dvz=$ .
6. Input traces must specify source and receiver positions via the header fields tr.sx and tr.gx. Offset is computed automatically.

Author: Zhenyue Liu, 03/01/95, Colorado School of Mines

Trino Salinas, 07/01/96, Colorado School of Mines,  
extended the code to migrate data from a nonflat  
recording surface.

References :

- Bleistein, N., Cohen, J., and Hagin, F., 1987, Two and one-half dimensional Born inversion with arbitrary reference: *Geophysics*, 52, 26-36.
- Liu, Z., 1993, A Kirchhoff approach to seismic modeling and pre-stack depth migration: CWP Annual Report, CWP, Colorado School of Mines.
- Wiggins, J. W., 1984, Kirchhoff integral extrapolation and migration of nonplanar data: *Geophysics*, 49, 1239-1248.

SUMIXGATHERS - mix two gathers

```
sumixgathers file1 file2 > stdout [optional parameters]
```

Required Parameters:

ntr=tr.ntr if ntr header field is not set, then ntr is mandatory

Optional Parameters: none

Notes: Both files have to be sorted by offset

Mixes two gathers keeping only the traces of the first file if the offset is the same. The purpose is to substitute only traces non existing in file1 by traces interpolated store in file2. ",

Example. If file1 is original data file and file 2 is obtained by resampling with Radon transform, then the output contains original traces with gaps filled

Credits:

Daniel Trad. UBC

Trace header fields accessed: ns, dt, ntr

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SUMIX - compute weighted moving average (trace MIX) on a panel  
of seismic data

```
sumix <stdin >sdout  
mix=.6,1,1,1,.6 array of weights for weighted average
```

Note:

The number of values defined by mix=val1,val2,... determines the number  
of traces to be averaged, the values determine the weights.

Examples:

```
sumix <stdin mix=.6,1,1,1,.6 >sdout (default) mix over 5 traces weights  
sumix <stdin mix=1,1,1 >sdout simple 3 trace moving average
```

Author:

CWP: John Stockwell, Oct 1995

Trace header fields accessed: ns

SUMUTE - mute above (or below) a user-defined polygonal curve with ",  
the distance along the curve specified by key header word

sumute <stdin >stdout xmute= tmute= [optional parameters]

Required parameters:

xmute= array of position values as specified by  
the 'key' parameter

tmute= array of corresponding time values (sec)  
in case of air wave muting, correspond to  
air blast duration

... or input via files:

nmute= number of x,t values defining mute

xfile= file containing position values as specified by  
the 'key' parameter

tfile= file containing corresponding time values (sec)

Optional parameters:

key=offset Key header word specifying trace offset  
=tracl use trace number instead

ntaper=0 number of points to taper before hard

mute (sine squared taper)

mode=0 =1 to zero BELOW the polygonal curve  
=2 to mute below AND above a straight line  
in that case xmute,tmute describes the total

time length of the muted zone

linvel=330 linear velocity

tm0=0 time shift of linear mute at \'key\'=0

Notes:

The tmute interpolant is extrapolated to the left by the smallest time  
sample on the trace and to the right by the last value given in the  
tmute array.

The files tfile and xfile are files of binary (C-style) floats.

In the context of this program "above" means earlier time and  
"below" means later time (above and below as seen on a seismic section).

The below=2 option is intended for removing air waves. The mute is  
is over a narrow window above and below the polygonal line specified

by the values in `tmute`, `xmute` or `tfile` and `xfile`.

If data are spatial, such as the (z-x) output of a migration, then depth values are used in place of times in `tmute` and `tfile`. The value of the depth sampling interval is given by the `d1` header field

Caveat: if data are seismic time sections, then `tr.dt` must be set. If data are seismic depth sections, then `tr.trid` must be set to 30, and `tr.d1` header field must be set.

Credits:

SEP: Shuki Ronen

CWP: Jack K. Cohen, Dave Hale, John Stockwell

DELPHI: Alexander Koek

Trace header fields accessed: `ns`, `dt`, `delrt`, `key=keyword`, `trid`, `d1`

Trace header fields modified: `muts` or `mute`

SUNAN - remove NaNs & Infs from the input stream

```
sunan <in.su >out.su
```

Optional parameters:

```
verbose=1 echo locations of NaNs or Infs to stderr  
=0 silent
```

Notes:

A simple program to remove NaNs and Infs from an input stream.  
The program sets NaNs and Infs to 0.0.

Author: Reginald H. Beardsley 2003 rhb@acm.org

A simple program to remove NaNs & Infs from an input stream. They shouldn't be there, but it can be hard to find the cause and fix the problem if you can't look at the data.

SUNHMOSPIKE - generates SPIKE test data set with a choice of several  
Non-Hyperbolic MOveouts

```
sunhmospike [optional parameters] > out_data_file
```

Optional parameters:

nt=300 number of time samples

ntr=20 number of traces

dt=0.001 time sample rate in seconds

offref=2000 reference offset

gopt= 1 = parabolic transform model

2 = Foster/Mosher pseudo hyperbolic option model

3 = linear tau-p model

depthref=400 reference depth used when gopt=2

offinc=100 offset increment

nspk=4 number of events

p1 = 0 event moveout for event #1 in ms on reference offset

t1 = 100 intercept time ms event #1

a1 = 1.0 amplitude for event #1

p2 = 200 event moveout for event #2 in ms on reference offset

t2 = 100 intercept time ms for spike #2

a2 = 1.0 amplitude for event #2

p3 = 0; event moveout for event #3 in ms on reference offset

t3 = 200 intercept time for spike #3

a3 = 1.0 amplitude for event #3

p4 = 120 event moveout for event #4 in ms on reference offset

t4 = 200 intercept time s for spike #4

a4 = 1.0 amplitude for event #4

cdp = 1 output cdp number

Notes:

Creates a common cdp su data file with up to four spike events  
for impulse response studies for suradon, and sutifowler

Credits:

CWP: Shuki Ronen, Chris Liner,

Modified: CWP by John Anderson, April, 1994, to have  
appropriate trace header words and default values  
for SUTIFOWLER tests

SUNMO - NMO for an arbitrary velocity function of time and CDP

```
sunmo <stdin >stdout [optional parameters]
```

Optional Parameters:

tnmo=0 NMO times corresponding to velocities in vnmo

vnmo=1500 NMO velocities corresponding to times in tnmo

anis1=0 two anisotropy coefficients making up quartic term

anis2=0 in traveltime curve, corresponding to times in tnmo

cdp= CDPs for which vnmo & tnmo are specified (see Notes)

smute=1.5 samples with NMO stretch exceeding smute are zeroed

lmute=25 length (in samples) of linear ramp for stretch mute

sscale=1 =1 to divide output samples by NMO stretch factor

invert=0 =1 to perform (approximate) inverse NMO

ixoffset=0 do not consider cross-line offset

=1 read cross-line offset from trace header

upward=0 =1 to scan upward to find first sample to kill

Notes:

For constant-velocity NMO, specify only one vnmo=constant and omit tnmo.

The anisotropy coefficients anis1, anis2 permit non-hyperbolicity due to layering, mode conversion, or anisotropy. Default is isotropic NMO.

For NMO with a velocity function of time only, specify the arrays

```
vnmo=v1,v2,... tnmo=t1,t2,...
```

where v1 is the velocity at time t1, v2 is the velocity at time t2, ...

The times specified in the tnmo array must be monotonically increasing.

Linear interpolation and constant extrapolation of the specified velocities is used to compute the velocities at times not specified.

The same holds for the anisotropy coefficients as a function of time only.

For NMO with a velocity function of time and CDP, specify the array

```
cdp=cdp1,cdp2,...
```

and, for each CDP specified, specify the vnmo and tnmo arrays as described

above. The first (vnmo,tnmo) pair corresponds to the first cdp, and so on.

Linear interpolation and constant extrapolation of  $1/\text{velocity}^2$  is used to compute velocities at CDPs not specified.

The same holds for the anisotropy coefficients as a function of time and CDP.

Moveout is defined by

$$v^2 = \frac{1 + anis1 x^2 + \dots + anis2 x^4}{1 + anis2 x^2}$$

Note: In general, the user should set the cdp parameter. The default is to use tr.cdp from the first trace and assume only one cdp.

Caveat:

Nmo cannot handle negative moveout as in triplication caused by anisotropy. But negative moveout happens necessarily for negative anis1 at sufficiently large offsets. Then the error-negative moveout- is printed. Check anis1. An error (anis2 too small) is also printed if the denominator of the quartic term becomes negative. Check anis2. These errors are prompted even if they occur in traces which would not survive the NMO-stretch threshold. Chop off enough far-offset traces (e.g. with suwind) if anis1, anis2 are fine for near-offset traces.

NMO interpolation error is less than 1% for frequencies less than 60% of the Nyquist frequency.

Exact inverse NMO is impossible, particularly for early times at large offsets and for frequencies near Nyquist with large interpolation errors.

Credits:

SEP: Shuki, Chuck Sword

CWP: Shuki, Jack, Dave Hale, Bjoern Rommel

Modified: 08/08/98 - Carlos E. Theodoro - option for lateral offset

Modified: 07/11/02 - Sang-yong Suh -

added "upward" option to handle decreasing velocity function.

Technical Reference:

The Common Depth Point Stack

William A. Schneider

Proc. IEEE, v. 72, n. 10, p. 1238-1254

1984

Trace header fields accessed: ns, dt, delrt, offset, cdp, sy

SUNORMALIZE - Trace balancing by rms, max, or median ",

```
sunormalize <stdin >stdout t0=0 t1=TMAX norm=rms
```

Required parameters:

dt=tr.dt if not set in header, dt is mandatory

ns=tr.ns if not set in header, ns is mandatory

Optional parameters:

norm=rms type of norm rms, max, med

t0=0.0 starting time for window

t1=TMAX ending time for window

Author: Ramone Carbonell,

Inst. Earth Sciences-CSIC Barcelona, Spain, April 1998.

Modifications: Nils Maercklin,

RISSC, University of Naples, Italy, September 2006

(fixed user input of ns, dt, if values are not set in header).

Trace header fields accessed: ns, dt

Trace header fields modified: none

SUNULL - create null (all zeroes) traces

```
sunull nt= [optional parameters] >outdata
```

Required parameter

nt= number of samples per trace

Optional parameters

ntr=5 number of null traces to create

dt=0.004 time sampling interval

Rationale: It is sometimes useful to insert null traces between "panels" in a shell loop.

See also: sukill, sumute, suzero

Credits:

CWP: Jack K. Cohen

Trace header fields set: ns, dt, tracl

SUOCEXT - smaller Offset EXTrapolation via Offset Continuation  
method for common-offset gathers

```
suocext <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= offextr= [...]
```

Required Parameters:

cdpmin= minimum cdp (integer number) for which to apply DMO  
cdpmax= maximum cdp (integer number) for which to apply DMO  
dxcdp= distance between adjacent cdp bins (m)  
noffmix= number of offsets to mix (see notes)  
offextr= offset to extrapolate

Optional Parameters:

tdmo=0.0 times corresponding to rms velocities in vdm0 (s)  
vdm0=1500.0 rms velocities corresponding to times in tdmo (m/s)  
sdmo=1.0 DMO stretch factor; try 0.6 for typical v(z)  
fmax=0.5/dt maximum frequency in input traces (Hz)  
verbose=0 =1 for diagnostic print  
tmpdir= if non-empty, use the value as a directory path prefix  
for storing temporary files; else if the CWP\_TMPDIR  
environment variable is set use its value for the path;  
else use tmpfile()

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes. One common-offset gather usually is enough.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

The tdmo and vdm0 arrays specify a velocity function of time that is used to implement a first-order correction for depth-variable velocity. The times in tdmo must be monotonically increasing.

For each offset, the minimum time at which a non-zero sample exists is used to determine a mute time. Output samples for times earlier than this", mute time will be zeroed. Computation time may be significantly reduced

if the input traces are zeroed (muted) for early times at large offsets.

A term for better amplitude reconstruction was added to Hale's formulation.

Credits: Carlos E. Theodoro (modification of Hale's SUDMOFK program)

Technical Reference:

C. Theodoro & K. Larner, 1998

Extrapolation of seismic data to small offsets (CWP-276).

Dip-Moveout Processing - SEG Course Notes

Dave Hale, 1988

Bleistein, Cohen & Jaramillo, 1997

True amplitude transformation to zero offset of data from  
curved reflectors (CWP-262).

Trace header fields accessed: ns, dt, delrt, offset, cdp.

Trace header fields modified: offset.

SUOLDTONEW - convert existing su data to xdr format

suoldtonew <oldsu >newsu

Required parameters:

none

Optional parameters:

none

Notes:

This program is used to convert native machine datasets to xdr-based, system-independent format.

Author: Stewart A. Levin, Mobil, 1966

SUOP2 - do a binary operation on two data sets

```
suop2 data1 data2 op=diff [trid=111] >stdout
```

Required parameters:

none

Optional parameter:

op=diff difference of two panels of seismic data  
=sum sum of two panels of seismic data  
=prod product of two panels of seismic data  
=quo quotient of two panels of seismic data  
=ptdiff differences of a panel and single trace  
=ptsum sum of a panel and single trace  
=ptprod product of a panel and single trace  
=ptquo quotient of a panel and single trace  
=zipper do "zipper" merge of two panels

trid=FUNPACKNYQ output trace identification code. (This option is active only for op=zipper)

For SU version 39 FUNPACNYQ=111

(See: sukeyword trid)

Note1: Output = data1 "op" data2 with the header of data1

Note2: For convenience and backward compatibility, this program may be called without an op code as:

For: panel "op" panel operations:

```
susum file1 file2 == suop2 file1 file2 op=sum  
sudiff file1 file2 == suop2 file1 file2 op=diff  
suprod file1 file2 == suop2 file1 file2 op=prod  
suquo file1 file2 == suop2 file1 file2 op=quo
```

For: panel "op" trace operations:

```
suptsum file1 file2 == suop2 file1 file2 op=ptsum  
suptdiff file1 file2 == suop2 file1 file2 op=ptdiff  
suptprod file1 file2 == suop2 file1 file2 op=ptprod  
suptquo file1 file2 == suop2 file1 file2 op=ptquo
```

Note3: If an explicit op code is used it must FOLLOW the filenames.

Note4: With op=quo and op=ptquo, divide by 0 is trapped and 0 is returned.

Note5: Weighted operations can be specified by setting weighting coefficients for the two datasets:

w1=1.0

w2=1.0

Note6: With op=zipper, it is possible to set the output trace id code (See: sukeyword trid)

This option processes the traces from two files interleaving its samples. Both files must have the same trace length and must not longer than SU\_NFLTS/2 (as in SU 39 SU\_NFLTS=32768).

Being "tr1" a trace of data1 and "tr2" the corresponding trace of data2, The merged trace will be :

```
tr[2*i]= tr1[i]
tr[2*i+1] = tr2[i]
```

The default value of output tr.trid is that used by sufft and suifft, which is the trace id reserved for the complex traces obtained through the application of sufft. See also, suamp.

For operations on non-SU binary files use:farith

Credits:

SEP: Shuki Ronen

CWP: Jack K. Cohen

CWP: John Stockwell, 1995, added panel op trace options.

: Fernando M. Roxo da Motta <petro@roxoxo.org> - added zipper op

Notes:

If efficiency becomes important consider inverting main loop and repeating operation code within the branches of the switch.

SUOP - do unary arithmetic operation on segys

suop <stdin >stdout op=abs

Required parameters:

none

Optional parameter:

op=abs operation flag

abs : absolute value

avg : remove average value

ssqrt : signed square root

sqr : square

ssqr : signed square

sgn : signum function

exp : exponentiate

slog : signed natural log

slog10: signed common log

cos : cosine

sin : sine

tan : tangent

cosh : hyperbolic cosine

sinh : hyperbolic sine

tanh : hyperbolic tangent

norm : divide trace by Max. Value

db : 20 \* slog10 (data)

neg : negate value

posonly : pass only positive values

negonly : pass only negative values

sum : running sum trace integration

diff : running diff trace differentiation

refl :  $(v[i+1] - v[i]) / (v[i+1] + v[i])$

mod2pi : modulo 2 pi

inv : inverse

rmsamp : rms amplitude

nop : no operation

Note: Binary ops are provided by suop2.

Operations inv, slog and slog10 are "punctuated", meaning that if, the input contains 0 values, 0 values are returned.

For file operations on non-SU format binary files use: farith

Credits:

CWP: Shuki, Jack

Toralf Foerster: norm and db operations, 10/95.

Notes:

If efficiency becomes important consider inverting main loop  
and repeating operation code within the branches of the switch.

Note on db option. The following are equivalent:

```
... | sufft | suamp | suop op=norm | suop op=slog10 |\
sugain scale=20| suxgraph style=normal
```

```
... | sufft | suamp | suop op=db | suxgraph style=normal
```

SUPACK1 - pack segy trace data into chars

```
supack1 <seggy_file >packed_file gpow=0.5
```

Required parameters:

none

Optional parameter:

gpow=0.5 exponent used to compress the dynamic range of the traces

Credits:

CWP: Jack K. Cohen, Shuki Ronen, Brian Sumner

Caveats:

This program is for single site use. Use segywrite to make a portable tape.

We are storing the local header words, ungpow and unscale, required by suunpack1 as floats. Although not essential (compare the handling of such fields as dt), it allows us to demonstrate the convenience of using the natural data type. In any case, the data itself is non-portable floats in general, so we aren't giving up any intrinsic portability.

Notes:

ungpow and unscale are defined in segy.h

trid = CHARPACK is defined in su.h and segy.h

Trace header fields accessed: ns

Trace header fields modified: ungpow, unscale, trid

SUPACK2 - pack segy trace data into 2 byte shorts

```
supack2 <segy_file >packed_file gpow=0.5
```

Required parameters:

none

Optional parameter:

gpow=0.5 exponent used to compress the dynamic range of the traces

Credits:

CWP: Jack K. Cohen, Shuki Ronen, Brian Sumner

Revised: 7/4/95 Stewart A. Levin Mobil

Changed encoding to ensure 2 byte length (short is 8 bytes on Cray).

Caveats:

This program is for single site use. Use segywrite to make a portable tape.

We are storing the local header words, ungpow and unscale, required by suunpack2 as floats.

Notes:

ungpow and unscale are defined in segy.h

trid = SHORTPACK is defined in su.h and segy.h

Trace header fields accessed: ns

Trace header fields modified: ungpow, unscale, trid

SUPASTE - paste existing SEGY headers on existing data

```
supaste <bare_data >segys ns= head=headers ftn=0
```

Required parameter:

ns=the number of samples per trace

Optional parameters:

head=headers file with segy headers

ftn=0 Fortran flag

0 = unformatted data from C

1 = ... from Fortran

verbose=0 1= echo number of traces pasted

Caution:

An incorrect ns field will munge subsequent processing.

Notes:

This program is used when the option head=headers is used in  
sustrip. See: sudoc sustrip for more details

Credits:

CWP: Jack K. Cohen

SUPEF - Wiener predictive error filtering

supef <stdin >stdout [optional parameters]

Required parameters:

dt is mandatory if not set in header

Optional parameters:

cdp= CDPs for which minlag, maxlag, pnoise, mincorr, maxcorr are set (see Notes)

minlag=dt first lag of prediction filter (sec)

maxlag=last lag default is (tmax-tmin)/20

pnoise=0.001 relative additive noise level

mincorr=tmin start of autocorrelation window (sec)

maxcorr=tmax end of autocorrelation window (sec)

showwiener=0 =1 to show Wiener filter on each trace

mix=1,... array of weights (floats) for moving average of the autocorrelations

outpar=/dev/null output parameter file, contains the Wiener filter if showwiener=1 is set

method=linear for linear interpolation of cdp values

=mono for monotonic cubic interpolation of cdps

=akima for Akima's cubic interpolation of cdps

=spline for cubic spline interpolation of cdps

Trace header fields accessed: ns, dt

Trace header fields modified: none

Notes:

1) To apply spiking decon (Wiener filtering with no gap):

Run the following command

```
suacor < data.su | suximage perc=95
```

You will see horizontal strip running across the center of your plot. This is the autocorrelation wavelet for each trace. The idea of spiking decon is to apply a Wiener filter with no gap to the data to collapse the waveform into a spike. The idea is to pick the width of the autocorrelation waveform from beginning to end (not trough to trough) and use this time for MAXLAG\_SPIKING:

```
supef < data.su maxlag=MAXLAG_SPIKING > dataspiked.su
```

## 2) Prediction Error Filter (i.e. gapped Wiener filtering)

The purpose of gapped decon is to suppress repetitions in the data such as those caused by water bottom multiples.

To look for the period of the repetitions

```
suacor ntout=1000 < dataspiked.su | suximage perc=95
```

The value of `ntout` must be larger than the default 100. The idea is to look for repetitions in the autocorrelation. These repetitions will appear as a family of parallel stripes above and below the main autocorrelation waveform. Set `MAXLAG_PEF` to the period of the repetitions. Set `MINLAG_PEF` to be slightly larger than the value of `MAXLAG_SPIKING` that you used to spike the data.

```
supef < dataspiked.su minlag=MINLAG_PEF maxlag=MAXLAG_PEF > datapef.su
```

Some experimentation may be required to get a satisfactory result.

3) It may be effective to sort your data into cdp gathers with `susort`, and perform `sunmo` correction to the water speed with `sunmo`, prior to attempts to suppress water bottom multiples. After applying `supef`, the user should apply inverse `nmo` to undo the `nmo` to water speed prior to further processing.

For a filter expressed as a function of cdp, specify the array

```
cdp=cdp1,cdp2,...
```

and for each cdp specified, specify the minlag and maxlag arrays as

```
minlag=min1,min2,... maxlag=max1,max2,...
```

It is required that the number of minlag and maxlag values be equal to the number of cdp's specified. If the number of values in these arrays does not equal the number of cdp's, only the first value will be used.

Caveat:

The `showweiner=1` option writes out the wiener filter to `outpar`, and the prediction error filter to `stdout`, which is "

```
1,0,0,...,-wiener[0],...,-wiener[imaxlag-1]
```

where the sample value of `-wiener[0]`, is `iminlag` in the pe-filter.

The pe-filter is output as a SU format datafile, one pe-filter for each

trace input.

Credits:

CWP: Shuki Ronen, Jack K. Cohen, Ken Lerner

    CWP: John Stockwell, added mixing feature (April 1998)

    CSM: Tanya Slota (September 2005) added cdp feature

Technical Reference:

A. Ziolkowski, "Deconvolution", for value of maxlag default:  
page 91:  $\text{imaxlag} < \text{nt}/10$ . I took  $\text{nt}/20$ .

Notes:

The prediction error filter is  $1, 0, 0, \dots, 0, -\text{wiener}[0], \dots$ ,  
so no point in explicitly forming it.

If  $\text{imaxlag} < 2 * \text{iminlag} - 1$ , then we don't need to compute the  
autocorrelation for lags:

$\text{imaxlag} - \text{iminlag} + 1, \dots, \text{iminlag} - 1$

It doesn't seem worth the duplicated code to implement this.

Trace header fields accessed: ns

SUPERMUTE - permute or transpose a 3d datacube

supermute <stdin >sdout

Required parameters:

none

Optional parameters:

n1=ns from header number of samples in the fast direction

n2=ntr from header number of samples in the med direction ",

n3=1 number of samples in the slow direction

o1=1 new fast direction

o2=2 new med direction

o3=3 new slow direction

d1=1 output interval in new fast direction

d2=1 output interval in new med direction

d3=1 output interval in new slow direction

Credits:

VT: Matthias Imhof

Trace header fields accessed: ns, ntr

Trace header fields modified: d1=1, f1=1, d2=1, f2=1, ns, ntr

SUPGC - Programmed Gain Control--apply agc like function  
but the same function to all traces preserving  
relative amplitudes spatially.

Required parameter:

file= name of input file

Optional parameters:

ntrscan=200 number of traces to scan for gain function

lwindow=1.0 length of time window in seconds

Author: John Anderson (visitor to CWP from Mobil)

Trace header fields accessed: ns, dt

SUPICKAMP - pick amplitudes within user defined and resampled window

```
supickamp <stdin >stdout d2= [optional parameters]
```

Required parameters:

d2= sampling interval for slow dimension

(required if key-parameter not specified)

Optional parameters:

key= Key header word specifying trace offset  
(alternatively, specify d2,x2beg)

x\_above= array of lateral position values

(upper window corner)

t\_above= array of time values

(upper window corner)

... or input via files:

t\_xabove= file containing time and lateral position values  
(upper window corner)

t\_xbelow= file containing time and lateral position values  
(lower window corner)

wl= window width if t\_xbelow is not specified  
(No windowing if not specified)

dt\_resamp=dt resampling interval within pick window  
(dt has to come from trace headers)

tmin=0 minimum time in input trace

x2beg=0 first lateral position

format=ascii write ascii data to stdout

=binary for binary floats to stdout

verbose=1 writes complete pick information into outpar

=2 writes complete pick information into outpar

in tab-delimited column format

outpar=/dev/tty output parameter file; contains output  
from verbose

arg1=max output (first dimension) to stdout

arg2=i2 output (second dimension) to stdout

(see notes for other options)

Notes:

Window can be defined using

(1) vectors x\_above, t\_above, [wl]

(2) file t\_xabove, [wl] or

(3) files t\_xabove, t\_xbelow

files t\_xabove, t\_xbelow can be generated using xwigb's picking algorithm. The lateral positions have to be monotonically increasing or decreasing for both vector and file input.

verbose=1 or 2 writes min, max, abs[max], energy and associated times tmin,tmax,tabs to outpar, together with global values. verbose=0 only outputs global values.

Acceptable arg-parameters for lateral positions are

(1) x2 (2) i2 = trace number

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset)

Type sukeyword -o to see the complete list of SU keywords.

Credits:

CWP: Andreas Rueger July 06, 1996

MTU: David Forel, Jan. 26, 2005 Add verbose=2 option

SUPLANE - create common offset data file with up to 3 planes

suplane [optional parameters] >stdout

Optional Parameters:

npl=3 number of planes  
nt=64 number of time samples  
ntr=32 number of traces  
taper=0 no end-of-plane taper  
= 1 taper planes to zero at the end  
offset=400 offset  
dt=0.004 time sample interval in seconds  
...plane 1 ...  
dip1=0 dip of plane #1 (ms/trace)  
len1= 3\*ntr/4 HORIZONTAL extent of plane (traces)  
ct1= nt/2 time sample for center pivot  
cx1= ntr/2 trace for center pivot  
...plane 2 ...  
dip2=4 dip of plane #2 (ms/trace)  
len2= 3\*ntr/4 HORIZONTAL extent of plane (traces)  
ct2= nt/2 time sample for center pivot  
cx2= ntr/2 trace for center pivot  
...plane 3 ...  
dip3=8 dip of plane #3 (ms/trace)  
len3= 3\*ntr/4 HORIZONTAL extent of plane (traces)  
ct3= nt/2 time sample for center pivot  
cx3= ntr/2 trace for center pivot

liner=0 use parameters  
= 1 parameters set for 64x64 data set  
with separated dipping planes.

Credits:

CWP: Chris Liner

Trace header fields set: ns, dt, offset, tracl

SUPOFILT - POLarization FILTer for three-component data

supofilt <stdin >stdout [optional parameters]

Required parameters:

dfile=polar.dir file containing the 3 components of the  
direction of polarization  
wfile=polar.rl file name of weighting polarization parameter

Optional parameters:

dt=(from header) time sampling intervall in seconds  
smooth=1 1 = smooth filter operators, 0 do not  
sl=0.05 smoothing window length in seconds  
wpow=1.0 raise weighting function to power wpow  
dpow=1.0 raise directivity functions to power dpow  
verbose=0 1 = echo additional information

Notes:

Three adjacent traces are considered as one three-component dataset.

This program SUPOFILT is an extension to the polarization analysis program supolar. The files wfile and dfile are SU files as written by SUPOLAR.

Author: Nils Maercklin,  
GeoForschungsZentrum (GFZ) Potsdam, Germany, 1999-2000.  
E-mail: nils@gfz-potsdam.de

References:

Benhama, A., Cliet, C. and Dubesset, M., 1986: Study and Application of spatial directional filtering in three component recordings. Geophysical Prospecting, vol. 36.  
Kanasewich, E. R., 1981: Time Sequence Analysis in Geophysics, The University of Alberta Press.  
Kanasewich, E. R., 1990: Seismic Noise Attenuation, Handbook of Geophysical Exploration, Pergamon Press, Oxford.

Trace header fields accessed: ns, dt

## SUPOLAR - POLarization analysis of three-component data

supolar <stdin [optional parameters]

### Required parameters:

none

### Optional parameters:

dt=(from header)	time sampling intervall in seconds
wl=0.1	correlation window length in seconds
win=boxcar	correlation window shape, choose "boxcar", "hanning", "bartlett", or "welsh"
file=polar	base of output file name(s)
rl=1	1 = rectilinearity evaluating 2 eigenvalues, 2, 3 = rectilinearity evaluating 3 eigenvalues
rlq=1.0	contrast parameter for rectilinearity
dir=1	1 = 3 components of direction of polarization (the only three-component output file)
tau=0	1 = global polarization parameter
ellip=0	1 = principal, subprincipal, and transverse ellipticities e21, e31, and e32
pln=0	1 = planarity measure
f1=0	1 = flatness or oblateness coefficient
l1=0	1 = linearity coefficient
amp=0	1 = amplitude parameters: instantaneous, quadratic, and eigenresultant ir, qr, and er
theta=0	1, 2, 3 = incidence angle of principal axis
phi=0	1, 2, 3 = horizontal azimuth of principal axis
angle=rad	unit of angles theta and phi, choose "rad", "deg", or "gon"
all=0	1, 2, 3 = set all output flags to that value
verbose=0	1 = echo additional information

### Notes:

Three adjacent traces are considered as one three-component dataset.

Correct calculation of angles theta and phi requires the first of these traces to be the vertical component, followed by the two horizontal components (e.g. Z, N, E, or Z, inline, crossline). Significant signal energy on Z is necessary to resolve the 180 deg ambiguity of phi (options phi=2,3 only).

Each calculated polarization attribute is written into its own SU file. These files get the same base name (set with "file=") and the parameter flag as an extension (e.g. polar.rl).

In case of a tapered correlation window, the window length `wl` may have to be increased compared to the boxcar case, because of their smaller effective widths (Bartlett, Hanning: 1/2, Welsh: 1/3).

Range of values:

parameter	option	interval	
rl	1, 2	0.0 ... 1.0	(1.0: linear polarization)
rl	3	-1.0 ... 1.0	
tau, l1	1	0.0 ... 1.0	(1.0: linear polarization)
pln, f1	1	0.0 ... 1.0	(1.0: planar polarization)
e21, e31, e32	1	0.0 ... 1.0	(0.0: linear polarization)
theta	1	-pi/2... pi/2	rad
theta	2, 3	0.0 ... pi/2	rad
phi	1	-pi/2... pi/2	rad
phi	2	-pi ... pi	rad (see notes above)
phi	3	0.0 ... 2 pi	rad (see notes above)

Author: Nils Maercklin,  
 GeoForschungsZentrum (GFZ) Potsdam, Germany, 1998-2001.  
 E-mail: nils@gfz-potsdam.de

References:

- Jurkevics, A., 1988: Polarization analysis of three-component array data. Bulletin of the Seismological Society of America, vol. 78, no. 5.
- Kanasewich, E. R., 1981: Time Sequence Analysis in Geophysics. The University of Alberta Press.
- Kanasewich, E. R., 1990: Seismic Noise Attenuation. Handbook of Geophysical Exploration, Pergamon Press, Oxford.
- Meyer, J. H. 1988: First Comparative Results of Integral and Instantaneous Polarization Attributes for Multicomponent Seismic Data. Institut Francais du Petrole.
- Press, W. H., Teukolsky, S. A., Vetterling, W. T., and Flannery, B. P. 1996: Numerical Recipes in C - The Art of Scientific Computing. Cambridge University Press, Cambridge.

Samson, J. C., 1973: Description of the Polarisation States of Vector Processes: Application to ULF Electromagnetic Fields. Geophysical Journal vol. 34, p. 403-419.

Sheriff, R. E., 1991: Encyclopedic Dictionary of Exploration Geophysics. 3rd ed., Society of Exploration Geophysicists, Tulsa.

Trace header fields accessed: ns, dt  
Trace header fields modified: none

SUPUT - Connect SU program to file descriptor for output stream.

```
su_module | suput fp=$1
```

This program is for interfacing " outside processing systems with SU. Typically, the outside system would execute the SU command file. The outside system provides the file descriptor it would like to read from to the command file to be an argument for suput.

Example: su\_module | suput fp=\$1

```
fd=-1      file_descriptor_for_output_stream_from_su
verbose=0  minimal listing
           =1  asks for message with each trace processed.
```

Author: John Anderson (visiting scholar from Mobil) July 1994

SUPWS - Phase stack or phase-weighted stack (PWS) of adjacent traces having the same key header word

```
supws <stdin >stdout [optional parameters]
```

Required parameters:

none

Optional parameters:

key=cdp key header word to stack on  
pwr=1.0 raise phase stack to power pwr  
dt=(from header) time sampling intervall in seconds  
sl=0.0 window length in seconds used for smoothing  
of the phase stack (weights)  
ps=0 0 = output is PWS, 1 = output is phase stack  
verbose=0 1 = echo additional information

Note:

Phase weighted stacking is a tool for efficient incoherent noise reduction. An amplitude-unbiased coherency measure is designed based on the instantaneous phase, which is used to weight the samples of an ordinary, linear stack. The result is called the phase-weighted stack (PWS) and is cleaned from incoherent noise. PWS thus permits detection of weak but coherent arrivals.

The phase-stack (coherency measure) has values between 0 and 1.

If the stacking is over cdp and the PWS option is set, then the offset header field is set to zero. Otherwise, output traces get their headers from the first trace of each data ensemble to stack, including the offset field. Use "sushw" afterwards, if this is not acceptable.

Author: Nils Maercklin,  
GeoForschungsZentrum (GFZ) Potsdam, Germany, 2001.  
E-mail: nils@gfz-potsdam.de

References:

B. L. N. Kennett, 2000: Stacking three-component seismograms.  
Geophysical Journal International, vol. 141, p. 263-269.  
M. Schimmel and H. Paulssen, 1997: Noise reduction and detection

of weak , coherent signals through phase-weighted stacks.  
Geophysical Journal International, vol. 130, p. 497-505.  
M. T. Taner, A. F. Koehler, and R. E. Sheriff, 1979: Complex  
seismic trace analysis. Geophysics, vol. 44, p. 1041-1063.

Trace header fields accessed: ns

Trace header fields modified: nhs, offset

SUQUANTILE - display some quantiles or ranks of a data set

suquantile <stdin >stdout [optional parameters]

Required parameters:

none (no-op)

Optional parameters:

panel=1 flag; 0 = do trace by trace (vs. whole data set)

quantiles=1 flag; 0 = give ranks instead of quantiles

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Credits:

CWP: Jack K. Cohen

Trace header fields accessed: ns, tracl, mark

SURADON - compute forward or reverse Radon transform or remove multiples by using the parabolic Radon transform to estimate multiples and subtract.

suradon <stdin >stdout [Optional Parameters]

Optional Parameters:

choose=0     0 Forward Radon transform  
              1 Compute data minus multiples  
              2 Compute estimate of multiples  
              3 Compute forward and reverse transform  
              4 Compute inverse Radon transform  
igopt=1     1 parabolic transform:  $g(x) = \text{offset}^2$   
              2 Foster/Mosher psuedo hyperbolic transform  
                $g(x) = \sqrt{\text{depth}^2 + \text{offset}^2}$   
              3 Linear tau-p:  $g(x) = \text{offset}$   
              4 abs linear tau-p:  $g(x) = \text{abs}(\text{offset})$   
offref=2000.     reference maximum offset to which maximum and minimum  
                  moveout times are associated  
interoff=0.     intercept offset to which tau-p times are associated  
pmin=-200     minimum moveout in ms on reference offset  
pmax=400     maximum moveout in ms on reference offset  
dp=16     moveout increment in ms on reference offset  
pmula=80     moveout in ms on reference offset where multiples begin  
              at maximum time  
pmulb=200     moveout in ms on reference offset where multiples begin  
              at zero time  
depthref=500.   Reference depth for Foster/Mosher hyperbolic transform  
nwin=1     number of windows to use through the mute zone  
f1=60.     High-end frequency before taper off  
f2=80.     High-end frequency  
prewhite=0.1    Prewhitening factor in percent.  
cdpkey=cdp     name of header word for defining ensemble  
offkey=offset   name of header word with spatial information  
nxmax=120     maximum number of input traces per ensemble  
ltaper=7     taper (integer) for mute tapering function

Optimizing Parameters:

The following parameters are occasionally used to avoid spatial aliasing problems on the linear tau-p transform. Not recommended for other transforms...

ninterp=0     number of traces to interpolate between each input trace  
              prior to computing transform

freq1=3.0      low-end frequency in Hz for picking (good default: 3 Hz)  
                   (Known bug: freq1 cannot be zero)  
 freq2=20.0     high-end frequency in Hz for picking (good default: 20 Hz)  
 lagc=400       length of AGC operator for picking (good default: 400 ms)  
 lent=5         length of time smoother in samples for picker  
                   (good default: 5 samples)  
 lenx=1         length of space smoother in samples for picker  
                   (good default: 1 sample)  
 xopty=1        1 = use differences for spatial derivative  
                   (works with irregular spacing)  
                   0 = use FFT derivative for spatial derivatives  
                   (more accurate but requires regular spacing and  
                   at least 16 input tracs--will switch to differences  
                   automatically if have less than 16 input traces)

Credits:

CWP: John Anderson (visitor to CSM from Mobil) Spring 1993

Multiple removal notes:

Usually the input data are NMO corrected CMP gathers. The first pass is to compute a parabolic Radon transform and identify the multiples in the transform domain. Then, the module is run on all the data using "choose=1" to estimate and subtract the multiples. See the May, 1993 CWP Project Review for more extensive documentation.

NWIN notes:

The parabolic transform runs with higher resolution if the mute zone is honored. When "nwin" is specified larger than one (say 6), then multiple windows are used through the mute zone. It is assumed in this case that the input data are sorted by the offkey header item from small offset to large offset. This causes the code to run 6 times longer. The mute time is taken from the "muts" header word. You may have to manually set this header field yourself, if it is not already set.

References:

Anderson, J. E., 1993, Parabolic and linear 2-D, tau-p transforms using the generalized radon transform, in May 11-14, 1993 Project Review, Consortium Project on Seismic Inverse methods for Complex Structures, CWP-137, Center for Wave Phenomena

internal report.

Other References cited in above paper:

- Beylkin, G., 1987, The discrete Radon transform: IEEE Transactions of Acoustics, Speech, and Signal Processing, 35, 162-712.
- Chapman, C.H., 1981, Generalized Radon transforms and slant stacks: Geophysical Journal of the Royal Astronomical Society, 66, 445-453.
- Foster, D. J. and Mosher, C. C., 1990, Multiple suppression using curvilinear Radon transforms: SEG Expanded Abstracts 1990, 1647-1650.
- Foster, D. J. and Mosher, C. C., 1992, Suppression of multiples using the Radon transform: Geophysics, 57, No. 3, 386-395.
- Gulunay, N., 1990, F-X domain least-squares Tau-P and Tau-Q: SEG Expanded Abstracts 1990, 1607-1610.
- Hampson, D., 1986, Inverse velocity stacking for multiple elimination: J. Can. Soc. Expl. Geophys., 22, 44-55.
- Hampson, D., 1987, The discrete Radon transform: a new tool for image enhancement and noise suppression: SEG Expanded Abstracts 1978, 141-143.
- Johnston, D.E., 1990, Which multiple suppression method should I use? SEG Expanded Abstracts 1990, 1750-1752.

Trace header words accessed: ns, dt, cdpkey, offkey, muts

SURAMP - Linearly taper the start and/or end of traces to zero.

suramp <stdin >stdout [optional parameters]

Required parameters:

if dt is not set in header, then dt is mandatory

Optional parameters

tmin=tr.delrt/1000 end of starting ramp (sec)

tmax=(nt-1)\*dt beginning of ending ramp (sec)

dt = (from header) sampling interval (sec)

The taper is a linear ramp from 0 to tmin and/or tmax to the end of the trace. Default is a no-op!

Credits:

CWP: Jack K. Cohen, Ken Larner

Trace header fields accessed: ns, dt, delrt

SURANDSPIKE - make a small data set of RANDom SPIKEs

```
surandspike [optional parameters] > out_data_file
```

Creates a common offset su data file with random spikes

Optional parameters:

n1=500 number of time samples

n2=200 number of traces

dt=0.002 time sample rate in seconds

nspk=20 number of spikes per trace

amax=0.2 abs(max) spike value

mode=1 different spikes on each trace

=2 same spikes on each trace

seed=from\_clock random number seed (integer)

Credits:

ARAMCO: Chris Liner

Trace header fields set: ns, dt, offset

SURANDSTAT - Add RANDOM time shifts STATIC errors to seismic traces

```
surandstat <stdin >stdout [optional parameters]
```

Required parameters:

none

Optional Parameters:

seed=from\_clock random number seed (integer)  
max=tr.dt maximum random time shift (ms)  
scale=1.0 scale factor for shifts

Credits:

ARAMCO: Chris Liner 3/26/05

SURANGE - get max and min values for non-zero header entries

surange <stdin

Optional parameters:

key= Header key(s) to range (default=all)

Note: Gives partial results if interrupted

Credits:

Geocon: Garry Perratt (output one header per line;  
option to specify headers to range;  
added first & last values where min<max)

Based upon original by:

SEP: Stew Levin

CWP: Jack K. Cohen

Note: the use of "signal" is inherited from BSD days and may  
break on some UNIXs. It is dicy in that the responsibility  
for program termination is lateraled back to the main.

SURECIP - sum opposing offsets in prepared data (see below)

```
surecip <stdin >stdout
```

Sum traces with equal positive and negative offsets (i.e. assume reciprocity holds).

Usage:

```
suabshw <data >absdata
```

```
susort cdp offset <absdata | surecip >sumdata
```

Note that this processing stream can be simply evoked by:

```
recip data sumdata
```

Credits:

SEP: Shuki Ronen

CWP: Jack Cohen

Caveat:

The assumption is that this operation is not a mainstay processing item. Hence the recommended implementation via the 'recip' shell script. If it becomes a mainstay, then a much faster code can quickly be drummed up by incorporating portions of suabshw and susort.

Trace header fields accessed: ns

Trace header fields modified: nhs, tracl, sx, gx

SUREDUCE - convert traces to display in reduced time ",

```
sureduce <stdin >stdout rv=
```

Required parameters:

dt=tr.dt if not set in header, dt is mandatory

Optional parameters:

rv=8.0 reducing velocity in km/sec ",

Note: Useful for plotting refraction seismic data.

To remove reduction, do:

```
sufliip < reduceddata.su flip=3 | sureduce rv=RV > flip.su
```

```
sufliip < flip.su flip=3 > unreduceddata.su
```

Trace header fields accessed: dt, ns, offset

Trace header fields modified: none

Author: UC Davis: Mike Begnaud March 1995

Trace header fields accessed: ns, dt, offset

SUREFCON - Convolution of user-supplied Forward and Reverse refraction shots using XY trace offset in reverse shot

```
surefcon <forshot sufile=revshot xy=trace offseted >stdout
```

Required parameters:

sufile= file containing SU trace to use as reverse shot

xy= Number of traces offseted from the 1st trace in sufile

Optional parameters:

none

Trace header fields accessed: ns

Trace header fields modified: ns

Notes:

This code implements the Refraction Convolution Section (RCS) method of generalized reciprocal refraction travelttime analysis developed by Derecke Palmer and Leoni Jones.

The time sampling interval on the output traces is half of that on the traces in the input files.

Example:

```
surefcon <DATA sufile=DATA xy=1 | ...
```

Here, the su data file, "DATA", convolved the nth trace by (n+xy)th trace in the same file

Credits: (based on suconv)

CWP: Jack K. Cohen, Michel Dietrich

UNSW: D. Palmer, K.T. LEE

CAVEATS: no space-variable or time-variable capacity.  
The more than one trace allowed in sufile is the beginning of a hook to handle the spatially variant case.

Trace header fields accessed: ns

Trace header fields modified: ns

Notes:

This code implements the refraction convolution

section (RCS) method  
method described in:

Palmer, D, 2001a, Imaging refractors with the convolution section,  
Geophysics 66, 1582-1589.

Palmer, D, 2001b, Resolving refractor ambiguities with amplitudes,  
Geophysics 66, 1590-1593.

Exploration Geophysics (2005) 36, 1825

Butsuri-Tansa (Vol. 58, No.1)

Mulli-Tansa (Vol. 8,

A simple approach to refraction statics with the  
Generalized Main Reciprocal Method and the Refraction  
Convolution Section Heading

by Derecke Palmer Leonie Jones

SURELANAN - REsidual-moveout semblance ANalysis for ANisotropic media

surelan refl= npicks= [optional parameters]

Required parameters:

reflector file: reflec =

number of points in the reflector file =

Optional Parameters:

nr1=51 number of r1-parameter samples

dr1=0.01 r1-parameter sampling interval

fr1=-0.25 first value of r1-parameter

nr2=51 number of r2-parameter samples

dr2=0.01 r2-parameter sampling interval

fr2=-0.25 first value of r2-parameter

dzratio=5 ratio of output to input depth sampling intervals

nsmooth=dzratio\*2+1 length of semblance num and den smoothing window

verbose=0 =1 for diagnostic print on stderr

method=linear for linear interpolation of the interface

=mono for monotonic cubic interpolation of interface

=akima for Akima's cubic interpolation of interface

=spline for cubic spline interpolation of interface

Note:

1. This program is part of Debashish Sarkar's anisotropic model building technique.
2. Input migrated traces should be sorted by cdp - surelan outputs a group of semblance traces every time cdp changes. Therefore, the output will be useful only if cdp gathers are input.
3. The residual-moveout semblance for cdp gathers is based on  $z(h)*z(h) = z(0)*z(0) + r1*h^2 + r2*h^4/[h^2+z(0)^2]$  where z depth and h is the half-offset.

SURELAN - compute residual-moveout semblance for cdp gathers based on  $z(h)*z(h) = z(0)*z(0) + r*h*h$  where  $z$  depth and  $h$  offset.

surelan <stdin >stdout [optional parameters]

Optional Parameters:

nr=51 number of r-parameter samples  
dr=0.01 r-parameter sampling interval  
fr=-0.25 first value of b-parameter  
smute=1.5 samples with RMO stretch exceeding smute are zeroed  
dзраtio=5 ratio of output to input depth sampling intervals  
nsmooth=dзраtio\*2+1 length of semblance num and den smoothing window  
verbose=0 =1 for diagnostic print on stderr

Note:

1. This program is part of Zhenyue Liu's velocity analysis technique.
2. Input migrated traces should be sorted by cdp - surelan outputs a group of semblance traces every time cdp changes. Therefore, the output will be useful only if cdp gathers are input.
3. The parameter  $r$  may take negative values. The range of  $r$  can be controlled by maximum of  $(z(h)*z(h)-z(0)*z(0))/(h*h)$

SURESAMP - Resample in time

suresamp <stdin >stdout [optional parameters]

Required parameters:

none

Optional Parameters:

nt=tr.ns      number of time samples on output  
dt=            time sampling interval on output  
              default is:  
              tr.dt/10<sup>6</sup>      seismic data  
              tr.d1            non-seismic data  
tmin=         time of first sample in output  
              default is:  
              tr.delrt/10<sup>3</sup>    seismic data  
              tr.f1            non-seismic data  
rf=            resampling factor;  
              if defined, set nt=nt\_in\*rf and dt=dt\_in/rf  
verbose=0     =1 for advisory messages

Example 1: (assume original data had dt=.004 nt=256)

```
sufilter <data f=40,50 amps=1.,0. |  
suresamp nt=128 dt=.008 | ...
```

Using the resampling factor rf, this example translates to:

```
sufilter <data f=40,50 amps=1.,0. | suresamp rf=0.5 | ...
```

Note the typical anti-alias filtering before sub-sampling!

Example 2: (assume original data had dt=.004 nt=256)

```
suresamp <data nt=512 dt=.002 | ...
```

or use:

```
suresamp <data rf=2 | ...
```

Example 3: (assume original data had d1=.1524 nt=8192)

```
sufilter <data f=0,1,3,3.28 amps=1,1,1,0 |  
suresamp <data nt=4096 dt=.3048 | ...
```

Example 4: (assume original data had d1=.5 nt=4096)

```
suresamp <data nt=8192 dt=.25 | ...
```

Credits:

CWP: Dave (resamp algorithm), Jack (SU adaptation)  
CENPET: Werner M. Heigl - modified for well log support  
RISSC: Nils Maercklin 2006 - minor fixes, added rf option

Algorithm:

Resampling is done via 8-coefficient sinc-interpolation.  
See "\$CWPROOT/src/cwp/lib/intsinc8.c" for technical details.

Trace header fields accessed: ns, dt, delrt, d1, f1, trid  
Trace header fields modified: ns, dt, delrt (only when set tmin)  
d1, f1 (only when set tmin)

SURESSTAT - Surface consistent source and receiver statics calculation

```
suresstat <stdin [optional parameters]
```

Required parameters:

ssol= output file source statics

rsol= output file receiver statics

ntraces= number of traces in input data set (must be correct!)

Optional parameters:

ntpicks=50 maximum static shift (samples)

niter=5 number of iterations

nshot=240 largest shot number (fldr=1 to nshot)

nr=335 largest receiver number (tracf=1 to nr)

nc=574 maximum number of cmp's (for array allocation)

sfold=96 maximum shot gather fold

rfold=96 maximum receiver gather fold

cfold=48 maximum cmp gather fold

sub=0 subtract super trace 1 from super trace 2 (=1)

sub=0 strongly biases static to a value of 0

mode=0 use global maximum in cross-correlation window

=1 choose the peak perc=percent smaller than the global max.

perc=10. percent of global max (used only for mode=1)

verbose=0 print diagnostic output (verbose=1)

Notes:

Estimates surface-consistent source and receiver statics, meaning that there is one static correction value estimated for each shot and receiver position.

The method employed here is based on the method of Ronen and Claerbout: Geophysics 50, 2759-2767 (1985).

The input consists of moveout-corrected SU data sorted in shot gathers. The output files are binary files containing the source and receiver statics, as a function of shot number (trace header fldr) and receiver station number (trace header tracf).

The code builds a supertrace1 and supertrace2, which are subsequently cross-correlated. The program then picks the time lag associated with the largest peak in the cross-correlation according to two possible criteria set by the parameter "mode". If mode=0, the maximum of the cross-correlation window is chosen. If mode=1, the program will pick

a peak which is up to perc=percent smaller than the global maximum, but closer to zero lag than the global maximum. (Choosing mode=0 is recommended.)

The geometry can be irregular: the program simply computes a static correction for each shot record (fldr=1 to fldr=nshot), with any missing shots being assigned a static of 0. A static correction for each receiver station (tracf=1 to tracf=nr) is calculated, with missing receivers again assigned a static of 0. ",

The ntraces parameter must be equal to the number of prestack traces. The ntpick parameter sets the maximum allowable shift desired (in samples NOT time).

The niter parameter sets the number of iterations desired.

The nshot parameter must be equal to the maximum fldr number in the data. Note that this number might be different from the actual number of shot records in the data (i.e., the maximum ep number). For getting the correct maximum fldr number, you may use the surange command.

The nr parameter must be equal to the largest number of receivers per shot in the whole data.

The nc parameter must be equal to the number of prestack traces in the data.

The sfold parameter must be equal to the nr parameter.

The rfold parameter must be equal to the maximum ep number.

The cfold parameter must be equal to the maximum CDP fold, which is equal to the maximum number under the cdpt entry in the output of the surange command.

To apply the static corrections, use sustatic with hdrs=3

Reference:

Ronen, J. and Claerbout, J., 1985, Surface-consistent residual statics estimation by stack-power maximization: Geophysics, vol. 50, 2759-2767.

Credits:

CWP: Timo Tjan, 4 October 1994

rewritten by Thomas Pratt, USGS, Feb. 2000.

Trace header fields accessed: ns, dt, tracf, fldr, cdp



SUSEHW - Set the value the Header Word denoting trace number within an Ensemble defined by the value of another header word

```
susetehw <stdin >stdout [options]
```

Required Parameters:

none

Optional Parameters:

key1=cdp Key header word defining the ensemble

key2=cdpt Key header word defining the count within the ensemble

a=1 starting value of the count in the ensemble

b=1 increment or decrement within the ensemble

Notes:

This code was written because suresstat requires cdpt to be set.

The computation is

$$\text{val}(\text{key2}) = a + b*i$$

The input data must first be sorted into constant key1 gathers.

Example: setting the cdpt field ",

```
susetehw < cdpgathers.su a=1 b=1 key1=cdp key2=cdpt > new.su
```

Credits:

CWP: John Stockwell (Feb 2008) in answer to a question by Warren Franz based on various codes, including susplit, susshw, suchw

SUSHAPE - Wiener shaping filter

```
sushape <stdin >stdout [optional parameters]
```

Required parameters:

w= vector of input wavelet to be shaped or ...

...or ...

wfile= ... file containing input wavelet in SU (SEG Y trace) format

d= vector of desired output wavelet or ...

...or ...

dfile= ... file containing desired output wavelet in SU format

dt=tr.dt if tr.dt is not set in header, then dt is mandatory

Optional parameters:

nshape=trace length of shaping filter

pnoise=0.001 relative additive noise level

showshaper=0 =1 to show shaping filter

Notes:

Example of commandline input wavelets:

```
sushape < indata w=0,-.1,.1,... d=0,-.1,1,.1,... > shaped_data
```

```
sushape < indata wfile=inputwavelet.su dfile=desire.su > shaped_data
```

To get the shaping filters into an ascii file:

```
... | sushape ... showshaper=1 2>file | ... (sh or ksh)
```

```
(... | sushape ... showshaper=1 | ...) >&file (csh)
```

Credits:

CWP: Jack Cohen

CWP: John Stockwell, added wfile and dfile options

Trace header fields accessed: ns, dt

Trace header fields modified: none

SUSHIFT - shifted/windowed traces in time

```
sushift <stdin >stdout [tmin= ] [tmax= ]
```

tmin= min time to pass

tmax= max time to pass

dt= sample rate in microseconds

fill=0.0 value to place in padded samples

(defaults for tmin and tmax are calculated from the first trace.

verbose= 1 echos parameters to stdout

Background :

tmin and tmax must be given in seconds

In the high resolution single channel seismic profiling the sample interval is short, the shot rate and the number of samples are high. To reduce the file size the delrt time is changed during a profiling trip. To process and display a seismic section a constant delrt is needed. This program does this job.

The SEG-Y header variable delrt (delay in ms) is a short integer. That's why in the example shown below delrt is rounded to 123 !

```
... | sushift tmin=0.1234 tmax=0.2234 | ...
```

The dt= and fill= options are intended for manipulating velocity volumes in trace format. In particular models which were hung from the water bottom when created & which then need to have the water layer added." ,

Author:

Toralf Foerster  
Institut fuer Ostseeforschung Warnemuende  
Sektion Marine Geologie  
Seestrasse 15  
D-18119 Rostock, Germany

Trace header fields accessed: ns, delrt

Trace header fields modified: ns, delrt



SUSHW - Set one or more Header Words using trace number, mod and integer divide to compute the header word values or input the header word values from a file

... compute header fields

```
sushw <stdin >stdout key=cdp,.. a=0,.. b=0,.. c=0,.. d=0,.. j=...,..
```

... or read headers from a binary file

```
sushw <stdin > stdout key=key1,.. infile=binary_file
```

Required Parameters for setting headers from infile:

key=key1,key2 ... is the list of header fields as they appear in infile  
infile= binary file of values for field specified by  
key1,key2,...

Optional parameters ():

key=cdp,... header key word(s) to set

a=0,... value(s) on first trace

b=0,... increment(s) within group

c=0,... group increment(s)

d=0,... trace number shift(s)

j=ULONG\_MAX,ULONG\_MAX,... number of elements in group

Notes:

Fields that are getparred must have the same number of entries as key words being set. Any field that is not getparred is set to the default value(s) above. Explicitly setting j=0 will set j to ULONG\_MAX.

The value of each header word key is computed using the formula:

$$i = itr + d$$
$$val(key) = a + b * (i \% j) + c * (i / j)$$

where itr is the trace number (first trace has itr=0, NOT 1)

Examples:

1. set every dt field to 4ms

```
sushw <indata key=dt a=4000 |...
```

2. set the sx field of the first 32 traces to 6400, the second 32 traces to 6300, decrementing by -100 for each 32 trace groups

```
...| sushw key=sx a=6400 c=-100 j=32 |...
```

3. set the offset fields of each group of 32 traces to 200,400,...,6400

```
...| sushw key=offset a=200 b=200 j=32 |...
```

4. perform operations 1., 2., and 3. in one call

```
..| sushw key=dt,sx,offset a=4000,6400,200 b=0,0,200 c=0,-100,0 j=0,32,32 |
```

In this example, we set every dt field to 4ms. Then we set the first 32 shotpoint fields to 6400, the second 32 shotpoint fields to 6300 and so forth. Next we set each group of 32 offset fields to 200, 400, ..., 6400.

Example of a typical processing sequence using suchw:

```
sushw <indata key=dt a=4000 |
sushw key=sx a=6400 c=-100 j=32 |
sushw key=offset a=200 b=200 j=32 |
suchw key1=gx key2=offset key3=sx b=1 c=1 |
suchw key1=cdp key2=gx key3=sx b=1 c=1 d=2 >outdata
```

Again, it is possible to eliminate the multiple calls to both sushw and suchw, as in Example 4.

Reading header values from a binary file:

If the parameter infile=binary\_file is set, then the values that are to be set for the fields specified by key=key1,key2,... are read from that file. The values are read sequentially from the file and assigned trace by trace to the input SU data. The infile consists of C (unformatted) binary floats in the form of an array of size (nkeys)\*(ntraces) where nkeys is the number of floats in the first (fast) dimension and ntraces is the number of traces.

Comment:

Users wishing to edit one or more header fields (as in geometry setting) may do this via the following sequence:

```
sugethw < sudata output=geom key=key1,key2 ... > hdrfile
```

Now edit the ASCII file hdrfile with any editor, setting the fields appropriately. Convert hdrfile to a binary format via:

```
a2b < hdrfile n1=nfields > binary_file
```

Then set the header fields via:

```
sushw < sudata infile=binary_file key1 key2 ... > sudata.edited
```

Caveat:

If the (number of traces)\*(number of key words) exceeds the number of values in the infile then the user may still set a single header field on the remaining traces via the parameters key=keyword a,b,c,d,j.

Example:

```
sushw < sudata=key1,key2 ... infile=binary_file [Optional Parameters]
```

Credits:

SEP: Einar Kajartansson

CWP: Jack K. Cohen

CWP: John Stockwell, added multiple fields and infile= options

Caveat:

All constants are cast to doubles.

SUSORT - sort on any segy header keywords

```
susort <stdin >stdout [[+/-]key1 [+/-]key2 ...]
```

Susort supports any number of (secondary) keys with either ascending (+, the default) or descending (-) directions for each. The default sort key is cdp.

Note: Only the following types of input/output are supported  
Disk input --> any output  
Pipe input --> Disk output

Note: If the the CWP\_TMPDIR environment variable is set use its value for the path; else use tmpfile()

Example:

To sort traces by cdp gather and within each gather by offset with both sorts in ascending order:

```
susort <INDATA >OUTDATA cdp offset
```

Caveat: In the case of Pipe input a temporary file is made to hold the ENTIRE data set. This temporary is either an actual disk file (usually in /tmp) or in some implementations, a memory buffer. It is left to the user to be SENSIBLE about how big a file to pipe into susort relative to the user's computer.

Credits:

SEP: Einar, Stew

CWP: Shuki, Jack

Caveats:

Since the algorithm depends on sign reversal of the key value to obtain a descending sort, the most significant figure may be lost for unsigned data types. The old SEP support for tape input was removed in version 1.16---version 1.15 is in the Portability directory for those who may want to input SU data stored on tape.

Trace header fields modified: tracl, tracr

SUSORTY - make a small 2-D common shot off-end data set in which the data show geometry values to help visualize data sorting.

```
susorty [optional parameters] > out_data_file
```

Optional parameters:

```
nt=100  number of time samples
nshot=10 number of shots
dshot=10 shot interval (m)
noff=20  number of offsets
doff=20  offset increment (m)
```

Notes:

Creates a common shot su data file for sort visualization

time samples	quantity
-----	-----
first 25%	shot coord
second 25%	rec coord
third 25%	offset
fourth 25%	cmp coord

1. default is shot ordered (hsv2 cmap looks best to me)

```
susorty | suximage legend=1 units=meters cmap=hsv2
```

2. sort on cmp (note random order within a cmp)

```
susorty | susort cdp > junk.su
suximage < junk.su legend=1 units=meters cmap=hsv2
```

3. sort to cmp and subsort on offset

```
susorty | susort cdp offset > junk.su
suximage < junk.su legend=1 units=meters cmap=hsv2
```

Credits:

CWP: Chris Liner 10.09.01

Trace header fields set: ns, dt, sx, gx, offset, cdp, tracl

SUSPECFK - F-K Fourier SPECTrum of data set

suspecfk <infile >outfile [optional parameters]

Optional parameters:

dt=from header time sampling interval

dx=from header(d2) or 1.0 spatial sampling interval

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note: To facilitate further processing, the sampling intervals  
in frequency and wavenumber as well as the first  
frequency (0) and the first wavenumber are set in the  
output header (as respectively d1, d2, f1, f2).

Note: The relation:  $w = 2 \pi F$  is well known, but there  
doesn't seem to be a commonly used letter corresponding  
to F for the spatial conjugate transform variable. We  
use K for this. More specifically we assume a phase:  
 $i(w t - k x) = 2 \pi i(F t - K x)$ .  
and F, K define our notion of frequency, wavenumber.

Credits:

CWP: Dave (algorithm), Jack (reformatting for SU)

Trace header fields accessed: ns, dt, d2

Trace header fields modified: tracl, ns, dt, trid, d1, f1, d2, f2

SUSPECFX - Fourier SPECTrum (T -> F) of traces

suspecfx <infile >outfile

Note: To facilitate further processing, the sampling interval  
in frequency and first frequency (0) are set in the  
output header.

Credits:

CWP: Dave (algorithm), Jack (reformatting for SU)

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt, trid, d1, f1

SUSPECK1K2 - 2D (K1,K2) Fourier SPECTrum of (x1,x2) data set

suspeck1k2 <infile >outfile [optional parameters]

Optional parameters:

d1=from header(d1) or 1.0 spatial sampling interval in first (fast) dimension

d2=from header(d2) or 1.0 spatial sampling interval in second (slow) dimension

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path prefix for storing temporary files; else if the CWP\_TMPDIR environment variable is set use its value for the path; else use tmpfile()

Notes:

Because the data are assumed to be purely spatial (i.e. non-seismic), the data are assumed to have trace id (30), corresponding to (z,x) data

To facilitate further processing, the sampling intervals in wavenumber as well as the first frequency (0) and the first wavenumber are set in the output header (as respectively d1, d2, f1, f2).

The relation:  $w = 2 \pi F$  is well known for frequency, but there doesn't seem to be a commonly used letter corresponding to F for the spatial conjugate transform variables. We use K1 and K2 for this. More specifically we assume a phase:

$$-i(k_1 x_1 + k_2 x_2) = -2 \pi i(K_1 x_1 + K_2 x_2).$$

and K1, K2 define our respective wavenumbers.

Credits:

CWP: John Stockwell, 26 April 1995, based on original code by Dave Hale and Jack Cohen

Trace header fields accessed: ns, d1, d2, trid

Trace header fields modified: tracl, ns, dt, trid, d1, f1, d2, f2

SUSPIKE - make a small spike data set

```
susprike [optional parameters] > out_data_file
```

Creates a common offset su data file with up to four spikes  
for impulse response studies

Optional parameters:

nt=64 number of time samples

ntr=32 number of traces

dt=0.004 time sample rate in seconds

offset=400 offset

nspk=4 number of spikes

ix1= ntr/4 trace number (from left) for spike #1

it1= nt/4 time sample to spike #1

ix2 = ntr/4 trace for spike #2

it2 = 3\*nt/4 time for spike #2

ix3 = 3\*ntr/4; trace for spike #3

it3 = nt/4; time for spike #3

ix4 = 3\*ntr/4; trace for spike #4

it4 = 3\*nt/4; time for spike #4

Credits:

CWP: Shuki Ronen, Chris Liner

Trace header fields set: ns, dt, offset

SUSPLIT - Split traces into different output files by keyword value

```
susplit <stdin >stdout [options]
```

Required Parameters:

none

Optional Parameters:

key=cdp Key header word to split on (see segy.h)

stem=split\_ Stem name for output files

middle=key middle of name of output files

suffix=.su Suffix for output files

numlength=3 Length of numeric part of filename

verbose=0 =1 to echo filenames, etc.

close=0 =1 to close files before opening new ones

Credits:

Geocon: Garry Perratt hacked together from various other codes

SUSTACK - stack adjacent traces having the same key header word

```
sustack <stdin >stdout [Optional parameters]
```

Required parameters:

none

Optional parameters:

key=cdp header key word to stack on  
normpow=1.0 each sample is divided by the  
normpow'th number of non-zero values  
stacked (normpow=0 selects no division)  
repeat=0 =1 repeats the stack trace nrepeat times  
nrepeat=10 repeats stack trace nrepeat times in  
output file  
verbose=0 verbose = 1 echos information

Notes:

-----

The offset field is set to zero on the output traces, unless the user is stacking with key=offset. In that case, the value of the offset field is left unchanged.

Sushw can be used afterwards if this is not acceptable.

For VSP users:

The stack trace appears ten times in the output file when setting repeat=1 and nrepeat=10. Corridor stacking can be achieved by properly muting the upgoing data with SUMUTE before stacking.

Credits:

SEP: Einar Kjartansson

CWP: Jack K. Cohen, Dave Hale

CENPET: Werner M. Heigl - added repeat trace functionality

Note:

The "valxxx" subroutines are in su/lib/valpkge.c. In particular,  
"valcmp" shares the annoying attribute of "strcmp" that  
if (valcmp(type, val, valnew) {  
...  
}

will be performed when val and valnew are different.

Trace header fields accessed: ns

Trace header fields modified: nhs, tracl, offset

SUSTATICRRS - Elevation STATIC corrections, apply corrections from headers or from a source and receiver statics file, includes application of Residual Refraction Statics

sustaticrrs <stdin >stdout [optional parameters]

Required parameters:

none

Optional Parameters:

v0=v1 or user-defined or from header, weathering velocity

v1=user-defined or from header, subweathering velocity

hdrs=0 =1 to read statics from headers

=2 to read statics from files

sign=1 =-1 to subtract statics from traces(up shift)

Options when hdrs=2:

sou\_file= input file for source statics (ms)

rec\_file= input file for receiver statics (ms)

ns=240 number of sources

nr=335 number of receivers

no=96 number of offsets

Options when hdrs=3:

blvl\_file= base of the near-surface model file (sampled at CMP locations)

refr\_file= horizontal reference datum file (sampled at CMP locations)

nsamp= number of midpoints on line

fx= first x location in velocity model

dx= midpoint interval

V\_r= replacement velocity

mx= number of velocity model samples in lateral direction

mz= number of velocity model samples in vertical direction

dzv= velocity model depth interval

vfile= near-surface velocity model

Options when hdrs=4:

nsamp= number of midpoints on line

fx= first x location in velocity model "

dx= midpoint interval "

Options when hdrs=5:

none

Notes:

For hdrs=1, statics calculation is not performed, statics correction is applied to the data by reading statics (in ms) from the header.

For hdrs=0, field statics are calculated, and input field sut is assumed measured in ms.  
output field sstat =  $10^{\text{scale1}} * (\text{sdel} - \text{selev} + \text{sdepth}) / \text{swevel}$   
output field gstat =  $\text{sstat} - \text{sut} / 1000$ .  
output field tstat =  $\text{sstat} + \text{gstat} + 10^{\text{scale1}} * (\text{selev} - \text{gelev}) / \text{wevel}$

For hdrs=2, statics are surface consistently obtained from the statics files. The geometry should be regular. The source- and receiver-statics files should be unformatted C binary floats and contain the statics (in ms) as a function of surface location.

For hdrs=3, residual refraction statics and average refraction statics are computed. For hdrs=4, residual refraction statics are applied, and for hdrs=5, average refraction statics are applied (Cox, 1999). These three options are coupled in many data processing sequences: before stack residual and average refraction statics are computed but only residual refractions statics are applied, and after stack average refraction statics are applied. Refraction statics are often split like this to avoid biasing stacking velocities. The files blvl\_file and refr\_file are the base of the velocity model defined in vfile and the final reference datum, as described by Cox (1999), respectively. Residual refraction statics are stored in the header field gstat, and the average statics are stored in the header field tstat. V\_r is the replacement velocity as described by Cox (1999). The velocity file, vfile, is designed to work with a horizontal upper surface defined in refr\_file. If the survey has irregular topography, the horizontal upper surface should be above the highest topographic point on the line, and the velocity between this horizontal surface and topography should be some very large value, such as 999999999, so that the traveltimes through that region are inconsequential.

Credits:

CWP: Jamie Burns

CWP: Modified by Mohammed Alfaraj, 11/10/1992, for reading statics from headers and including sign (+-) option

CWP: Modified by Timo Tjan, 29 June 1995, to include input of source and receiver statics from files.

CWP: Modified by Chris Robinson, 11/2000, to include the splitting of refraction statics into residuals and averages

Trace header fields accessed: ns, dt, delrt, gelev, selev, sdepth, gdel, sdel, swevel, sut, scale1

Trace header fields modified: sstat, gstat, tstat

References:

Cox, M., 1999, Static corrections for seismic reflection surveys:  
Soc. Expl. Geophys.

SUSTATIC - Elevation static corrections, apply corrections from headers or from a source and receiver statics file

sustatic <stdin >stdout [optional parameters]

Required parameters:

none

Optional Parameters:

v0=v1 or user-defined or from header, weathering velocity

v1=user-defined or from header, subweathering velocity

hdrs=0 =1 to read statics from headers

=2 to read statics from files

=3 to read from output files of suresstat

sign=1 =-1 to subtract statics from traces(up shift)

Options when hdrs=2 and hdrs=3:

sou\_file= input file for source statics (ms)

rec\_file= input file for receiver statics (ms)

ns=240 number of sources

nr=335 number of receivers

no=96 number of offsets

Notes:

For hdrs=1, statics calculation is not performed, statics correction is applied to the data by reading statics (in ms) from the header.

For hdrs=0, field statics are calculated, and

input field sut is assumed measured in ms.

output field sstat =  $10^{\text{scale1}} * (\text{sdel} - \text{selev} + \text{sdepth}) / \text{swevel}$

output field gstat = sstat - sut/1000.

output field tstat = sstat + gstat +  $10^{\text{scale1}} * (\text{selev} - \text{gelev}) / \text{wevel}$

For hdrs=2, statics are surface consistently obtained from the statics files. The geometry should be regular.

The source- and receiver-statics files should be unformatted C binary floats and contain the statics (in ms) as a function of surface location.

For hdrs=3, statics are read from the output files of suresstat, with the same options as hdrs=2 (but use no=max traces per shot and assume that ns=max shot number and nr=max receiver number).

For each shot number (trace header fldr) and each receiver number (trace header tracf) the program will look up the appropriate static correction. The geometry need not be regular as each trace is treated independently.

Credits:

CWP: Jamie Burns

CWP: Modified by Mohammed Alfaraj, 11/10/1992, for reading  
statics from headers and including sign (+-) option

CWP: Modified by Timo Tjan, 29 June 1995, to include input of  
source and receiver statics from files.

modified by Thomas Pratt, USGS, Feb, 2000 to read statics from  
the output files of suresstat

Trace header fields accessed: ns, dt, delrt, gelev, selev,  
sdepth, gdel, sdel, swevel, sut, scalel, fldr, tracf

Trace header fields modified: sstat, gstat, tstat

SUSTKVEL - convert constant dip layer interval velocity model to the stacking velocity model required by sunmo

```
sustkvel v= h= dip=0.0 outpar=/dev/tty
```

Required parameters:

v= interval velocities

h= layer thicknesses at the cmp

Optional parameters:

dip=0.0 (constant) dip of the layers (degrees)

outpar=/dev/tty output parameter file in the form required by sunmo:

tv=zero incidence time pick vector

v=stacking velocities vector

Examples:

```
sustkvel v=5000,6000,8000,10000 h=1000,1200,1300,1500 outpar=stkpar  
sunmo <data.cdp par=stkpar >data.nmo
```

```
sustkvel par=intpar outpar=stkpar  
sunmo <data.cdp par=stkpar >data.nmo
```

If the file, intpar, contains:

```
v=5000,6000,8000,10000
```

```
h=1000,1200,1300,1500
```

then the two examples are equivalent. The created parameter file, stkpar, is in the form of the velocity model required by sunmo.

Note: sustkvel does not have standard su syntax since it does not operate on seismic data. Hence stdin and stdout are not used.

Caveat: Does not accept a series of interval velocity models to produce a variable velocity file for sunmo.

Credits:

CWP: Jack

Technical Reference:

The Common Depth Point Stack

William A. Schneider

Proc. IEEE, v. 72, n. 10, p. 1238-1254

1984

Formulas:

Note: All sums on  $i$  are from 1 to  $k$

From Schneider:

Let  $h[i]$  be the  $i$ th layer thickness measured at the cmp and  $v[i]$  the  $i$ th interval velocity.

Set:

$$t[i] = h[i]/v[i]$$

$$t0[k] = 2 \text{ Sum } t[i] * \cos(\text{dip})$$

$$vs[k] = (1.0/\cos(\text{dip})) \text{ sqrt}(\text{Sum } v[i]*v[i]*t[i] / \text{Sum } t[i])$$

Define:

$$t0by2[k] = \text{Sum } h[i]/v[i]$$

$$vh[k] = \text{Sum } v[i]*h[i]$$

Then:

$$t0[k] = 2 * t0by2[k] * \cos(\text{dip})$$

$$vs[k] = \text{sqrt}(vh[k] / t0by2[k]) / \cos(\text{dip})$$

SUSTOLT - Stolt migration for stacked data or common-offset gathers

```
sustolt <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [...]
```

Required Parameters:

```
cdpmin=  minimum cdp (integer number) in dataset
cdpmax=  maximum cdp (integer number) in dataset
dxcdp=   distance between adjacent cdp bins (m)
```

Optional Parameters:

```
noffmix=1 number of offsets to mix (for unstacked data only)
tmig=0.0 times corresponding to rms velocities in vmig (s)
vmig=1500.0 rms velocities corresponding to times in tmig (m/s)
smig=1.0 stretch factor (0.6 typical if vrms increasing)
vscale=1.0 scale factor to apply to velocities
fmax=Nyquist maximum frequency in input data (Hz)
lstaper=0 length of side tapers (# of traces)
lbtaper=0 length of bottom taper (# of samples)
verbose=0 =1 for diagnostic print
tmpdir= if non-empty, use the value as a directory path
prefix for storing temporary files; else if the
the CWP_TMPDIR environment variable is set use
its value for the path; else use tmpfile()
```

Notes:

If unstacked traces are input, they should be NMO-corrected and sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes. If both NMO and DMO are applied, then this is equivalent to prestack time migration (though the velocity profile is assumed  $v(t)$ , only).

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should be specified for unstacked data only. noffmix should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through migration to other traces in adjacent cdps within that mix.

The tmig and vmig arrays specify a velocity function of time that is used to implement Stolt's stretch for depth-variable velocity. The

stretch factor smig is often referred to as the "W" factor.  
The times in tmig must be monotonically increasing.

Credits:

CWP: Dave Hale

Trace header fields accessed: ns, dt, delrt, offset, cdp

SUSTRIP - remove the SEG Y headers from the traces

```
sustrip <stdin >stdout head=/dev/null outpar=/dev/tty ftn=0
```

Required parameters:

none

Optional parameters:

head=/dev/null file to save headers in

outpar=/dev/tty output parameter file, contains:

number of samples (n1=)

number of traces (n2=)

sample rate in seconds (d1=)

ftn=0 Fortran flag

0 = write unformatted for C

1 = ... for Fortran

Notes:

Invoking head=filename will write the trace headers into filename.

You may paste the headers back onto the traces with supaste

See: sudoc supaste for more information

Credits:

SEP: Einar Kjartansson

CWP: Jack K. Cohen

Trace header fields accessed: ns, dt

SUSWAPBYTES - SWAP the BYTES in SU data to convert data from big endian to little endian byte order, and vice versa

suswapbytes < stdin [optional parameter] > sdtout

format=0 foreign to native

=1 native to foreign

ns=from header if ns not set in header, must be set by hand

Notes:

The 'native' endian is the endian (byte order) of the machine you are running this program on. The 'foreign' endian is the opposite byte order.

Examples of big endian machines are: IBM RS6000, SUN, NeXT

Examples of little endian machines are: PCs, DEC

Caveat: this code has not been tested on DEC

Credits:

CWP: adapted for SU by John Stockwell

based on a code supplied by:

Institute fur Geophysik, Hamburg: Jens Hartmann (June 1993)

Trace header fields accessed: ns

SUSYNCZ - SYNthetic seismograms for piecewise constant V(Z) function  
True amplitude (primaries only) modeling for 2.5D

```
susyncz > outfile [parameters]
```

Required parameters:

none

Optional Parameters:

ninf=4            number of interfaces (not including upper surface)  
dip=5\*i            dips of interfaces in degrees (i=1,2,3,4)  
zint=100\*i        z-intercepts of interfaces at x=0 (i=1,2,3,4)  
v=1500+ 500\*i     velocities below surface & interfaces (i=0,1,2,3,4)  
rho=1,1,1,1,1    densities below surface & interfaces (i=0,1,2,3,4)  
nline=1           number of (identical) lines  
ntr=32            number of traces  
dx=10            trace interval  
tdelay=0         delay in recording time after source initiation  
dt=0.004         time interval  
nt=128            number of time samples

Notes:

The original purpose of this code was to create some nontrivial data for Brian Sumner's CZ suite.

The program produces zero-offset data over dipping reflectors.

In the original fortran code, some arrays had the index interval 1:ninf, as a natural way to index over the subsurface reflectors. This indexing was preserved in this C translation. Consequently, some arrays in the code do not use the 0 "slot".

Example:

```
susyncz | sufilter | sugain tpow=1 | display_program
```

Trace header fields set: tracl, ns, dt, delrt, ntr, sx, gx

Credits:

CWP: Brian Sumner, 1983, 1985, Fortran design and code  
CWP: Stockwell & Cohen, 1995, translation to C



SUSYNLVCW - SYNthetic seismograms for Linear Velocity function  
for mode Converted Waves

susynlvcw >outfile [optional parameters]

Optional Parameters:

nt=101 number of time samples  
dt=0.04 time sampling interval (sec)  
ft=0.0 first time (sec)  
nxo=1 number of source-receiver offsets  
dxo=0.05 offset sampling interval (km)  
fxo=0.0 first offset (km, see notes below)  
xo=fxo,fxo+dxo,... array of offsets (use only for non-uniform offsets)  
nxm=101 number of midpoints (see notes below)  
dxm=0.05 midpoint sampling interval (km)  
fxm=0.0 first midpoint (km)  
nxs=101 number of shotpoints (see notes below)  
dxs=0.05 shotpoint sampling interval (km)  
fxs=0.0 first shotpoint (km)  
x0=0.0 distance x at which v00 is specified  
z0=0.0 depth z at which v00 is specified  
v00=2.0 velocity at x0,z0 (km/sec)  
gamma=1.0 velocity ratio, upgoing/downgoing  
dvdx=0.0 derivative of velocity with distance x (dv/dx)  
dvdz=0.0 derivative of velocity with depth z (dv/dz)  
fpeak=0.2/dt peak frequency of symmetric Ricker wavelet (Hz)  
ref="1:1,2;4,2" reflector(s): "amplitude:x1,z1;x2,z2;x3,z3;...  
smooth=0 =1 for smooth (piecewise cubic spline) reflectors  
er=0 =1 for exploding reflector amplitudes  
ls=0 =1 for line source; default is point source  
ob=1 =1 to include obliquity factors  
sp=1 =1 to account for amplitude spreading  
=0 for constant amplitudes throught out  
tmin=10.0\*dt minimum time of interest (sec)  
ndpfz=5 number of diffractors per Fresnel zone  
verbose=0 =1 to print some useful information

Notes:

Offsets are signed - may be positive or negative. Receiver locations are computed by adding the signed offset to the source location.

Specify either midpoint sampling or shotpoint sampling, but not both.

If neither is specified, the default is the midpoint sampling above.

More than one ref (reflector) may be specified. When obliquity factors are included, then only the left side of each reflector (as the x,z reflector coordinates are traversed) is reflecting. For example, if x coordinates increase, then the top side of a reflector is reflecting. Note that reflectors are encoded as quoted strings, with an optional reflector amplitude: preceding the x,z coordinates of each reflector. Default amplitude is 1.0 if amplitude: part of the string is omitted.

Note that  $\gamma < 1$  implies P-SV mode conversion,  $\gamma > 1$  implies SV-P, and  $\gamma = 1$  implies no mode conversion.

based on Dave Hale's code susynlv, but modified  
by Mohammed Alfaraj to handle mode conversion  
Date of modification: 01/07/92

Trace header fields set: trid, counit, ns, dt, delrt,  
tracl, tracr, fldr, tracf,  
cdp, cdpt, d2, f2, offset, sx, gx

SUSYNLVFTI - SYNthetic seismograms for Linear Velocity function in a  
Factorized Transversely Isotropic medium

susynlvfti >outfile [optional parameters]

Optional Parameters:

nt=101 number of time samples

dt=0.04 time sampling interval (sec)

ft=0.0 first time (sec)

kilounits=1 input length units are km or kilo-feet  
=0 for m or ft

Note: Output (sx,gx,offset) are always m or ft

nxo=1 number of source-receiver offsets

dxo=0.05 offset sampling interval (kilounits)

fxo=0.0 first offset (kilounits, see notes below)

xo=fxo,fxo+dxo,... array of offsets (use only for non-uniform offsets)

nxm=101 number of midpoints (see notes below)

dxm=0.05 midpoint sampling interval (kilounits)

fxm=0.0 first midpoint (kilounits)

nxs=101 number of shotpoints (see notes below)

dxs=0.05 shotpoint sampling interval (kilounits)

fxs=0.0 first shotpoint (kilounits)

x0=0.0 distance x at which v00 is specified

z0=0.0 depth z at which v00 is specified

v00=2.0 velocity at x0,z0 (kilounits/sec)

dvdx=0.0 derivative of velocity with distance x (dv/dx)

dvdz=0.0 derivative of velocity with depth z (dv/dz)

fpeak=0.2/dt peak frequency of symmetric Ricker wavelet (Hz)

ref=1:1,2;4,2 reflector(s): "amplitude:x1,z1;x2,z2;x3,z3;..."

smooth=0 =1 for smooth (piecewise cubic spline) reflectors

er=0 =1 for exploding reflector amplitudes

ls=0 =1 for line source; default is point source

ob=0 =1 to include obliquity factors

tmin=10.0\*dt minimum time of interest (sec)

ndpfz=5 number of diffractors per Fresnel zone

verbose=1 =1 to print some useful information

For transversely isotropic media:

angxs=0.0 angle of symmetry axis with the vertical (degrees)

define the media using either

a=1.0 corresponding to the ratio of elastic coef.(c1111/c3333)

f=0.4 corresponding to the ratio of elastic coef. (c1133/c3333)

l=0.3 corresponding to the ratio of elastic coef. (c1313/c3333)

Alternately use Tompson\'s parameters:  
delta=0 Thomsen\'s 1986 defined parameter  
epsilon=0 Thomsen\'s 1986 defined parameter  
ntries=40 number of iterations in Snell\'s law and offset searches  
epsx=.001 lateral offset tolerance  
epst=.0001 reflection time tolerance  
nitmax=12 max number of iterations in travel time integrations

Notes:

Offsets are signed - may be positive or negative. Receiver locations are computed by adding the signed offset to the source location.

Specify either midpoint sampling or shotpoint sampling, but not both. If neither is specified, the default is the midpoint sampling above.

More than one ref (reflector) may be specified. When obliquity factors are included, then only the left side of each reflector (as the x,z reflector coordinates are traversed) is reflecting. For example, if x coordinates increase, then the top side of a reflector is reflecting. Note that reflectors are encoded as quoted strings, with an optional reflector amplitude: preceding the x,z coordinates of each reflector. Default amplitude is 1.0 if amplitude: part of the string is omitted.

Concerning the choice of delta and epsilon. The difference between delta", and epsilon should not exceed one. A possible break down of the program is the result. This is caused primarily by the break down in the two point", ray-tracing. Also keep the values of delta and epsilon between 2 and -2.

## SUSYNLV - SYNthetic seismograms for Linear Velocity function

susynlv >outfile [optional parameters]

### Optional Parameters:

nt=101	number of time samples
dt=0.04	time sampling interval (sec)
ft=0.0	first time (sec)
kilounits=1	input length units are km or kilo-feet
=0 for m or ft	
Note: Output (sx,gx,offset) are always m or ft	
nxo=1	number of source-receiver offsets
dxo=0.05	offset sampling interval (kilounits)
fxo=0.0	first offset (kilounits, see notes below)
xo=fxo,fxo+dxo,...	array of offsets (use only for non-uniform offsets)
nxm=101	number of midpoints (see notes below)
dxm=0.05	midpoint sampling interval (kilounits)
fxm=0.0	first midpoint (kilounits)
nxs=101	number of shotpoints (see notes below)
dxs=0.05	shotpoint sampling interval (kilounits)
fxs=0.0	first shotpoint (kilounits)
x0=0.0	distance x at which v00 is specified
z0=0.0	depth z at which v00 is specified
v00=2.0	velocity at x0,z0 (kilounits/sec)
dvdx=0.0	derivative of velocity with distance x (dv/dx)
dvdz=0.0	derivative of velocity with depth z (dv/dz)
fpeak=0.2/dt	peak frequency of symmetric Ricker wavelet (Hz)
ref="1:1,2;4,2"	reflector(s): "amplitude:x1,z1;x2,z2;x3,z3;..."
smooth=0	=1 for smooth (piecewise cubic spline) reflectors
er=0	=1 for exploding reflector amplitudes
ls=0	=1 for line source; default is point source
ob=1	=1 to include obliquity factors
tmin=10.0*dt	minimum time of interest (sec)
ndpfz=5	number of diffractors per Fresnel zone
verbose=0	=1 to print some useful information

### Notes:

Offsets are signed - may be positive or negative. Receiver locations are computed by adding the signed offset to the source location.

Specify either midpoint sampling or shotpoint sampling, but not both. If neither is specified, the default is the midpoint sampling above.

More than one ref (reflector) may be specified. Do this by putting additional ref= entries on the commandline. When obliquity factors are included, then only the left side of each reflector (as the x,z reflector coordinates are traversed) is reflecting. For example, if x coordinates increase, then the top side of a reflector is reflecting. Note that reflectors are encoded as quoted strings, with an optional reflector amplitude: preceding the x,z coordinates of each reflector. Default amplitude is 1.0 if amplitude: part of the string is omitted.

Credits: CWP Dave Hale, 09/17/91, Colorado School of Mines  
UTulsa Chris Liner 5/22/03 added kilounits flag

Trace header fields set: trid, counit, ns, dt, delrt,  
tracl, tracr, fldr, tracf,  
cdp, cdpt, d2, f2, offset, sx, gx

SUSYNVXZCS - SYNthetic seismograms of common shot in V(X,Z) media via Kirchhoff-style modeling

susynvxzcs<vfile >outfile nx= nz= [optional parameters]

Required Parameters:

<vfile           file containing velocities v[nx] [nz]  
>outfile        file containing seismograms of common offset  
nx=             number of x samples (2nd dimension) in velocity  
nz=             number of z samples (1st dimension) in velocity

Optional Parameters:

nt=501           number of time samples  
dt=0.004        time sampling interval (sec)  
ft=0.0          first time (sec)  
fpeak=0.2/dt    peak frequency of symmetric Ricker wavelet (Hz)  
nxg=            number of receivers of input traces  
dxg=15          receiver sampling interval (m)  
fxg=0.0         first receiver (m)  
nxd=5           skipped number of receivers  
nxs=1           number of offsets  
dxs=50          shot sampling interval (m)  
fxs=0.0         first shot (m)  
dx=50           x sampling interval (m)  
fx=0.           first x sample (m)  
dz=50           z sampling interval (m)  
nxb=nx/2        band width centered at midpoint (see note)  
nxc=0           horizontal range in which velocity is changed  
nzc=0           vertical range in which velocity is changed  
pert=0          =1 calculate time correction from v\_p[nx] [nz]  
vpfile          file containing slowness perturbation array v\_p[nx] [nz]  
ref="1:1,2;4,2" reflector(s): "amplitude:x1,z1;x2,z2;x3,z3;...  
smooth=0        =1 for smooth (piecewise cubic spline) reflectors  
ls=0            =1 for line source; =0 for point source  
tmin=10.0\*dt    minimum time of interest (sec)  
ndpfz=5         number of diffractors per Fresnel zone  
verbose=0       =1 to print some useful information

Notes:

This algorithm is based on formula (58) in Geo. Pros. 34, 686-703, by N. Bleistein.

Traveltime and amplitude are calculated by finite difference which

is done only in one of every NXD receivers; in skipped receivers, interpolation is used to calculate traveltime and amplitude. ", For each receiver, traveltime and amplitude are calculated in the horizontal range of  $(xg-nxb*dx, xg+nxb*dx)$ . Velocity is changed by constant extrapolation in two upper triangular corners whose width is  $nxc*dx$  and height is  $nzc*dz$ .

Eikonal equation will fail to solve if there is a polar turned ray. In this case, the program shows the related geometric information. There are three ways to remove the turned rays: smoothing velocity, reducing  $nxb$ , and increasing  $nxc$  and  $nzc$  (if the turned ray occurs in shallow areas). To prevent traveltime distortion from an over-smoothed velocity, traveltime is corrected based on the slowness perturbation.

More than one ref (reflector) may be specified. Note that reflectors are encoded as quoted strings, with an optional reflector amplitude: preceding the x,z coordinates of each reflector. Default amplitude is 1.0 if amplitude: part of the string is omitted.

Author: Zhenyue Liu, 07/20/92, Center for Wave Phenomena  
Many subroutines borrowed from Dave Hale's program: SUSYNLV

Trino Salinas, 07/30/96, fixed a bug in the geometry setting to allow the spread move with the shots.

Trace header fields set: trid, counit, ns, dt, delrt,  
tracl. tracr, fldr, tracf,  
sx, gx

SUSYNVXZ - SYNthetic seismograms of common offset V(X,Z) media via Kirchhoff-style modeling

susynvxz >outfile [optional parameters]

Required Parameters:

<vfile file containing velocities v[nx][nz]

nx= number of x samples (2nd dimension)

nz= number of z samples (1st dimension)

Optional Parameters:

nxb=nx band centered at midpoint

nxd=1 skipped number of midpoints

dx=100 x sampling interval (m)

fx=0.0 first x sample

dz=100 z sampling interval (m)

nt=101 number of time samples

dt=0.04 time sampling interval (sec)

ft=0.0 first time (sec)

nxo=1 number of offsets

dxo=50 offset sampling interval (m)

fxo=0.0 first offset (m)

nxm=101 number of midpoints

dxm=50 midpoint sampling interval (m)

fxm=0.0 first midpoint (m)

fpeak=0.2/dt peak frequency of symmetric Ricker wavelet (Hz)

ref="1:1,2;4,2" reflector(s): "amplitude:x1,z1;x2,z2;x3,z3;...

smooth=0 =1 for smooth (piecewise cubic spline) reflectors

ls=0 =1 for line source; default is point source

tmin=10.0\*dt minimum time of interest (sec)

ndpfz=5 number of diffractors per Fresnel zone

verbose=0 =1 to print some useful information

Notes:

This algorithm is based on formula (58) in Geo. Pros. 34, 686-703, by N. Bleistein.

Offsets are signed - may be positive or negative. ",  
Traveltime and amplitude are calculated by finite differences which is done only in part of midpoints; in the skipped midpoint, interpolation is used to calculate traveltime and amplitude. ",

More than one ref (reflector) may be specified.

Note that reflectors are encoded as quoted strings, with an optional

reflector amplitude: preceding the x,z coordinates of each reflector.  
Default amplitude is 1.0 if amplitude: part of the string is omitted.

CWP: Zhenyue Liu, 07/20/92

Many subroutines borrowed from Dave Hale's program: SUSYNLV

Trace header fields set: trid, counit, ns, dt, delrt,  
tracl. tracr,  
cdp, cdpt, d2, f2, offset, sx, gx

SUTAB - print non zero header values and data for non-graphic terminals

```
sutab <stdin itmin=0 itmax=last_sample count=all
```

Required parameters:

none

Optional parameters:

itmin=0 first time sample (zero-based) to plot

itmax= (last sample) last time sample (zero-based) to plot

count= (all traces) number of traces to plot

Example:

```
sutab <DATA itmin=32 itmax=63 count=10
```

Requests tab plot of samples 32 to 63 on the first 10 traces of DATA.

Credits:

CWP: Shuki Ronen, Jack K. Cohen

Trace header fields accessed: ns

SUTAPER - Taper the edge traces of a data panel to zero.

```
sutaper <stdin >stdout [optional parameters]
```

Optional Parameters:

ntr=tr.ntr number of traces. If tr.ntr is not set, then  
ntr is mandatory  
tr1=0 number of traces to be tapered at beginning  
tr2=tr1 number of traces to be tapered at end  
min=0. minimum amplitude factor of taper  
tbeg=0 length of taper (ms) at trace start  
tend=0 length of taper (ms) at trace end  
taper=1 taper type  
=1 linear (default)  
=2 sine  
=3 cosine  
=4 gaussian (+/-3.8)  
=5 gaussian (+/-2.0)

Notes:

To eliminate the taper, choose tbeg=0. and tend=0. and tr1=0

Credits:

CWP: Chris Liner, Jack K. Cohen

Trace header fields accessed: ns, ntr

Rewrite: Tagir Galikeev, October 2002

SUTAUP - forward and inverse T-X and F-K global slant stacks

```
sutaup <infile >outfile [optional parameters]
```

Optional Parameters:

```
option=1 =1 for forward F-K domain computation
=2 for forward T-X domain computation
=3 for inverse F-K domain computation
=4 for inverse T-X domain computation
dt=tr.dt (from header) time sampling interval (secs)
nx=ntr (counted from data) number of horizontal samples (traces)
dx=1 horizontal sampling interval (m)
npoints=71 number of points for rho filter
pmin=0.0 minimum slope for Tau-P transform (s/m)
pmax=1/500 maximum slope for Tau-P transform (s/m)
np=nx number of slopes for Tau-P transform
ntau=nt number of time samples in Tau-P domain
fmin=3 minimum frequency of interest

verbose=0 verbose = 1 echoes information
```

```
tmpdir= if non-empty, use the value as a directory path
prefix for storing temporary files; else if the
the CWP_TMPDIR environment variable is set use
its value for the path; else use tmpfile()
```

Notes:

The cascade of a forward and inverse tau-p transform preserves the relative amplitudes in a data panel, but not the absolute amplitudes meaning that a scale factor must be applied to data output by such a cascade before the output may be compared to the original data. This is a characteristic of the algorithm employed in this program. (Suradon does not have this problem.)

Credits: CWP: Gabriel Alvarez, 1995.

Reference:

Levin, F., editor, 1991, Slant-Stack Processing, Geophysics Reprint Series #14, SEG Press, Tulsa.

Trace header fields accessed: ns, dt

Trace header fields modified: dt,d2,f2

SUTIFOWLER VTI constant velocity prestack time migration  
velocity analysis via Fowler's method

sutifowler ncdps=250 vmin=1500 vmax=6000 dx=12.5

Required Parameter:

ncdps= number of input cdp's

Optional Parameters:

choose=1 1 do full prestack time migration

2 do only DMO

3 do only post-stack migrations

4 do only stacking velocity analysis

getcvstacks=0 flag to set to 1 if inputting precomputed cvstacks  
(vmin, nvstack, and ncdps must match SUCVS4FOWLER job)

vminstack=vmin minimum velocity panel in m/s in input cvstacks

etamin=0. minimum eta (see paper by Tariq Alkhalifah)

etamax=0.5 maximum eta (see paper by Tariq Alkhalifah)

neta=1 number of eta values to image

d=0. Thomsen's delta

vpvs=0.5 assumed vp/vs ratio (not critical -- default almost always ok)

dx=25. cdp x increment

vmin=1500. minimum velocity panel in m/s to output

vmax=8000. maximum velocity panel in m/s to output

nv=75 number of velocity panels to output

nvstack=180 number of stacking velocity panels to compute

( Let offmax be the maximum offset, fmax be

the maximum freq to preserve, and tmute be

the starting mute time in sec on offmax, then

the recommended value for nvstack would be

$nvstack = 4 + (\text{offmax} * \text{offmax} * \text{fmax}) / (0.6 * \text{vmin} * \text{vmin} * \text{tmute})$

---you may want to make do with less---

nypad=0 number of traces to padd for spatial fft

Ideally nypad =  $(0.5 * \text{tmax} * \text{vmax} + 0.5 * \text{offmax}) / \text{dx}$

lmute=24 length of mute taper in ms

nonhyp=1 1 if do mute at  $2 * \text{offset} / \text{vmin}$  to avoid non-hyperbolic  
moveout, 0 otherwise

lbtaper=0 length of bottom taper in ms

lstaper=0 length of side taper in traces

dtout=1.5\*dt output sample rate in s, note: typically

$\text{fmax} = \text{salias} * 0.5 / \text{dtout}$

mxfold=120 maximum number of offsets/input cmp

salias=0.8 fraction of output frequencies to force within sloth  
antialias limit. This controls muting by offset of

the input data prior to computing the cv stacks  
for values of choose=1 or choose=2.  
file=sutifowler root name for temporary files  
p=not Enter a path name where to put temporary files.  
specified Can enter multiple times to use multiple disk  
systems.  
The default uses information from the .VND file  
in the current directory if it exists, or puts  
unique temporary files in the current directory.  
ngroup=20 Number of cmps per velocity analysis group.  
printfile=stderr The output file for printout from this program.

Required trace header words on input are ns, dt, cdp, offset.  
On output, trace headers are rebuilt from scratch with  
ns - number of samples  
dt - sample rate in usec  
cdp - the output cmp number (0 based)  
offset - the output velocity  
tracf - the output velocity index (0 based)  
fldr - index for velocity analysis group (0 based, groups of ngroup cdps)  
ep - central cmp for velocity analysis group  
igc - index for choice of eta (0 based)  
igi - eta\*100  
sx=gx - x coordinate as icmp\*dx  
tracl=tracr -sequential trace count (1 based)

Note: Due to aliasing considerations, the small offset-to-depth  
ratio assumption inherent in the TI DMO derivation, and the  
poor stacking of some large-offset events associated with TI non-hyperbolic  
moveout, a fairly stiff initial mute is recommended for the  
long offsets. As a result, this method may not work well  
where you have multiple reflections to remove via stacking.

Note: The temporary files can be split over multiple disks by building  
a .VND file in your working directory. The .VND file is ascii text  
with the first line giving the number of directories followed by  
successive lines with one line per directory name.

Note: The output data order has primary key equal to cdp, secondary  
key equal to eta, and tertiary key equal to velocity.

Credits:

CWP: John Anderson (visitor to CSM from Mobil) Spring 1993



SUTIHALEDMO - TI Hale Dip MoveOut (based on Hale's PhD thesis)

```
sutihaledmo <infile >outfile [optional parameters]
```

Required Parameters:

nxmax maximum number of midpoints in common offset gather

Optional Parameters:

option=1 1 = traditional Hale DMO (from PhD thesis)  
2 = Bleistein's true amplitude DMO  
3 = Bleistein's cos\*cos weighted DMO  
4 = Zhang's DMO  
5 = Tsvankin's anisotropic DMO  
6 = Tsvankin's VTI DMO weak anisotropy approximation  
dx=50. midpoint sampling interval between traces  
in a common offset gather. (usually shot  
interval in meters)  
v=1500.0 velocity (in meters/sec)  
(must enter a positive value for option=3)  
(for excluding evanescent energy)  
h=200.0 source-receiver half-offset (in meters)  
ntpad=0 number of time samples to pad  
nxpad=h/dx number of midpoints to pad  
file=vnmo name of file with vnmo as a function of p  
used for option=5--otherwise not used  
(Generate this file by running program  
sutivel with appropriate list of Thomsen's  
parameters.)  
e=0. Thomsen's epsilon  
d=0. Thomsen's delta

Note:

This module assumes a single common offset gather after NMO is to be input, DMO corrected, and output. It is useful for computing theoretical DMO impulse responses. The Hale algorithm is computationally intensive and not commonly used for bulk processing of all of the offsets on a 2-D line as there are cheaper alternative algorithms. The Hale algorithm is commonly used in theoretical studies. Bulk processing for multiple common offset gathers is typically done using other modules.

Test run: suspik | sutihaledmo nxmax=32 option=1 v=1500 | suxwib &

Author: (Visitor to CSM from Mobil) John E. Anderson Spring 1994

References: Anderson, J.E., and Tsvankin, I., 1994, Dip-moveout by  
Fourier transform in anisotropic media, CWP-146

SUTIVEL - SU Transversely Isotropic velocity table builder  
computes vnmo or vphase as a function of Thomsen's parameters and  
theta and optionally interpolate to constant increments in slowness

Optional Parameters:

a=2500. alpha (vertical p velocity)  
b=1250. beta (vertical sv velocity)  
e=.20 epsilon (horiz p-wave anisotropy)  
d=.10 delta (strange parameter)  
maxangle=90.0 max angle in degrees  
nangle=9001 number of angles to compute  
verbose=0 set to 1 to see full listing  
np=8001 number of slowness values to output  
option=1 1=output vnmo(p) (result used for TI DMO)  
2=output vnmo(theta) in degrees  
3=output vnmo(theta) in radians  
4=output vphase(p)  
5=output vphase(theta) in degrees  
6=output vphase(theta) in radians  
7=output first derivative vphase(p)  
8=output first derivative vphase(theta) in degrees  
9=output first derivative vphase(theta) in radians  
10=output second derivative vphase(p)  
11=output second derivative vphase(theta) in degrees  
12=output second derivative vphase(theta) in radians  
13=( 1/vnmo(0)^2 -1/vnmo(theta)^2 )/p^2 test vs theta  
(result should be zero for all theta for d=e)  
14=return vnmo(p) for weak anisotropy  
normalize=0 =1 means scale vnmo by cosine and scale vphase by  
1/sqrt(1+2\*e\*sin(theta)\*sin(theta))  
(only useful for vphase when d=e for constant  
result)  
=0 means output vnmo or vphase unnormalized

Output on standard output is ascii text with:

line 1: number of values  
line 2: abscissa increment (p or theta increment, always starts at zero)  
line 3-n: one value per line

Author: (visitor to CSM from Mobil) John E. Anderson, Spring 1994

SUTSQ -- time axis time-squared stretch of seismic traces

sutsq [optional parameters] <stdin >stdout

Required parameters:

none

Optional parameters:

tmin= .1\*nt\*dt    minimum time sample of interest  
                  (only needed for forward transform)  
dt= .004            output sample rate  
                  (only needed for inverse transform)  
flag= 1            1=forward transform: time to time squared  
                  -1=inverse transform: time squared to time

Note: The output of the forward transform always starts with time squared equal to zero. 'tmin' is used to avoid aliasing the early times.

Caveats:

Amplitudes are not well preserved.

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt

SUTTOZ - resample from time to depth

suttoz <stdin >stdout [optional parms]

Optional Parameters:

$nz=1+(nt-1)*dt*vmax/(2.0*dz)$  number of depth samples in output

$dz=vmin*dt/2$  depth sampling interval (defaults avoids aliasing)

$fz=v(ft)*ft/2$  first depth sample

$t=0.0, \dots$  times corresponding to interval velocities in  $v$

$v=1500.0, \dots$  interval velocities corresponding to times in  $t$

$vfile=$  binary (non-ascii) file containing velocities  $v(t)$

$verbose=0 >0$  to print depth sampling information

Notes:

Default value of  $nz$  set to avoid aliasing

The  $t$  and  $v$  arrays specify an interval velocity function of time.

Note that  $t$  and  $v$  are given as arrays of floats separated by commas, for example:

$t=0.0, 0.01, .2, \dots$   $v=1500.0, 1720.0, 1833.5, \dots$  with the number of  $t$  values equaling the number of  $v$  values. The velocities are linearly interpolated to make a continuous, piecewise linear  $v(t)$  profile.

Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in  $t$  must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If  $vfile$  is specified, then the  $t$  and  $v$  arrays are ignored.

see selfdoc of `suztot` for depth to time conversion

Trace header fields accessed:  $ns$ ,  $dt$ , and  $delrt$

Trace header fields modified:  $trid$ ,  $ns$ ,  $d1$ , and  $f1$

Credits:

CWP: Dave Hale c. 1992

SUTVBAND - time-variant bandpass filter (sine-squared taper)

```
sutvband <stdin >stdout tf= f=
```

Required parameters:

```
dt = (from header)      time sampling interval (sec)
tf=                    times for which f-vector is specified
f=f1,f2,f3,f4         Corner frequencies corresponding to the
                      times in tf. Specify as many f= as
                      there are entries in tf.
```

The filters are applied in frequency domain.

Example:

```
sutvband <data tf=.2,1.5 f=10,12.5,40,50 f=10,12.5,30,40 | ...
```

Credits:

CWP: Jack, Ken

Trace header fields accessed: ns, dt, delrt

SUTXTAPER - TAPER in (X,T) the edges of a data panel to zero.

sutxtaper <stdin >stdout [optional parameters]

Optional Parameters:

low=0. minimum amplitude factor of taper

tbeg=0 length of taper (ms) at trace start

tend=0 length of taper (ms) at trace end

taper=1 taper type  
=1 linear (default)  
=2 sine  
=3 cosine  
=4 gaussian (+/-3.8)  
=5 gaussian (+/-2.0)

key=tr set key to compute x-domain taper weights

default is using internal tracecount (tr)

tr1=0 number of traces to be tapered at beg (key=tr)

tr2=tr1 number of traces to be tapered at end (key=tr)

min=0. minimum value of key where taper starts (amp=1.)

max=0. maximum value of key where taper starts (amp=1.)

dx=1. length of taper (in key units)

if key=tr (unset) length is tr1 and (ntr-tr2)

Notes:

Taper type is used for trace (x-domain) tapering as well as for time domain tapering.

The taper is applied to all traces <tr1 (or key<min) and >tr2 (or key >max) and all time samples <tbeg and >tend.

Taper weights are amp\*1 for traces  $n$   $tr1 < n < tr2$  and computed for all other traces corresponding to the taper typ.

If key is given the taper length is defined by dx, otherwise the length of taper is tr1 and (ntr-tr2) respectively.

To eliminate the taper, choose tbeg=0. and tend=0. and tr1=0

If key is set, min,max values take precedence over tr1,tr2.

Credits: (based on sutaper)

CWP: Chris Liner, Jack K. Cohen

Trace header fields accessed: ns

Rewrite: Tagir Galikeev, October 2002

Rewrite: Gerald Klein, IFM-GEOMAR, April 2004

SUUNPACK1 - unpack segy trace data from chars to floats

```
suunpack1 <packed_file >unpacked_file
```

suunpack1 is the approximate inverse of supack1

Credits:

CWP: Jack K. Cohen, Shuki Ronen, Brian Sumner

Caveats:

This program is for single site use with supack1. See the supack1 header comments.

Notes:

ungpow and unscale are defined in segy.h

trid = CHARPACK is defined in su.h and segy.h

Trace header fields accessed: ns, trid, ungpow, unscale

Trace header fields modified: trid, ungpow, unscale

SUUNPACK2 - unpack segy trace data from shorts to floats

```
suunpack2 <packed_file >unpacked_file
```

suunpack2 is the approximate inverse of supack2

Credits:

CWP: Jack K. Cohen, Shuki Ronen, Brian Sumner

Revised: 7/4/95 Stewart A. Levin Mobil

Changed decoding to parallel 2 byte encoding of supack2

Caveats:

This program is for single site use with supack2. See the supack2 header comments.

Notes:

ungpow and unscale are defined in segy.h

trid = SHORTPACK is defined in su.h and segy.h

Trace header fields accessed: ns, trid, ungpow, unscale

Trace header fields modified: trid, ungpow, unscale

SUUTM - UTM projection of longitude and latitude in SU trace headers

suutm <stdin >stdout [optional parameters]

Optional parameters:

counit=(from header) input coordinate units code:  
                          =1: length (meters or feet; no UTM projection)  
                          =2: seconds of arc  
                          =3: decimal degrees  
                          =4: degrees, minutes, seconds  
idx=23                  reference ellipsoid index (default is WGS 1984)  
a=(from idx)          user-specified semimajor axis of ellipsoid  
f=(from idx)          user-specified flattening of ellipsoid  
zkey=                  if set, header key to store UTM zone number  
verbose=0              =1: echo ellipsoid parameters  
  
lon0=                  central meridian for TM projection in degrees  
                          (default uses the 60 standard UTM longitude zones)  
xoff=500000          false Easting (default: UTM)  
ysoff=10000000      false Northing, southern hemisphere (default: UTM)  
ynoff=0              false Northing, northern hemisphere (default: UTM)

Notes:

Universal Transverse Mercator (UTM) coordinates are defined between latitudes 80S (-80) and 84N (84). Longitude values must be between -180 degrees (west) and 179.999... degrees (east).

Latitudes are read from sy and gy (N positive), and longitudes are read from sx and gx (E positive).

The UTM zone is determined from the receiver coordinates gy and gx.

Use suazimuth to calculate shot-receiver azimuths and offsets.

Reference ellipsoids:

An ellipsoid may be specified by its semimajor axis a and its flattening f, or one of the following ellipsoids may be selected by its index idx (semimajor axes in meters):

- 0 Sphere with radius of 6371000 m
- 1 Airy 1830
- 2 Australian National 1965
- 3 Bessel 1841 (Ethiopia, Indonesia, Japan, Korea)
- 4 Bessel 1841 (Namibia)
- 5 Clarke 1866

- 6 Clarke 1880
- 7 Everest (Brunei, E. Malaysia)
- 8 Everest (India 1830)
- 9 Everest (India 1956)
- 10 Everest (Pakistan)
- 11 Everest (W. Malaysia, Singapore 1948)
- 12 Everest (W. Malaysia 1969)
- 13 Geodetic Reference System 1980 (GRS 1980)
- 14 Helmert 1906
- 15 Hough 1960
- 16 Indonesian 1974
- 17 International 1924 / Hayford 1909
- 18 Krassovsky 1940
- 19 Modified Airy
- 20 Modified Fischer 1960
- 21 South American 1969
- 22 World Geodetic System 1972 (WGS 1972)
- 23 World Geodetic System 1984 (WGS 1984) / NAD 1983

UTM grid:

The Universal Transverse Mercator (UTM) system is a world wide coordinate system defined between 80S and 84N. It divides the Earth into 60 six-degree zones. Zone number 1 has its central meridian at 177W (-177 degrees), and numbers increase eastward.

Within each zone, an Easting of 500,000 m is assigned to its central meridian to avoid negative coordinates. On the northern hemisphere, Northings start at 0 m at the equator and increase northward. On the southern hemisphere a false Northing of 10,000,000 m is applied, i.e. Northings start at 10,000,000 m at the equator and decrease southward.

Coordinate encoding (sx,sy,gx,gy):

- count=1 units of length (coordinates are not converted)
- count=2 seconds of arc
- count=3 decimal degrees
- count=4 degrees, minutes and seconds encoded as integer DDDMMSS  
with scalco=1 or DDDMMSS.ss with scalco=-100 (see segy.h)

Units of length are also assumed, if count <= 0 or count >= 5.

Author:

Nils Maercklin, RISSC, University of Naples, Italy, March 2007

References:

- NIMA (2000). Department of Defense World Geodetic System 1984 - its definition and relationships with local geodetic systems. Technical Report TR8350.2. National Imagery and Mapping Agency, Geodesy and Geophysics Department, St. Louis, MO. 3rd edition.
- J. P. Snyder (1987). Map Projections - A Working Manual. U.S. Geological Survey Professional Paper 1395, 383 pages. U.S. Government Printing Office.

Trace header fields accessed: sx, sy, gx, gy, scalco, counit

Trace header fields modified: sx, sy, gx, gy, scalco, counit

SUVCAT - append one data set to another, with or without an overlap region. Data in the overlap may be determined by one of several methods.

```
suvcat data1 data2 >stdout
```

Required parameters:  
none

Optional parameters for overlapping sections:

taplen=0 Length of overlap in integer number of samples. (Default is 0.)

tatype=0 Type of taper or combination method in the overlap region.  
0 - average  
1 - maximum magnitude  
2 - cosine scaled  
3 - summation

Computational Notes:

This program vertically concatenates traces from data2 onto the end of the corresponding traces in data1, with a region of overlap, defined by taplen. Data in the overlapping region is combined by the method specified by tatype. The currently available methods are:

tatype=0 output is assigned the unweighted average of each point in the overlap  
tatype=1 output is assigned the value of the maximum absolute value of each point in the overlap  
tatype=2 output is assigned the weighted average of each point in the overlap, where the output is the sum of  $\cos(x)$  times the values on the first section, and  $1-\cos(x)$  times the values on the second section, where  $x$  is factor that goes from 0 to  $\pi/2$  across the overlap. This favors the upper section in the upper part of the overlap, and favors the lower section in the lower part of the overlap.  
tatype=3 output is assigned the sum of the amplitudes at each sample in the overlap

Credits:

CWP: Jack K. Cohen, Michel Dietrich (Original SUVCAT)

Steven D. Sheaffer (modified to include overlap)

IfG Kiel: Thies Beilecke (added taptype=3)

Trace header fields accessed: ns

Trace header fields modified: ns

SUVEL2DF - compute stacking VELOCITY semblance for a single time in over Vnmo and eta in 2-D

suvel2df <stdin >stdout [optional parameters]

Required Parameters:

tn zero-offset time of reflection  
offsetm Maximum offset considered

Optional Parameters:

nv=50 number of velocities  
dv=50.0 velocity sampling interval  
fv=1500.0 first velocity  
nvh=50 number of horizontal velocities  
dvh=50.0 horizontal velocity sampling interval  
fvh=1500.0 first horizontal velocity  
xod=1.5 maximum offset-to-depth ratio to resolve  
dtratio=5 ratio of output to input time sampling intervals  
nsmooth=dtratio\*2+1 length of semblance num and den smoothing window  
verbose=0 =1 for diagnostic print on stderr  
vavg=fv+0.5\*(nv-1)\*dv average velocity used in the search

Notes:

Semblance is defined by the following quotient:

$$s(t) = \frac{\sum_{j=0}^{n-1} q(t,j)^2}{\sum_{j=0}^{n-1} [q(t,j)]^2}$$

where n is the number of non-zero samples after muting.

Smoothing (nsmooth) is applied separately to the numerator and denominator before computing this semblance quotient.

Input traces should be sorted by cdp - suvel2df outputs a group of semblance traces every time cdp changes. Therefore, the output will be useful only if cdp gathers are input.

Credits:

CWP: Tariq Alkhalifah, February 1997

Trace header fields accessed: ns, dt, delrt, offset, cdp.

Trace header fields modified: ns, dt, offset.

SUVELAN\_NCCS - compute stacking VELOCITY panel for cdp gathers  
using Normalized CrossCorrelation Sum

```
suvelan_uccs <stdin >stdout [optional parameters]
```

Optional Parameters:

nx=tr.cdpt	number of traces in cdp
nv=50	number of velocities
dv=50.0	velocity sampling interval
fv=1500.0	first velocity
smute=1.5	samples with NMO stretch exceeding smute are zeroed
dtratio=5	ratio of output to input time sampling intervals
nsmooth=dtratio*2+1	length of smoothing window
verbose=0	=1 for diagnostic print on stderr
pwr=1.0	semblance value to the power

Notes:

Normalized CrossCorrelation sum: sum all possible crosscorrelation trace pairs in a CMP gather for each trial velocity and zero-offset two-way travel time inside a time window. This coherence measure is normalized by dividing each crosscorrelation trace pair by the geometric mean of the energy, inside the chosen time window, of each trace pair involved in each crosscorrelation. Then, to achieve a maximum amplitude of unity, the result is multiplied by  $2/(M(M-1))$ , which is the inverse of the total number of crosscorrelation. The normalization allows to bring out weak reflection as long as these reflections have moveouts close to a hyperbola.

Credits:

CWP: Valmore Celis, Sept 2002

Based on the original code: suvelan.c

Colorado School of Mines: Dave Hale, c. 1989

Trace header fields accessed: ns, dt, delrt, offset, cdp, cdpt

Trace header fields modified: ns, dt, offset, cdp

Reference: Neidell, N.S., and Taner, M.T., 1971, Semblance and other coherency measures for multichannel data: Geophysics, 36, 498-509.



SUVELAN\_NSEL - compute stacking VELOCITY panel for cdp gathers using the Normalized Selective CrossCorrelation sum

```
suvelan_usel <stdin >stdout [optional parameters]
```

Optional Parameters:

<code>nx=tr.cdpt</code>	number of traces in cdp
<code>dx=tr.d2</code>	offset increment
<code>nv=50</code>	number of velocities
<code>dv=100.0</code>	velocity sampling interval
<code>fv=1500.0</code>	first velocity
<code>tau=0.5</code>	threshold for significance values
<code>smute=1.5</code>	samples with NMO stretch exceeding smute are zeroed
<code>dtratio=5</code>	ratio of output to input time sampling intervals
<code>nsmooth=dtratio*2+1</code>	length of smoothing window
<code>verbose=0</code>	=1 for diagnostic print on stderr
<code>pwr=1.0</code>	semblance value to the power

Notes:

Normalized Selective CrossCorrelation Sum: is based on the coherence measure known as crosscorrelation sum. The difference is that the selective approach sum only crosscorrelation pairs with relatively large differential moveout, thus increasing the resolving power in the velocity spectra compared to that achieved by conventional methods. The normalization is achieved in much the same way of normalizing the conventional crosscorrelation sum.

Each crosscorrelation is divided by the geometric mean of the energy of the traces involved, and the multiplying by a constant to achieve maximum amplitude of unity. The constant is just the inverse of the total number of crosscorrelations included in the sum. The selection is made using a parabolic approximation of the differential moveout and imposing a threshold for those differential moveouts.

That threshold is the parameter tau in this program, which varies between 0 to 1. A value of tau=0, means conventional crosscorrelation sum is applied implying that all crosscorrelations are included in the sum. In contrast, a value of tau=1 (not recommended) means that only the crosscorrelation formed by the trace pair involving the shortest and longest offset is included in the sum. Intermediate values will produce percentages of the crosscorrelations included in the sum that will be shown in the screen before computing the velocity spectra. Typical values for tau are between 0.2 and 0.6, producing approximated percentages of crosscorrelations summed

between 60% and 20%. The higher the value of tau the lower the percentage and higher the increase in the resolving power of velocity spectra.

Keeping the percentage of crosscorrelations included in the sum between 20% and 60% will increase resolution and avoid the presence of artifacts in the results. In data contaminated by random noise or statics distortions is recommended to maintain the percentage of crosscorrelations included in the sum above 25%. After computing the velocity spectra one might want to adjust the level and number of contours before velocity picking.

Credits: CWP: Valmore Celis, Sept 2002

Based on the original code: suvelan.c  
Colorado School of Mines: Dave Hale c. 1989

References:

Neidell, N.S., and Taner, M.T., 1971, Semblance and other  
coherency measures for multichannel data: Geophysics, 36, 498-509.  
Celis, V. T., 2002, Selective-correlation velocity analysis: CSM thesis.

Trace header fields accessed: ns, dt, delrt, offset, cdp  
Trace header fields modified: ns, dt, offset, cdp

SUVELAN - compute stacking velocity semblance for cdp gathers

suvelan <stdin >stdout [optional parameters]

Optional Parameters:

nv=50	number of velocities
dv=50.0	velocity sampling interval
fv=1500.0	first velocity
anis1=0.0	quartic term, numerator of an extended quartic term
anis2=0.0	in denominator of an extended quartic term
smute=1.5	samples with NMO stretch exceeding smute are zeroed
dtratio=5	ratio of output to input time sampling intervals
nsmooth=dtratio*2+1	length of semblance num and den smoothing window
verbose=0	=1 for diagnostic print on stderr
pwr=1.0	semblance value to the power

Notes:

Velocity analysis is usually a two-dimensional screen for optimal values of the vertical two-way traveltime and stacking velocity. But if the traveltime curve is no longer close to a hyperbola, the quartic term of the traveltime series should be considered. In its easiest form (with anis2=0) the optimization of all parameters requires a three-dimensional screen. This is done by a repetition of the conventional two-dimensional screen with a variation of the quartic term. The extended quartic term is more accurate, though the function is no more a polynomial. When screening for optimal values the theoretical dependencies between these parameters can be taken into account. The traveltime function is defined by

$$t^2 = t_0^2 + \frac{1}{v^2} x^2 + \frac{\text{anis1}}{1 + \text{anis2} x^2} x^4$$

The coefficients anis1, anis2 are assumed to be small, that means the non-hyperbolicity is assumed to be small. Triplications cannot be handled.

Semblance is defined by the following quotient:

$$s(t) = \frac{[\sum_{j=0}^{n-1} q(t,j)]^2}{n \sum_{j=0}^{n-1} [q(t,j)]^2}$$

j=0

where n is the number of non-zero samples after muting.  
Smoothing (nsmooth) is applied separately to the numerator and denominator before computing this semblance quotient.

Then, the semblance is set to the power of the parameter pwr. With pwr > 1 the difference between semblance values is stretched in the upper half of the range of semblance values [0,1], but compressed in the lower half of it; thus, the few large semblance values are enhanced. With pwr < 1 the many small values are enhanced, thus more discernible against background noise. Of course, always at the expense of the respective other feature.

Input traces should be sorted by cdp - suvelan outputs a group of semblance traces every time cdp changes. Therefore, the output will be useful only if cdp gathers are input.

Credits:

CWP, Colorado School of Mines:

Dave Hale (everything except ...)

Bjoern Rommel (... the quartic term)

SINTEF, IKU Petroleumsforskning

Bjoern Rommel (... the power-of-semblance function)

Trace header fields accessed: ns, dt, delrt, offset, cdp

Trace header fields modified: ns, dt, offset, cdp

SUVELAN\_UCCS - compute stacking VELOCITY panel for cdp gathers  
using UnNormalized CrossCorrelation Sum

```
suvelan_uccs <stdin >stdout [optional parameters]
```

Optional Parameters:

nx=tr.cdpt	number of traces in cdp
nv=50	number of velocities
dv=50.0	velocity sampling interval
fv=1500.0	first velocity
smute=1.5	samples with NMO stretch exceeding smute are zeroed
dtratio=5	ratio of output to input time sampling intervals
nsmooth=dtratio*2+1	length of smoothing window
verbose=0	=1 for diagnostic print on stderr
pwr=1.0	semblance value to the power

Notes:

Unnormalized crosscorrelation sum: sum all possible crosscorrelation trace pairs in a CMP gather for each trial velocity and zero-offset two-way travel time inside a time window. This unnormalized coherency measure produces large spectral amplitudes for strong reflections and small spectral amplitudes for weaker ones. If M is the number of traces in the CMP gather  $M(M-1)/2$  is the total number of crosscorrelations for each trial velocity and zero-offset two-way traveltime.

Credits: CWP: Valmore Celis, Sept 2002

Based on the original code: suvelan.c

Colorado School of Mines: Dave Hale c. 1989

Reference: Neidell, N.S., and Taner, M.T., 1971, Semblance and other coherency measures for multichannel data: Geophysics, 36, 498-509.

Trace header fields accessed: ns, dt, delrt, offset, cdp

Trace header fields modified: ns, dt, offset, cdp

SUVELAN\_USEL - compute stacking velocity panel for cdp gathers using the UnNormalized Selective CrossCorrelation Sum

```
suvelan_usel <stdin >stdout [optional parameters]
```

Optional Parameters:

nx=tr.cdpt	number of traces in cdp
dx=tr.d2	offset increment
nv=50	number of velocities
dv=50.0	velocity sampling interval
fv=1500.0	first velocity
tau=0.5	threshold for significance values
smute=1.5	samples with NMO stretch exceeding smute are zeroed
dtratio=5	ratio of output to input time sampling intervals
nsmooth=dtratio*2+1	length of smoothing window
verbose=0	=1 for diagnostic print on stderr
pwr=1.0	semblance value to the power

Notes:

UnNormalized Selective CrossCorrelation sum: is based on the coherence measure known as crosscorrelation sum. The difference is that the selective approach sum only crosscorrelation pairs with relatively large differential moveout, thus increasing the resolving power in the velocity spectra compared to that achieved by conventional methods. The selection is made using a parabolic approximation of the differential moveout and imposing a threshold for those differential moveouts.

That threshold is the parameter tau in this program, which varies between 0 to 1. A value of tau=0, means conventional crosscorrelation sum is applied implying that all crosscorrelations are included in the sum. In contrast, a value of tau=1 (not recommended) means that only the crosscorrelation formed by the trace pair involving the shortest and longest offset is included in the sum. Intermediate values will produce percentages of the crosscorrelations included in the sum that will be shown in the screen before computing the velocity spectra. Typical values for tau are between 0.2 and 0.6, producing approximated percentages of crosscorrelations summed between 60% and 20%. The higher the value of tau the lower the percentage and higher the increase in the resolving power of velocity spectra.

Keeping the percentage of crosscorrelations included in the sum between 20% and 60% will increase resolution and avoid the precense of artifacts in the results. In data contaminated by random noise or statics distortions is

recomended to mantaing the percentage of crosscorrelations included in the sum above 25%. After computing the velocity spectra one might want to adjust the level and number of contours before velocity picking.

Credits: CWP: Valmore Celis, Sept 2002

Based on the original code: suvelan\_.c  
Colorado School of Mines: Dave Hale c. 1989

References:

Neidell, N.S., and Taner, M.T., 1971, Semblance and other coherency measures for multichannel data: Geophysics, 36, 498-509.  
Celis, V. T., 2002, Selective-correlation velocity analysis: CSM thesis.

Trace header fields accessed: ns, dt, delrt, offset, cdp

Trace header fields modified: ns, dt, offset, cdp

SUVIBRO - Generates a Vibroseis sweep (linear, linear-segment, dB per Octave, dB per Hertz, T-power)

```
suviro [optional parameters] > out_data_file
```

Optional Parameters:

```
dt=0.004 time sampling interval
sweep=1    linear sweep
          =2 linear-segment
          =3 decibel per octave
          =4 decibel per hertz
          =5 t-power
swconst=0.0 sweep constant (see note)
f1=10.0 sweep frequency at start
f2=60.0 sweep frequency at end
tv=10.0 sweep length
phz=0.0 initial phase (degrees)
fseg=10.0,60.0 frequency segments (see notes)
tseg=0.0,10.0 time segments (see notes)
t1=1.0 length of taper at start (see notes)
t2=1.0 length of taper at end (see notes)
taper=1 linear
      =2 sine
=3 cosine
=4 gaussian (+/-3.8)
=5 gaussian (+/-2.0)
```

Notes:

The default tapers are linear envelopes. To eliminate the taper, choose t1=t2=0.0.

"swconst" is active only with nonlinear sweeps, i.e. when sweep=3,4,5. ",

"tseg" and "fseg" arrays are used when only sweep=2

Author: CWP: Michel Dietrich

Rewrite: Tagir Galikeev, CWP, 7 October 1994

Trace header fields set: ns, dt, tracl, sfs, sfe, slen, styp

SUVLENGTH - Adjust variable length traces to common length

suvlength <vdata >stdout

Required parameters:

none

Optional parameters:

ns output number of samples (default: 1st trace ns)

SUWAVEFORM - generate a seismic wavelet

suwaveform <stdin >stdout [optional parameters]

Required parameters:

one of the optional parameters listed below

Optional parameters:

type=akb	wavelet type
akb:	AKB wavelet defined by max frequency fpeak
berlage:	Berlage wavelet
gauss:	Gaussian wavelet defined by frequency fpeak
gaussd:	Gaussian first derivative wavelet
ricker1:	Ricker wavelet defined by frequency fpeak
ricker2:	Ricker wavelet defined by half and period
spike:	spike wavelet, shifted by time tspike
unit:	unit wavelet, i.e. amplitude = 1 = const.
dt=0.004	time sampling interval in seconds
ns=	if set, number of samples in output trace
fpeak=20.0	peak frequency of a Berlage, Ricker, or Gaussian, and maximum frequency of an AKB wavelet in Hz
half=1/fpeak	Ricker wavelet "ricker2": half-length
period=c*half	Ricker wavelet "ricker2": period ( $c=\sqrt{6}/\pi$ )
distort=0.0	Ricker wavelet "ricker2": distortion factor
decay=4*fpeak	Berlage wavelet: exponential decay factor in 1/sec
tn=2	Berlage wavelet: time exponent
ipa=-90	Berlage wavelet: initial phase angle in degrees
tspike=0.0	Spike wavelet: time at spike in seconds
verbose=0	1: echo output wavelet length

Notes:

If ns is not defined, the program determines the trace length depending on the dominant signal period.

The Ricker wavelet "ricker1" and the Gaussian wavelet "gauss" are zero-phase. For these two wavelets, the trace header word delrt is set such that the peak amplitude is at t=0 seconds. If this is not acceptable, use "sushw key=delrt a=0".

The Ricker wavelets can be defined either by the peak frequency `fpeak` ("ricker1") or by its half-length, the period, and a distortion factor ("ricker2"). "ricker" is an acceptable alias for "ricker1".

The Berlage wavelet is defined by the peak frequency `fpeak`, a time time exponent `tn` describing the wavelet shape at its beginning, and an exponential decay factor describing the amplitude decay towards later times. The parameters `tn` and `decay` are non-negative, real numbers; `tn` is typically a small integer number and `decay` a multiple of the dominant signal period  $1/fpeak$ . Additionally, an initial phase angle can be given; use -90 or 90 degrees for zero-amplitude at the beginning.

For an AKB wavelet, `fpeak` is the maximum frequency; the peak frequency is about 1/3 of the `fpeak` value.

The output wavelet can be normalized or scaled with "sugain". Use "suviBro" to generate a Vibroseis sweep.

Example:

A normalized, zero-phase Ricker wavelet with a peak frequency of 15 Hz is generated and convolved with a spike dataset:

```
suwaveform type=ricker1 fpeak=15 | sugain pbal=1 > wavelet.su
suplane npl=1 | suconv sufile=wavelet.su | suxwigg
```

Caveat:

This program does not check for aliasing.

Author:

Nils Maercklin, RISSC, University of Napoli, Italy, 2006

References:

- Aldridge, D. F. (1990). The Berlage wavelet. *Geophysics*, vol. 55(11), p. 1508-1511.
- Alford, R., Kelly, K., and Boore, D. (1947). Accuracy of finite-difference modeling of the acoustic wave equation. *Geophysics*, vol. 39, p. 834-842. (AKB wavelet)
- Sheriff, R. E. (2002). *Encyclopedic dictionary of applied geophysics*. Society of Exploration Geophysicists, Tulsa. (Ricker wavelet, page 301)

Notes:

For more information on the wavelets type "sudoc waveforms"  
or have a look at "\$CWPROOT/src/cwp/lib/waveforms.c".

Credits:

CWP, the authors of the subroutines in "waveforms.c".

Trace header fields set: ns, dt, trid, delrt

SUWEIGHT - weight traces by header parameter, such as offset

```
suweight < stdin > stdout [optional parameters]
```

Required Parameters:

<none>

Optional parameters:

key=offset keyword of header field to weight traces by

a=1.0 constant weighting parameter (see notes below)

b=.0005 variable weighting parameter (see notes below)

... or use values of a header field for the weighting ...

key2= keyword of header field to draw weights from

scale=.0001 scale factor to apply to header field values

inv=0 weight by header value

=1 weight by inverse of header value

Notes:

This code is initially written with offset weighting in mind, but may be used for other, user-specified schemes.

The rationale for this program is to correct for unwanted linear amplitude trends with offset prior to either CMP stacking or AVO work. The code has to be edited should other functions of a keyword be required.

The default form of the weighting is to multiply the amplitudes of the traces by a factor of:  $( a + b*\text{keyword} )$ .

If key2= header field is set then this program uses the weighting values read from that header field, instead. Note, that because most header fields are integers, the scale=.0001 permits 10001 in the header to represent 1.0001.

To see the list of available keywords, type: `sukeyword -o <CR>`

Credits:

Author: CWP: John Stockwell February 1999.

Written for Chris Walker of UniqueStep Ltd., Bedford, U.K.

inv option added by Garry Perratt (Geocon).

header fields accessed: ns, keyword

SUWELLRF - convert WELL log depth, velocity, density data into a uniformly sampled normal incidence Reflectivity Function of time

```
suwellrf [required parameters] [optional parameters] > [stdout]
```

Required Parameters:

dvrfile= file containing depth, velocity, and density values

...or...

dvfile= file containing depth and velocity values

drfile= file containing depth and density values

...or...

dfile= file containing depth values

vfile= file containing velocity log values

rhofile= file containing density log values

nval= number of triplets of d,v,r values if dvrfile is set,  
number of pairs of d,v and d,r values dvfile and drfile  
are set, or number of values if dfile, vfile, and rhofile  
are set.

Optional Parameters:

dtout=.004 desired time sampling interval (sec) in output

ntr=1 number of traces to output

Notes:

The format of the input file(s) is C-style binary float. These files may be constructed from ascii file via:

```
a2b n1=3 < dvrfile.ascii > dvrfile.bin
```

...or...

```
a2b n1=2 < dvfile.ascii > dvfile.bin
```

```
a2b n1=2 < drfile.ascii > drfile.bin
```

...or...

```
a2b n1=1 < dfile.ascii > dfile.bin
```

```
a2b n1=1 < vfile.ascii > vfile.bin
```

```
a2b n1=1 < rhofile.ascii > rhofile.bin
```

A raw normal-incidence impedance reflectivity as a function of time is generated using the smallest two-way traveltime implied by the input velocities as the time sampling interval. This raw reflectivity trace is then resampled to the desired output time sampling interval via 8 point sinc interpolation. If the number of samples on the output exceeds SU\_NFLTS the output trace will be truncated to that value.

Caveat:

This program is really only a first rough attempt at creating a well log utility. User input and modifications are welcome.

See also: suresamp

Author: CWP: John Stockwell, Summer 2001, updated Summer 2002.  
inspired by a project by GP grad student Leo Brown

SUWINDPOLY - WINDOW data to extract traces on or within a respective POLYgonal line or POLYgon with coordinates specified by header keyword values

```
suwindpoly <stdin [Required parameters] [Optional params] file=outfile
```

Required parameters:

x=x1,x2,... list of X coordinates for vertices

y=y1,y2,... list of Y coordinates for vertices

file=file1,file2,... output filename(s)

Optional parameters

xkey=fldr X coordinate header key

ykey=ep Y coordinate header key

pass=0 polyline mode: pass traces near the polygonal line

=1 pass all traces interior to polygon

=2 pass all traces exterior to polygon

Optional parameters used in polyline pass=0 mode only:

The following need to be given if the unit increments in the X & Y directions are not equal. For example, if fldr increments by 1 and ep increments by 4 to form 25 x 25 m bins specify dx=25.0 & dy=6.25. The output binning key will be converted to integers by the scaling with the smaller of the two values.

dx=1.0 unit increment distance in X direction

dy=1.0 unit increment distance in Y direction

ilkey=tracl key for resulting inline index in polyline mode

xlkey=tracr key for resulting xline index in polyline mode

dw=1.0 distance in X-Y coordinate units of extracted line

to pass points to output. Width of resulting line is

2\*dw. Ignored if polygon mode is specified.

Notes:

In polyline mode (pass=0), a single trace may be output multiple times if it meets the acceptance criteria (distance from line segment < dw) for multiple line segments. However, the headers will be distinct and will associate the output trace with a line segment. This behavior facilitates creation of 3D supergathers from polyline output. Use susort after running in polyline mode.

x=& y=lists should be repeated for as many polygons as needed when pass=1 or pass=2.

In polygon mode, the polygon closes itself from the last vertex to the first.

Example:

```
suwindpoly <input.su x=10,20,50 y=0,30,60 dw=10 pass=0 file=out.su
```

Credits: Reginald H. Beardsley [rhb@acm.org](mailto:rhb@acm.org)

originally: `suxarb.c` adapted from the SLT/SU package.

SUWIND - window traces by key word

```
suwind <stdin >stdout [options]
```

Required Parameters:

none

Optional Parameters:

verbose=0 =1 for verbose

key=tracl Key header word to window on (see segy.h)

min=LONG\_MIN min value of key header word to pass

max=LONG\_MAX max value of key header word to pass

abs=0 =1 to take absolute value of key header word

j=1 Pass every j-th trace ...

s=0 ... based at s (if ((key - s)%j) == 0)

skip=0 skip the initial N traces

count=ULONG\_MAX ... up to count traces

reject=none Skip traces with specified key values

accept=none Pass traces with specified key values(see notes)

processing, but do no window the data

ordered=0 =1 if traces sorted in increasing keyword value

=-1 if traces are sorted in a decreasing order

Options for vertical windowing (time gating):

dt=tr.dt (from header) time sampling interval (sec) (seismic data)

=tr.d1 (nonseismic)

f1=tr.delrt (from header) first sample (seismic data)

=tr.f1 (nonseismic)

tmin=0.0 min time to pass

tmax=(from header) max time to pass

itmin=0 min time sample to pass

itmax=(from header) max time sample to pass

nt=itmax-itmin+1 number of time samples to pass

Notes:

On large data sets, the count parameter should be set if possible. Otherwise, every trace in the data set will be examined. However, the count parameter overrides the accept parameter, so you can't specify count if you want true unconditional acceptance.

The skip= option allows the user to skip over traces, which helps for selecting traces far from the beginning of the dataset. Caveat: skip only works with disk input.

The ordered= option will speed up the process if the data are sorted in according to the key.

The accept option is a bit strange--it does NOT mean accept ONLY the traces on the accept list! It means accept these traces, even if they would otherwise be rejected (except as noted in the previous paragraph). To implement accept-only, you can use the max=0 option (rejecting everything). For example, to accept only the tracd values 4, 5 and 6:  
... | suwind max=0 accept=4,5,6 | ...

Another example is the case of suppressing nonseismic traces in a seismic data set. By the SEG Y standard header field trace id, trid=1 designates traces as being seismic traces. Other traces, such as calibration traces may be designated by another value.

Example: trid=1 seismic and trid=0 is nonseismic. To reject nonseismic traces  
... | suwind key=trid reject=0 | ...

On most 32 bit machines, LONG\_MIN, LONG\_MAX and ULONG\_MAX are about -2E9,+2E9 and 4E9, they are defined in limits.h.

Selecting times beyond the maximum in the data induces zero padding (up to SU\_NFLTS).

The time gating here is to the nearest neighboring sample or time value. Gating to the exact temporal value requires resampling if the selected times fall between samples on the trace. Use suresamp to perform the time gating in this case.

It doesn't really make sense to specify both itmin and tmin, but specifying itmin takes precedence over specifying tmin. Similarly, itmax takes precedence over tmax and tmax over nt. If dt in header is not set, then dt is mandatory

Credits:

SEP: Einar Kjartansson

CWP: Shuki Ronen, Jack Cohen, Chris Liner

Warnemuende: Toralf Foerster

CENPET: Werner M. Heigl (modified to include well log data)

Trace header fields accessed: ns, dt, delrt, keyword

Trace header fields modified: ns, delrt, ntr

SUXCOR - correlation with user-supplied filter

```
suxcor <stdin >stdout filter= [optional parameters]
```

Required parameters: ONE of

sufile= file containing SU traces to use as filter

filter= user-supplied correlation filter (ascii)

Optional parameters:

vibroseis=0 =nsout for correlating vibroseis data

first=1 supplied trace is default first element of correlation. =0 for it to be second.

panel=0 use only the first trace of sufile as filter

=1 xcor trace by trace an entire gather

ftwin=0 first sample on the first trace of the window (only with panel=1)

ltwin=0 first sample on the last trace of the window (only with panel=1)

ntwin=nt number of samples in the correlation window (only with panel=1)

ntrc=48 number of traces on a gather (only with panel=1)

Trace header fields accessed: ns

Trace header fields modified: ns

Notes: It is quietly assumed that the time sampling interval on the single trace and the output traces is the same as that on the traces in the input file. The sufile may actually have more than one trace, but only the first trace is used when panel=0. When panel=1 the number of traces in the sufile MUST be the same as the number of traces in the input.

Examples:

```
suplane | suwind min=12 max=12 >TRACE
```

```
suxcor<DATA sufile=TRACE |...
```

Here, the su data file, "DATA", is correlated trace by trace with the the single su trace, "TRACE".

```
suxcor<DATA filter=1,2,1 | ...
```

Here, the su data file, "DATA", is correlated trace by trace with the the filter shown.

Correlating vibroseis data with a vibroseis sweep:

```
suxcor < data sufile=sweep vibroseis=nsout |...
```

is equivalent to, but more efficient than:

```
suxcor < data sufile=sweep |  
suwind itmin=nsweep itmax=nsweep+nsout | sushw key=delrt a=0.0 |...
```

sweep=vibroseis sweep in SU format, nsweep=number of samples on the vibroseis sweep, nsout=desired number of samples on output

or

```
suxcor < data sufile=sweep |  
suwind itmin=nsweep itmax=nsweep+nsout | sushw key=delrt a=0.0 |...
```

tsweep=sweep length in seconds, tout=desired output trace length in seconds

In the spatially variant case (panel=1), a window with linear slope can be defined:

ftwin is the first sample of the first trace in the gather,  
ltwin is the first sample of the last trace in the gather,  
ntwin is the length of the window,  
ntrc is the the number of traces in a gather.

If the data consists of a number gathers which need to be correlated with the same number gathers in the sufile, ntrc assures that the correlating window re-starts for each gather.

The default window is non-sloping and takes the entire trace into account (ftwin=ltwin=0, ntwinn=nt).

Credits:

CWP: Jack K. Cohen, Michel Dietrich

CWP: modified by Ttjan to include cross correlation of panels permitting spatially and temporally varying cross correlation.

UTK: modified by Rick Williams for vibroseis correlation option.

CAVEATS:

In the option, panel=1 the number of traces in the sufile must be the same as the number of traces on the input.

Trace header fields accessed: ns

Trace header fields modified: ns

SUXEDIT - examine segy diskfiles and edit headers

suxedit diskfile (open for possible header modification if writable)  
suxedit <diskfile (open read only)

The following commands are recognized:

number read in that trace and print nonzero header words  
<CR> go to trace one step away (step is initially -1)  
+ read in next trace (step is set to +1)  
- read in previous trace (step is set to -1)  
dN advance N traces (step is set to N)  
% print some percentiles of the trace data  
r print some ranks (rank[j] = jth smallest datum)  
p [n1 [n2]] tab plot sample n1 to n2 on current trace  
g [tr1 tr2] ["opts"] wiggle plot (graph) the trace  
[traces tr1 to tr2]  
f wiggle plot the Fourier transform of the trace  
! key=val change a value in a field (e.g. ! tracr=101)  
? print help file  
q quit

NOTE: sample numbers are 1-based (first sample is 1).

Credits:

SEP: Einar Kjartansson, Shuki Ronen, Stew Levin

CWP: Jack K. Cohen

Trace header fields accessed: ns

Trace header fields modified: ntr (only for internal plotting)

SUZERO -- zero-out (or set constant) data within a time window

suzero itmax= < indata > outdata

Required parameters

itmax= last time sample to zero out

Optional parameters

itmin=0 first time sample to zero out

value=0 value to set

See also: sukill, sumute

Credits:

CWP: Chris

Geocon: Garry Perratt (added value= option)

Trace header fields accessed: ns

SUZZTOT - resample from depth to time

suzztot <stdin >stdout [optional parms]

Optional Parameters:

nt=1+(nz-1)\*2.0\*dz/(vmax\*dt) number of time samples in output

dt=2\*dz/vmin time sampling interval (defaults avoids aliasing)

ft=2\*fz/v(fz) first time sample

z=0.0,... depths corresponding to interval velocities in v

v=1500.0,... interval velocities corresponding to depths in v

vfile= binary (non-ascii) file containing velocities v(z)

verbose=0 >0 to print depth sampling information

Notes:

Default value of nt set to avoid aliasing

The z and v arrays specify an interval velocity function of depth.

Note that z and v are given as arrays of floats separated by commas, for example:

z=0.0,100,200,... v=1500.0,1720.0,1833.5,... with the number of z values equaling the number of v values. The velocities are linearly interpolated to produce a piecewise linear v(z) profile. This fact must be taken into account when attempting to use this program as the inverse of suttotz.

Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in z must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If vfile is specified, then the z and v arrays are ignored.

see the selfdoc of suttotz for time to depth conversion

Trace header fields accessed: ns, dt, and delrt

Trace header fields modified: trid, ns, d1, and f1

Credits:

CWP: John Stockwell, 2005,

based on suttotz.c written by Dave Hale c. 1992

SUPSCONTOUR - PostScript CONTOUR plot of a segy data set

supscoutour <stdin [optional parameters] | ...

Optional parameters:

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the pscontour selfdoc for the remaining parameters.

On NeXT: supscoutour < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2

Credits:

CWP: Dave Hale and Zhiming Li (pscontour, etc.)

Jack Cohen and John Stockwell (supscontour, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Aarhus University: Morten W. Pedersen copied everything from the xwigb source and just replaced all occurrences of the word

Notes:

When the number of traces isn't known, we need to count the traces for pscontour. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSCUBECONTOUR - PostScript CUBE plot of a segy data set

supscubecontour <stdin [optional parameters] | ...

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the pscubecontour selfdoc for the remaining parameters.

example: supscubecontour < infile [optional parameters] | gv -

Credits:

CWP: Dave Hale and Zhiming Li (pscube)  
Jack K. Cohen (suxmovie)  
John Stockwell (supscubecontour)

Notes:

When n2 isn't getparred, we need to count the traces for pscube. Although we compute ntr, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSCUBE - PostScript CUBE plot of a segy data set

```
supscube <stdin [optional parameters] | ...
```

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the pscube selfdoc for the remaining parameters.

On NeXT: supscube < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (pscube)  
Jack K. Cohen (suxmovie)  
John Stockwell (supscube)

Notes:

When `n2` isn't getparred, we need to count the traces for pscube. Although we compute `ntr`, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use `tr.data`, we allocate a trace buffer for code clarity.

SUPSGRAPH - PostScript GRAPH plot of a segy data set

supsgraph <stdin [optional parameters] | ...

Optional parameters:

style=seismic seismic is default here, =normal is alternate  
(see psgraph selfdoc for style definitions)

nplot is the number of traces (ntr is an acceptable alias for nplot)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the psgraph selfdoc for the remaining parameters.

On NeXT: supsgraph < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (pswignp, etc.)  
Jack Cohen and John Stockwell (supswignp, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for pswignp. You can make this value "known" either by getparring nplot or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSIMAGE - PostScript IMAGE plot of a segy data set

supsimage <stdin [optional parameters] | ...

Optional parameters:

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range.

Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the psimage selfdoc for the remaining parameters.

On NeXT: supsimage < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2

Credits:

CWP: Dave Hale and Zhiming Li (psimage, etc.)  
Jack Cohen and John Stockwell (supsimage, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for psimage. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.  
"remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSMAX - PostScript of the MAX, min, or absolute max value on each trace of a SEG Y (SU) data set

```
supsmx <stdin >postscript file [optional parameters]
```

Optional parameters:

mode=max max value

=min min value

=abs absolute max value

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the sumax selfdoc for additional parameter.

See the psgraph selfdoc for the remaining parameters.

Credits:

CWP: John Stockwell, based on Jack Cohen's SU JACKet

Notes:

When the number of traces isn't known, we need to count the traces for psgraph. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

SUPSMOVIEW - PostScript MOVIE plot of a segy data set

```
supsmovie <stdin [optional parameters] | ...
```

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the psmovie selfdoc for the remaining parameters.

On NeXT: supsmovie < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (psmovie)  
Jack K. Cohen (suxmovie)  
John Stockwell (supsmovie)

Notes:

When `n2` isn't getparred, we need to count the traces for `psmovie`. In this case: we are using `tmpfile` because on many machines it is implemented as a memory area instead of a disk file. Although we compute `ntr`, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use `tr.data`, we allocate a trace buffer for code clarity.

SUPSWIGB - PostScript Bit-mapped WIGgle plot of a segy data set

supswigb <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
    the CWP\_TMPDIR environment variable is set use  
    its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: pswigb  
See the pswigb selfdoc for the remaining parameters.

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2, keyword (if set)

Credits:

CWP: Dave Hale and Zhiming Li (pswigb, etc.)

Jack Cohen and John Stockwell (supswigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor scale factors, added vsp style

Notes:

When the number of traces isn't known, we need to count the traces for pswigb. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSWIGP - PostScript Polygon-filled WIGgle plot of a segy data set

supswigp <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, values of x2 are set from header field  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or  
vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
    the CWP\_TMPDIR environment variable is set use  
    its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is  
time and the "slow dimension" is usually trace number or range.  
Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to override the header values if  
not.

If key=keyword is set, then the values of x2 are taken from the header  
field represented by the keyword (for example key=offset, will show  
traces in true offset). This permit unequally spaced traces to be plotted.  
Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: pswigp  
See the pswigp selfdoc for the remaining parameters.

On NeXT: supswigp < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2, key specified by key

Credits:

CWP: Dave Hale and Zhiming Li (pswigp, etc.)

Jack Cohen and John Stockwell (supswigp, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor scale factors, added vsp style

Notes:

When the number of traces isn't known, we need to count the traces for pswigp. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXCONTOUR - X CONTOUR plot of Seismic UNIX tracefile via vector plot call

suxwigb <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

verbose=0                    =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: xcontour See the xcontour selfdoc for the remaining parameters.

Credits:

CWP: Dave Hale and Zhiming Li (xwigb, etc.)

Jack Cohen and John Stockwell (suxwigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Aarhus University: Morten W. Pedersen copied everything from the xwigb source and just replaced all occurrences of the word xwigb with xcountour ;-)

Notes:

When the number of traces isn't known, we need to count the traces for xcountour. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXGRAPH - X-windows GRAPH plot of a segy data set

```
suxgraph <stdin [optional parameters] | ...
```

Optional parameters:

style=seismic seismic is default here, =normal is alternate  
(see xgraph selfdoc for style definitions)

nplot= number of traces (ntr is an acceptable alias for nplot)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the xgraph selfdoc for the remaining parameters.

```
On NeXT:    suxgraph < infile [optional parameters] | open
```

Credits:

CWP: Dave Hale and Zhiming Li (pswignp, etc.)  
Jack Cohen and John Stockwell (supswignp, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for pswignp. You can make this value "known" either by getparrng nplot or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXIMAGE - X-windows IMAGE plot of a segy data set

suximage infile= [optional parameters] | ... (direct I/O)

or

suximage <stdin [optional parameters] | ... (sequential I/O)

Optional parameters:

infile=NULL SU data to be plotted, default stdin with sequential access  
if 'infile' provided, su data read by (fast) direct access

with ftr,dtr and n2 suimage will pass a subset of data  
to the plotting program-ximage:

ftr=1 First trace to be plotted

dtr=1 Trace increment to be plotted

n2=tr.ntr (Max) number of traces to be plotted (ntr is an alias for n2)

Priority: first try to read from parameter line;

if not provided, check trace header tr.ntr;

if still not provided, figure it out using ftello

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set or was set to 0)

key= key for annotating d2 (slow dimension)

If annotation is not at proper increment, try

setting d2; only first trace's key value is read

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the ximage selfdoc for the remaining parameters.

#### Credits:

CWP: Dave Hale and Zhiming Li (ximage, etc.)

Jack Cohen and John Stockwell (suximage, etc.)

MTU: David Forel, June 2004, added key for annotating d2

ConocoPhillips: Zhaobo Meng, Dec 2004, added direct I/O

#### Notes:

When provide ftr and dtr and infile, suximage can be used to plot multi-dimensional volumes efficiently. For example, for a Offset-CDP dataset with 32 offsets, the command line  
suximage infile=volume3d.su ftr=1 dtr=32 ... &  
will display the zero-offset common offset data with ranrom access. It is highly recommend to use infile= to view large datasets, since using stdin only allows sequential access, which is very slow for large datasets.

When the number of traces isn't known, we need to count the traces for ximage. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXMAX - X-windows graph of the MAX, min, or absolute max value on each trace of a SEG Y (SU) data set

```
suxmax <stdin [optional parameters]
```

Optional parameters:

mode=max max value

=min min value

=abs absolute max value

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the sumax selfdoc for additional parameter.

See the xgraph selfdoc for the remaining parameters.

Credits:

CWP: John Stockwell, based on Jack Cohen's SU JACKet

Notes:

When the number of traces isn't known, we need to count the traces for xgraph. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

SUXMOVIE - X MOVIE plot of a 2D or 3D segy data set

suxmovie <stdin [optional parameters]

Optional parameters:

n1=tr.ns                    number of samples per trace  
ntr=tr.ntr                 number of traces in the data set  
n2=tr.shortpad or tr.ntr number of traces in inline direction  
n3=ntr/n2                  number of traces in crossline direction

d1=tr.d1 or tr.dt/10<sup>6</sup>    sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)

d2=tr.d2                  sampling interval in the slow dimension  
    =1.0 (if not set)

d3=1.0                    sampling interval in the slowest dimension

f1=tr.f1 or 0.0            first sample in the z dimension  
f2=tr.f2 or 1.0            first sample in the x dimension  
f3=1.0

mode=0                    0= x,z slice movie through y dimension (in line)  
                          1= y,z slice movie through x dimension (cross line)  
                          2= x,y slice movie through z dimension (time slice)

verbose=0                 =1 to print some useful information

tmpdir=    if non-empty, use the value as a directory path  
          prefix for storing temporary files; else if the  
          the CWP\_TMPDIR environment variable is set use  
          its value for the path; else use tmpfile()

Notes:

For seismic data, the "fast dimension" is either time or depth and the "slow dimension" is usually trace number. The 3D data set is expected to have n3 sets of n2 traces representing the horizontal coverage of n2\*d2 in x and n3\*d3 in y direction.

The data is read to memory with and piped to xmovie with the respective sampling parameters.

See the xmovie selfdoc for the remaining parameters and X functions.

SUXPICKER - X-windows WIGgle plot PICKER of a segy data set

suxpicker <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field  
specified by keyword  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

See the xpicker selfdoc for the remaining parameters.

Credits:

CWP: Dave Hale and Zhiming Li (xpicker, etc.)  
Jack Cohen and John Stockwell (suxpicker, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for xpicker. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXWIGB - X-windows Bit-mapped WIGgle plot of a segy data set  
This is a modified suxwigb that uses the depth or coordinate scaling  
when such values are used as keys.

```
suxwigb <stdin [optional parameters] | ...
```

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or  
vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                   =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is  
time and the "slow dimension" is usually trace number or range.  
Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to override the header values if  
not.

If key=keyword is set, then the values of x2 are taken from the header  
field represented by the keyword (for example key=offset, will show  
traces in true offset). This permit unequally spaced traces to be plotted.  
Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: xwigb  
See the xwigb selfdoc for the remaining parameters.

Credits:

CWP: Dave Hale and Zhiming Li (xwigb, etc.)

Jack Cohen and John Stockwell (suxwigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor  
scale factors, added vsp style

Notes:

When the number of traces isn't known, we need to count  
the traces for xwigb. You can make this value "known"  
either by getparring n2 or by having the ntr field set  
in the trace header. A getparred value takes precedence  
over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array,  
but just content ourselves with copying trace by trace from  
the data "file" to the pipe into the plotting program.  
Although we could use tr.data, we allocate a trace buffer  
for code clarity.

PSBBOX - change BoundingBox of existing PostScript file

```
psbbox < PostScriptfile [optional parameters] > PostScriptfile
```

Optional Parameters:

llx= new llx

lly= new lly

urx= new urx

ury= new ury

verbose=1 =1 for info printed on stderr (0 for no info)

PSCONTOUR - PostScript CONTOURing of a two-dimensional function  $f(x_1, x_2)$

pscontour n1= [optional parameters] <binaryfile >postscriptfile

Required Parameters:

n1                            number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0                        sampling interval in 1st dimension  
f1=d1                         first sample in 1st dimension  
x1=f1,f1+d1,...             array of monotonic sampled values in 1st dimension  
n2=all                        number of samples in 2nd (slow) dimension  
d2=1.0                        sampling interval in 2nd dimension  
f2=d2                         first sample in 2nd dimension  
x2=f2,f2+d2,...             array of monotonic sampled values in 2nd dimension  
nc=5                          number of contour values  
dc=(zmax-zmin)/nc            contour interval  
fc=min+dc                    first contour  
c=fc,fc+dc,...              array of contour values  
cwidth=1.0,...              array of contour line widths  
cgray=0.0,...                array of contour grays (0.0=black to 1.0=white)  
ccolor=none,...              array of contour colors; none means use cgray  
cdash=0.0,...                array of dash spacings (0.0 for solid)  
labelcf=1                    first labeled contour (1,2,3,...)  
labelcper=1                  label every labelcper-th contour  
nlabelc=nc                    number of labeled contours (0 no contour label)  
nplaces=6                    number of decimal places in contour label  
xbox=1.5                     offset in inches of left side of axes box  
ybox=1.5                     offset in inches of bottom side of axes box  
wbox=6.0                     width in inches of axes box  
hbox=8.0                     height in inches of axes box  
x1beg=x1min                  value at which axis 1 begins  
x1end=x1max                  value at which axis 1 ends  
d1num=0.0                    numbered tic interval on axis 1 (0.0 for automatic)  
f1num=x1min                  first numbered tic on axis 1 (used if d1num not 0.0)  
n1tic=1                      number of tics per numbered tic on axis 1  
grid1=none                    grid lines on axis 1 - none, dot, dash, or solid  
label1=                      label on axis 1  
x2beg=x2min                  value at which axis 2 begins  
x2end=x2max                  value at which axis 2 ends  
d2num=0.0                    numbered tic interval on axis 2 (0.0 for automatic)  
f2num=x2min                  first numbered tic on axis 2 (used if d2num not 0.0)  
n2tic=1                      number of tics per numbered tic on axis 2

grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelfont=Helvetica	font name for axes labels
labelsize=18	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
labelcfont=Helvetica-Bold	font name for contour labels
labelcsize=6	font size of contour labels
labelccolor=black	color of contour labels
titlecolor=black	color of title
axescolor=black	color of axes
gridcolor=black	color of grid
axeswidth=1	width (in points) of axes
ticwidth=axeswidth	width (in points) of tic marks
gridwidth=axeswidth	width (in points) of grid lines
style=seismic	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)

Note.

The line width of unlabeled contours is designed as a quarter of that of labeled contours.

All color specifications may also be made in X Window style Hex format  
example: axescolor=#255

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
Helvetica-Narrow-Oblique NewCentrySchlbk-Bold"  
NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic  
type: sudoc pscontour for more information

Notes:

For nice even-numbered contours, use the parameters `fc` and `dc`

Example: if the range of the `z` values of a data set range between approximately -1000 and +1000, then use `fc=-1000 nc=10` and `dc=100` to get contours spaced by even 100's.

AUTHOR: Dave Hale, Colorado School of Mines, 05/29/90

MODIFIED: Craig Artley, Colorado School of Mines, 08/30/91  
    BoundingBox moved to top of PostScript output

MODIFIED: Zhenyue Liu, Colorado School of Mines, 08/26/93  
    Values are labeled on contours

MODIFIED: Craig Artley, Colorado School of Mines, 12/16/93  
    Added color options (Courtesy of Dave Hale, Advance Geophysical).

Modified: Morten Wendell Pedersen, Aarhus University, 23/3-97  
    Added `ticwidth, axeswidth, gridwidth` parameters

PSCCONTOUR - PostScript Contour plot of a data CUBE

```
pscubecontour n1= n2= n3= [optional parameters] <binaryfile >postscriptfile
or
pscubecontour n1= n2= n3= front= side= top= [optional parameters] >postscriptfile
```

Data formats supported:

1. Entire cube read from stdin ( $n1*n2*n3$  floats) [default format]
2. Faces read from stdin ( $n1*n2$  floats for front, followed by  $n1*n3$  floats for side, and  $n2*n3$  floats for top) [specify faces=1]
3. Faces read from separate data files [specify filenames]

Required Parameters:

n1	number of samples in 1st (fastest) dimension
n2	number of samples in 2nd dimension
n3	number of samples in 3rd (slowest) dimension

Optional Parameters:

front	name of file containing front panel
side	name of file containing side panel
top	name of file containing top panel
faces=0	=1 to read faces from stdin (data format 2)
d1=1.0	sampling interval in 1st dimension
f1=0.0	first sample in 1st dimension
d2=1.0	sampling interval in 2nd dimension
f2=0.0	first sample in 2nd dimension
d3=1.0	sampling interval in 3rd dimension
f3=0.0	first sample in 3rd dimension
d1s=1.0	factor by which to scale d1 before imaging
d2s=1.0	factor by which to scale d2 before imaging
d3s=1.0	factor by which to scale d3 before imaging
nc=5	number of contour values
dc=(zmax-zmin)/nc	contour interval
fc=min+dc	first contour
c=fc,fc+dc,...	array of contour values
cwidth=1.0,...	array of contour line widths
cgray=0.0,...	array of contour grays (0.0=black to 1.0=white)
ccolor=none,...	array of contour colors; none means use cgray
cdash=0.0,...	array of dash spacings (0.0 for solid)
labelcf=1	first labeled contour (1,2,3,...)
labelcper=1	label every labelcper-th contour
nlabelc=nc	number of labeled contours (0 no contour label)
nplaces=6	number of decimal places in contour label

xbox=1.5	offset in inches of left side of axes box
ybox=1.5	offset in inches of bottom side of axes box
size1=4.0	size in inches of 1st axes (vertical)
size2=4.0	size in inches of 2nd axes (horizontal)
size3=3.0	size in inches of 3rd axes (projected)
angle=45	projection angle of cube in degrees (0<angle<90) (angle between 2nd axis and projected 3rd axis)
x1end=x1max	value at which axis 1 ends
d1num=0.0	numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min	first numbered tic on axis 1 (used if d1num not 0.0)
n1tic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
x2beg=x2min	value at which axis 2 begins
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
x3end=x3max	value at which axis 3 ends
d3num=0.0	numbered tic interval on axis 3 (0.0 for automatic)
f3num=x3min	first numbered tic on axis 3 (used if d3num not 0.0)
n3tic=1	number of tics per numbered tic on axis 3
grid3=none	grid lines on axis 3 - none, dot, dash, or solid
label3=	label on axis 3
labelfont=Helvetica	font name for axes labels
labelsize=18	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
titlecolor=black	color of title
labelcfont=Helvetica-Bold	font name for contour labels
labelcsize=6	font size of contour labels
labelccolor=black	color of contour labels
axescolor=black	color of axes
gridcolor=black	color of grid

All color specifications may also be made in X Window style Hex format  
example: axescolor=#255

Note: The values of x1beg=x1min, x2end=x2max and x3beg=x3min cannot be changed.

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
Helvetica-Narrow-Oblique NewCenturySchlbk-Bold"  
NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic

(Original codes pscontour and pscube)

AUTHOR: Craig Artley, Colorado School of Mines, 03/12/93

NOTE: Original written by Zhiming Li & Dave Hale, CSM, 07/01/90

Completely rewritten, the code now bears more similarity to  
psimage than the previous pscube. Faces of cube now rendered  
as three separate images, rather than as a single image. The  
output no longer suffers from stretching artifacts, and the  
code is simpler. -Craig

MODIFIED: Craig Artley, Colorado School of Mines, 12/17/93

Added color options.

PSCCONTOUR: mashed together from pscube and pscontour  
to generate 3d contour plots by Claudia Vanelle, Institute of Geophysics,  
University of Hamburg, Germany somewhen in 2000

PSCUBE was "merged" with PSCONTOUR to create PSCUBECONTOUR  
by Claudia Vanelle, Applied Geophysics Group Hamburg  
somewhen in 2000

PSCUBE - PostScript image plot with Legend of a data CUBE

```
pscube n1= n2= n3= [optional parameters] <binaryfile >postscriptfile
```

or

```
pscube n1= n2= n3= front= side= top= [optional parameters] >postscriptfile
```

Data formats supported:

1. Entire cube read from stdin ( $n1*n2*n3$  floats) [default format]
2. Faces read from stdin ( $n1*n2$  floats for front, followed by  $n1*n3$  floats for side, and  $n2*n3$  floats for top) [specify faces=1]
3. Faces read from separate data files [specify filenames]

Required Parameters:

n1	number of samples in 1st (fastest) dimension
n2	number of samples in 2nd dimension
n3	number of samples in 3rd (slowest) dimension

Optional Parameters:

front	name of file containing front panel
side	name of file containing side panel
top	name of file containing top panel
faces=0	=1 to read faces from stdin (data format 2)
d1=1.0	sampling interval in 1st dimension
f1=0.0	first sample in 1st dimension
d2=1.0	sampling interval in 2nd dimension
f2=0.0	first sample in 2nd dimension
d3=1.0	sampling interval in 3rd dimension
f3=0.0	first sample in 3rd dimension
perc=100.0	percentile used to determine clip
clip=(perc percentile)	clip used to determine bclip and wclip
bperc=perc	percentile for determining black clip value
wperc=100.0-perc	percentile for determining white clip value
bclip=clip	data values outside of [bclip,wclip] are clipped
wclip=-clip	data values outside of [bclip,wclip] are clipped
brgb=0.0,0.0,0.0	red, green, blue values corresponding to black
wrgb=1.0,1.0,1.0	red, green, blue values corresponding to white
bhls=0.0,0.0,0.0	hue, lightness, saturation corresponding to black
whls=0.0,1.0,0.0	hue, lightness, saturation corresponding to white
bps=12	bits per sample for color plots, either 12 or 24
d1s=1.0	factor by which to scale d1 before imaging
d2s=1.0	factor by which to scale d2 before imaging
d3s=1.0	factor by which to scale d3 before imaging
verbose=1	=1 for info printed on stderr (0 for no info)

xbox=1.5	offset in inches of left side of axes box
ybox=1.5	offset in inches of bottom side of axes box
size1=4.0	size in inches of 1st axes (vertical)
size2=4.0	size in inches of 2nd axes (horizontal)
size3=3.0	size in inches of 3rd axes (projected)
angle=45	projection angle of cube in degrees (0<angle<90) (angle between 2nd axis and projected 3rd axis)
x1end=x1max	value at which axis 1 ends
d1num=0.0	numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min	first numbered tic on axis 1 (used if d1num not 0.0)
n1tic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
x2beg=x2min	value at which axis 2 begins
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
x3end=x3max	value at which axis 3 ends
d3num=0.0	numbered tic interval on axis 3 (0.0 for automatic)
f3num=x3min	first numbered tic on axis 3 (used if d3num not 0.0)
n3tic=1	number of tics per numbered tic on axis 3
grid3=none	grid lines on axis 3 - none, dot, dash, or solid
label3=	label on axis 3
labelfont=Helvetica	font name for axes labels
labelsize=18	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
titlecolor=black	color of title
axescolor=black	color of axes
gridcolor=black	color of grid
legend=0	=1 display the color scale if ==1, resize xbox,ybox,width,height
lstyle=vertleft	Vertical, axis label on left side =vertright (Vertical, axis label on right side) =horibottom (Horizontal, axis label on bottom)
units=	unit label for legend
legendfont=times_roman10	font name for title
following are defaults	for lstyle=0. They are changed for other lstyles
lwidth=1.2	colorscale (legend) width in inches
lheight=height/3	colorscale (legend) height in inches

lx=1.0                    colorscale (legend) x-position in inches  
 ly=(height-lheight)/2+xybox    colorscale (legend) y-position in pixels  
 lbeg= lmin or wclip-5\*perc    value at which legend axis begins  
 lend= lmax or bclip+5\*perc    value at which legend axis ends  
 ldnum=0.0            numbered tic interval on legend axis (0.0 for automatic)  
 lfnum=lmin            first numbered tic on legend axis (used if dlnum not 0.0)  
 lntic=1              number of tics per numbered tic on legend axis  
 lgrid=none            grid lines on legend axis - none, dot, dash, or solid

All color specifications may also be made in X Window style Hex format  
 example:    axescolor=#255

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
 Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
 Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
 Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
 Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
 Helvetica-Narrow-Oblique NewCentrySchlbk-Bold"  
 NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
 Palatino-BoldItalic Palatino-Italics Palatino-Roman  
 SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
 Symbol Times-Bold Times-BoldItalic  
 Times-Roman Times-Italic ZapfChancery-MediumItalic

Note: The values of x1beg=x1min, x2end=x2max and x3beg=x3min cannot be changed.

PSEPSI - add an EPSI formatted preview bitmap to an EPS file

```
psepsi <epsfile >epsifile
```

Note:

This application requires

- (1) that gs (the Ghostscript interpreter) exist, and
  - (2) that the input EPS file contain a BoundingBox and EndComments.
- Ghostscript is used to build the preview bitmap, which is then merged with the input EPS file to make the output EPSI file.

## PSGRAPH - PostScript GRAPHer

Graphs  $n[i]$  pairs of  $(x,y)$  coordinates, for  $i = 1$  to  $nplot$ .

```
psgraph n= [optional parameters] <binaryfile >postscriptfile
```

### Required Parameters:

$n$  array containing number of points per plot

### Data formats supported:

- 1.a.  $x_1, y_1, x_2, y_2, \dots, x_n, y_n$
- b.  $x_1, x_2, \dots, x_n, y_1, y_2, \dots, y_n$  (must set `pairs=0`)
2.  $y_1, y_2, \dots, y_n$  (must give non-zero `d1[]=`)
3.  $x_1, x_2, \dots, x_n$  (must give non-zero `d2[]=`)
4. `nil` (must give non-zero `d1[]=` and non-zero `d2[]=`)

The formats may be repeated and mixed in any order, but if formats 2-4 are used, the `d1` and `d2` arrays must be specified including `d1[]=0.0 d2[]=0.0` entries for any internal occurrences of format 1. Similarly, the `pairs` array must contain place-keeping entries for plots of formats 2-4 if they are mixed with both formats 1.a and 1.b. Also, if formats 2-4 are used with non-zero `f1[]` or `f2[]` entries, then the corresponding array(s) must be fully specified including `f1[]=0.0` and/or `f2[]=0.0` entries for any internal occurrences of format 1 or formats 2-4 where the zero entries are desired.

Available colors are all the common ones and many more. The complete list of 68 colors is in the file `$CWPROOT/src/psplot/basic.c`.

### Optional Parameters:

<code>nplot=</code> number of $n$ 's	number of plots
<code>d1=0.0,...</code>	x sampling intervals (0.0 if x coordinates input)
<code>f1=0.0,...</code>	first x values (not used if x coordinates input)
<code>d2=0.0,...</code>	y sampling intervals (0.0 if y coordinates input)
<code>f2=0.0,...</code>	first y values (not used if y coordinates input)
<code>pairs=1,...</code>	=1 for data pairs in format 1.a, =0 for format 1.b
<code>linewidth=1.0,...</code>	line widths (in points) (0.0 for no lines)
<code>linegray=0.0,...</code>	line gray levels (black=0.0 to white=1.0)
<code>linecolor=none,...</code>	line colors; none means use linegray
	Typical use: <code>linecolor=red,yellow,blue,...</code>
<code>lineon=1.0,...</code>	length of line segments for dashed lines (in points)
<code>lineoff=0.0,...</code>	spacing between dashes (0.0 for solid line)
<code>mark=0,1,2,3,...</code>	indices of marks used to represent plotted points
<code>marksize=0.0,0.0,...</code>	size of marks (0.0 for no marks)
<code>xbox=1.5</code>	offset in inches of left side of axes box

ybox=1.5	offset in inches of bottom side of axes box
wbox=6.0	width in inches of axes box
hbox=8.0	height in inches of axes box
x1beg=x1min	value at which axis 1 begins
x1end=x1max	value at which axis 1 ends
d1num=0.0	numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min	first numbered tic on axis 1 (used if d1num not 0.0)
n1tic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
x2beg=x2min	value at which axis 2 begins
x2end=x2max	value at which axis 2 ends
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelfont=Helvetica	font name for axes labels
labelsize=18	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
titlecolor=black	color of title
axescolor=black	color of axes
gridcolor=black	color of grid
axeswidth=1	width (in points) of axes
ticwidth=axeswidth	width (in points) of tic marks
gridwidth=axeswidth	width (in points) of grid lines
style=normal	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)
reverse=0	=1 to reverse sequence of plotting curves",

Note: n1 and n2 are acceptable aliases for n and nplot, respectively.

mark index:

1. asterisk
2. x-cross
3. open triangle
4. open square
5. open circle
6. solid triangle
7. solid square
8. solid circle

All color specifications may also be made in X Window style Hex format  
example: `axescolor=#255`

Example:

```
psgraph n=50,100,20 d1=2.5,1,0.33 <datafile >psfile
plots three curves with equally spaced x values in one plot frame
x1-coordinates are  $x1(i) = f1+i*d1$  for  $i = 1$  to  $n$  ( $f1=0$  by default)
number of  $x2$ 's and then  $x2$ -coordinates for each curve are read
sequentially from datafile.
```

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
Helvetica-Narrow-Oblique NewCentrySchlbk-Bold"  
NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic

PSIMAGE - PostScript IMAGE plot of a uniformly-sampled function  $f(x_1, x_2)$

psimage n1= [optional parameters] <binaryfile >postscriptfile

Required Parameters:

n1 number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0 sampling interval in 1st dimension

f1=0.0 first sample in 1st dimension

n2=all number of samples in 2nd (slow) dimension

d2=1.0 sampling interval in 2nd dimension

f2=0.0 first sample in 2nd dimension

perc=100.0 percentile used to determine clip

clip=(perc percentile) clip used to determine bclip and wclip

bperc=perc percentile for determining black clip value

wperc=100.0-perc percentile for determining white clip value

bclip=clip data values outside of [bclip,wclip] are clipped

wclip=-clip data values outside of [bclip,wclip] are clipped

bclip and wclip will be set to be inside

[lbeg,lend] if lbeg and/or lend are supplied

threecolor=1 supply 3 color values instead of only two,

using not only black and white, but f.e. red,  
green and blue

brgb=0.0,0.0,0.0 red, green, blue values corresponding to black

grgb=1.0,1.0,1.0 red, green, blue values corresponding to grey

wrgb=1.0,1.0,1.0 red, green, blue values corresponding to white

bhls=0.0,0.0,0.0 hue, lightness, saturation corresponding to black

ghls=0.0,1.0,0.0 hue, lightness, saturation corresponding to grey

whls=0.0,1.0,0.0 hue, lightness, saturation corresponding to white

bps=12 bits per sample for color plots, either 12 or 24

d1s=1.0 factor by which to scale d1 before imaging

d2s=1.0 factor by which to scale d2 before imaging

verbose=1 =1 for info printed on stderr (0 for no info)

xbox=1.5 offset in inches of left side of axes box

ybox=1.5 offset in inches of bottom side of axes box

width=6.0 width in inches of axes box

height=8.0 height in inches of axes box

xlbeg=x1min value at which axis 1 begins

xlend=x1max value at which axis 1 ends

d1num=0.0 numbered tic interval on axis 1 (0.0 for automatic)

f1num=x1min first numbered tic on axis 1 (used if d1num not 0.0)

n1tic=1 number of tics per numbered tic on axis 1

```

grid1=none  grid lines on axis 1 - none, dot, dash, or solid
label1=  label on axis 1
x2beg=x2min  value at which axis 2 begins
x2end=x2max  value at which axis 2 ends
d2num=0.0  numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min  first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1  number of tics per numbered tic on axis 2
grid2=none  grid lines on axis 2 - none, dot, dash, or solid
label2=  label on axis 2
labelfont=Helvetica  font name for axes labels
labelsize=18  font size for axes labels
title=  title of plot
titlefont=Helvetica-Bold  font name for title
titlesize=24  font size for title
titlecolor=black  color of title
axescolor=black  color of axes
gridcolor=black  color of grid
axeswidth=1  width (in points) of axes
ticwidth=axeswidth  width (in points) of tic marks
gridwidth=axeswidth  width (in points) of grid lines
style=seismic  normal (axis 1 horizontal, axis 2 vertical) or
seismic (axis 1 vertical, axis 2 horizontal)
legend=0  =1 display the color scale
lnice=0  =1 nice legend arrangement
              (overrides vbox,lx,width,height parameters)
lstyle=vertleft  Vertical, axis label on left side
=vertright (Vertical, axis label on right side)
=horibottom (Horizontal, axis label on bottom)
units=  unit label for legend
legendfont=times_roman10  font name for title
following are defaults for lstyle=0. They are changed for other lstyles
lwidth=1.2  colorscale (legend) width in inches
lheight=height/3  colorscale (legend) height in inches
lx=1.0  colorscale (legend) x-position in inches
ly=(height-lheight)/2+xybox  colorscale (legend) y-position in pixels
lbeg= lmin or wclip-5*perc  value at which legend axis begins
lend= lmax or bclip+5*perc  value at which legend axis ends
ldnum=0.0  numbered tic interval on legend axis (0.0 for automatic)
lfnun=lmin  first numbered tic on legend axis (used if d1num not 0.0)
lntic=1  number of tics per numbered tic on legend axis
lgrid=none  grid lines on legend axis - none, dot, dash, or solid

curve=curve1,curve2,...  file(s) containing points to draw curve(s)

```



MODIFIED: Craig Artley, Colorado School of Mines, 08/30/91  
    BoundingBox moved to top of PostScript output

MODIFIED: Craig Artley, Colorado School of Mines, 12/16/93  
    Added color options (Courtesy of Dave Hale, Advance Geophysical).

Modified: Morten Wendell Pedersen, Aarhus University, 23/3-97  
    Added ticwidth, axeswidth, gridwidth parameters

MODIFIED: Torsten Schoenfelder, Koeln, Germany 006/07/97  
    colorbar (legend) (as in ximage (by Berend Scheffers, Delft))

MODIFIED: Brian K. Macy, Phillips Petroleum, 01/14/99  
    Added curve plotting option

MODIFIED: Torsten Schoenfelder, Koeln, Germany 02/10/99  
    color scale with interpolation of three colors

MODIFIED: Ekkehart Tessmer, University of Hamburg, Germany, 08/22/2007  
    Added dashing option to curve plotting

PSLABEL - output PostScript file consisting of a single TEXT string on a specified background. (Use with psmerge to label plots.)

```
pslabel t= [t=] [optional parameters] > epsfile
```

Required Parameters (can have multiple specifications to mix fonts):

t= text string to write to output

Optional Parameters:

f=Times-Bold font for text string  
(multiple specifications for each t)  
size=30 size of characters in points (72 points/inch)  
tcolor=black color of text string  
bcolor=white color of background box  
nsub=0 number of characters to subtract when  
computing size of background box (not all  
characters are the same size so the  
background box may be too big at times.)

Example:

```
pslabel t="(a) " f=Times-Bold t="h" f=Symbol t="=0.04" nsub=3 > epsfile
```

This example yields the PostScript equivalent of the string  
(written here in LaTeX notation)  $(a)\eta=0.04$

Notes:

This program produces a (color if desired) PostScript text string that can be positioned and pasted on a PostScript plot using psmerge see selfdoc of psmerge for further information.

Possible fonts: Helvetica, Helvetica-Oblique, Helvetica-Bold, Helvetica-BoldOblique, Times-Roman, Times-Italic, Times-Bold, Times-BoldItalic, Courier, Courier-Bold, Courier-Oblique, Courier-BoldOblique, Symbol

Possible colors: greenyellow, yellow, goldenrod, dandelion, apricot, peach, melon, yelloworange, orange, burntorange, bittersweet, redorange, mahogany, maroon, brickred, red, orangered, rubinered, wildstrawberry, salmon, carnationpink, magenta, violetred, rhodamine, mulberry, redviolet, fuchsia, lavender, thistle, orchid, darkorchid, purple, plum, violet, royalpurple, blueviolet, periwinkle, cadetblue, cornflowerblue, midnightblue, naveblue, royalblue, blue, cerulean, cyan, processblue, skyblue, turquoise, tealblue, aquamarine, bluegreen, emerald, junglegreen, seagreen, green, forestgreen,

pinegreen, limegreen, yellowgreen, springgreen, olivegreen, rawsienna, sepia,  
brown, tan, white, black, gray

All color specifications may also be made in X Window style Hex format  
example: `tcolor=#255`

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
Helvetica-Narrow-Oblique NewCentrySchlbk-Bold"  
NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic

AUTHOR: John E. Anderson, Visiting Scientist from Mobil, 1994

PSMANAGER - printer MANAGER for HP 4MV and HP 5Si Mx Laserjet  
PostScript printing

```
psmanager < stdin [optional parameters] > stdout
```

Required Parameters:

none

Optional Parameters:

papersize=0 paper size (US Letter default)

=1 US Legal

=2 A4

=3 11x17

orient=0 paper orientation (Portrait default)

=1 Landscape

tray=3 printing tray (Bottom tray default)

=1 tray 1 (multipurpose slot)

=2 tray 2

manual=0 no manual feed

=1 (Manual Feed)

media=0 regular paper

=1 Transparency

=2 Letterhead

=3 Card Stock

=4 Bond

=5 Labels

=6 Prepunched

=7 Recycled

=8 Preprinted

=9 Color (printing on colored paper)

Notes:

The option manual=1 implies tray=1. The media options apply only to the HP LaserJet 5Si MX model printer.

Examples:

overheads:

```
psmanager < postscript_file manual=1 media=1 | lpr
```

labels:

```
psmanager < postscript_file manual=1 media=5 | lpr
```

Notes: This code was reverse engineered using output from  
the NeXTStep printer manager.

Author: John Stockwell, June 1995, October 1997

Reference:  
PostScript Printer Description File Format Specification,  
version 4.2, Adobe Systems Incorporated

PSMERGE - MERGE PostScript files

psmerge in= [optional parameters] >postscriptfile

Required Parameters:

in=                            postscript file to merge

Optional Parameters:

origin=0.0,0.0                x,y origin in inches

scale=1.0,1.0                 x,y scale factors

rotate=0.0                    rotation angle in degrees

translate=0.0,0.0            x,y translation in inches

Notes:

More than one set of in, origin, scale, rotate, and translate parameters may be specified. Output x and y coordinates are determined by:

$$x = tx + (x-ox)*sx*\cos(d) - (y-oy)*sy*\sin(d)$$

$$y = ty + (x-ox)*sx*\sin(d) + (y-oy)*sy*\cos(d)$$

where tx,ty are translate coordinates, ox,oy are origin coordinates, sx,sy are scale factors, and d is the rotation angle. Note that the order of operations is shift (origin), scale, rotate, and translate.

If the number of occurrences of a given parameter is less than the number of input files, then the last occurrence of that parameter will apply to all subsequent files.

PSMOVIE - PostScript MOVIE plot of a uniformly-sampled function  $f(x_1, x_2, x_3)$

psmovie n1= [optional parameters] <binaryfile >postscriptfile

Required Parameters:

n1                    number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0                sampling interval in 1st dimension  
f1=0.0                first sample in 1st dimension  
n2=all                number of samples in 2nd (slow) dimension  
d2=1.0                sampling interval in 2nd dimension  
f2=0.0                first sample in 2nd dimension  
perc=100.0            percentile used to determine clip  
clip=(perc percentile) clip used to determine bclip and wclip  
bperc=perc            percentile for determining black clip value  
wperc=100.0-perc     percentile for determining white clip value  
bclip=clip            data values outside of [bclip,wclip] are clipped  
wclip=-clip           data values outside of [bclip,wclip] are clipped  
d1s=1.0               factor by which to scale d1 before imaging  
d2s=1.0               factor by which to scale d2 before imaging  
verbose=1             =1 for info printed on stderr (0 for no info)  
xbox=1.0              offset in inches of left side of axes box  
ybox=1.5              offset in inches of bottom side of axes box  
wbox=6.0              width in inches of axes box  
hbox=8.0              height in inches of axes box  
x1beg=x1min           value at which axis 1 begins  
x1end=x1max           value at which axis 1 ends  
d1num=0.0             numbered tic interval on axis 1 (0.0 for automatic)  
f1num=x1min           first numbered tic on axis 1 (used if d1num not 0.0)  
n1tic=1               number of tics per numbered tic on axis 1  
grid1=none            grid lines on axis 1 - none, dot, dash, or solid  
label1=               label on axis 1  
x2beg=x2min           value at which axis 2 begins  
x2end=x2max           value at which axis 2 ends  
d2num=0.0             numbered tic interval on axis 2 (0.0 for automatic)  
f2num=x2min           first numbered tic on axis 2 (used if d2num not 0.0)  
n2tic=1               number of tics per numbered tic on axis 2  
grid2=none            grid lines on axis 2 - none, dot, dash, or solid  
label2=               label on axis 2  
labelfont=Helvetica   font name for axes labels  
labelsize=18           font size for axes labels  
title=                title of plot

titlefont=Helvetica-Bold font name for title  
 titlesize=24 font size for title  
 style=seismic normal (axis 1 horizontal, axis 2 vertical) or  
 seismic (axis 1 vertical, axis 2 horizontal)  
 n3=1 number of samples in third dimension  
 title2= second title to annotate different frames  
 loopdsp=3 display loop type (1=loop over n1; 2=loop over n2;  
 3=loop over n3)  
 d3=1.0 sampling interval in 3rd dimension  
 f3=d3 first sample in 3rd dimension

NeXT: view movie via: psmovie < infile n1= [optional params...] | open  
 Note: currently only the Preview Application can handle the multipage  
 PostScript output by this program.

All color specifications may also be made in X Window style Hex format  
 example: axescolor=#255

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
 Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
 Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
 Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
 Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
 Helvetica-Narrow-Oblique NewCenturySchlbk-Bold"  
 NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
 Palatino-BoldItalic Palatino-Italics Palatino-Roman  
 SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
 Symbol Times-Bold Times-BoldItalic  
 Times-Roman Times-Italic ZapfChancery-MediumItalic

PSWIGB - PostScript WIGgle-trace plot of  $f(x_1, x_2)$  via Bitmap  
Best for many traces. Use PSWIGP (Polygon version) for few traces.

pswignb n1= [optional parameters] <binaryfile >postscriptfile

Required Parameters:

n1 number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0 sampling interval in 1st dimension  
f1=0.0 first sample in 1st dimension  
n2=all number of samples in 2nd (slow) dimension  
d2=1.0 sampling interval in 2nd dimension  
f2=0.0 first sample in 2nd dimension  
x2=f2,f2+d2,... array of sampled values in 2nd dimension  
bias=0.0 data value corresponding to location along axis 2  
perc=100.0 percentile for determining clip  
clip=(perc percentile) data values < bias+clip and > bias-clip are clipped  
xcur=1.0 wiggle excursion in traces corresponding to clip  
wt=1 =0 for no wiggle-trace; =1 for wiggle-trace  
va=1 =0 for no variable-area; =1 for variable-area fill  
=2 for variable area, solid/grey fill  
SHADING: 2<= va <=5 va=2 lightgrey, va=5 black",  
nbpi=72 number of bits per inch at which to rasterize  
verbose=1 =1 for info printed on stderr (0 for no info)  
xbox=1.5 offset in inches of left side of axes box  
ybox=1.5 offset in inches of bottom side of axes box  
wbox=6.0 width in inches of axes box  
hbox=8.0 height in inches of axes box  
x1beg=x1min value at which axis 1 begins  
x1end=x1max value at which axis 1 ends  
d1num=0.0 numbered tic interval on axis 1 (0.0 for automatic)  
f1num=x1min first numbered tic on axis 1 (used if d1num not 0.0)  
n1tic=1 number of tics per numbered tic on axis 1  
grid1=none grid lines on axis 1 - none, dot, dash, or solid  
label1= label on axis 1  
x2beg=x2min value at which axis 2 begins  
x2end=x2max value at which axis 2 ends  
d2num=0.0 numbered tic interval on axis 2 (0.0 for automatic)  
f2num=x2min first numbered tic on axis 2 (used if d2num not 0.0)  
n2tic=1 number of tics per numbered tic on axis 2  
grid2=none grid lines on axis 2 - none, dot, dash, or solid  
label2= label on axis 2

`labelfont=Helvetica` font name for axes labels  
`labelsize=18` font size for axes labels  
`title=` title of plot  
`titlefont=Helvetica-Bold` font name for title  
`titlesize=24` font size for title  
`titlecolor=black` color of title  
`axescolor=black` color of axes  
`gridcolor=black` color of grid  
`axeswidth=1` width (in points) of axes  
`ticwidth=axeswidth` width (in points) of tic marks  
`gridwidth=axeswidth` width (in points) of grid lines  
`style=seismic` normal (axis 1 horizontal, axis 2 vertical) or  
seismic (axis 1 vertical, axis 2 horizontal)  
`interp=0` no display interpolation  
`=1` use 8 point sinc interpolation  
`curve=curve1,curve2,...` file(s) containing points to draw curve(s)  
`npair=n1,n2,n2,...` number(s) of pairs in each file  
`curvecolor=black,..` color of curve(s)  
`curvewidth=axeswidth` width (in points) of curve(s)  
`curvedash=0` solid curve(s), dash indices 1,...,11 produce  
curve(s) with various dash styles

Notes:

The `interp` option may be useful for high `nbpi` values, however, it tacitly assumes that the data are purely oscillatory. Non-oscillatory data will not be represented correctly when this option is set.

The curve file is an ascii file with the points specified as `x1 x2` pairs, one pair to a line. A "vector" of curve files and curve colors may be specified as `curvefile=file1,file2,etc.` and `curvecolor=color1,color2,etc.`, and the number of pairs of values in each file as `npair=npair1,npair2,...` .

All color specifications may also be made in X Window style Hex format  
example: `axescolor=#255`

Legal font names are:

`AvantGarde-Book` `AvantGarde-BookOblique` `AvantGarde-Demi` `AvantGarde-DemiOblique"`  
`Bookman-Demi` `Bookman-DemiItalic` `Bookman-Light` `Bookman-LightItalic`  
`Courier` `Courier-Bold` `Courier-BoldOblique` `Courier-Oblique`  
`Helvetica` `Helvetica-Bold` `Helvetica-BoldOblique` `Helvetica-Oblique`  
`Helvetica-Narrow` `Helvetica-Narrow-Bold` `Helvetica-Narrow-BoldOblique`  
`Helvetica-Narrow-Oblique` `NewCenturySchlbk-Bold"`

NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic

PSWIGP - PostScript WIGgle-trace plot of  $f(x_1, x_2)$  via Polygons  
Best for few traces. Use PSWIGB (Bitmap version) for many traces.

pswigp n1= [optional parameters] <binaryfile >postscriptfile

Required Parameters:

n1 number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0 sampling interval in 1st dimension  
f1=0.0 first sample in 1st dimension  
n2=all number of samples in 2nd (slow) dimension  
d2=1.0 sampling interval in 2nd dimension  
f2=0.0 first sample in 2nd dimension  
x2=f2,f2+d2,... array of sampled values in 2nd dimension  
bias=0.0 data value corresponding to location along axis 2  
perc=100.0 percentile for determining clip  
clip=(perc percentile) data values < bias+clip and > bias-clip are clipped  
xcur=1.0 wiggle excursion in traces corresponding to clip  
fill=1 =0 for no fill;  
>0 for pos. fill;  
<0 for neg. fill  
=2 for pos. fill solid, neg. fill grey  
=-2 for neg. fill solid, pos. fill grey  
SHADING: 2<=abs(fill)<=5 2=lightgrey 5=black  
linewidth=1.0 linewidth in points (0.0 for thinnest visible line)  
tracecolor=black color of traces; should contrast with background  
backcolor=none color of background; none means no background  
verbose=1 =1 for info printed on stderr (0 for no info)  
xbox=1.5 offset in inches of left side of axes box  
ybox=1.5 offset in inches of bottom side of axes box  
wbox=6.0 width in inches of axes box  
hbox=8.0 height in inches of axes box  
x1beg=x1min value at which axis 1 begins  
x1end=x1max value at which axis 1 ends  
d1num=0.0 numbered tic interval on axis 1 (0.0 for automatic)  
f1num=x1min first numbered tic on axis 1 (used if d1num not 0.0)  
n1tic=1 number of tics per numbered tic on axis 1  
grid1=none grid lines on axis 1 - none, dot, dash, or solid  
label1= label on axis 1  
x2beg=x2min value at which axis 2 begins  
x2end=x2max value at which axis 2 ends  
d2num=0.0 numbered tic interval on axis 2 (0.0 for automatic)

f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelfont=Helvetica	font name for axes labels
labelsize=18	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
titlecolor=black	color of title
axescolor=black	color of axes
gridcolor=black	color of grid
axeswidth=1	width (in points) of axes
ticwidth=axeswidth	width (in points) of tic marks
gridwidth=axeswidth	width (in points) of grid lines
style=seismic	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)
curve=curve1,curve2,...	file(s) containing points to draw curve(s)
npair=n1,n2,n2,...	number(s) of pairs in each file
curvecolor=black,..	color of curve(s)
curvewidth=axeswidth	width (in points) of curve(s)
curvedash=0	solid curve(s), dash indices 1,...,11 produce curve(s) with various dash styles

Note: linewidth=0.0 produces the thinnest possible line on the output device. Thus the result is device-dependent, but generally looks the best for seismic traces.

The curve file is an ascii file with the points specified as x1 x2 pairs, one pair to a line. A "vector" of curve files and curve colors may be specified as curvefile=file1,file2,etc. and similarly curvecolor=color1,color2,etc, and the number of pairs of values in each file as npair=npair1,npair2,... .

All color specifications may also be made in X Window style Hex format example: axescolor=#255

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
 Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
 Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
 Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique

Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
Helvetica-Narrow-Oblique NewCenturySchlbk-Bold"  
NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic

LCMAP - List Color Map of root window of default screen

Usage: lomap

LPROP - List PROPERTIES of root window of default screen of display

Usage: lprop

SCMAP - set default standard color map (RGB\_DEFAULT\_MAP)

Usage: scmap

XCONTOUR - X CONTOUR plot of  $f(x_1, x_2)$  via vector plot call

xcontour n1= [optional parameters] <binaryfile [>psplotfile]

X Functionality:

Button 1 Zoom with rubberband box

Button 2 Show mouse (x1,x2) coordinates while pressed

q or Q key Quit

s key Save current mouse (x1,x2) location to file

p or P key Plot current window with pswigb (only from disk files)

Required Parameters:

n1 number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0 sampling interval in 1st dimension

f1=0.0 first sample in 1st dimension

x1=f1,f1+d1,... array of sampled values in 1nd dimension

n2=all number of samples in 2nd (slow) dimension

d2=1.0 sampling interval in 2nd dimension

f2=0.0 first sample in 2nd dimension

x2=f2,f2+d2,... array of sampled values in 2nd dimension

mpicks=/dev/tty file to save mouse picks in

verbose=1 =1 for info printed on stderr (0 for no info)

nc=5 number of contour values

dc=(zmax-zmin)/nc contour interval

fc=min+dc first contour

c=fc,fc+dc,... array of contour values

cwidth=1.0,... array of contour line widths

ccolor=none,... array of contour colors; none means use cgray

cdash=0.0,... array of dash spacings (0.0 for solid)

labelcf=1 first labeled contour (1,2,3,...)

labelcper=1 label every labelcper-th contour

nlabelc=nc number of labeled contours (0 no contour label)

nplaces=6 number of decimal places in contour labeling

xbox=50 x in pixels of upper left corner of window

ybox=50 y in pixels of upper left corner of window

wbox=550 width in pixels of window

hbox=700 height in pixels of window

x1beg=x1min value at which axis 1 begins

x1end=x1max value at which axis 1 ends

d1num=0.0 numbered tic interval on axis 1 (0.0 for automatic)

f1num=x1min first numbered tic on axis 1 (used if d1num not 0.0)

n1tic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
x2beg=x2min	value at which axis 2 begins
x2end=x2max	value at which axis 2 ends
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelfont=Erg14	font name for axes labels
title=	title of plot
titlefont=Rom22	font name for title
windowtitle=xwigg	title on window
labelcolor=blue	color for axes labels
titlecolor=red	color for title
gridcolor=blue	color for grid lines
labelccolor=black	color of contour labels
labelcfont=fixed	font name for contour labels
style=seismic normal	(axis 1 horizontal, axis 2 vertical) or
seismic	(axis 1 vertical, axis 2 horizontal)

"),

Notes:

For some reason the contour might slight differ from ones generated by pscontour (probably due to the pixel nature of the plot coordinates)

The line width of unlabeled contours is designed as a quarter of that of labeled contours.

AUTHOR: Morten Wendell Pedersen, Aarhus University

All the coding is based on snippets taken from xwigg, ximage and pscontour All I have done is put the parts together and put in some bugs ;-)

So credits should go to the authors of these packages...

Caveats and Notes:

The code has been developed under Linux 1.3.20/Xfree 3.1.2E (X11 6.1) with gcc-2.7.0 But hopefully it should work on other platforms as well

Since all the contours are drawn by Vector plot call's everytime the

Window is exposed, the exposing can be darn slow  
OOPS This should be history... Now I keep my window content with backing store so I won't have to redraw my window unless I really have to...

Portability Question: I guess I should check if the display supports backingstore and redraw if it doesn't (see DoesBackingStore(3) )  
I have to be able to use CWBackingStore==Always (other values can be NonUseful and WhenMapped

Since I put the contour labels everytime I draw one contour level the area that contains the label will be crossed by the the next contour lines... (this bug also seems to be present in pscontour)  
To fix this I have to redraw all the labels after been through all the contour calls  
Right now I can't see a way to fix this without actually to through the entire label positioning again....Overkill I would say

The relative short length of the contour segments will propably mask the cdash settings  
which means it is disposable (but I know how to draw dashed lines :)  
A way of fixing this could be to get all connected point and then use XDrawlines or XDrawSegments... just an idea...No idea if it'll work.

I think there is a bug in xContour since my plot coordinates increase North and west ward instead of south and eastward

I need to check the Self Doc so if the right parameters are described (I have been through it a couple of times but....)

All functions need a heavy cleanup for unused variables  
I suppose there is a couple of memory leaks due to missing free'ing of numerous pointers (especially fonts,GC's & colors could be a problem...

I have to browse through the internal pscontour call... basically what I have done is just putting pscontour instead of pswigb... Instead of repositioning the input file pointer (which doesnt work with pipes) one should consider the use of temporary file  
or write your zoombox to pscontour (...how one does that?)

Wish List:

The use of cgray's unused until now... I guess I'll need to allocate a gray Colormap -> meaning that the code not will run at other display

than 8 bit Pseudocolor :( (with the use of present version of the colormap library (code in \$CWPROOT/src/xplot/lib ) )

The format of contour label should be open for the user..

It could be nice if one could choose to have a pixmap (like ximage ) underlying the contours... this should be defined either by the input data or by a seperate file

eg useful for viewing traveltime contours on top a plot of the velocity field

XESPB - X windows display of Encapsulated PostScript as a single Bitmap

Usage: xepsb < stdin

Caveat: your system must have Display PostScript Graphics

NOTE: This program is included as a demo of EPS -> X programming.

See: xepsp and xpsp these are more advanced versions

XEPSP - X windows display of Encapsulated PostScript

Usage: xepsp < stdin

Caveat: your system must have Display PostScript Graphics

Note:

this program is a more advanced version of xepsb. See also: xepsp

XIMAGE - X IMAGE plot of a uniformly-sampled function  $f(x_1, x_2)$

ximage n1= [optional parameters] <binaryfile

X Functionality:

Button 1 Zoom with rubberband box

Button 2 Show mouse (x1,x2) coordinates while pressed

q or Q key Quit

s key Save current mouse (x1,x2) location to file

p or P key Plot current window with pswigb (only from disk files)

a or page up keys enhance clipping by 10%

c or page down keys reduce clipping by 10%

up,down,left,right keys move zoom window by half width/height

i or +(keypad) zoom in by factor 2

o or -(keypad) zoom out by factor 2

... change colormap interactively

r install next RGB - colormap

R install previous RGB - colormap

h install next HSV - colormap

H install previous HSV - colormap

H install previous HSV - colormap

(Move mouse cursor out and back into window for r,R,h,H to take effect)

Required Parameters:

n1 number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0 sampling interval in 1st dimension

f1=0.0 first sample in 1st dimension

n2=all number of samples in 2nd (slow) dimension

d2=1.0 sampling interval in 2nd dimension

f2=0.0 first sample in 2nd dimension

mpicks=/dev/tty file to save mouse picks in

perc=100.0 percentile used to determine clip

clip=(perc percentile) clip used to determine bclip and wclip

bperc=perc percentile for determining black clip value

wperc=100.0-perc percentile for determining white clip value

bclip=clip data values outside of [bclip,wclip] are clipped

wclip=-clip data values outside of [bclip,wclip] are clipped

balance=0 bclip & wclip individually

=1 set them to the same abs value

if specified via perc (avoids colorbar skew)

cmap=hsv\*n*\ or rgb\*m*\ \*n*\ is a number from 0 to 13  
 \*m*\ is a number from 0 to 11  
 cmap=rgb0 is equal to cmap=gray  
 cmap=hsv1 is equal to cmap=hue  
 (compatibility to older versions)  
 legend=0           =1 display the color scale  
 units= unit label for legend  
 legendfont=times\_roman10   font name for title  
 verbose=1 =1 for info printed on stderr (0 for no info)  
 xbox=50 x in pixels of upper left corner of window  
 ybox=50 y in pixels of upper left corner of window  
 wbox=550 width in pixels of window  
 hbox=700 height in pixels of window  
 lwidth=16 colorscale (legend) width in pixels  
 lheight=hbox/3 colorscale (legend) height in pixels  
 lx=3 colorscale (legend) x-position in pixels  
 ly=(hbox-lheight)/3   colorscale (legend) y-position in pixels  
 x1beg=x1min value at which axis 1 begins  
 x1end=x1max value at which axis 1 ends  
 d1num=0.0 numbered tic interval on axis 1 (0.0 for automatic)  
 f1num=x1min first numbered tic on axis 1 (used if d1num not 0.0)  
 n1tic=1 number of tics per numbered tic on axis 1  
 grid1=none grid lines on axis 1 - none, dot, dash, or solid  
 label1= label on axis 1  
 x2beg=x2min value at which axis 2 begins  
 x2end=x2max value at which axis 2 ends  
 d2num=0.0 numbered tic interval on axis 2 (0.0 for automatic)  
 f2num=x2min first numbered tic on axis 2 (used if d2num not 0.0)  
 n2tic=1 number of tics per numbered tic on axis 2  
 grid2=none grid lines on axis 2 - none, dot, dash, or solid  
 label2= label on axis 2  
 labelfont=Erg14 font name for axes labels  
 title= title of plot  
 titlefont=Rom22 font name for title  
 windowtitle=ximage title on window  
 labelcolor=blue color for axes labels  
 titlecolor=red color for title  
 gridcolor=blue color for grid lines  
 style=seismic           normal (axis 1 horizontal, axis 2 vertical) or  
 seismic (axis 1 vertical, axis 2 horizontal)  
 blank=0 This indicates what portion of the lower range  
 to blank out (make the background color). The  
 value should range from 0 to 1.

plotfile=plotfile.ps filename for interactive plotting (P)  
curve=curve1,curve2,... file(s) containing points to draw curve(s)  
npair=n1,n2,n2,... number(s) of pairs in each file  
curvecolor=color1,color2,... color(s) for curve(s)  
blockinterp=0 whether to use block interpolation (0=no, 1=yes)

NOTES:

The curve file is an ascii file with the points specified as x1 x2 pairs separated by a space, one pair to a line. A "vector" of curve files and curve colors may be specified as curvefile=file1,file2,etc. and curvecolor=color1,color2,etc, and the number of pairs of values in each file as npair=npair1,npair2,... .

AUTHOR: Dave Hale, Colorado School of Mines, 08/09/90

Stewart A. Levin, Mobil - Added ps print option

Brian Zook, Southwest Research Institute, 6/27/96, added blank option

Toralf Foerster, Baltic Sea Research Institute, 9/15/96, new colormaps

Berend Scheffers, Delft, colorbar (legend)

Brian K. Macy, Phillips Petroleum, 11/27/98, added curve plotting option

G.Klein, GEOMAR Kiel, 2004-03-12, added cursor scrolling and  
interactive change of zoom and clipping.

Zhaobo Meng, ConocoPhillips, 12/02/04, added amplitude display

Garry Perratt, Geocon, 08/04/05, modified perc handling to center colorbar if balance-

INTL2B\_block - blocky interpolation of a 2-D array of bytes

intl2b\_block blocky interpolation of a 2-D array of bytes

Function Prototype:

```
void intl2b_block(int nxin, float dxin, float fxin,  
int nyin, float dyin, float fyin, unsigned char *zin,  
int nxout, float dxout, float fxout,  
int nyout, float dyout, float fyout, unsigned char *zout);
```

Input:

nxin number of x samples input (fast dimension of zin)  
dxin x sampling interval input  
fxin first x sample input  
nyin number of y samples input (slow dimension of zin)  
dyin y sampling interval input  
fyin first y sample input  
zin array[nyin][nxin] of input samples (see notes)  
nxout number of x samples output (fast dimension of zout)  
dxout x sampling interval output  
fxout first x sample output  
nyout number of y samples output (slow dimension of zout)  
dyout y sampling interval output  
fyout first y sample output

Output:

zout array[nyout][nxout] of output samples (see notes)

Notes:

The arrays zin and zout must be passed as pointers to the first element of a two-dimensional contiguous array of unsigned char values.

Constant extrapolation of zin is used to compute zout for output x and y outside the range of input x and y.

Author: James Gunning, CSIRO Petroleum 1999. Hacked from int12b() by Dave Hale, Colorado School of Mines, c. 1989-1991

XPICKER - X wiggle-trace plot of  $f(x_1, x_2)$  via Bitmap with PICKing

xpicker n1= [optional parameters] <binaryfile

X Menu functionality:

- Pick Filename Window default is pick\_file
- Load load an existing Pick Filename
- Save save to Pick Filename
- View only/Pick default is View, click to enable Picking
- Add/Delete default is Add, click to delete picks
- Cross off/on default is Cross off, click to enable Crosshairs

In View mode:

- a or page up keys           enhance clipping by 10%
- c or page down keys        reduce clipping by 10%
- up,down,left,right keys    move zoom window by half width/height
- i or +(keypad)            zoom in by factor 2
- o or -(keypad)            zoom out by factor 2
- l lock the zoom while moving the cursor
- u unlock the zoom

Notes:

- Menu selections and toggles ("clicks") are made with button 1
- Pick selections are made with button 3
- Edit a pick selection by dragging it with button 3 down or by making a new pick on that trace
- Reaching the window limits while moving within changes the zoom factor in this direction. The use of zoom locking(l) disables it

Other X Mouse functionality:

- Mouse Button 1 Zoom with rubberbox
- Mouse Button 2 Show mouse (x1,x2) coordinates while pressed

The following keys are active in View Only mode:

Required Parameters:

n1= number of samples in 1st (fast) dimension

Optional Parameters:

- mpicks=pick\_file name of output (input) pick file
- d1=1.0 sampling interval in 1st dimension
- f1=d1 first sample in 1st dimension
- n2=all number of samples in 2nd (slow) dimension



=0 save picks in the order (x2,x1)

Notes:

Xpicker will try to detect the endian value of the X-display and will set it to the right value. If it gets obviously wrong information the endian value will be set to the endian value of the machine that is given at compile time as the value of CWPENDIAN defined in cwp.h and set via the compile time flag ENDIANFLAG in Makefile.config.

The only time that you might want to change the value of the endian variable is if you are viewing traces on a machine with a different byte order than the machine you are creating the traces on AND if for some reason the automatic detection of the display byte order fails. Set endian to that of the machine you are viewing the traces on.

The interp flag is useful for making better quality wiggle trace for making plots from screen dumps. However, this flag assumes that the data are purely oscillatory. This option may not be appropriate for all data sets.

If the x2file= option is set, then the values from the specified file will define the set of "acceptable" values of x2 for xpicker to output. The format is a single column of ASCII values. The number of specified values is arbitrary.

Such a file can be built from an SU data set via:

```
sugethw < sudata key=offset output=geom > x2example
```

If the value of x2file= is not set, then xpicker will use the values specified via: x2=.,.,.,. or those that are", computed from the values of f2= and d2= as being the "acceptable values.

See the selfdoc of suxpicker for information on using key fields from the SU trace headers directly.

AUTHOR: Dave Hale, Colorado School of Mines, 08/09/90  
with picking by Wenying Cai of University of Utah.  
Endian stuff by Morten Pedersen and John Stockwell of CWP.  
Interp stuff by Tony Kocurko of Memorial University of Newfoundland  
Modified to include acceptable values by Bill Lutter of the

Department of Geology, University of Wisconsin 10/96  
MODIFIED: P. Michaels, Boise State Univeristy 29 December 2000  
Added solid/grey color scheme for peaks/troughs

G.Klein, IFG Kiel University, 2003-09-29, added cursor scrolling and  
interactive change of zoom and clipping.

NOTES:

Interactive picker improved to allow x-axis of picks to be  
coordinated with "key=header" parameter set in driver routine  
suxpicker. Multiple picks per trace are now allowed.

Input:

The command line of suxpicker is unchanged. The parameter "key=header"  
set in suxpicker controls a) trace x-axis displayed via xpicker and  
b) the header values in the first column of a pick file either read in  
or written out from xpicker c) header values expected in optional file  
or written out from xpicker c) header values expected in optional file  
x2file= which reads into xpicker allowable trace x-axis values.

a) example command line: suxpicker key=offset < shot10.plotpik

b) pick file format:

x-axis\_value\_1 time\_1  
x-axis\_value\_2 time\_2  
x-axis\_value\_3 time\_3  
etc.  
x-axis\_value\_n time\_n

pick file example:

1000.000000 0.500000  
2000.000000 1.000000  
3000.000000 1.500000  
4000.000000 2.000000  
5000.000000 2.500000

c) format of optional file x2file=:

header\_value\_1  
header\_value\_2  
etc.  
header\_val\_m

If file "x2file=" exists in directory from which suxpicker is

invoked, then these trace header x-axis values are the only allowable x-axis pick values used in the pick "add" or "delete" menu operation. Header values do not need to be sorted or 1 to 1 with input traces. Further, pick file x-axis values can be read into xpicker via load operation without having to match key\_pickx1\_val x-axis values and can also be rewritten out an output pickfile. As indicated, only the "add" and "delete" pick operations are influenced by existence of this file.

Offset header values for "x2file=" can be generated by the command line:

```
sugethw < su_segyfile key=offset output=geom > x2examplefile=
```

Output: Only change is in format of pick\_file (format described above). If x2file= file exists then x-axis value of added picks will be forced to nearest allowable trace x-axis value (input values of x2file= file). If x2file= is not set, then the values of x2 that are either assigned uniformly to the traces via f2 and d2, or by the vector of values of x2=.,.,.,. will be the "acceptable" values.

Strategy:

a) malloc() and realloc() used to dynamically allocate memory for array of x-axis value read in from optional file x2file=. This is done in function read\_keyval().

b) The pick file dimensions are set in main program via malloc() and then initialized (\*apick)[i].picked = FALSE) in function init\_picks(). The pick file is declared as pick\_t \*\*apick, in order to use realloc() as needed in functions load\_picks where the pick file is read in and edit\_picks where picks are added. The call to realloc() and further initializing is performed in function realloc\_picks().

c) If x2file= file exists the mouse derived x-axis value for a pick to be added is checked against allowable x-axis values to find the closest match via function add\_pick called from edit\_picks. If the pick is to be deleted, first a search is done to find the closest x-axis value, then the existing pick values are searched to find the closest radial value ( $x**2 + t**2$ ) via function del\_pick() invoked from edit\_picks.

d) Code modifications are limited to above mentioned functions, except for additional parameters passed to functions `edit_picks`, `load_picks`, `save_picks`, and `check_buttons`.

XPS - Display conforming PostScript in an X-window

```
xps < stdin
```

Note: this is the most advanced version of xpsb and xps.

Caveat: your system must have Display PostScript Graphics

XWIGB - X WIGgle-trace plot of  $f(x_1, x_2)$  via Bitmap

xwigb n1= [optional parameters] <binaryfile

X Functionality:

Button 1 Zoom with rubberband box

Button 2 Show mouse (x1,x2) coordinates while pressed

q or Q key Quit

s key Save current mouse (x1,x2) location to file

p or P key Plot current window with pswigb (only from disk files)

a or page up keys enhance clipping by 10%

c or page down keys reduce clipping by 10%

up,down,left,right keys move zoom window by half width/height

i or +(keypad) zoom in by factor 2

o or -(keypad) zoom out by factor 2

l lock the zoom while moving the cursor

u unlock the zoom

1,2,...,9 Zoom/Move factor of the window size

Notes:

Reaching the window limits while moving within changes the zoom factor in this direction. The use of zoom locking(1) disables it

Required Parameters:

n1 number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0 sampling interval in 1st dimension

f1=0.0 first sample in 1st dimension

n2=all number of samples in 2nd (slow) dimension

d2=1.0 sampling interval in 2nd dimension

f2=0.0 first sample in 2nd dimension

x2=f2,f2+d2,... array of sampled values in 2nd dimension

mpicks=/dev/tty file to save mouse picks in

bias=0.0 data value corresponding to location along axis 2

perc=100.0 percentile for determining clip

clip=(perc percentile) data values  $< \text{bias} + \text{clip}$  and  $> \text{bias} - \text{clip}$  are clipped

xcur=1.0 wiggle excursion in traces corresponding to clip

wt=1 =0 for no wiggle-trace; =1 for wiggle-trace

va=1 =0 for no variable-area; =1 for variable-area fill

=2 for variable area, solid/grey fill

SHADING:  $2 \leq \text{va} \leq 5$  va=2 light grey, va=5 black

verbose=0 =1 for info printed on stderr (0 for no info)

```

xbox=50  x in pixels of upper left corner of window
ybox=50  y in pixels of upper left corner of window
wbox=550  width in pixels of window
hbox=700  height in pixels of window
x1beg=x1min  value at which axis 1 begins
x1end=x1max  value at which axis 1 ends
d1num=0.0  numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min  first numbered tic on axis 1 (used if d1num not 0.0)
n1tic=1  number of tics per numbered tic on axis 1
grid1=none  grid lines on axis 1 - none, dot, dash, or solid
x2beg=x2min  value at which axis 2 begins
x2end=x2max  value at which axis 2 ends
d2num=0.0  numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min  first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1  number of tics per numbered tic on axis 2
grid2=none  grid lines on axis 2 - none, dot, dash, or solid
label2=  label on axis 2
labelfont=Erg14  font name for axes labels
title=  title of plot
titlefont=Rom22  font name for title
windowtitle=xwigg  title on window
labelcolor=blue  color for axes labels
titlecolor=red  color for title
gridcolor=blue  color for grid lines
style=seismic  normal (axis 1 horizontal, axis 2 vertical) or
seismic (axis 1 vertical, axis 2 horizontal)
endian=  =0 little endian =1 big endian
interp=0  no interpolation in display
=1 use 8 point sinc interpolation
wigclip=0  If 0, the plot box is expanded to accommodate
the larger wiggles created by xcur>1. If this
flag is non-zero, the extra-large wiggles are
are clipped at the boundary of the plot box.
plotfile=plotfile.ps  filename for interactive plotting (P)
curve=curve1,curve2,...  file(s) containing points to draw curve(s)
npair=n1,n2,n2,...  number(s) of pairs in each file
curvecolor=color1,color2,...  color(s) for curve(s)

```

Notes:

Xwigg will try to detect the endian value of the X-display and will set it to the right value. If it gets obviously wrong information the endian value will be set to the endian value of the machine that is given at compile time as the value of CWPENDIAN defined in cwp.h

and set via the compile time flag ENDIANFLAG in Makefile.config.

The only time that you might want to change the value of the endian variable is if you are viewing traces on a machine with a different byte order than the machine you are creating the traces on AND if for some reason the automatic detection of the display byte order fails. Set endian to that of the machine you are viewing the traces on.

The interp flag is useful for making better quality wiggle trace for making plots from screen dumps. However, this flag assumes that the data are purely oscillatory. This option may not be appropriate for all data sets.

The curve file is an ascii file with the points specified as x1 x2 pairs, separated by a space, one pair to a line. A "vector" of curve files and curve colors may be specified as curvefile=file1,file2,etc. and curvecolor=color1,color2,etc, and the number of pairs of values in each file as npair=npair1,npair2,... .

AUTHOR: Dave Hale, Colorado School of Mines, 08/09/90

Endian stuff by:

Morten Wendell Pedersen, Aarhus University (visiting CSM, June 1995)  
& John Stockwell, Colorado School of Mines, 5 June 1995

Stewart A. Levin, Mobil - Added ps print option  
John Stockwell - Added optional sinc interpolation  
Stewart A. Levin, Mobil - protect title, labels in pswigb call

Brian J. Zook, SwRI - Added style=normal and wigclip flag

Brian K. Macy, Phillips Petroleum, 11/27/98, added curve plotting option  
Curve plotting notes:

MODIFIED: P. Michaels, Boise State Univeristy 29 December 2000  
Added solid/grey color scheme for peaks/troughs

G.Klein, IFG Kiel University, 2002-09-29, added cursor scrolling and  
interactive change of zoom and clipping.  
IFM-GEOMAR Kiel, 2004-03-12, added zoom locking  
IFM-GEOMAR Kiel, 2004-03-25, interactive plotting fixed

## XGRAPH - X GRAPHer

Graphs  $n[i]$  pairs of  $(x,y)$  coordinates, for  $i = 1$  to  $nplot$ .

`xgraph n= [optional parameters] <binaryfile`

### X Functionality:

q or Q key      Quit

### Required Parameters:

n                      array containing number of points per plot

### Optional Parameters:

`nplot=`number of n's      number of plots  
`d1=0.0,...`              x sampling intervals (0.0 if x coordinates input)  
`f1=0.0,...`              first x values (not used if x coordinates input)  
`d2=0.0,...`              y sampling intervals (0.0 if y coordinates input)  
`f2=0.0,...`              first y values (not used if y coordinates input)  
`pairs=1,...`              =1 for data pairs in format 1.a, =0 for format 1.b  
`linewidth=1,1,...`      line widths in pixels (0 for no lines)  
`linecolor=2,3,...`      line colors (black=0, white=1, 2,3,4 = RGB, ...)  
`mark=0,1,2,3,...`      indices of marks used to represent plotted points  
`marksize=0,0,...`      size of marks in pixels (0 for no marks)  
`x1beg=x1min`            value at which axis 1 begins  
`x1end=x1max`            value at which axis 1 ends  
`x2beg=x2min`            value at which axis 2 begins  
`x2end=x2max`            value at which axis 2 ends  
`reverse=0`              =1 to reverse sequence of plotting curves "

### Optional resource parameters (defaults taken from resource database):

`windowtitle=`            title on window  
`width=`                  width in pixels of window  
`height=`                 height in pixels of window  
`nTic1=`                  number of tics per numbered tic on axis 1  
`grid1=`                  grid lines on axis 1 - none, dot, dash, or solid  
`label1=`                 label on axis 1  
`nTic2=`                  number of tics per numbered tic on axis 2  
`grid2=`                  grid lines on axis 2 - none, dot, dash, or solid  
`label2=`                 label on axis 2  
`labelFont=`             font name for axes labels  
`title=`                  title of plot  
`titleFont=`             font name for title  
`titleColor=`            color for title  
`axesColor=`             color for axes

gridColor= color for grid lines  
style= normal (axis 1 horizontal, axis 2 vertical) or  
seismic (axis 1 vertical, axis 2 horizontal)

Data formats supported:

- 1.a.  $x_1, y_1, x_2, y_2, \dots, x_n, y_n$
- b.  $x_1, x_2, \dots, x_n, y_1, y_2, \dots, y_n$
2.  $y_1, y_2, \dots, y_n$  (must give non-zero  $d1[]$ )
3.  $x_1, x_2, \dots, x_n$  (must give non-zero  $d2[]$ )
4. nil (must give non-zero  $d1[]$  and non-zero  $d2[]$ )

The formats may be repeated and mixed in any order, but if formats 2-4 are used, the  $d1$  and  $d2$  arrays must be specified including  $d1[]=0.0$   $d2[]=0.0$  entries for any internal occurrences of format 1. Similarly, the pairs array must contain place-keeping entries for plots of formats 2-4 if they are mixed with both formats 1.a and 1.b. Also, if formats 2-4 are used with non-zero  $f1[]$  or  $f2[]$  entries, then the corresponding array(s) must be fully specified including  $f1[]=0.0$  and/or  $f2[]=0.0$  entries for any internal occurrences of format 1 or formats 2-4 where the zero entries are desired.

mark index:

1. asterisk
2. x-cross
3. open triangle
4. open square
5. open circle
6. solid triangle
7. solid square
8. solid circle

Note:  $n1$  and  $n2$  are acceptable aliases for  $n$  and  $nplot$ , respectively.

Example:

```
xgraph n=50,100,20 d1=2.5,1,0.33 <datafile
  plots three curves with equally spaced x values in one plot frame
  x1-coordinates are  $x1(i) = f1+i*d1$  for  $i = 1$  to  $n$  ( $f1=0$  by default)
  number of x2's and then x2-coordinates for each curve are read
  sequentially from datafile.
```

XMOVIE - image one or more frames of a uniformly sampled function  $f(x_1, x_2)$

xmovie n1= n2= [optional parameters] <fileoffloats

X Functionality:

Button 1 Zoom with rubberband box

Button 2 reverse the direction of the movie.

Button 3 stop and start the movie.

q or Q key Quit

s or S key stop display and switch to Step mode

b or B key set frame direction to Backward

f or F key set frame direction to Forward

n or N key same as 'f'

c or C key set display mode to Continuous mode

Required Parameters:

n1= number of samples in 1st (fast) dimension

n2= number of samples in 2nd (slow) dimension

Optional Parameters:

d1=1.0 sampling interval in 1st dimension

f1=0.0 first sample in 1st dimension

d2=1.0 sampling interval in 2nd dimension

f2=0.0 first sample in 2nd dimension

perc=100.0 percentile used to determine clip

clip=(perc percentile) clip used to determine bclip and wclip

bperc=perc percentile for determining black clip value

wperc=100.0-perc percentile for determining white clip value

bclip=clip data values outside of [bclip,wclip] are clipped

wclip=-clip data values outside of [bclip,wclip] are clipped

x1beg=x1min value at which axis 1 begins

x1end=x1max value at which axis 1 ends

x2beg=x2min value at which axis 2 begins

x2end=x2max value at which axis 2 ends

fframe=1 value corresponding to first frame

dframe=1 frame sampling interval

loop=0 =1 to loop over frames after last frame is input

=2 to run movie back and forth

interp=1 =0 for a non-interpolated, blocky image

verbose=1 =1 for info printed on stderr (0 for no info)

idm=0 =1 to set initial display mode to stepmode

Optional resource parameters (defaults taken from resource database):

windowtitle= title on window and icon  
 width= width in pixels of window  
 height= height in pixels of window  
 nTic1= number of tics per numbered tic on axis 1  
 grid1= grid lines on axis 1 - none, dot, dash, or solid  
 label1= label on axis 1  
 nTic2= number of tics per numbered tic on axis 2  
 grid2= grid lines on axis 2 - none, dot, dash, or solid  
 label2= label on axis 2  
 labelFont= font name for axes labels  
 title= title of plot  
 titleFont= font name for title  
 titleColor= color for title  
 axesColor= color for axes  
 gridColor= color for grid lines  
 style= normal (axis 1 horizontal, axis 2 vertical) or  
 seismic (axis 1 vertical, axis 2 horizontal)  
 sleep= delay between frames in microseconds

Color options:

cmap=gray gray, hue, saturation, or default colormaps may be specified  
 bhue=0 hue mapped to bclip (hue and saturation maps)  
 whue=240 hue mapped to wclip (hue and saturation maps)  
 sat=1 saturation (hue map only)  
 bright=1 brightness (hue and saturation maps)  
 white=(bclip+wclip)/2 data value mapped to white (saturation map only)

Notes:

Colors are specified using the HSV color wheel model:

Hue: 0=360=red, 60=yellow, 120=green, 180=cyan, 240=blue, 300=magenta

Saturation: 0=white, 1=pure color

Value (brightness): 0=black, 1=maximum intensity

For the saturation mapping (cmap=sat), data values between white and bclip are mapped to bhue, with saturation varying from white to the pure color.

Values between wclip and white are similarly mapped to whue.

For the hue mapping (cmap=hue), data values between wclip and bclip are mapped to hues between whue and bhue. Intermediate hues are found by moving counterclockwise around the circle from bhue to whue. To reverse the polarity of the image, exchange bhue and whue. Equivalently, exchange bclip and wclip (setting perc=0 is an easy way to do this). Hues in excess of 360 degrees can be specified in order to reach the opposite side of the color circle, or to wrap around the circle more than once.

The title string may contain a C printf format string containing a conversion character for the frame number. The frame number is computed from dframe and fframe. E.g., try setting title="Frame %g".

XRECTS - plot rectangles on a two-dimensional grid

xrects x1min= x1max= x2min= x2max= [optional parameters] <rectangles

Required Parameters:

x1min	minimum x1 coordinate
x1max	maximum x1 coordinate
x2min	minimum x2 coordinate
x2max	maximum x2 coordinate

Optional Parameters:

color=red	color used for rectangles
-----------	---------------------------

Optional resource parameters (defaults taken from resource database):

width=	width in pixels of window
height=	height in pixels of window
nTic1=	number of tics per numbered tic on axis 1
grid1=	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
nTic2=	number of tics per numbered tic on axis 2
grid2=	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelFont=	font name for axes labels
title=	title of plot
titleFont=	font name for title
titleColor=	color for title
axesColor=	color for axes
gridColor=	color for grid lines
style=	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)

FFTLAB - Motif-X based graphical 1D Fourier Transform

Usage: fftlab

Caveat: you must have the Motif Developer's package to install this code

SUPSCONTOUR - PostScript CONTOUR plot of a segy data set

supscoutour <stdin [optional parameters] | ...

Optional parameters:

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the pscontour selfdoc for the remaining parameters.

On NeXT: supscoutour < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2

Credits:

CWP: Dave Hale and Zhiming Li (pscontour, etc.)

Jack Cohen and John Stockwell (supscontour, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Aarhus University: Morten W. Pedersen copied everything from the xwigb source and just replaced all occurrences of the word

Notes:

When the number of traces isn't known, we need to count the traces for pscontour. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSCUBECONTOUR - PostScript CUBE plot of a segy data set

supscubecontour <stdin [optional parameters] | ...

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the pscubecontour selfdoc for the remaining parameters.

example: supscubecontour < infile [optional parameters] | gv -

Credits:

CWP: Dave Hale and Zhiming Li (pscube)  
Jack K. Cohen (suxmovie)  
John Stockwell (supscubecontour)

Notes:

When `n2` isn't getparred, we need to count the traces for pscube. Although we compute `ntr`, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use `tr.data`, we allocate a trace buffer for code clarity.

SUPSCUBE - PostScript CUBE plot of a segy data set

```
supscube <stdin [optional parameters] | ...
```

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the pscube selfdoc for the remaining parameters.

On NeXT: supscube < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (pscube)  
Jack K. Cohen (suxmovie)  
John Stockwell (supscube)

Notes:

When `n2` isn't getparred, we need to count the traces for pscube. Although we compute `ntr`, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use `tr.data`, we allocate a trace buffer for code clarity.

SUPSGRAPH - PostScript GRAPH plot of a segy data set

supsgraph <stdin [optional parameters] | ...

Optional parameters:

style=seismic seismic is default here, =normal is alternate  
(see psgraph selfdoc for style definitions)

nplot is the number of traces (ntr is an acceptable alias for nplot)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the psgraph selfdoc for the remaining parameters.

On NeXT: supsgraph < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (pswign, etc.)  
Jack Cohen and John Stockwell (supswign, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for pswign. You can make this value "known" either by getparring nplot or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSIMAGE - PostScript IMAGE plot of a segy data set

supsimage <stdin [optional parameters] | ...

Optional parameters:

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range.

Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the psimage selfdoc for the remaining parameters.

On NeXT: supsimage < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2

Credits:

CWP: Dave Hale and Zhiming Li (psimage, etc.)  
Jack Cohen and John Stockwell (supsimage, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for psimage. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.  
"remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSMAX - PostScript of the MAX, min, or absolute max value on each trace of a SEG Y (SU) data set

```
supsmx <stdin >postscript file [optional parameters]
```

Optional parameters:

mode=max max value

=min min value

=abs absolute max value

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the sumax selfdoc for additional parameter.

See the psgraph selfdoc for the remaining parameters.

Credits:

CWP: John Stockwell, based on Jack Cohen's SU JACKet

Notes:

When the number of traces isn't known, we need to count the traces for psgraph. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

SUPSMOVIE - PostScript MOVIE plot of a segy data set

```
supsmovie <stdin [optional parameters] | ...
```

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the psmovie selfdoc for the remaining parameters.

On NeXT: supsmovie < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (psmovie)  
Jack K. Cohen (suxmovie)  
John Stockwell (supsmovie)

Notes:

When n2 isn't getparred, we need to count the traces for psmovie. In this case: we are using tmpfile because on many machines it is implemented as a memory area instead of a disk file. Although we compute ntr, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSWIGB - PostScript Bit-mapped WIGgle plot of a segy data set

supswigb <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or  
vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
    the CWP\_TMPDIR environment variable is set use  
    its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: pswigb  
See the pswigb selfdoc for the remaining parameters.

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2, keyword (if set)

Credits:

CWP: Dave Hale and Zhiming Li (pswigb, etc.)

Jack Cohen and John Stockwell (supswigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor scale factors, added vsp style

Notes:

When the number of traces isn't known, we need to count the traces for pswigb. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSWIGP - PostScript Polygon-filled WIGgle plot of a segy data set

supswigp <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, values of x2 are set from header field  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or  
vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
    the CWP\_TMPDIR environment variable is set use  
    its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is  
time and the "slow dimension" is usually trace number or range.  
Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to override the header values if  
not.

If key=keyword is set, then the values of x2 are taken from the header  
field represented by the keyword (for example key=offset, will show  
traces in true offset). This permit unequally spaced traces to be plotted.  
Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: pswigp  
See the pswigp selfdoc for the remaining parameters.

On NeXT: supswigp < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2, key specified by key

Credits:

CWP: Dave Hale and Zhiming Li (pswigp, etc.)

Jack Cohen and John Stockwell (supswigp, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor scale factors, added vsp style

Notes:

When the number of traces isn't known, we need to count the traces for pswigp. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXCONTOUR - X CONTOUR plot of Seismic UNIX tracefile via vector plot call

```
suxwig <stdin [optional parameters] | ...
```

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

verbose=0                    =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: xcontour See the xcontour selfdoc for the remaining parameters.

Credits:

CWP: Dave Hale and Zhiming Li (xwigb, etc.)

Jack Cohen and John Stockwell (suxwigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Aarhus University: Morten W. Pedersen copied everything from the xwigb source and just replaced all occurrences of the word xwigb with xcountour ;-)

Notes:

When the number of traces isn't known, we need to count the traces for xcountour. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXGRAPH - X-windows GRAPH plot of a segy data set

```
suxgraph <stdin [optional parameters] | ...
```

Optional parameters:

style=seismic seismic is default here, =normal is alternate  
(see xgraph selfdoc for style definitions)

nplot= number of traces (ntr is an acceptable alias for nplot)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the xgraph selfdoc for the remaining parameters.

On NeXT: `suxgraph < infile [optional parameters] | open`

Credits:

CWP: Dave Hale and Zhiming Li (pswignp, etc.)  
Jack Cohen and John Stockwell (supswignp, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for pswignp. You can make this value "known" either by getparrng nplot or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXIMAGE - X-windows IMAGE plot of a segy data set

```
suximage infile= [optional parameters] | ... (direct I/O)
or
suximage <stdin [optional parameters] | ... (sequential I/O)
```

Optional parameters:

infile=NULL SU data to be plotted, default stdin with sequential access  
if 'infile' provided, su data read by (fast) direct access

with ftr,dtr and n2 suimage will pass a subset of data  
to the plotting program-ximage:

ftr=1 First trace to be plotted  
dtr=1 Trace increment to be plotted  
n2=tr.ntr (Max) number of traces to be plotted (ntr is an alias for n2)  
Priority: first try to read from parameter line;  
if not provided, check trace header tr.ntr;  
if still not provided, figure it out using ftello

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set or was set to 0)

key= key for annotating d2 (slow dimension)  
If annotation is not at proper increment, try  
setting d2; only first trace's key value is read

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the ximage selfdoc for the remaining parameters.

#### Credits:

CWP: Dave Hale and Zhiming Li (ximage, etc.)

Jack Cohen and John Stockwell (suximage, etc.)

MTU: David Forel, June 2004, added key for annotating d2

ConocoPhillips: Zhaobo Meng, Dec 2004, added direct I/O

#### Notes:

When provide ftr and dtr and infile, suximage can be used to plot multi-dimensional volumes efficiently. For example, for a Offset-CDP dataset with 32 offsets, the command line  
suximage infile=volume3d.su ftr=1 dtr=32 ... &  
will display the zero-offset common offset data with ranrom access. It is highly recommend to use infile= to view large datasets, since using stdin only allows sequential access, which is very slow for large datasets.

When the number of traces isn't known, we need to count the traces for ximage. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXMAX - X-windows graph of the MAX, min, or absolute max value on each trace of a SEG Y (SU) data set

```
suxmax <stdin [optional parameters]
```

Optional parameters:

mode=max max value

=min min value

=abs absolute max value

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the sumax selfdoc for additional parameter.

See the xgraph selfdoc for the remaining parameters.

Credits:

CWP: John Stockwell, based on Jack Cohen's SU JACKet

Notes:

When the number of traces isn't known, we need to count the traces for xgraph. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

SUXMOVIE - X MOVIE plot of a 2D or 3D segy data set

suxmovie <stdin [optional parameters]

Optional parameters:

n1=tr.ns                    number of samples per trace  
ntr=tr.ntr                  number of traces in the data set  
n2=tr.shortpad or tr.ntr number of traces in inline direction  
n3=ntr/n2                   number of traces in crossline direction

d1=tr.d1 or tr.dt/10<sup>6</sup>    sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)

d2=tr.d2                  sampling interval in the slow dimension  
    =1.0 (if not set)

d3=1.0                    sampling interval in the slowest dimension

f1=tr.f1 or 0.0            first sample in the z dimension  
f2=tr.f2 or 1.0            first sample in the x dimension  
f3=1.0

mode=0                    0= x,z slice movie through y dimension (in line)  
                          1= y,z slice movie through x dimension (cross line)  
                          2= x,y slice movie through z dimension (time slice)

verbose=0                        =1 to print some useful information

tmpdir=    if non-empty, use the value as a directory path  
          prefix for storing temporary files; else if the  
          the CWP\_TMPDIR environment variable is set use  
          its value for the path; else use tmpfile()

Notes:

For seismic data, the "fast dimension" is either time or depth and the "slow dimension" is usually trace number. The 3D data set is expected to have n3 sets of n2 traces representing the horizontal coverage of n2\*d2 in x and n3\*d3 in y direction.

The data is read to memory with and piped to xmovie with the respective sampling parameters.

See the xmovie selfdoc for the remaining parameters and X functions.

SUXPICKER - X-windows WIGgle plot PICKER of a segy data set

suxpicker <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field  
specified by keyword  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

See the xpicker selfdoc for the remaining parameters.

Credits:

CWP: Dave Hale and Zhiming Li (xpicker, etc.)  
Jack Cohen and John Stockwell (suxpicker, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for xpicker. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXWIGB - X-windows Bit-mapped WIGgle plot of a segy data set  
This is a modified suxwigb that uses the depth or coordinate scaling  
when such values are used as keys.

```
suxwigb <stdin [optional parameters] | ...
```

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or  
vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                   =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is  
time and the "slow dimension" is usually trace number or range.  
Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to override the header values if  
not.

If key=keyword is set, then the values of x2 are taken from the header  
field represented by the keyword (for example key=offset, will show  
traces in true offset). This permit unequally spaced traces to be plotted.  
Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: xwigb  
See the xwigb selfdoc for the remaining parameters.

Credits:

CWP: Dave Hale and Zhiming Li (xwigb, etc.)

Jack Cohen and John Stockwell (suxwigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor  
scale factors, added vsp style

Notes:

When the number of traces isn't known, we need to count  
the traces for xwigb. You can make this value "known"  
either by getparring n2 or by having the ntr field set  
in the trace header. A getparred value takes precedence  
over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array,  
but just content ourselves with copying trace by trace from  
the data "file" to the pipe into the plotting program.  
Although we could use tr.data, we allocate a trace buffer  
for code clarity.

SXPLOT - X Window plot a triangulated sloth function  $s(x_1, x_2)$

sxplot <modelfile [optional parameters]

Optional Parameters:

edgecolor=cyan	color to draw fixed edges
tricolor=yellow	color to draw non-fixed edges of triangles
=none	non-fixed edges of triangles are not shown
bclip=minimum sloth	sloth value corresponding to black
wclip=maximum sloth	sloth value corresponding to white
x1beg=x1min	value at which x1 axis begins
x1end=x1max	value at which x1 axis ends
x2beg=x2min	value at which x2 axis begins
x2end=x2max	value at which x2 axis ends
cmap=gray	gray, hue, or default colormaps may be specified

Optional resource parameters (defaults taken from resource database):

width=	width in pixels of window
height=	height in pixels of window
nTic1=	number of tics per numbered tic on axis 1
grid1=	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
nTic2=	number of tics per numbered tic on axis 2
grid2=	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelFont=	font name for axes labels
title=	title of plot
titleFont=	font name for title
titleColor=	color for title
axesColor=	color for axes
gridColor=	color for grid lines
style=	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)

AUTHOR: Dave Hale, Colorado School of Mines, 05/17/91

GBBEAM - Gaussian beam synthetic seismograms for a sloth model

gbbeam <rayends >syntraces xg= zg= [optional parameters]

Required Parameters:

xg= x coordinates of receiver surface

zg= z coordinates of receiver surface

Optional Parameters:

ng=101 number of receivers (uniform distributed along surface)

krecord=1 integer index of receiver surface (see notes below)

ang=0.0 array of angles corresponding to amplitudes in amp

amp=1.0 array of amplitudes corresponding to angles in ang

bw=0 beamwidth at peak frequency

nt=251 number of time samples

dt=0.004 time sampling interval

ft=0.0 first time sample

reftrans=0 =1 complex refl/transm. coefficients considered

prim =1, only single-reflected rays are considered "

=0, only direct hits are considered

atten=0 =1 add noncausal attenuation

=2 add causal attenuation

lscale= if defined restricts range of extrapolation

aperture= maximum angle of receiver aperture

fpeak=0.1/dt peak frequency of ricker wavelet

infofile ASCII-file to store useful information

NOTES:

Only rays that terminate with index krecord will contribute to the synthetic seismograms at the receiver (xg,zg) locations. The receiver locations are determined by cubic spline interpolation of the specified (xg,zg) coordinates.

AUTHOR: Dave Hale, Colorado School of Mines, 02/09/91

MODIFIED: Andreas Rueger, Colorado School of Mines, 08/18/93

Modifications include: 2.5-D amplitudes, computation of reflection/transmission losses, attenuation, timewindow, lscale, aperture, beam width, etc.

NORMRAY - dynamic ray tracing for normal incidence rays in a sloth model

```
normray <modelfile >rayends [optional parameters]
```

Optional Parameters:

caustic 0: show all rays 1: show only caustic rays  
nonsurface 0: show rays which reach surface 1: show all rays  
surface 0: shot ray from subsurface 1: from surface  
nrays number of location to shoot rays  
dangle increment of ray angle for one location  
nangle number of rays shot from one location  
ashift shift first taking off angle  
xs1 x of shooting location  
zs1 z of shooting location  
nangle=101 number of takeoff angles  
fangle=-45 first takeoff angle (in degrees)  
rayfile file of ray x,z coordinates of ray-edge intersections  
nxz=101 number of (x,z) in optional rayfile (see notes below)  
wavefile file of ray x,z coordinates uniformly sampled in time  
nt=101 number of (x,z) in optional wavefile (see notes below)  
infofile ASCII-file to store useful information  
fresnelfile used if you want to plot the fresnel volumes.  
default is <fresnelfile.bin>  
outparfile contains parameters for the plotting software.  
default is <outpar>  
krecord if specified, only rays incident at interface with index  
krecord are displayed and stored  
prim =1, only single-reflected rays are plotted ",  
=0, only direct hits are displayed  
ffreq=-1 FresnelVolume frequency  
refseq=1,0,0 index of reflector followed by sequence of reflection (1)  
transmission(0) or ray stops(-1).  
The default rayend is at the model boundary.  
NOTE:refseq must be defined for each reflector

NOTES:

The rayends file contains ray parameters for the locations at which the rays terminate.

The rayfile is useful for making plots of ray paths.  
nxz should be larger than twice the number of triangles intersected by the rays.

The wavefile is useful for making plots of wavefronts.

The time sampling interval in the wavefile is  $t_{max}/(nt-1)$ , where  $t_{max}$  is the maximum time for all rays.

The infofile is useful for collecting information along the individual rays. The fresnelfile contains data used to plot the Fresnel volumes. The outparfile stores information used for the plotting software.

AUTHOR: Dave Hale, Colorado School of Mines, 02/16/91

MODIFIED: Andreas Rueger, Colorado School of Mines, 08/12/93

Modifications include: functions writeFresnel, checkIfSourceIsOnEdge; options refseq=, krecord=, prim=, infofile=; computation of reflection/transmission losses, attenuation.

MODIFIED: Boyi Ou, Colorado School of Mines, 4/14/95

Notes:

This code can shoot rays from specified interface by users, normally you need to use gbmodel2 to generate interface parameters for this code, both code have a parameter named nrays, it should be same. If you just want to shoot rays from one specified location, you need to specify xs1,zs1, otherwise, leave them alone. If you want to shoot rays from surface, you need to define surface equal to 1. The rays from one location will be approximately symmetric with direction Normal\_direction - ashift.(if nangle is odd, it is symmetric, even, almost symmetric. The formula for the first take off angle is:  $angle = normal\_direction - nangle/2 * dangle - ashift$ . If you only want to see caustics, you specify caustic=1, if you want to see rays which does not reach surface, you specify nonsurface=1.

/

TRI2UNI - convert a TRIangulated model to UNIformly sampled model

tri2uni <triangfile >uniformfile n2= n1= [optional parameters]

Required Parameters:

n1=                    number of samples in the first (fast) dimension  
n2=                    number of samples in the second dimension

Optional Parameters:

d1=1.0                sampling interval in first (fast) dimension  
d2=1.0                sampling interval in second dimension  
f1=0.0                first value in dimension 1 sampled  
f2=0.0                first value in dimension 2 sampled

Note:

The triangulated/uniformly-sampled quantity is assumed to be sloth= $1/v^2$

AUTHOR: Dave Hale, Colorado School of Mines, 04/23/91

TRIMODEL - make a triangulated sloth ( $1/\text{velocity}^2$ ) model

trimodel >modelfile [optional parameters]

Optional Parameters:

xmin=0.0	minimum horizontal coordinate (x)
xmax=1.0	maximum horizontal coordinate (x)
zmin=0.0	minimum vertical coordinate (z)
zmax=1.0	maximum vertical coordinate (z)
xedge=	x coordinates of an edge
zedge=	z coordinates of an edge
sedge=	sloth along an edge
kedge=	array of indices used to identify edges
normray	0:do not generate parameters 1: does it
normface	specify which interface to shoot rays
nrays	number of locations to shoot rays
sfill=	x, z, x0, z0, s00, dsdx, dsdz to fill a region
densfill=	x, z, dens to fill a region
qfill=	x, z, Q-factor to fill a region
maxangle=5.0	maximum angle (deg) between adjacent edge segments

Notes:

More than set of xedge, zedge, and sedge parameters may be specified, but the numbers of these parameters must be equal.

Within each set, vertices will be connected by fixed edges.

Edge indices in the k array are used to identify edges specified by the x and z parameters. The first k index corresponds to the first set of x and z parameters, the second k index corresponds to the second set, and so on.

After all vertices and their corresponding sloth values have been inserted into the model, the optional sfill parameters are used to fill closed regions bounded by fixed edges. Let (x,z) denote any point inside a closed region. Sloth inside this region is determined by  $s(x,z) = s00+(x-x0)*dsdx+(z-z0)*dsdz$ . The (x,z) component of the sfill parameter is used to identify a closed region.

AUTHOR: Dave Hale, Colorado School of Mines, 02/12/91

MODIFIED: Andreas Rueger, Colorado School of Mines, 01/18/93

Fill regions with attenuation Q-factors and density values.

MODIFIED: Craig Artley, Colorado School of Mines, 03/27/94

Corrected bug in computing s00 in makeSlothForTri() function.

MODIFIED: Boyi Ou, Colorado School of Mines, 4/14/95

Make code to generate interface parameters for shooting rays  
from specified interface

NOTE:

When you use normface to specify interface, the number of interface might not be the number of interface in the picture, for example, you build a one interface model, this interface is very long, so in the shell, you use three part of xedge,zedge,sedge to make this interface, so when you use normface to specify interface, this interface is just part of whole interface. If you want see the normal rays from entire interface, you need to maek normal ray picture few times, and merge them together.

TRIRAY - dynamic RAY tracing for a TRIangulated sloth model

```
triray <modelfile >rayends [optional parameters]
```

Optional Parameters:

xs=(max-min)/2 x coordinate of source (default is halfway across model)

zs=min z coordinate of source (default is at top of model)

nangle=101 number of takeoff angles

fangle=-45 first takeoff angle (in degrees)

langle=45 last takeoff angle (in degrees)

rayfile= file of ray x,z coordinates of ray-edge intersections

nxz=101 number of (x,z) in optional rayfile (see notes below)

wavefile= file of ray x,z coordinates uniformly sampled in time

nt=101 number of (x,z) in optional wavefile (see notes below)

infofile= ASCII-file to store useful information

fresnelfile= used if you want to plot the fresnel volumes.

default is <fresnelfile.bin>

outparfile= contains parameters for the plotting software.

default is <outpar>

krecord= if specified, only rays incident at interface with index  
krecord are displayed and stored

prim= 1, only single-reflected rays are plotted

=0, only direct hits are displayed

ffreq=-1 FresnelVolume frequency

refseq=1,0,0 index of reflector followed by sequence of reflection (1)  
transmission(0) or ray stops(-1).

The default rayend is at the model boundary.

NOTE:refseq must be defined for each reflector

NOTES:

The rayends file contains ray parameters for the locations at which  
the rays terminate.

The rayfile is useful for making plots of ray paths.

nxz should be larger than twice the number of triangles intersected  
by the rays.

The wavefile is useful for making plots of wavefronts.

The time sampling interval in the wavefile is  $t_{max}/(nt-1)$ ,  
where  $t_{max}$  is the maximum time for all rays.

The infofile is useful for collecting information along the  
individual rays. The fresnelfile contains data used to plot  
the Fresnel volumes. The outparfile stores information used

for the plotting software.

AUTHOR: Dave Hale, Colorado School of Mines, 02/16/91

MODIFIED: Andreas Rueger, Colorado School of Mines, 08/12/93

Modifications include: functions writeFresnel, checkIfSourceIsOnEdge;  
options refseq=, krecord=, prim=, infofile=;  
computation of reflection/transmission losses, attenuation.

TRISEIS - Gaussian beam synthetic seismograms for a sloth model

triseis <modelfile >seisfile xs= zs= xg= zg= [optional parameters]

Required Parameters:

xs= x coordinates of source surface  
zs= z coordinates of source surface  
xg= x coordinates of receiver surface  
zg= z coordinates of receiver surface

Optional Parameters:

ns=1 number of sources uniformly distributed along s surface  
ds= increment between source locations (see notes below)  
fs=0.0 first source location (relative to start of s surface)  
ng=101 number of receivers uniformly distributed along g surface  
dg= increment between receiver locations (see notes below)  
fg=0.0 first receiver location (relative to start of g surface)  
dgds=0.0 change in receiver location with respect to source location  
krecord=1 integer index of receiver surface (see notes below)  
kreflect=-1 integer index of reflecting surface (see notes below)  
prim =1, only single-reflected rays are considered "  
=0, only direct hits are considered  
bw=0 beamwidth at peak frequency  
nt=251 number of time samples  
dt=0.004 time sampling interval  
ft=0.0 first time sample  
nangle=101 number of ray takeoff angles  
fangle=-45 first ray takeoff angle (in degrees)  
langle=45 last ray takeoff angle (in degrees)  
reftrans=0 =1 complex refl/transm. coefficients considered  
atten=0 =1 add noncausal attenuation  
=2 add causal attenuation  
lscale= if defined restricts range of extrapolation  
fpeak=0.1/dt peak frequency of ricker wavelet  
aperture= maximum angle of receiver aperture

NOTES:

Only rays that terminate with index krecord will contribute to the synthetic seismograms at the receiver (xg,zg) locations. The source and receiver locations are determined by cubic spline interpolation of the specified (xs,zs) and (xg,zg) coordinates. The default source location increment (ds) is determined to span the source surface defined by (xs,zs). Likewise for dg.

AUTHOR: Dave Hale, Colorado School of Mines, 02/09/91  
MODIFIED: Andreas Rueger, Colorado School of Mines, 08/18/93  
Modifications include: 2.5-D amplitudes, correction for ref/transm,  
timewindow, lscale, aperture, beam width, etc.

UNI2TRI - convert UNIformly sampled model to a TRIangulated model

uni2tri <sllothfile >modelfile n2= n1= [optional parameters]

Required Parameters:

n1= number of samples in first (fast) dimension  
n2= number of samples in second dimension

Optional Parameters:

d1=1.0 sampling interval in dimension 1  
d2=1.0 sampling interval in dimension 2  
f1=0.0 first value in dimension 1  
f2=0.0 first value in dimension 2  
ifile= triangulated model file used as initial model  
errmax= maximum sloth error (see notes below)  
verbose=1 =0 for silence  
=1 to report maximum error at each stage to stderr  
=2 to also write the normalized error to efile  
efile=emax.dat filename for error file (for verbose=2)  
mm=0 output every mm-th intermediate model (0 for none)  
mfile=intmodel intermediate models written to intmodel%d  
method=3 =1 add 1 vertex at maximum error  
=2 add vertex to every triangle that exceeds errmax  
=3 method 2, but avoid closely spaced vertices  
tol=10 closeness criterion for (in samples)  
sfill= x, z, x0, z0, s00, dsdx, dsdz to fill a region

Notes:

Triangles are constructed until the maximum error is not greater than the user-specified errmax. The default errmax is 1% of the maximum value in the sampled input file.

After the uniform values have been triangulated, the optional sfill parameters are used to fill closed regions bounded by fixed edges. Let (x,z) denote any point inside a closed region. Values inside this region is determined by  $s(x,z) = s00+(x-x0)*dsdx+(z-z0)*dsdz$ . The (x,z) component of the sfill parameter is used to identify a closed region.

The uniformly sampled quantity is assumed to be sloth=1/v<sup>2</sup>.

AUTHOR: Craig Artley, Colorado School of Mines, 03/31/94  
NOTE: After a program outlined by Dave Hale, 12/27/90.

SPSPLOT - plot a triangulated sloth function  $s(x,z)$  via PostScript

`spsplot <modelfile >postscriptfile [optional parameters]`

Optional Parameters:

<code>gedge=0.0</code>	gray to draw fixed edges (in interval [0.0,1.0])
<code>gtri=1.0</code>	gray to draw non-fixed edges of triangles
<code>gmin=0.0</code>	min gray to shade triangles (in interval [0.0,1.0])
<code>gmax=1.0</code>	max gray to shade triangles (in interval [0.0,1.0])
<code>sgmin=minimum s(x,z)</code>	$s(x,y)$ corresponding to <code>gmin</code>
<code>sgmax=maximum s(x,z)</code>	$s(x,y)$ corresponding to <code>gmax</code>
<code>xbox=1.5</code>	offset in inches of left side of axes box
<code>ybox=1.5</code>	offset in inches of bottom side of axes box
<code>wbox=6.0</code>	width in inches of axes box
<code>hbox=8.0</code>	height in inches of axes box
<code>xbeg=xmin</code>	value at which x axis begins
<code>xend=xmax</code>	value at which x axis ends
<code>dxnum=0.0</code>	numbered tic interval on x axis (0.0 for automatic)
<code>fxnum=xmin</code>	first numbered tic on x axis (used if <code>dxnum</code> not 0.0)
<code>nxtic=1</code>	number of tics per numbered tic on x axis
<code>gridx=none</code>	grid lines on x axis - none, dot, dash, or solid
<code>labelx=</code>	label on x axis
<code>zbegin=zmin</code>	value at which z axis begins
<code>zend=zmax</code>	value at which z axis ends
<code>dznum=0.0</code>	numbered tic interval on z axis (0.0 for automatic)
<code>fznum=zmin</code>	first numbered tic on z axis (used if <code>dznum</code> not 0.0)
<code>nztic=1</code>	number of tics per numbered tic on z axis
<code>gridz=none</code>	grid lines on z axis - none, dot, dash, or solid
<code>labelz=</code>	label on z axis
<code>labelfont=Helvetica</code>	font name for axes labels
<code>labelsize=12</code>	font size for axes labels
<code>title=</code>	title of plot
<code>titlefont=Helvetica-Bold</code>	font name for title
<code>titlesize=24</code>	font size for title
<code>titlecolor=black</code>	color of title
<code>axescolor=black</code>	color of axes
<code>gridcolor=black</code>	color of grid
<code>style=seismic</code>	normal (z axis horizontal, x axis vertical) or seismic (z axis vertical, x axis horizontal)

Note: A value of `gedge` or `gtri` outside the interval [0.0,1.0] results in that class of edge not being drawn.

AUTHOR: Dave Hale, Colorado School of Mines, 10/18/90  
MODIFIED: Craig Artley, Colorado School of Mines, 03/27/94  
Tweaks to improve PostScript header, add basic color support.

NOTE: Have observed errors in output when compiled with optimization  
under NEXTSTEP 3.1. Caveat Emptor.

Modified: Morten Wendell Pedersen, Aarhus University, 23/3-97  
Added ticwidth, axeswidth, gridwidth parameters

Shells:

-----  
ARGV - give examples of dereferencing char \*\*argv

Usage: argv

-----  
COPYRIGHT - insert CSM COPYRIGHT lines at top of files in working directory

Usage: copyright file(s)

-----  
CPALL , RCPALL - for local and remote directory tree/file transfer

Usage: cpall sourcedir destinationdir

Caveat: destinationdir must exist and be writeable by the user

Usage: rcpall sourcedir remotemachine destinationdir

If user name is different on the remote machine, then second" entry is "remotemachine -l remoteusername"

Caveats: rsh, copy, and write permissions required

You must be on the source machine,  
destinationdir must exist and be writeable by the user.

Notes: Both of these shell scripts use tar to do the transfer.

-----  
CWPFIND - look for files with patterns in CWROOT/src/cwp/lib

Usage: cwpsfind pattern\_fragment

        cwpsfind -e exact\_pattern

-----  
DIRTREE - show DIRectory TREE

Usage: dirtree

-----  
FILETYPE - list all files of given type

Usage: filetype string\_from\_file\_output

Examples:

filetype text - list printable files  
filetype stripped - list unstripped files

-----  
Grep - recursively call egrep in pwd

Usage: Grep [-egrep\_options] pattern

Caution: Do NOT redirect into file in pwd, either use something like >../Grep.out or perhaps pipe output into mail to yourself.

Author: Jack, 7/95

-----  
NEWCASE - Changes the case of all the filenames in a directory, dir

Usage: newcase -l dir change all filenames to lower case  
-u dir change all filenames to upper case

Notes: Useful for files downloaded from VAX.

-----  
OVERWRITE - copy stdin to stdout after EOF

This shell is called from the shell script: replace

-----  
PRECEDENCE - give table of C precedences from Kernighan and Ritchie

Usage: precedence

-----  
REPLACE - REPLACE string1 with string2 in files

Usage: replace string1 string2 files

-----  
THIS\_YEAR - print the current year

Usage: this\_year

NOTES - useful for building dated filenames, etc.

-----  
TIME\_NOW - prints time in ZULU format with no spaces

Usage: time\_now

Note: Useful for building dated filenames

-----  
TODAYS\_DATE - prints today's date in ZULU format with no spaces

Usage: todays\_date

Note: Useful for building dated filenames

-----  
USERNAMES - get list of all login names

Usage: usernames

-----  
VARLIST - list variables used in a Fortran program

Usage: varlist file.f ...

Output is in the file: vars.file

-----  
WEEKDAY - prints today's WEEKDAY designation

Usage: weekday

Note: Useful for building dated filenames

-----  
ZAP - kill processes by name

Typical usages:

```
zap ximage
```

```
zap 'xmovie|xgraph'
```

Zap accepts full pattern matching for the process names

Caveat: zap assumes that the FIRST field produced by the Unix "ps" command is the pid (process identifier) number. If not, change the number in the awk print statement to the appropriate field.

Author: Jack, 6/95 -- after Kernighan and Pike's zap

-----  
GENDOCS - generate complete list of selfdocs in latex form

Usage: gendocs -o output filename is: selfdocs.tex

-----  
STRIPTOTXT - put files from \$CWPROOT/src/doc/Stripped into a new  
directory in the form \$CWPROOT/src/TXT/NAME.txt

Usage: striptotxt

Author: John Stockwell, Sept 2001

-----  
UPDATEDOCALL - put self-docs in ../doc/Stripped

Usage: updatedocall

Note: this shell uses updatedoc to update the database used by  
suname and gendocs

-----  
UPDATEDOC - put self-docs in ../doc/Stripped and ../doc/Headers

Usage: updatedoc path

Notes:

Paths include: cwp/main cwp/lib cwp/shell par/main par/lib par/shell  
xplot/main xplot/lib psplot/main psplot/lib psplot/shell  
Xtcwp/main Xtcwp/lib su/main su/lib su/shell su/graphics/psplot  
su/graphics/xplot tri/main tri/lib xtri tri/graphics/psplot  
tetra/lib tetra/main  
comp/dct/lib comp/dct/main comp/dct/libutil comp/dwpt/1d/lib  
comp/dwpt/1d/main comp/dwpt/2d/lib comp/dwpt/2d/main

Use: updatedocall to update full directory, use updatehead to  
to update the master header file.

This shell builds the database used by suname and gendocs

-----  
UPDATEHEAD - update ../doc/Headers/Headers.all

Usage: updatehead

Notes:

This file builds the database used by suname

-----  
LOOKPAR - show getpar lines in SU code with defines evaluated

Usage: lookpar filename ...

-----  
MAXDIFF - find absolute maximum difference in two segy data sets

Usage: maxdiff file1 file2

-----  
RECIP - sum opposing (reciprocal) offsets in cdp sorted data

Usage: recip <stdin >stdout

-----  
RMAXDIFF - find percentage maximum difference in two segy data sets

Usage: rmaxdiff file1 file2

-----  
SUAGC - perform agc on SU data

Note: this is an interface to sugain for backward compatibility  
See selfdoc of: sugain for more information

-----  
SUBAND - Trapezoid-like Sin squared tapered Bandpass filter via SUFILTER

Usage: suband < stdin > stdout

Note: this shell mimics the old program SUBAND, supersceded by SUFILTER  
See selfdoc of: sufilter for more information

-----  
SUDIFF, SUSUM, SUPROD, SUQUO, SUPTDIFF, SUPTSUM,  
SUPTPROD, SUPTQUO - difference, sum, product, quotient of two SU data  
sets via suop2

Usage:

```
sudiff file1 file2 > stdout
susum file1 file2 > stdout
...etc
```

Note: uses `suop2` to perform the computation

-----  
SUDOC - get DOC listing for code

Usage: `sudoc name`

Note: Use this shell script to get selfdoc information for codes labeled with an asterisk (\*) or pound sign (#) in `suname list`

-----  
SUENV - Instantaneous amplitude, frequency, and phase via: SUATTRIBUTES

Usage: `suenv < stdin > stdout`

Note: this shell mimics the old program SUENV, superseded by SUATTRIBUTES  
See selfdoc of: `suattributes` for more information

-----  
SUFIND - get info from self-docs

Usage: `sufind [-v -n] string`

`sufind string` gives a brief synopsis  
`sufind -v string` is a verbose hunt for relevant items  
`sufind -n name_fragment` searches for command name

-----  
SUFIND - get info from self-docs

Usage: `sufind [-v -n] string`

`sufind string` gives a brief synopsis  
`sufind -v string` is a verbose hunt for relevant items  
`sufind -n name_fragment` searches for command name

Author: CWP: Jack K. Cohen, 1992  
Modified by: CWP: S. Narahara, 04/11/1998.

-----  
SUGENDOCs - generate complete list of selfdocs in latex form

Usage: sugendocs -o output filename is: selfdocs.tex

Note: this shell simply calls gendocs

-----  
SUHELP - list the CWP/SU programs and shells

Usage: suhelp

-----  
SUKEYWORD -- guide to SU keywords in segy.h

Usage: sukeyword -o to begin at the top of segy.h  
sukeyword [string] to find [string]

Note: keyword= occurs in many SU programs.

-----  
SUNAME - get name line from self-docs

Usage: suname [name]

Note: dummy selfdocs have been included in all cwp and shell programs  
that don't have automatic selfdocs.

-----  
UNGLITCH - zonk outliers in data

Usage: unglitch < stdin

Note: this shell just invokes: sugain < stdin qclip=.99 > stdout  
See selfdoc of: sugain for further information

-----

MERGE2 - put 2 standard size PostScript figures on one page

Usage: merge2 fig1 fig2

Notes: Translation values are hard-coded numbers that work well for standard size (8.5 x 11) figures.

See selfdoc of: psmerge for details

-----

MERGE4 - put 4 standard size PostScript plots on one page

Usage: merge4 ulfig urfig llfig lrfig

Note: Translation values are hard-coded numbers that work well for standard size (8.5 x 11) figures.

See selfdoc of: psmerge for further information

Libs:

BASIC - Basic C function interface to PostScript

```
beginps write PostScript prolog (including %%Pages comment)
endps write PostScript trailer (including %%Pages comment)
begineps write encapsulated PostScript prolog (no %%Pages comment)
endeps write encapsulated PostScript trailer (no %%Pages comment)
boundingbox set BoundingBox to llx lly urx ury
newpage print "%%%Page: label ordinal" to stdout
showpage print "showpage" to stdout
gsave print "GS" to stdout
grestore print "GR" to stdout
newpath print "NP" to stdout
closepath print "CP" to stdout
clip print "clip" to stdout
translate print "tx ty TR" to stdout, tx,ty = translation in x,y
scale print "sx sy SC" to stdout, sx,sy = scaling in x,y
rotate print "angle RO" to stdout, angle = rotation angle
concat print "m[0] m[1] m[2] m[3] m[4] m[5] CAT" to stdout
setgray print "gray setgray" to stdout, gray is 0-255 gray level
setrgbcolor print "red green blue setrgbcolor" to stdout
red,green,blue = 0-255 red,green,blue levels
setcolor set color by name based on definition in color structure
setlinewidth print "width SLW" to stdout, width = desired line width
setlinejoin print "code setlinejoin"
setdash print "[ dash ] offset setdash" to stdout
dash = array defining dash, offset = dash offset
moveto print "x y M" to stdout, move to x,y
rmoveto print "x y RM" to stdout, move to x,y
lineto print "x y L" to stdout, draw a line to x,y
rlineto print "x y RL" to stdout, draw a line to x,y
arc print "x y r ang1 ang2 arc" to stdout, draw an arc
x,y = vertex r = radius from ang1 to ang2
stroke print "S" to stdout
fill print "F" to stdout
show print "str SH" to stdout, show a string
justshow justify and show a string
image write a sampled gray-scale image
rgbimage write sampled color (rgb) image
setfont execute findfont, scalefont, and setfont for specified font
and size
fontbbox determine font bounding box for specified font and size
fontheight return maximum height for specified font and size
```

fontwidth return maximum width for specified font and size  
fontcapheight return maximum capheight for specified font and size  
fontxheight return maximum xheight for specified font and size  
fontdescender return maximum descender for specified font and size  
polyline draw a segmented line  
markto draw a mark at specified location  
rectclip set a rectangular clipping path  
rectfill draw a filled rectangle  
strokerect stroke a rectangle

Function Prototypes:

```
void beginps (void);
void endps (void);
void begineps (void);
void endeps (void);
void newpage (const char *label, int ordinal);
void boundingbox (int llx, int lly, int urx, int ury);
void showpage (void);
void gsave (void);
void grestore (void);
void newpath (void);
void closepath (void);
void clip(void);
void translate (float tx, float ty);
void scale (float sx, float sy);
void rotate (float angle);
void concat (float m[]);
void setgray (float gray);
void setrgbcolor (float red, float green, float blue);
void setcolor (const char *name);
void setlinewidth (float width);
void setlinejoin (int code);
void setdash (float dash[], int ndash, float offset);
void moveto (float x, float y);
void rmoveto (float x, float y);
void lineto (float x, float y);
void rlineto (float x, float y);
void arc (float x, float y, float r, float ang1, float ang2);
void stroke (void);
void fill (void);
void show (const char *str);
void justshow (float just, const char *str);
void image (int w, int h, int bps, float m[], unsigned char *samples);
```

```
void rgbimage (int w, int h, int bpc, float m[], unsigned char *samples);
void cymkimage (int w, int h, int bpc, float m[], unsigned char *samples);
void setfont (const char *fontname, float fontsize);
void fontbbox (const char *fontname, float fontsize, float bbox[]);
float fontheight (const char *fontname, float fontsize);
float fontwidth (const char *fontname, float fontsize);
float fontcapheight (const char *fontname, float fontsize);
float fontxheight (const char *fontname, float fontsize);
float fontdescender (const char *fontname, float fontsize);
float fontascender (const char *fontname, float fontsize);
void polyline (const float *x, const float *y, int n);
void markto (float x, float y, int index, float size);
void rectclip (float x, float y, float width, float height);
void rectfill (float x, float y, float width, float height);
void rectstroke (float x, float y, float width, float height);
```

justshow:

Input:

just justification factor  
str string

image:

Input:

w width of image (in samples)  
h height of image (in samples)  
bps number of bits per sample  
m array[6] containing image matrix  
samples array[w\*h] of sample values

rgbimage:

Input:

w width of image (in samples)  
h height of image (in samples)  
bpc number of bits per component  
m array[6] containing image matrix  
samples array[3\*w\*h] of sample values

cymkimage:

Input:

w width of image (in samples)  
h height of image (in samples)  
bpc number of bits per component  
m array[6] containing image matrix

samples array[4\*w\*h] of sample values

polyline:

Input:

x array[n] of x-coordinates

y array[n] of y-coordinates

n number of points

markto:

Input:

x x-coordinate of mark

y y-coordinate of mark

index type of mark to draw

size size of mark

rectclip:

Input:

x x-coordinate of clipping path origin

y y-coordinate of clipping path origin

width width of clipping path

height height of clipping path

rectfill:

Input:

x x-coordinate of rectangle origin

y y-coordinate of rectangle origin

width width of rectangle

height height of rectangle

strokerect:

Input:

x x-coordinate of rectangle origin

y y-coordinate of rectangle origin

width width of rectangle

height height of rectangle

Notes:

The majority of these routines are self explanatory. They are just C wrappers that echo PostScript graphics commands.

justshow:

The justification factor positions the string relative to the current point.

just" may assume any value, but the common uses are:

-1.0 right-justify the string

-0.5 center the string on the current point

0.0 left-justify the string (like using "show")

image:

Level 1 PostScript implementations support 1, 2, 4, and 8 bits per sample. Level 2 adds support for 12 bits per sample.

Samples are hex-encoded, and output lines are limited to 78 characters.

rgbimage:

In general, Level 1 PostScript implementations do not support rgbimage. Level 2 supports 1, 2, 4, 8, and 12 bits per color component. The samples array should contain three color components (in R,G,B... order) for each sample value. Samples are hex-encoded, and output lines are limited to 78 characters.

polyline:

The path is stroked every 200 points.

References:

Author: Dave Hale, Colorado School of Mines, 1989

with modifications by Craig Artley, Colorado School of Mines, 1991, and

additions by Dave Hale, Advance Geophysical, 1992.

PSAXESBOX3 - Functions draw an axes box via PostScript, estimate bounding box  
these are versions of psAxesBox and psAxesBox3 for psmovie.

psAxesBox3 draw an axes box via PostScript

psAxesBBox3 estimate bounding box for an axes box drawn via psAxesBox3

Function Prototypes:

```
void psAxesBox3(  
float x, float y, float width, float height,  
float x1Beg, float x1End, float p1Beg, float p1End,  
float d1Num, float f1Num, int n1Tic, int grid1, char *label1,  
float x2Beg, float x2End, float p2Beg, float p2End,  
float d2Num, float f2Num, int n2Tic, int grid2, char *label2,  
char *labelFont, float labelSize,  
char *title, char *titleFont, float titleSize,  
int style, char *title2);  
void psAxesBBox3(  
float x, float y, float width, float height,  
char *labelFont, float labelSize,  
char *titleFont, float titleSize,  
int style, int bbox[]);
```

Input:

x x coordinate of lower left corner of box

y y coordinate of lower left corner of box

width width of box

height height of box

x1Beg axis value at beginning of axis 1

x1End axis value at end of axis 1

p1Beg pad value at beginning of axis 1

p1End pad value at end of axis 1

d1Num numbered tic increment for axis 1 (0.0 for automatic)

f1Num first numbered tic for axis 1

n1Tic number of horizontal tics per numbered tic for axis 1

grid1 grid code for axis 1: NONE, DOT, DASH, or SOLID

label1 label for axis 1

x2Beg axis value at beginning of axis 2

x2End axis value at end of axis 2

p2Beg pad value at beginning of axis 2

p2End pad value at end of axis 2

d2Num vertical numbered tic increment (0.0 for automatic)

f2Num first numbered vertical tic

n2Tic number of vertical tics per numbered tic

grid2 grid code for vertical axis: NONE, DOT, DASH, or SOLID  
label2 vertical axis label  
labelFont name of font to use for axes labels  
labelSize size of font to use for axes labels  
title axes box title  
titleFont name of font to use for title  
titleSize size of font to use for title  
style NORMAL (axis 1 on bottom, axis 2 on left)  
    SEISMIC (axis 1 on left, axis 2 on top)  
title2 second title

psAxesBBox3:

Input:

x x coordinate of lower left corner of box  
y y coordinate of lower left corner of box  
width width of box  
height height of box  
labelFont name of font to use for axes labels  
labelSize size of font to use for axes labels  
titleFont name of font to use for title  
titleSize size of font to use for title  
style NORMAL (axis 1 on bottom, axis 2 on left)  
    SEISMIC (axis 1 on left, axis 2 on top)

Output:

bbox bounding box (bbox[0:3] = llx, lly, ulx, uly)

Notes:

psAxesBox3:

psAxesBox will determine the numbered tic increment and first numbered tic automatically, if the specified increment is zero.

Pad values must be specified in the same units as the corresponding axes values. These pads are useful when the contents of the axes box requires more space than implied by the axes values. For example, the first and last seismic wiggle traces plotted inside an axes box will typically extend beyond the axes values corresponding to the first and last traces. However, all tics will lie with the limits specified in the axes values (x1Beg, x1End, x2Beg, x2End).

psAxesBBox3:

psAxesBBox uses font sizes to estimate the bounding box for an axes box drawn with psAxesBox. To be on the safe side, psAxesBBox overestimates.

psAxesBBox assumes that the axes labels and titles do not extend beyond the corresponding edges of the axes box.

References:

(see references in basic.c)

Author: Dave Hale, Colorado School of Mines, 06/27/89

modified by Zhiming Li, CSM, 7/1/90

PSAXESBOX - Functions to draw PostScript axes and estimate bounding box

psAxesBox Draw an axes box via PostScript

psAxesBBox estimate bounding box for an axes box drawn via psAxesBox

Function Prototypes:

```
void psAxesBox(  
float x, float y, float width, float height,  
float x1Beg, float x1End, float p1Beg, float p1End,  
float d1Num, float f1Num, int n1Tic, int grid1, char *label1,  
float x2Beg, float x2End, float p2Beg, float p2End,  
float d2Num, float f2Num, int n2Tic, int grid2, char *label2,  
char *labelFont, float labelSize,  
char *title, char *titleFont, float titleSize,  
char *titleColor, char *axesColor, char *gridColor,  
float ticwidth, float axeswidth, float gridwidth,  
int style);
```

```
void psAxesBBox(  
float x, float y, float width, float height,  
char *labelFont, float labelSize,  
char *titleFont, float titleSize,  
int style, int bbox[]);
```

psAxesBox:

Input:

x x coordinate of lower left corner of box

y y coordinate of lower left corner of box

width width of box

height height of box

x1Beg axis value at beginning of axis 1

x1End axis value at end of axis 1

p1Beg pad value at beginning of axis 1

p1End pad value at end of axis 1

d1Num numbered tic increment for axis 1 (0.0 for automatic)

f1Num first numbered tic for axis 1

n1Tic number of horizontal tics per numbered tic for axis 1

grid1 grid code for axis 1: NONE, DOT, DASH, or SOLID

label1 label for axis 1

x2Beg axis value at beginning of axis 2

x2End axis value at end of axis 2

p2Beg pad value at beginning of axis 2

p2End pad value at end of axis 2

d2Num vertical numbered tic increment (0.0 for automatic)  
f2Num first numbered vertical tic  
n2Tic number of vertical tics per numbered tic  
grid2 grid code for vertical axis: NONE, DOT, DASH, or SOLID  
label2 vertical axis label  
labelFont name of font to use for axes labels  
labelSize size of font to use for axes labels  
title axes box title  
titleFont name of font to use for title  
titleSize size of font to use for title  
titleColor color to use for title  
axesColor color to use for axes and axes labels  
gridColor color to use for grid lines  
axeswidth width (in points) of axes  
ticwidth width (in points) of tic marks  
gridwidth width (in points) of grid lines  
style NORMAL (axis 1 on bottom, axis 2 on left)  
SEISMIC (axis 1 on left, axis 2 on top)

psAxesBBox:

Input:

x x coordinate of lower left corner of box  
y y coordinate of lower left corner of box  
width width of box  
height height of box  
labelFont name of font to use for axes labels  
labelSize size of font to use for axes labels  
titleFont name of font to use for title  
titleSize size of font to use for title  
style NORMAL (axis 1 on bottom, axis 2 on left)  
SEISMIC (axis 1 on left, axis 2 on top)

Output:

bbox bounding box (bbox[0:3] = llx, lly, ulx, uly)

Notes:

psAxesBox:

psAxesBox will determine the numbered tic increment and first numbered tic automatically, if the specified increment is zero. Axis numbering is in scientific notation, if necessary and is plotted to four significant digits.

Pad values must be specified in the same units as the corresponding axes values. These pads are useful when the contents of the axes box

requires more space than implied by the axes values. For example, the first and last seismic wiggle traces plotted inside an axes box will typically extend beyond the axes values corresponding to the first and last traces. However, all tics will lie with the limits specified in the axes values (x1Beg, x1End, x2Beg, x2End).

psAxesBBox:

psAxesBBox uses font sizes to estimate the bounding box for an axes box drawn with psAxesBox. To be on the safe side, psAxesBBox overestimates.

psAxesBBox assumes that the axes labels and titles do not extend beyond the corresponding edges of the axes box.

References:

(see References for basic.c)

Author: Dave Hale, Colorado School of Mines, 06/27/89

Modified: Ken Lerner, Colorado School of Mines, 08/30/90

Modified: Dave Hale, Advance Geophysical, 10/18/92

Added color parameters for title, axes, and grid.

Modified: Morten Wendell Pedersen, Aarhus University, 23/3-97

Added ticwidth, axeswidth, gridwidth parameters

PSCAXESBOX - Draw an axes box for cube via PostScript

psCubeAxesBox Draw an axes box for cube via PostScript

Function Prototype:

```
void psCubeAxesBox(
float x, float y, float size1, float size2, float size3, float angle,
float x1Beg, float x1End, float p1Beg, float p1End,
float d1Num, float f1Num, int n1Tic, int grid1, char *label1,
float x2Beg, float x2End, float p2Beg, float p2End,
float d2Num, float f2Num, int n2Tic, int grid2, char *label2,
float x3Beg, float x3End, float p3Beg, float p3End,
float d3Num, float f3Num, int n3Tic, int grid3, char *label3,
char *labelFont, float labelSize,
char *title, char *titleFont, float titleSize,
char *titleColor, char *axesColor, char *gridColor);
```

Input:

x x coordinate of lower left corner of box  
y y coordinate of lower left corner of box  
size1 size of 1st dimension of the input cube  
size2 size of 2nd dimension of the input cube  
size3 size of 3rd dimension of the input cube  
angle projection angle of the cube  
x1Beg axis value at beginning of axis 1  
x1End axis value at end of axis 1  
p1Beg pad value at beginning of axis 1  
p1End pad value at end of axis 1  
d1Num numbered tic increment for axis 1 (0.0 for automatic)  
f1Num first numbered tic for axis 1  
n1Tic number of tics for axis 1  
grid1 grid code for axis 1: NONE, DOT, DASH, or SOLID  
label1 label for axis 1  
x2Beg axis value at beginning of axis 2  
x2End axis value at end of axis 2  
p2Beg pad value at beginning of axis 2  
p2End pad value at end of axis 2  
d2Num numbered tic increment for axis 2 (0.0 for automatic)  
f2Num first numbered tic for axis 2  
n2Tic number of tics for axis 2  
grid2 grid code for axis 2: NONE, DOT, DASH, or SOLID  
label2 label for axis 2  
x3Beg axis value at beginning of axis 3

x3End axis value at end of axis 3  
p3Beg pad value at beginning of axis 3  
p3End pad value at end of axis 3  
d3Num numbered tic increment for axis 3 (0.0 for automatic)  
f3Num first numbered tic for axis 3  
n3Tic number of tics for axis 3  
grid3 grid code for axis 3: NONE, DOT, DASH, or SOLID  
label3 label for axis 3  
labelFont name of font to use for axes labels  
labelSize size of font to use for axes labels  
title axes box title  
titleFont name of font to use for title  
titleSize size of font to use for title  
titleColor color to use for title  
axesColor color to use for axes and axes labels  
gridColor color to use for grid lines  
Authors: Zhiming Li & Dave Hale, Colorado School of Mines, 6/90  
Modified: Craig Artley, Colorado School of Mines, 3/12/93  
Changed name to psCubeAxesBox (from psAxes3), fixed minor bugs.  
Modified: Craig Artley, Colorado School of Mines, 12/16/93  
Added color parameters for title, axes, and grid.

PSCONTOUR - draw contour of a two-dimensional array via PostScript

psContour draw contour of a two-dimensional array via PostScript

Function Prototype:

```
void psContour (float c, int nx, float x[], int ny, float y[], float z[],
float lcs, char *lcf, char *lcc, float *w, int nplaces);
```

Input:

c contour value

nx number of x-coordinates

x array of x-coordinates (see notes below)

ny number of y-coordinates

y array of y-coordinates (see notes below)

lcs font size of contour label

lcf font name of contour label

lcc color of contour label

LSB flag arrays (see Notes):

z array of nx\*ny z(x,y) values (see notes below)

w array of nx\*ny z(x,y) values (see notes below)

Notes:

The two-dimensional array z is actually passed as a one-dimensional array containing nx\*ny values, stored with nx fast and ny slow.

The x and y arrays define a grid that is not necessarily uniformly-sampled. Linear interpolation of z values on the grid defined by the x and y arrays is used to determine z values between the gridpoints.

The two least significant bits of z are used to mark intersections of the contour with the x,y grid; therefore, the z values will almost always be altered (slightly) by contour.

pscontour isolates the use of PostScript to four internal functions:

void coninit(void) - called before any contour drawing

void conmove(float x, float y) - moves current position to x,y

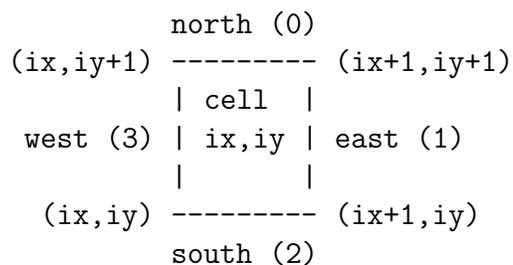
void condraw(float x, float y) - draws from current position to x,y

void condone(void) - called when contour drawing is done

These functions can usually be replaced with equivalent functions in other graphics environments.

The w array is used to restrict the range of contour labeling that occurs only if  $w < 1$ .

As suggested in the reference, the following scheme is used to refer to a cell of the two-dimensional array z:



Reference:

Cottafava, G. and Le Moli, G., 1969, Automatic contour map: Commuincations of the ACM, v. 12, n. 7, July, 1969.

Author: Dave Hale, Colorado School of Mines, 06/28/89  
contour labeling added by: Zhenyue Liu, August 1993

PSDRAWCURVE - Functions to draw a curve from a set of points

psDrawCurve Draw a curve from a set of points via PostScript  
Function Prototypes:

```
void psDrawCurve(  
float x, float y, float width, float height,  
float x1Beg, float x1End, float p1Beg, float p1End,  
float x2Beg, float x2End, float p2Beg, float p2End,  
float *x1curve, float *x2curve, int ncurve,  
char *curveColor, float curvewidth, int curvedash, int style);  
psDrawCurve:
```

Input:

x x coordinate of lower left corner of box

y y coordinate of lower left corner of box

width width of box

height height of box

x1Beg axis value at beginning of axis 1

x1End axis value at end of axis 1

p1Beg pad value at beginning of axis 1

p1End pad value at end of axis 1

x2Beg axis value at beginning of axis 2

x2End axis value at end of axis 2

p2Beg pad value at beginning of axis 2

p2End pad value at end of axis 2

x1curve vector of x1 coordinates for points along curve

x2curve vector of x2 coordinates for points along curve

ncurve number of points along curve

curveColor color to use for curve

curvewidth width (in points) of curve

style NORMAL (axis 1 on bottom, axis 2 on left)

SEISMIC (axis 1 on left, axis 2 on top)

Author: Brian Macy, Phillips Petroleum Co., 11/20/98

(Adapted after Dave Hale and other's psAxesBox routine)

PSLEGENDBOX - Functions to draw PostScript axes and estimate bounding box

psLegendBox Draw an legend box via PostScript

psLegendBBox estimate bounding box for an legend box drawn via psLegendBox

Function Prototypes:

```
void psLegendBox(  
float x, float y, float width, float height,  
float x1Beg, float x1End, float p1Beg, float p1End,  
float d1Num, float f1Num, int n1Tic, int grid1, char *label1,  
char *labelFont, float labelSize,  
char *axesColor, char *gridColor,  
int style);
```

```
void psLegendBBox(  
float x, float y, float width, float height,  
char *labelFont, float labelSize,  
int style, int bbox[]);
```

psLegendBox:

Input:

x x coordinate of lower left corner of box

y y coordinate of lower left corner of box

width width of box

height height of box

x1Beg axis value at beginning of axis 1

x1End axis value at end of axis 1

p1Beg pad value at beginning of axis 1

p1End pad value at end of axis 1

d1Num numbered tic increment for axis 1 (0.0 for automatic)

f1Num first numbered tic for axis 1

n1Tic number of horizontal tics per numbered tic for axis 1

grid1 grid code for axis 1: NONE, DOT, DASH, or SOLID

label1 label for axis 1

labelFont name of font to use for axes labels

labelSize size of font to use for axes labels

axesColor color to use for axes and axes labels

gridColor color to use for grid lines

style VERTLEFT (Vertical, axis label on left side)

VERTRIGHT (Vertical, axis label on right side)

HORIBOTTOM (Horizontal, axis label on bottom)

psLegendBBox:

Input:

x x coordinate of lower left corner of box

y y coordinate of lower left corner of box

width width of box

height height of box

labelFont name of font to use for axes labels

labelSize size of font to use for axes labels

style VERTLEFT (Vertical, axis label on left side)

VERTRIGHT (Vertical, axis label on right side)

HORIBOTTOM (Horizontal, axis label on bottom)

Output:

bbox bounding box (bbox[0:3] = llx, lly, ulx, uly)

Notes:

psLegendBox:

psLegendBox will determine the numbered tic increment and first numbered tic automatically, if the specified increment is zero. Axis numbering is in scientific notation, if necessary and is plotted to four significant digits.

Pad values must be specified in the same units as the corresponding Legend values. These pads are useful when the contents of the Legend box requires more space than implied by the Legend values. For example, the first and last seismic wiggle traces plotted inside an Legend box will typically extend beyond the Legend values corresponding to the first and last traces. However, all tics will lie with the limits specified in the Legend values (x1Beg, x1End, x2Beg, x2End).

psLegendBBox:

psLegendBBox uses font sizes to estimate the bounding box for an Legend box drawn with psLegendBox. To be on the safe side, psLegendBBox overestimates.

psLegendBBox assumes that the Legend labels and titles do not extend beyond the corresponding edges of the Legend box.

References:

(see References for basic.c)

Author: Dave Hale, Colorado School of Mines, 06/27/89

Modified: Ken Lerner, Colorado School of Mines, 08/30/90

Modified: Dave Hale, Advance Geophysical, 10/18/92

Added color parameters for title, axes, and grid.

Modified: Torsten Schoenfelder, Koeln, Germany, 07/06/97

Display a legend for ps file, move axis from left to right

Modified: Torsten Schoenfelder, Koeln, Germany, 10/02/98

Corrected width of bbox to include legend title

PSWIGGLE - draw wiggle-trace with (optional) area-fill via PostScript

psWiggle draw wiggle-trace with (optional) area-fill via PostScript

Function Prototype:

```
void psWiggle (int n, float z[], float zmin, float zmax, float zbase,
float yzmin, float yzmax, float xfirst, float xlast, int fill);
```

Inputs:

n number of samples to draw

z array to draw

zmin z values below zmin will be clipped

zmax z values above zmax will be clipped

zbase z values between zbase and either zmin or zmax will be filled

yzmin y-coordinate corresponding to zmin

yzmax y-coordinate corresponding to zmax

xfirst x-coordinate corresponding to z[0]

xlast x-coordinate corresponding to z[n-1]

fill = 0 for no fill

> 0 for fill between zbase and zmax

< 0 for fill between zbase and zmin

+2 for fill solid between zbase and zmax grey between zbase and zmin

-2 for fill solid between zbase and zmin grey between zbase and zmax

SHADING: 2<= abs(fill) <=5 abs(fill)=2 light grey abs(fill)=5 black

NOTES:

psWiggle reduces PostScript output by eliminating linetos when z values are essentially constant. The tolerance for detecting constant" z values is ZEPS\*(zmax-zmin), where ZEPS is a fraction defined below.

A more complete optimization would eliminate all connected line segments that are essentially colinear.

psWiggle breaks up the wiggle into segments that can be drawn without exceeding the PostScript pathlimit.

Author: Dave Hale, Colorado School of Mines, 07/03/89

Modified: Craig Artley, Colorado School of Mines, 04/13/92

Corrected dead trace bug. Now the last point of each segment is guaranteed to be drawn.

MODIFIED: Paul Michaels, Boise State University, 29 December 2000

added fill=+/-2 option of solid/grey color scheme

## AXESBOX - Functions to draw axes in X-windows graphics

xDrawAxesBox draw a labeled axes box

xSizeAxesBox determine optimal origin and size for a labeled axes box

### Function Prototypes:

```
void xDrawAxesBox (Display *dpy, Window win,
int x, int y, int width, int height,
float x1beg, float x1end, float p1beg, float p1end,
float d1num, float f1num, int n1tic, int grid1, char *label1,
float x2beg, float x2end, float p2beg, float p2end,
float d2num, float f2num, int n2tic, int grid2, char *label2,
char *labelfont, char *title, char *titlefont,
char *axescolor, char *titlecolor, char *gridcolor,
int style);
void xSizeAxesBox (Display *dpy, Window win,
char *labelfont, char *titlefont, int style,
int *x, int *y, int *width, int *height);
```

### xDrawAxesBox:

#### Input:

dpy display pointer

win window

x x coordinate of upper left corner of box

y y coordinate of upper left corner of box

width width of box

height height of box

x1beg axis value at beginning of axis 1

x1end axis value at end of axis 1

p1beg pad value at beginning of axis 1

p1end pad value at end of axis 1

d1num numbered tic increment for axis 1 (0.0 for automatic)

f1num first numbered tic for axis 1

n1tic number of tics per numbered tic for axis 1

grid1 grid code for axis 1: NONE, DOT, DASH, or SOLID

label1 label for axis 1

x2beg axis value at beginning of axis 2

x2end axis value at end of axis 2

p2beg pad value at beginning of axis 2

p2end pad value at end of axis 2

d2num numbered tic increment for axis 2 (0.0 for automatic)

f2num first numbered tic for axis 2

n2tic number of tics per numbered tic for axis 2

grid2 grid code for axis 2: NONE, DOT, DASH, or SOLID  
label2 label for axis 2  
labelfont name of font to use for axes labels  
title axes box title  
titlefont name of font to use for title  
axescolor name of color to use for axes  
titlecolor name of color to use for title  
gridcolor name of color to use for grid  
int style NORMAL (axis 1 on bottom, axis 2 on left)  
SEISMIC (axis 1 on left, axis 2 on top)

xSizeAxesBox:

Input:

dpy display pointer

win window

labelfont name of font to use for axes labels

titlefont name of font to use for title

int style NORMAL (axis 1 on bottom, axis 2 on left)

SEISMIC (axis 1 on left, axis 2 on top)

Output:

x x coordinate of upper left corner of box

y y coordinate of upper left corner of box

width width of box

height height of box

{

XFontStruct \*fa,\*ft;

Notes:

xDrawAxesBox:

will determine the numbered tic increment and first

numbered tic automatically, if the specified increment is zero.

Pad values must be specified in the same units as the corresponding axes values. These pads are useful when the contents of the axes box requires more space than implied by the axes values. For example, the first and last seismic wiggle traces plotted inside an axes box will typically extend beyond the axes values corresponding to the first and last traces. However, all tics will lie within the limits specified in the axes values (x1beg, x1end, x2beg, x2end).

xSizeAxesBox:

is intended to be used prior to xDrawAxesBox.

An "optimal" axes box is one that more or less fills the window, with little wasted space around the edges of the window.

Author: Dave Hale, Colorado School of Mines, 01/27/90

COLORMAP - Functions to manipulate X colormaps:

xCreateRGBDefaultMap create XA\_RGB\_DEFAULT\_MAP property of root window if it does not already exist

xGetFirstPixel return first pixel in range of contiguous pixels in XA\_RGB\_DEFAULT\_MAP

xGetLastPixel return last pixel in range of contiguous pixels in XA\_RGB\_DEFAULT\_MAP

xCreateHSVColormap create a 2 ramp colormap (HSV - Model)

xCreateRGBColormap create a 2 ramp colormap (RGB - Model)

Function Prototypes:

```
Status xCreateRGBDefaultMap (Display *dpy, XStandardColormap *scmap);
```

```
unsigned long xGetFirstPixel (Display *dpy);
```

```
unsigned long xGetLastPixel (Display *dpy);
```

```
Colormap xCreateRGBColormap (Display *dpy, Window win,  
char *str_cmap, int verbose)
```

```
Colormap xCreateHSVColormap (Display *dpy, Window win,  
char *str_cmap, int verbose)
```

xCreateRGBDefaultMap:

Input:

dpy display

Output:

scmap the standard colormap structure

xGetFirstPixel, xGetLastPixel:

Input:

dpy display

Notes:

PROBLEM

-----

Most mid-range display devices today support what X calls the "PseudoColor visual". Typically, only 256 colors (or gray levels) may be displayed simultaneously. Although these 256 colors may be chosen from a much larger (4096 or more) set of available colors, only 256 colors can appear on a display at one time.

These 256 colors are indexed by pixel values in a table called the colormap. Each window can have its own colormap, but only

one colormap can be installed in the display hardware at a time. (Again, only 256 colors may be displayed at one time.) The window manager is responsible for installing a window's colormap when that window becomes the key window.

Many of the applications we are likely to write require a large, contiguous range of pixels (entries in the colormap). In this range, we must be able to:

- (1) given a color (or gray), determine the corresponding pixel.
- (2) given a pixel, determine the corresponding color (or gray).

An example would be an imaging application that uses a gray scale to display images in shades of gray between black and white. Such applications are also likely to require a few additional colors for drawing axes, text, etc.

The problem is to coordinate the use of the limited number of 256 simultaneous colors so that windows for different applications appear reasonable, even when their particular colormaps are not installed in the display hardware. For example, we might expect an analog xclock's hands to be visible even when xclock's window is not the key window, when its colormap is not installed.

We should ensure that the range of contiguous pixels used by one application (perhaps for imaging) does not conflict with the pixels used by other applications to draw text, clock hands, etc.

## SOLUTION

-----

Applications that do not require special colormaps should simply use the default colormap inherited from the root window when new top-level windows are created.

Applications that do require a special colormap **MUST** create their own colormap. They must not assume that space will be available in the default colormap for a contiguous range of read/write pixels, because the server or window manager may have already allocated these pixels as read-only. Even if sufficient pixels are available in the default colormap, they should not be allocated by a single application. The default colormap should be used only for windows requiring a limited number of typical colors, such as red, yellow, etc.

Applications that require a contiguous range of read/write pixels should allocate these pixels in their window's private colormaps. They should determine which contiguous pixels to allocate from parameters in the standard colormap `XA_RGB_DEFAULT_MAP`. In particular, the first pixel in the range of contiguous pixels should be `base_pixel` and the last pixel in the range should be `base_pixel+red_max*red_mult+green_max*green_mult+blue_max*blue_mult`, where `base_pixel`, `red_max`, etc. are members in the `XStandardColormap` structure. On an 8-bit display, this range will typically provide 216 contiguous pixels, which may be set to a gray scale, color scale, or whatever. This leaves 40 colors for drawing text, axes, etc.

If the `XA_RGB_DEFAULT_MAP` does not exist, it should be created to consist of various colors composed of an equal number of reds, greens, and blues. For example, if 216 colors are to be allocated, then `red_max=green_max=blue_max=5`, `red_mult=36`, `green_mult=6`, and `blue_mult=1`. Because of the difficulty in forcing a particular pixel to correspond to a particular color in read-only color cells, these 216 colors will likely be read/write color cells unless created by the X server. In any case, these 216 colors should not be modified by any application. In creating custom colormaps, the only use of `XA_RGB_DEFAULT_MAP` should be in determining which 216 pixels to allocate for contiguous pixels.

In creating a custom colormap for a window, the application should initialize this colormap to the colors already contained in the window's colormap, which was inherited initially from its parent. This will ensure that typical colors already allocated by other applications will be consistent with pixels used by the application requiring the custom colormap. Ideally, windows might have different colormaps, but the only differences would be in the range of contiguous colors used for imaging, rendering, etc. Ideally, the pixels corresponding to colors used to draw text, axes, etc. would be consistent for all windows.

Unfortunately, it is impractical to maintain complete consistency among various private colormaps. For example, suppose a custom colormap is created for a window before other applications have had the opportunity to allocate their colors from the default colormap. Then, when the window with the custom colormap becomes the key window, the windows of the other applications may be displayed with false colors, since the colormap of the key window

may not contain the true colors. The colors used by the other applications did not exist when the custom colormap was created. One solution to this problem might be to initially allocate a set of "common" colors in the default colormap before launching any applications. This will increase the likelihood that typical colors will be consistent among various colormaps.

Functions are provided below to

- (1) create the standard colormap XA\_RGB\_DEFAULT\_MAP, if it does not exist,
- (2) determine the first and last pixels in the contiguous range of pixels,
- (3) create some common private colormaps

xCreateRGBDefaultMap:

This function returns 0 if the XA\_RGB\_DEFAULT\_MAP property does not exist and cannot be created. At least 8 contiguous color cells must be free in the default colormap to create the XA\_RGB\_DEFAULT\_MAP. If created, the red\_max, green\_max, and blue\_max values returned in scmap will be equal.

xGetFirstPixel, xGetLastPixel:

If it does not already exist, XA\_RGB\_DEFAULT\_MAP will be created. If XA\_RGB\_DEFAULT\_MAP does not exist and cannot be created, then this function returns 0.

xCreateRGBColormap, xCreateHSVColormap:

The returned colormap is only created; the window's colormap attribute is not changed, and the colormap is not installed by this function. The returned colormap is a copy of the window's current colormap, but with an RGB color scale allocated in the range of contiguous cells determined by XA\_RGB\_DEFAULT\_MAP. If it does not already exist, XA\_RGB\_DEFAULT\_MAP will be created.

Author: Dave Hale, Colorado School of Mines, 09/30/90

## DRAWCURVE - Functions to draw a curve from a set of points

xDrawCurve draw a curve from a set of points

Function Prototypes:

```
void xDrawCurve(Display *dpy, Window win,
int x, int y, int width, int height,
float x1beg, float x1end, float p1beg, float p1end,
float x2beg, float x2end, float p2beg, float p2end,
float *x1curve, float *x2curve, int ncurve,
char *curvecolor, int style);
```

xDrawCurve:

Input:

dpy display pointer

win window

x x coordinate of upper left corner of box

y y coordinate of upper left corner of box

width width of box

height height of box

x1beg axis value at beginning of axis 1

x1end axis value at end of axis 1

p1beg pad value at beginning of axis 1

p1end pad value at end of axis 1

x2beg axis value at beginning of axis 2

x2end axis value at end of axis 2

p2beg pad value at beginning of axis 2

p2end pad value at end of axis 2

x1curve vector of x1 coordinates for points along curve

x2curve vector of x2 coordinates for points along curve

ncurve number of points along curve

curvecolor name of color to use for axes

int style NORMAL (axis 1 on bottom, axis 2 on left)

SEISMIC (axis 1 on left, axis 2 on top)

Author: Brian Macy, Phillips Petroleum Co., 11/14/98

(Adapted after Dave Hale's xDrawAxesBox routine)

IMAGE - Function for making the image in an X-windows image plot

xNewImage make a new image of pixels from bytes

Function Prototype:

```
XImage *xNewImage (Display *dpy, unsigned long pmin, unsigned long pmax,  
int width, int height, float blank, unsigned char *bytes);
```

Input:

dpy display pointer

pmin minimum pixel value (corresponding to byte=0)

pmax maximum pixel value (corresponding to byte=255)

width number of bytes in x dimension

height number of bytes in y dimension

blank portion for blanking (0 to 1)

bytes unsigned bytes to be mapped to an image

Author: Dave Hale, Colorado School of Mines, 06/08/90

Revision: Brian Zook, Southwest Research Institute, 6/27/96 added blank option

This allows replacing the low end by the background.

LEGENDBOX - draw a labeled axes box for a legend (i.e. colorscale)

Function Prototype:

```
void xDrawLegendBox (Display *dpy, Window win,
int x, int y, int width, int height,
float bclip, float wclip, char *units, char *legendfont,
char *labelfont, char *title, char *titlefont,
char *axescolor, char *titlecolor, char *gridcolor,
int style);
```

Input:

dpy display pointer  
win window  
x x coordinate of upper left corner of box  
y y coordinate of upper left corner of box  
width width of box  
height height of box  
units label for legend  
legendfont name of font to use for legend labels  
labelfont name of font to use for axes labels  
title axes box title  
titlefont name of font to use for title  
axescolor name of color to use for axes  
titlecolor name of color to use for title  
gridcolor name of color to use for grid  
int style NORMAL (axis 1 on bottom, axis 2 on left)  
SEISMIC (axis 1 on left, axis 2 on top)

Notes:

xDrawLegendBox will determine the numbered tic increment and first numbered tic automatically, if the specified increment is zero.

Pad values must be specified in the same units as the corresponding axes values. These pads are useful when the contents of the axes box requires more space than implied by the axes values. For example, the first and last seismic wiggle traces plotted inside an axes box will typically extend beyond the axes values corresponding to the first and last traces. However, all tics will lie within the limits specified in the axes values (x1beg, x1end, x2beg, x2end).

Author: Dave Hale, Colorado School of Mines, 01/27/90

Author: Berend Scheffers , TNO Delft, 06/11/92

RUBBERBOX - Function to draw a rubberband box in X-windows plots

xRubberBox Track pointer with rubberband box

Function Prototype:

```
void xRubberBox (Display *dpy, Window win, XEvent event,  
int *x, int *y, int *width, int *height);
```

Input:

dpy display pointer  
win window ID  
event event of type ButtonPress

Output:

x x of upper left hand corner of box in pixels  
y y of upper left hand corner of box in pixels  
width width of box in pixels  
height height of box in pixels

Notes:

xRubberBox assumes that event is a ButtonPress event for the 1st button; i.e., it tracks motion of the pointer while the 1st button is down, and it sets x, y, w, and h and returns after a ButtonRelease event for the 1st button.

Before calling xRubberBox, both ButtonRelease and Button1Motion events must be enabled.

This is the same rubberbox.c as in Xtcwp/lib, only difference is that xRubberBox here is XtcwpRubberBox there, and a shift has been added to make the rubberbox more visible.

Author: Dave Hale, Colorado School of Mines, 01/27/90

WINDOW - Function to create a window in X-windows graphics

xNewWindow Create a new window and return the window ID

Function Prototype:

```
Window xNewWindow (Display *dpy, int x, int y, int width, int height,  
int border, int background, char *name);
```

Input:

dpy display pointer  
x x in pixels of upper left corner  
y y in pixels of upper left corner  
width width in pixels  
height height in pixels  
border border pixel  
background background pixel  
name name of window (also used for icon)

Notes:

The parent window is the root window.  
The border\_width is 4 pixels.

Author: Dave Hale, Colorado School of Mines, 01/06/90

XCONTOUR - draw contour of a two-dimensional array via X vectorplot calls

xContour draw contour of a two-dimensional array via X vector plot calls

Function Prototype:

```
void xContour(Display *dpy, Window win,GC gcc, GC gcl,  
              float *cp,int nx, float x[], int ny, float y[], float z[],  
              char lcflag,char *lcf,char *lcc, float *w, int nplaces)
```

Input:

c contour value

nx number of x-coordinates

x array of x-coordinates (see notes below)

ny number of y-coordinates

y array of y-coordinates (see notes below)

lcf font name of contour label

lcc color of contour label

Least Significant Bits:

z array of nx\*ny z(x,y) values (see notes below)

w array of nx\*ny z(x,y) values (see notes below)

Notes:

The two-dimensional array z is actually passed as a one-dimensional array containing nx\*ny values, stored with nx fast and ny slow.

The x and y arrays define a grid that is not necessarily uniformly-sampled. Linear interpolation of z values on the grid defined by the x and y arrays is used to determine z values between the gridpoints.

The two least significant bits of z are used to mark intersections of the contour with the x,y grid; therefore, the z values will almost always be altered (slightly) by contour.

xContour is a modified version of psContour where the use of conmove and condraw call have been changed to match X-Windows.

Since XDrawLine requires a start and end point, the use of a manually update of the position variables x0 and y0 is used instead of conmove.

The w array is used to restrict the range of contour labeling that occurs only if w<1.

As suggested in the reference, the following scheme is used to refer to a cell of the two-dimensional array z:

```

                north (0)
(ix,iy+1) ----- (ix+1,iy+1)
                | cell |
west (3) | ix,iy | east (1)
                |     |
(ix,iy)  ----- (ix+1,iy)
                south (2)

```

Reference:

Cottafava, G. and Le Moli, G., 1969, Automatic contour map:  
 Commuincations of the ACM, v. 12, n. 7, July, 1969.

Author: Morten Wendell Pedersen Aarhus University 07/20/96  
 Heavily based on psContour by

Dave Hale, Colorado School of Mines, 06/28/89

and with contour labeling added by: Zhenyue Liu, June 1993  
 (actually most of the credit should go to these two guys)

## AXES - the Axes Widget

XtcwpPointInAxesRectangle returns TRUE if point is inside axes rectangle, otherwise FALSE

XtcwpSetAxesValues set axes values

XtcwpSetAxesPads set axes pads

Function Prototype:

```
Boolean XtcwpPointInAxesRectangle (Widget w, Position x, Position y);
```

```
void XtcwpSetAxesValues (Widget w, float x1beg, float x1end, float x2beg, float x2end);
```

```
void XtcwpSetAxesPads (Widget w, float p1beg, float p1end, float p2beg, float p2end);
```

XtcwpPointInAxesRectangle:

Input:

w axes widget

x x coordinate of point

y y coordinate of point

XtcwpSetAxesValues:

Input:

w axes widget

x1beg axis value at beginning of axis 1

x1end axis value at end of axis 1

x2beg axis value at beginning of axis 2

x2end axis value at end of axis 2

XtcwpSetAxesPads:

Input:

w axes widget

p1beg axis pad at beginning of axis 1

p1end axis pad at end of axis 1

p2beg axis pad at beginning of axis 2

p2end axis pad at end of axis 2

Notes:

XtcwpPointInAxesRectangle:

This function is useful for determining whether or not input events occurred with the pointer inside the axes rectangle. I.e., the input callback function will typically call this function.

XtcwpSetAxesPads:

Pad values must be specified in the same units as the corresponding axes values. These pads are useful when the contents of the axes box require more space than implied by the axes values. For example, the first and last seismic wiggle traces plotted inside an axes box will typically extend beyond the axes values corresponding to the first and last traces. However, all tics will lie within the limits specified in the axes values (x1beg, x1end, x2beg, and x2end).

Author: Dave Hale, Colorado School of Mines, 08/28/90

Modified: Craig Artley, Colorado School of Mines, 06/03/93, Rotate label for vertical axis (Courtesy Dave Hale, Advance Geophysical).

COLORMAP - Functions to manipulate X colormaps:

XtcwpCreateRGBDefaultMap create XA\_RGB\_DEFAULT\_MAP property of root window if it does not already exist  
XtcwpGetFirstPixel return first pixel in range of contiguous pixels in XA\_RGB\_DEFAULT\_MAP  
XtcwpGetLastPixel return last pixel in range of contiguous pixels in XA\_RGB\_DEFAULT\_MAP  
XtcwpCreateRGBColormap create a colormap with an RGB color scale in contiguous cells  
XtcwpCreateGrayColormap create a colormap with a gray scale in contiguous cells  
XtcwpCreateHueColormap create a colormap with varying hues (blue to red) in contiguous cells  
XtcwpCreateSatColormap create a colormap with varying saturations in contiguous cells

Function Prototypes:

```
Status XtcwpCreateRGBDefaultMap (Display *dpy, XStandardColormap *scmap);
unsigned long XtcwpGetFirstPixel (Display *dpy);
unsigned long XtcwpGetLastPixel (Display *dpy);
Colormap XtcwpCreateRGBColormap (Display *dpy, Window win);
Colormap XtcwpCreateGrayColormap (Display *dpy, Window win);
Colormap XtcwpCreateHueColormap (Display *dpy, Window win);
Colormap XtcwpCreateSatColormap (Display *dpy, Window win,
float fhue, float lhue, float wfrac, float bright)
```

XtcwpCreateRGBDefaultMap:

Input:  
dpy display

Output:  
scmap the standard colormap structure

XtcwpGetFirstPixel, XtcwpGetLastPixel:

Input:  
dpy display

XtcwpCreateRGBColormap, XtcwpCreateGrayColormap, XtcwpCreateHueColormap:

Input:  
dpy display  
win window

XtcwpCreateSatColormap:

Input:

dpy display

win window

fhue first hue in colormap (saturation=1)

lhue last hue in colormap (saturation=1)

wfrac fractional position of white within the colormap (saturation=0)

bright brightness

Notes:

PROBLEM

-----

Most mid-range display devices today support what X calls the "PseudoColor visual". Typically, only 256 colors (or gray levels) may be displayed simultaneously. Although these 256 colors may be chosen from a much larger (4096 or more) set of available colors, only 256 colors can appear on a display at one time.

These 256 colors are indexed by pixel values in a table called the colormap. Each window can have its own colormap, but only one colormap can be installed in the display hardware at a time. (Again, only 256 colors may be displayed at one time.) The window manager is responsible for installing a window's colormap when that window becomes the key window.

Many of the applications we are likely to write require a large, contiguous range of pixels (entries in the colormap). In this range, we must be able to:

- (1) given a color (or gray), determine the corresponding pixel.
- (2) given a pixel, determine the corresponding color (or gray).

An example would be an imaging application that uses a gray scale to display images in shades of gray between black and white.

Such applications are also likely to require a few additional colors for drawing axes, text, etc.

The problem is to coordinate the use of the limited number of 256 simultaneous colors so that windows for different applications appear reasonable, even when their particular colormaps are not installed in the display hardware. For example, we might expect an analog xclock's hands to be visible even when xclock's window is not the key window, when its colormap is not installed.

We should ensure that the range of contiguous pixels used by one

application (perhaps for imaging) does not conflict with the pixels used by other applications to draw text, clock hands, etc.

#### SOLUTION

-----

Applications that do not require special colormaps should simply use the default colormap inherited from the root window when new top-level windows are created.

Applications that do require a special colormap **MUST** create their own colormap. They must not assume that space will be available in the default colormap for a contiguous range of read/write pixels, because the server or window manager may have already allocated these pixels as read-only. Even if sufficient pixels are available in the default colormap, they should not be allocated by a single application. The default colormap should be used only for windows requiring a limited number of typical colors, such as red, yellow, etc.

Applications that require a contiguous range of read/write pixels should allocate these pixels in their window's private colormaps. They should determine which contiguous pixels to allocate from parameters in the standard colormap `XA_RGB_DEFAULT_MAP`. In particular, the first pixel in the range of contiguous pixels should be `base_pixel` and the last pixel in the range should be `base_pixel+red_max*red_mult+green_max*green_mult+blue_max*blue_mult`, where `base_pixel`, `red_max`, etc. are members in the `XStandardColormap` structure. On an 8-bit display, this range will typically provide 216 contiguous pixels, which may be set to a gray scale, color scale, or whatever. This leaves 40 colors for drawing text, axes, etc.

If the `XA_RGB_DEFAULT_MAP` does not exist, it should be created to consist of various colors composed of an equal number of reds, greens, and blues. For example, if 216 colors are to be allocated, then `red_max=green_max=blue_max=5`, `red_mult=36`, `green_mult=6`, and `blue_mult=1`. Because of the difficulty in forcing a particular pixel to correspond to a particular color in read-only color cells, these 216 colors will likely be read/write color cells unless created by the X server. In any case, these 216 colors should not be modified by any application. In creating custom colormaps, the only use of `XA_RGB_DEFAULT_MAP` should be in determining which 216

pixels to allocate for contiguous pixels.

In creating a custom colormap for a window, the application should initialize this colormap to the colors already contained in the window's colormap, which was inherited initially from its parent. This will ensure that typical colors already allocated by other applications will be consistent with pixels used by the application requiring the custom colormap. Ideally, windows might have different colormaps, but the only differences would be in the range of contiguous colors used for imaging, rendering, etc. Ideally, the pixels corresponding to colors used to draw text, axes, etc. would be consistent for all windows.

Unfortunately, it is impractical to maintain complete consistency among various private colormaps. For example, suppose a custom colormap is created for a window before other applications have had the opportunity to allocate their colors from the default colormap. Then, when the window with the custom colormap becomes the key window, the windows of the other applications may be displayed with false colors, since the colormap of the key window may not contain the true colors. The colors used by the other applications did not exist when the custom colormap was created. One solution to this problem might be to initially allocate a set of "common" colors in the default colormap before launching any applications. This will increase the likelihood that typical colors will be consistent among various colormaps.

Functions are provided below to

- (1) create the standard colormap `XA_RGB_DEFAULT_MAP`, if it does not exist,
- (2) determine the first and last pixels in the contiguous range of pixels,
- (3) create some common private colormaps - gray scale, hue scale, etc.

`XtcwpCreateRGBDefaultMap`:

This function returns 0 if the `XA_RGB_DEFAULT_MAP` property does not exist and cannot be created. At least 8 contiguous color cells must be free in the default colormap to create the `XA_RGB_DEFAULT_MAP`. If created, the `red_max`, `green_max`, and `blue_max` values returned in `scmap` will be equal.

`XtcwpGetFirstPixel`, `XtcwpGetLastPixel`:

If it does not already exist, `XA_RGB_DEFAULT_MAP` will be created. If `XA_RGB_DEFAULT_MAP` does not exist and cannot be created, then this function returns 0.

XtcwpCreateRGBColormap, XtcwpCreateGrayColormap, XtcwpCreateHueColormap,  
XtcwpCreateSatColormap:

The returned colormap is only created; the window's colormap attribute is not changed, and the colormap is not installed by this function. The returned colormap is a copy of the window's current colormap, but with an RGB color scale allocated in the range of contiguous cells determined by XA\_RGB\_DEFAULT\_MAP. If it does not already exist, XA\_RGB\_DEFAULT\_MAP will be created.

Author: Dave Hale, Colorado School of Mines, 09/30/90

FX - Functions to support floating point coordinates in X

FMapFX map float x to x  
FMapFY map float y to y  
FMapFWidth map float width to width  
FMapFHeight map float height to height  
FMapFAngle map float angle to angle  
FMapFPoint map float x,y to x,y  
FMapFPoints map float points to points  
FMapX inverse map x to float x  
FMapY inverse map y to float y  
FMapWidth inverse map width to float width  
FMapHeight inverse map height to float height  
FMapAngle inverse map angle to float angle  
FMapPoint map x,y to float x,y  
FMapPoints map points to float points  
FSetGC set graphics context  
FSetMap set map (scales and shifts)  
FSetClipRectangle set clip rectangle  
FClipOn turn clip on  
FClipOff turn clip off  
FClipPoint clip point  
FClipLine clip line  
FClipRectangle clip rectangle  
FXCreateFGC create float graphics context  
FXFreeFGC free float graphic context  
FXDrawPoint draw point at float x,y (with clipping)  
FXDrawPoints draw float points (with clipping)  
FXDrawLine draw line from float x1,y1 to float x2,y2  
(with clipping)  
FXDrawLines draw lines between float points (with clipping)  
FXDrawRectangle draw rectangle with float x,y,width,height  
(with clipping)  
FXDrawArc draw arc with float x,y,width,height,angle1,angle2  
FXDrawString draw string at float x,y  
FXFillRectangle fill rectangle with float x,y,width,height (with  
clipping)

Function Prototypes:

```
int FMapFX (FGC fgc, float fx);  
int FMapFY (FGC fgc, float fy);  
int FMapFWidth (FGC fgc, float fwidth);  
int FMapFHeight (FGC fgc, float fheight);
```

```

int FMapFAngle (FGC fgc, float fangle);
void FMapFPoint (FGC fgc, float fx, float fy, int *x_return, int *y_return);
void FMapFPoints (FGC fgc, FXPoint fpoints[], int npoints,
XPoint points_return[]);
float FMapX (FGC fgc, int x);
float FMapY (FGC fgc, int y);
float FMapWidth (FGC fgc, int width);
float FMapHeight (FGC fgc, int height);
float FMapAngle (FGC fgc, int angle);
void FMapPoint (FGC fgc, int x, int y, float *fx_return, float *fy_return);
void FMapPoints (FGC fgc, XPoint points[], int npoints,
FXPoint fpoints_return[]);
void FSetGC (FGC fgc, GC gc);
void FSetMap (FGC fgc, int x, int y, int width, int height,
float fx, float fy, float fwidth, float fheight);
void FSetClipRectangle(FGC fgc, float fxa, float fya, float fxb, float fyb);
void FClipOn (FGC fgc);
void FClipOff (FGC fgc);
int FClipPoint (FGC fgc, float fx, float fy);
int FClipLine (FGC fgc, float fx1, float fy1, float fx2, float fy2,
float *fx1c, float *fy1c, float *fx2c, float *fy2c);
int FClipRectangle (FGC fgc, float fx, float fy, float fwidth, float fheight,
float *fxc, float *fyc, float *fwidthc, float *fheightc);
FGC FXCreateFGC (GC gc, int x, int y, int width, int height,
float fx, float fy, float fwidth, float fheight);
void FXFreeFGC (FGC fgc);
void FXDrawPoint (Display *display, Drawable d, FGC fgc, float fx, float fy);
void FXDrawPoints (Display *display, Drawable d, FGC fgc,
FXPoint fpoints[], int npoints, int mode);
void FXDrawLine (Display *display, Drawable d, FGC fgc,
float fx1, float fy1, float fx2, float fy2);
void FXDrawLines (Display *display, Drawable d, FGC fgc,
FXPoint fpoints[], int npoints, int mode);
void FXDrawRectangle (Display *display, Drawable d, FGC fgc,
float fx, float fy, float fwidth, float fheight);
void FXDrawArc (Display *display, Drawable d, FGC fgc,
float fx, float fy, float fwidth, float fheight,
float fangle1, float fangle2);
void FXDrawString (Display *display, Drawable d, FGC fgc,
float fx, float fy, char *string, int length);
void FXFillRectangle (Display *display, Drawable d, FGC fgc,
float fx, float fy, float fwidth, float fheight);

```

Notes:

The functions defined below are designed to resemble the equivalent X functions. For example, FXDrawLine() is analogous to XDrawLine. Each of the FXDraw<xxx>() functions requires an FGC instead of a GC (graphics context). An FGC contains a GC, along with the information required to transform floating point coordinates to integer (pixel) coordinates.

Additional functions are provided to transform floating point coordinates to integer coordinates and vice versa. Where feasible, macros are also provided to perform these coordinate transformations.

Clipping of floating point coordinates is supported, because clipping after mapping to integer coordinates is not valid when the mapped integer coordinates overflow the range of short integers. By clipping the floating point coordinates before mapping to integers, this overflow can be avoided. By default, clipping is turned off until a clip rectangle is specified or until clipping is explicitly turned on. Clipping is not currently supported for all FXDraw functions.

Author: Dave Hale, Colorado School of Mines, 07/24/90

Modified: Dave Hale, Colorado School of Mines, 05/18/91

Added floating point clipping capability to some FXDraw functions.

MISC - Miscellaneous X-Toolkit functions

XtcwpDrawString90 Draw a string rotated 90 degrees counter-clockwise

Function Prototype:

```
void XtcwpDrawString90 (Display *dpy, Drawable d, GC gc,  
int x, int y, char *string, int count);
```

Input:

dpy X display

d X drawable

gc X graphics context

x,y coordinates of baseline starting position of the string

string array[count] of characters to be drawn

count number of characters in string

Author: Dave Hale, Advance Geophysical, 06/03/93

RESCONV - general purpose resource type converters

XtcwpStringToFloat convert string to float in resource

Function Prototype:

```
void XtcwpStringToFloat (XrmValue *args, int *nargs,  
XrmValue *fromVal, XrmValue *toVal);
```

Author: Dave Hale, Colorado School of Mines, 08/28/90

RUBBERBOX - Function to draw a rubberband box in X-windows plots

XtcwpRubberbox Track pointer with rubberband box

Function Prototype:

```
void XtcwpRubberbox (Display *dpy, Window win, XEvent event,  
int *x, int *y, int *width, int *height);
```

Input:

dpy display pointer

win window ID

event event of type ButtonPress

Output:

x x of upper left hand corner of box in pixels

y y of upper left hand corner of box in pixels

width width of box in pixels

height height of box in pixels

Notes:

XtcwpRubberbox assumes that event is a ButtonPress event for the 1st button; i.e., it tracks motion of the pointer while the 1st button is down, and it sets x, y, w, and h and returns after a ButtonRelease event for the 1st button.

Before calling XtcwpRubberbox, both ButtonRelease and Button1Motion events must be enabled.

Author: Dave Hale, Colorado School of Mines, 01/27/90

RADIOBUTTONS - convenience functions creating and using radio buttons

XtcbwCreateStringRadioButtons create an XmFrame containing radio buttons labeled with strings

Function Prototypes:

```
Widget XtcbwCreateStringRadioButtons (Widget parent, char *label,  
int nstrings, char **strings, int first,  
void (*callback)(int selected, void *clientdata), void *clientdata);
```

Input:

parent parent widget  
label label for this collection of radio buttons  
nstrings number of strings  
strings array[nstrings] of character strings, one per button  
first index of button to be initially selected  
callback function called when radio buttons change state  
clientdata pointer to client data to be passed to callback

Notes:

This code depends on the Motif Developer's Package.

An integer index of the selected button (along with the clientdata pointer) is passed to the callback function.

The returned XmFrame is not managed.

Author: Dave Hale, Colorado School of Mines, 08/28/90

## SAMPLES - Motif-based Graphics Functions

samplesCreate  
samplesDraw  
samplesSetN  
samplesSetData  
samplesSetPlotValue  
samplesSetEditMode  
samplesSetOrigin

### Function Prototypes:

```
Samples *samplesCreate (Widget parent, char *title,  
void (*editDone)(Samples *s));  
void samplesDraw (Samples *s);  
void samplesSetN (Samples *s, int n);  
void samplesSetData (Samples *s, float *d);  
void samplesSetPlotValue (Samples *s, float pv);  
void samplesSetEditMode (Samples *s, EditMode m);  
void samplesSetOrigin (Samples *s, int i);
```

### Notes:

Watch this space.

Author: Dave Hale, Colorado School of Mines

fgethdr - get segy tape identification headers from the file by file pointer

Input:

fp            file pointer

Output:

chdr          3200 bytes of segy character header

bhdr          400 bytes of segy binary header

Authors: zhiming li and j. dulac , unocal

modified for CWP/SU: R. Beardsley

FGETTR - Routines to get an SU trace from a file

fgettr get a fixed-length segy trace from a file by file pointer  
fvgettr get a variable-length segy trace from a file by file pointer  
fgettra get a fixed-length trace from disk file by trace number  
gettr macro using fgettr to get a trace from stdin  
vgettr macro using fvgettr to get a trace from stdin  
gettra macro using fgettra to get a trace from stdin by trace number

Function Prototype:

```
int fgettr(FILE *fp, segy *tp);  
int fvgettr(FILE *fp, segy *tp);  
int fgettra(FILE *fp, segy *tp, int itr);
```

Returns:

fgettr, fvgettr:  
int: number of bytes read on current trace (0 after last trace)

fgettra:  
int: number of traces in disk file

Macros defined in segy.h

```
define gettr(x) fgettr(stdin, (x))  
define vgettr(x) fvgettr(stdin, (x))
```

Usage example:

```
    segy tr;  
    ...  
    while (gettr(&tr)) {  
        tr.offset = abs(tr.offset);  
        puttr(&tr);  
    }  
    ...
```

Authors: SEP: Einar Kjartansson, Stew Levin CWP: Shuki Ronen, Jack Cohen

Revised: 7/2/95 Stewart A. Levin Mobil

Major rewrite: Use xdr library for portable su output file  
format. Merge fgettr and fgettra into same source file.

Make input from multiple streams work (at long last!).

Revised: 11/22/95 Stewart A. Levin Mobil

Always set ntr for DISK input. This fixes susort failure.

Revised: 1/9/96 jkc CWP

Set lastfp on nread <=0 return, too.

Revised: 28 Mar, 2006 Stewart A. Levin Landmark Graphics

Reworked XDR to support random seeks on > 2GB files

and to read big endian SHORTPACK data on little endian machines.

FPUTTR - Routines to put an SU trace to a file

fputtr put a segy trace to a file by file pointer  
fvputtr put a segy trace to a file by file pointer (variable ns)  
puttr macro using fputtr to put a trace to stdin  
vputtr macro using fvputtr to put a trace to stdin (variable ns)

Function Prototype:

```
void fputtr(FILE *fp, segy *tp);  
void fvputtr(FILE *fp, segy *tp);
```

Returns:

void

Notes:

The functions puttr(x) vputtr(x) are macros defined in segy.h  
define puttr(x) fputtr(stdin, (x))  
define vputtr(x) fvputtr(stdin, (x))

Usage example:

```
    segy tr;  
    ...  
    while (gettr(&tr)) {  
        tr.offset = abs(tr.offset);  
        puttr(&tr);  
    }  
    ...
```

Authors: SEP: Einar Kjartansson, Stew Levin CWP: Shuki Ronen, Jack Cohen

HDRPKGE - routines to access the SEG Y header via the hdr structure.

gethval get a trace header word by index  
puthval put a trace header word by index  
getbhval get a binary header word by index  
putbhval put a binary header word by index  
gethdval get a trace header word by name  
puthdval put a trace header word by name

hdtype get the data type of a trace header word by name  
getkey get the name of a trace header word from its index

getindex get the index of a trace header word from the name

swaphval swap the trace header words by index  
swapbhval swap the binary header words by index  
gettapehval get a tape trace header word by index  
puttapehval put a tape trace header word by index  
gettapebhval get a tape binary header word by index  
puttapebhval put a tape binary header word by index  
printhead display non-null header field values

Function Prototypes:

```
void gethval(const segy *tr, int index, Value *valp);
void puthval(segy *tr, int index, Value *valp);
void putbhval(bhed *bh, int index, Value *valp);
void getbhval(const bhed *bh, int index, Value *valp);
void gethdval(const segy *tr, char *key, Value *valp);
void puthdval(segy *tr, char *key, Value *valp);
char *hdtype(const char *key);
char *getkey(const int index);
int getindex(const char *key);
void swaphval(segy *tr, int index);
void swapbhval(bhed *bh, int index);
void gettapehval(tapesegy *tapetr, int index, Value *valp);
void puttapehval(tapesegy *tapetr, int index, Value *valp);
void gettapebhval(tapebhed *tapetr, int index, Value *valp);
void puttapebhval(tapebhed *tapetr, int index, Value *valp);
void printhead(const segy *tp);
```

Notes:

This package includes only those routines that directly access

the "hdr" or "bhdr" structures. It does not include routines such as printfval, printftype, printfhead that use the routines in this package to indirectly access these structures.

Note that while gethdval and puthdval are more convenient to use than gethval and puthval, they incur an inefficiency in the common case of iterating code over a set of traces with a fixed key or keys. In such cases, it is advisable to set the index or indices outside the loop using getindex.

swaphval:

Byte-swapping is needed for converting SU data from big-endian to little-endian formats, and vice versa. The swap\_.... subroutines are based on subroutines provided by Jens Hartmann of the Institut fur Geophysik in Hamburg. These are found in ../cwp/lib/swapbyte.c.

Authors: SEP: Einar Kjartansson CWP: Jack Cohen, Shuki Ronen

swaphval: CWP: John Stockwell

TABPLOT - TABPLOT selected sample points on selected trace

tabplot tabplot selected sample points on selected trace

Function Prototype:

```
void tabplot(seggy *tp, int itmin, int itmax);
```

Input:

tp pointer to a seggy

itmin minimum time sample printed

itmax maximum time sample printed

Authors: CWP: Brian Sumner, Jack K. Cohen

VALPKGE - routines to handle variables of type Value

vtoi cast Value variable as an int  
vtol cast Value variable as a long  
vtof cast Value variable as a float  
vtod cast Value variable as a double  
atoval convert ascii to Value  
valtoabs take absolute value of a Value variable  
valcmp compare Value variables  
printfval printf a Value variable  
fprintfval fprintf a Value variable  
scanfval scanf a Value variable  
printftype printf for the type of a segy header word

Function Prototypes:

```
int vtoi(register cwp_String type, Value val);
long vtol(register cwp_String type, Value val);
float vtof(register cwp_String type, Value val);
double vtod(register cwp_String type, Value val);
void atoval(cwp_String type, cwp_String keyval, Value *valp);
Value valtoabs(cwp_String type, Value val);
int valcmp(register cwp_String type, Value val1, Value val2);
void printfval(register cwp_String type, Value val);
void fprintfval(FILE *stream, register cwp_String type, Value val);
void scanfval(register cwp_String type, Value *valp);
```

Notes:

A Value is defined by the following in .../su/include/su.h:

```
typedef union { * storage for arbitrary type *
char s[8];
short h;
unsigned short u;
long l;
unsigned long v;
int i;
unsigned int p;
float f;
double d;
unsigned int U:16;
unsigned int P:32;
} Value;
```

The use of the valpkge routines, as well as the hdrpkge routines, permits the user to change the definition of the types of the various fields of the segy data type, without breaking codes that look at part or all of these fields.

Authors: CWP: Jack K. Cohen, Shuki Ronen

ABEL - Functions to compute the discrete ABEL transform:

abelalloc allocate and return a pointer to an Abel transformer  
abelfree free an Abel transformer  
abel compute the Abel transform

Function prototypes:

```
void *abelalloc (int n);  
void abelfree (void *at);  
void abel (void *at, float f[], float g[]);
```

Input:

ns number of samples in the data to be transformed  
f[] array of floats, the function being transformed

Output:

at pointer to Abel transformer returned by abelalloc(int n)  
g[] array of floats, the transformed data returned by  
abel(\*at,f[],g[])

Notes:

The Abel transform is defined by:

$$g(y) = \frac{2}{|y|} \int_0^{\infty} dx f(x) / \sqrt{1 - (y/x)^2}$$

Linear interpolation is used to define the continuous function  $f(x)$  corresponding to the samples in  $f[]$ . The first sample  $f[0]$  corresponds to  $f(x=0)$  and the sampling interval is assumed to be 1. Therefore, the input samples correspond to  $0 \leq x \leq n-1$ . Samples of  $f(x)$  for  $x > n-1$  are assumed to be zero. These conventions imply that

$$g[0] = f[0] + 2*f[1] + 2*f[2] + \dots + 2*f[n-1]$$

References:

Hansen, E. W., 1985, Fast Hankel transform algorithm: IEEE Trans. on Acoustics, Speech and Signal Processing, v. ASSP-33, n. 3, p. 666-671. (Beware of several errors in the equations in this paper!)

Authors: Dave Hale and Lydia Deng, Colorado School of Mines, 06/01/90

AIRY - Approximate the Airy functions  $Ai(x)$ ,  $Bi(x)$  and their respective derivatives  $Ai'(x)$ ,  $Bi'(x)$

airya return approximation of  $Ai(x)$   
airypa return approximation of  $Ai'(x)$   
airyb return approximation of  $Bi(x)$   
airybp return approximation of  $Bi'(x)$

Function Prototypes:

```
float airya (float x);  
float airypa (float x);  
float airyb (float x);  
float airybp (float x);
```

Input:

x value at which to evaluate  $Ai(x)$

Returned:

```
airya  $Ai(x)$   
airypa  $Ai'(x)$   
airyb  $Bi(x)$   
airybp  $Bi'(x)$ 
```

Reference:

The approximation is derived from tables and formulas in Abramowitz and Stegun, p. 475-477.

Author: Dave Hale, Colorado School of Mines, 06/06/89

## ALLOC - Allocate and free multi-dimensional arrays

alloc1 allocate a 1-d array  
realloc1 re-allocate a 1-d array  
free1 free a 1-d array  
alloc2 allocate a 2-d array  
free2 free a 2-d array  
alloc3 allocate a 3-d array  
free3 free a 3-d array  
alloc4 allocate a 4-d array  
free4 free a 4-d array  
alloc5 allocate a 5-d array  
free5 free a 5-d array  
alloc6 allocate a 6-d array  
free6 free a 6-d array  
alloc1int allocate a 1-d array of ints  
realloc1int re-allocate a 1-d array of ints  
free1int free a 1-d array of ints  
alloc2int allocate a 2-d array of ints  
free2int free a 2-d array of ints  
alloc3int allocate a 3-d array of ints  
free3int free a 3-d array of ints  
alloc1float allocate a 1-d array of floats  
realloc1float re-allocate a 1-d array of floats  
free1float free a 1-d array of floats  
alloc2float allocate a 2-d array of floats  
free2float free a 2-d array of floats  
alloc3float allocate a 3-d array of floats  
free3float free a 3-d array of floats  
alloc4float allocate a 4-d array of floats  
free4float free a 4-d array of floats  
alloc5float allocate a 5-d array of floats  
free5float free a 5-d array of floats  
alloc6float allocate a 6-d array of floats  
free6float free a 6-d array of floats  
alloc4int allocate a 4-d array of ints  
free4int free a 4-d array of ints  
alloc5int allocate a 5-d array of ints  
free5int free a 5-d array of ints  
alloc5uchar allocate a 5-d array of unsigned chars  
free5uchar free a 5-d array of unsigned chars  
alloc5ushort allocate a 5-d array of unsigned shorts  
free5ushort free a 5-d array of unsigned shorts

alloc6ushort     allocate a 6-d array of unsigned shorts  
free6ushort     free a 6-d array of unsigned shorts  
alloc1double    allocate a 1-d array of doubles  
realloc1double  re-allocate a 1-d array of doubles  
free1double    free a 1-d array of doubles  
alloc2double    allocate a 2-d array of doubles  
free2double    free a 2-d array of doubles  
alloc3double    allocate a 3-d array of doubles  
free3double    free a 3-d array of doubles  
alloc1complex   allocate a 1-d array of complexes  
realloc1complex re-allocate a 1-d array of complexes  
free1complex    free a 1-d array of complexes  
alloc2complex   allocate a 2-d array of complexes  
free2complex    free a 2-d array of complexes  
alloc3complex   allocate a 3-d array of complexes  
free3complex    free a 3-d array of complexes

alloc1dcomplex  allocate a 1-d array of complexes  
realloc1dcomplex re-allocate a 1-d array of complexes  
free1dcomplex   free a 1-d array of complexes  
alloc2dcomplex  allocate a 2-d array of complexes  
free2dcomplex   free a 2-d array of complexes  
alloc3dcomplex  allocate a 3-d array of complexes  
free3dcomplex   free a 3-d array of complexes

#### Function Prototypes:

```
void *alloc1 (size_t n1, size_t size);  
void *realloc1 (void *v, size_t n1, size_t size);  
void free1 (void *p);  
void **alloc2 (size_t n1, size_t n2, size_t size);  
void free2 (void **p);  
void ***alloc3 (size_t n1, size_t n2, size_t n3, size_t size);  
void free3 (void ***p);  
void ****alloc4 (size_t n1, size_t n2, size_t n3, size_t n4, size_t size);  
void free4 (void ****p);  
                  size_t size);  
int *alloc1int (size_t n1);  
int *realloc1int (int *v, size_t n1);  
void free1int (int *p);  
int **alloc2int (size_t n1, size_t n2);  
void free2int (int **p);  
int ***alloc3int (size_t n1, size_t n2, size_t n3);  
void free3int (int ***p);
```

```

float *alloc1float (size_t n1);
float *realloc1float (float *v, size_t n1);
void free1float (float *p);
float **alloc2float (size_t n1, size_t n2);
void free2float (float **p);
float ***alloc3float (size_t n1, size_t n2, size_t n3);
void free3float (float ***p);
float ****alloc4float (size_t n1, size_t n2, size_t n3, size_t n4);
void free4float (float ****p);
                size_t n6);
int ****alloc4int (size_t n1, size_t n2, size_t n3, size_t n4);
void free4int (int ****p);
size_t n5);
        size_t n5);
        size_t n5,size_t n6);
double *alloc1double (size_t n1);
double *realloc1double (double *v, size_t n1);
void free1double (double *p);
double **alloc2double (size_t n1, size_t n2);
void free2double (double **p);
double ***alloc3double (size_t n1, size_t n2, size_t n3);
void free3double (double ***p);
complex *alloc1complex (size_t n1);
complex *realloc1complex (complex *v, size_t n1);
void free1complex (complex *p);
complex **alloc2complex (size_t n1, size_t n2);
void free2complex (complex **p);
complex ***alloc3complex (size_t n1, size_t n2, size_t n3);
void free3complex (complex ***p);

complex *alloc1dcomplex (size_t n1);
complex *realloc1dcomplex (dcomplex *v, size_t n1);
void free1dcomplex (dcomplex *p);
complex **alloc2dcomplex (size_t n1, size_t n2);
void free2dcomplex (dcomplex **p);
complex ***alloc3dcomplex (size_t n1, size_t n2, size_t n3);
void free3dcomplex (dcomplex ***p);

```

Notes:

The functions defined below are intended to simplify manipulation of multi-dimensional arrays in scientific programming in C. These functions are useful only because true multi-dimensional arrays

in C cannot have variable dimensions (as in FORTRAN). For example, the following function IS NOT valid in C:

```
void badFunc(a,n1,n2)
float a[n2][n1];
{
a[n2-1][n1-1] = 1.0;
}
```

However, the following function IS valid in C:

```
void goodFunc(a,n1,n2)
float **a;
{
a[n2-1][n1-1] = 1.0;
}
```

Therefore, the functions defined below do not allocate true multi-dimensional arrays, as described in the C specification. Instead, they allocate and initialize pointers (and pointers to pointers) so that, for example, `a[i2][i1]` behaves like a 2-D array.

The array dimensions are numbered, which makes it easy to add functions for arrays of higher dimensions. In particular, the 1st dimension of length `n1` is always the fastest dimension, the 2nd dimension of length `n2` is the next fastest dimension, and so on. Note that the 1st (fastest) dimension `n1` is the first argument to the allocation functions defined below, but that the 1st dimension is the last subscript in `a[i2][i1]`. (This is another important difference between C and Fortran.)

The allocation of pointers to pointers implies that more storage is required than is necessary to hold a true multi-dimensional array. The fraction of the total storage allocated that is used to hold pointers is approximately  $1/(n1+1)$ . This extra storage is unlikely to represent a significant waste for large `n1`.

The functions defined below are significantly different from similar functions described by Press et al, 1988, NR in C.

In particular, the functions defined below:

- (1) Allocate arrays of arbitrary size elements.
- (2) Allocate contiguous storage for arrays.
- (3) Return NULL if allocation fails (just like `malloc`).
- (4) Do not provide arbitrary lower and upper bounds for arrays.

Contiguous storage enables an allocated multi-dimensional array to be passed to a C function that expects a one-dimensional array.

For example, to allocate and zero an n1 by n2 two-dimensional array of floats, one could use

```
a = alloc2(n1,n2,sizeof(float));
zeroFloatArray(n1*n2,a[0]);
```

where zeroFloatArray is a function defined as

```
void zeroFloatArray(int n, float *a)
{
  int i;
  for (i=0; i<n; i++)
    a[i] = 0.0;
}
```

Internal error handling and arbitrary array bounds, if desired, should be implemented in functions that call the functions defined below, with the understanding that these enhancements may limit portability.

Author:        Dave Hale, Colorado School of Mines, 12/31/89  
              Zhaobo Meng, added 4D, 5D and 6D functions, 1996

## ANTIALIAS - Butterworth anti-aliasing filter

antialias use before increasing the sampling interval of data  
i.e. subsampling

### Function Prototype:

```
void antialias (float frac, int phase, int n, float p[], float q[]);
```

### Input:

frac current sampling interval / future interval (should be  $\leq 1$ )

phase =0 for zero-phase filter; =1 for minimum-phase filter

n number of samples

p array[n] of input samples

### Output:

q array[n] of output (anti-alias filtered) samples

### Notes:

The anti-alias filter is a recursive (Butterworth) filter. For zero-phase anti-alias filtering, the recursive filter is applied forwards and backwards.

Author: Dave Hale, Colorado School of Mines, 06/06/90

AXB - Functions to solve a linear system of equations  $Ax=b$  by LU decomposition, invert a square matrix or directly multiply an inverse matrix by another matrix (without explicitly computing the inverse).

LU\_decomposition Decompose a matrix (A) into a lower triangular (L) and an upper triangular (U) such that  $A=LU$

backward\_substitution Apply backward substitution to an LU decomposed matrix to solve the linear system of equations  $Ax=b$

inverse\_matrix compute the inverse of a square non-singular matrix

inverse\_matrix\_multiply computes the product  $A^{-1}B$  without explicitly computing the inverse matrix

Function prototypes:

```
void LU_decomposition (int nrows, float **matrix, int *idx, float *d);
void backward_substitution (int nrows, float **matrix, int *idx, float *b);
void inverse_matrix (int nrows, float **matrix);
void inverse_matrix_multiply (int nrows1, float **matrix1, int ncols2,
                             int nrows2, float **matrix2, float **out_matrix);
```

LU\_decomposition:

Input:

nrows number of rows of matrix to invert

matrix matrix of coefficients in linear system  $Ax=b$

Output:

matrix matrix containing LU decomposition (original matrix destroyed)

idx vector recording the row permutations effected by partial pivoting

d +/- 1 depending on whether the number of row interchanges was even or odd

backward\_substitution

Input:

nrows number of rows (and columns) of input matrix

matrix matrix of coefficients (after LU decomposition)

idx permutation vector obtained from routine LU\_decomposition

b right hand side vector in equation  $Ax=b$

Output:

b vector with the solution

inverse\_matrix

Input:

nrows number of rows (and columns) of input matrix  
matrix matrix to invert

Output:

matrix inverse of input matrix  
inverse\_matrix\_multiply  
nrows1 number of rows (and columns) of matrix to invert  
matrix1 square matrix to invert  
ncols2 number of columns of second matrix  
nrows2 number of rows of second matrix  
matrix second matrix (multiplier)

Output Parameters:

out\_matrix matrix containing the product of the inverse of the first  
matrix by the second one.

Note:

matrix1 and matrix2 are not destroyed, (not clobbered)

Notes:

To solve the set of linear equations  $Ax=b$ , first do the LU decomposition of A (which will clobber A with its LU decomposition) and then do the backward substitution with this new matrix and the right-hand side vector b. The vector b will be clobbered with the solution. Both, the original matrix and vector B, will have been destroyed.

The LU decomposition is carried out with the Crout's method with implicit partial pivoting that guarantees that the maximum pivot is used in every step of the algorithm.

The operation count to solve a linear system of equations via LU decomposition is  $1/3N^3$  and is a factor of 3 better than the standard Gauss-Jordan algorithm. To invert a matrix the count is the same with both algorithms:  $N^3$ .

Once a linear system  $Ax=b$  has been solved, to solve another linear system with the same matrix A but with different vector b, ONLY the back substitution has to be repeated with the new b (remember that the matrix in backsubstitution is not the original matrix but its LU decomposition)

If you want to compute  $A^{-1}B$  from matrices A and B, it is better to use the subroutine inverse\_matrix\_multiply rather than explicitly computing the inverse. This saves a whole matrix multiplication and is also more accurate.

References:

Press, Teukolsky, Vetterling and Flannery, Numerical Recipes in C:  
The art of scientific computing. Cambridge University Press.  
second edition. (1992).

Golub and Van Loan, Matrix Computations. John Hopkins University Press.  
Second Edition. (1989).

Horn and Johnson, Matrix Analysis. Cambridge University Press. (1985).

Credits:

Adapted from discussions in Numerical Recipes, by Gabriel Alvarez (1995)

BIGMATRIX - Functions to manipulate 2-dimensional matrices that are too big to fit in real memory, but that are small enough to fit in virtual memory:

bmalloc allocate a big matrix  
bmfree free a big matrix  
bmread read a vector from a big matrix  
bmwrite write a vector to a big matrix

Function Prototypes:

```
void *bmalloc (int nbpe, int n1, int n2);  
void bmfree (void *bm);  
void bmread (void *bm, int dir, int k1, int k2, int n, void *v);  
void bmwrite (void *bm, int dir, int k1, int k2, int n, void *v);
```

bmalloc:

Input:

nbpe number of bytes per matrix element  
n1 number of elements in 1st (fastest) dimension  
n2 number of elements in 2nd (slowest) dimension

Returned:

bm pointer to big matrix

bmfree:

Input:

bm pointer to big matrix state (returned by bmalloc)

bmread:

Input:

bm pointer to big matrix state (returned by bmalloc)  
d = 1 or 2: direction in which to read matrix elements  
k1 1st dimension index of first matrix element to read  
k2 2nd dimension index of first matrix element to read  
n number of elements to read

Output:

v array[n] to contain matrix elements read

bmwrite:

Input:

bm pointer to big matrix state (returned by bmalloc)  
d = 1 or 2: direction in which to write matrix elements

k1 1st dimension index of first matrix element to write  
k2 2nd dimension index of first matrix element to write  
n number of elements to write  
v array[n] containing matrix elements to write

Notes:

The bm functions provide access to a big 2-dimensional matrix along either the 1st or 2nd dimensions. Although, the matrix must be small enough to fit in virtual memory, it may be too large to fit in real memory. These functions provide equally efficient (or equally inefficient) access to vectors in a big matrix along either the 1st or 2nd dimensions.

For example, the following algorithm will efficiently transpose an n1 by n2 array of (n1\*n2) floats stored in a file:

```
void *bm;
float *v;
bm = bmalloc(sizeof(float),n1,n2);
for (i2=0; i2<n2; i2++) {
    (read n1 floats from input file into array v);
    bmwrite(bm,1,0,i2,n1,(char*)v);
}
for (i1=0; i1<n1; i1++) {
    bmread(bm,2,i1,0,n2,(char*)v);
    (write n2 floats in array v to output file);
}
bmfree(bm);
```

Author: Dave Hale, Colorado School of Mines, 05/17/89

BUTTERWORTH - Functions to design and apply Butterworth filters:

bfdesign design a Butterworth filter  
bfhighpass apply a high-pass Butterworth filter  
bflowpass apply a low-pass Butterworth filter

Function Prototypes:

```
void bfhighpass (int npoles, float f3db, int n, float p[], float q[]);  
void bflowpass (int npoles, float f3db, int n, float p[], float q[]);  
void bfdesign (float fpass, float apass, float fstop, float astop,  
int *npoles, float *f3db);
```

bfdesign:

Input:

fpass frequency in pass band at which amplitude is  $\geq$  apass  
apass amplitude in pass band corresponding to frequency fpass  
fstop frequency in stop band at which amplitude is  $\leq$  astop  
astop amplitude in stop band corresponding to frequency fstop

Output:

npoles number of poles  
f3db frequency at which amplitude is  $\sqrt{0.5}$  (-3 db)

bfhighpass and bflowpass:

Input:

npoles number of poles (and zeros); npoles $\geq$ 0 is required  
f3db 3 db frequency; nyquist = 0.5;  $0.0 \leq f3db \leq 0.5$  is required  
n length of p and q  
p array[n] to be filtered

Output:

q filtered array[n] (may be equivalent to p)

Notes:

- (1) Nyquist frequency equals 0.5
- (2) The following conditions must be true:  
( $0.0 < fpass$  &&  $fpass < 0.5$ ) &&  
( $0.0 < fstop$  &&  $fstop < 0.5$ ) &&  
( $fpass \neq fstop$ ) &&  
( $0.0 < astop$  &&  $astop < apass$  &&  $apass < 1.0$ )
- (3) if ( $fpass < fstop$ )

bfdesign:

Butterworth filter: compute number of poles and -3 db frequency for a low-pass or high-pass filter, given a frequency response constrained at two frequencies.

Author: Dave Hale, Colorado School of Mines, 06/02/89

## COMPLEX - Functions to manipulate complex numbers

cadd add two complex numbers  
csub subtract two complex numbers  
cmul multiply two complex numbers  
cdiv divide two complex numbers  
cplx make a complex number from two real numbers  
conjg complex conjugate of a complex number  
cneg negate a complex number  
cinv invert a complex number  
csqrt complex square root of a complex number  
cexp complex exponential of a complex number  
crmul multiply a complex number by a real number  
rcabs real magnitude of a complex number

### Structure:

```
typedef struct _complexStruct {  complex number
float r,i;
} complex;
```

### Function Prototypes:

```
complex cadd (complex a, complex b);
complex csub (complex a, complex b);
complex cmul (complex a, complex b);
complex cdiv (complex a, complex b);
float rcabs (complex z);
complex cplx (float re, float im);
complex conjg (complex z);
complex cneg (complex z);
complex cinv (complex z);
complex csqrt (complex z);
complex cexp (complex z);
complex crmul (complex a, float x);
```

### Notes:

The function "rcabs" was originally called "fcabs". This produced a collision on some systems so a new name was chosen.

### Reference:

Adapted from Press et al, 1988, Numerical Recipes in C (Appendix E).

Author: Dave Hale, Colorado School of Mines, 06/02/89

Modified: Dave Hale, Colorado School of Mines, 04/26/90

Added function `cinv()`.

## COMPLEXD - Functions to manipulate double-precision complex numbers

dcadd add two dcomplex numbers  
dcsub subtract two dcomplex numbers  
dcmul multiply two dcomplex numbers  
dcdiv divide two dcomplex numbers  
dcmplx make a dcomplex number from two real numbers  
dconjg dcomplex conjugate of a dcomplex number  
dcneg negate a dcomplex number  
dcinv invert a dcomplex number  
dcsqrt dcomplex square root of a dcomplex number  
dcexp dcomplex exponential of a dcomplex number  
dcrm mul multiply a dcomplex number by a real number  
drcabs real magnitude of a dcomplex number

### Structure:

```
typedef struct _dcomplexStruct { dcomplex number
double r,i;
} dcomplex;
```

### Function Prototypes:

```
dcomplex dcadd (dcomplex a, dcomplex b);
dcomplex dcsub (dcomplex a, dcomplex b);
dcomplex dcmul (dcomplex a, dcomplex b);
dcomplex dcdiv (dcomplex a, dcomplex b);
double drcabs (dcomplex z);
dcomplex dcmplx (double re, double im);
dcomplex dconjg (dcomplex z);
dcomplex dcneg (dcomplex z);
dcomplex dcinv (dcomplex z);
dcomplex dcsqrt (dcomplex z);
dcomplex dcexp (dcomplex z);
dcomplex dcrm mul (dcomplex a, double x);
```

### Notes:

The function "drcabs" was originally called "fcabs". This produced a collision on some systems so a new name was chosen.

### Reference:

Adapted from Press et al, 1988, Numerical Recipes in C (Appendix E).

Author: Dave Hale, Colorado School of Mines, 06/02/89

Modified: Dave Hale, Colorado School of Mines, 04/26/90

Added function `dcinv()`.

COMPLEXF - Subroutines to perform operations on complex numbers.  
This set of functions complement the one in complex.c  
of the CWP library

cipow raise a complex number to an integer power  
crpow raise a complex number to a real power  
rcpow raise a real number to a complex power  
ccpow raise a complex number to a complex power  
ccos compute the complex cosine of a complex angle  
csin compute the complex sine of a complex angle  
ccosh compute the complex hyperbolic cosine of a complex angle  
csinh compute the complex hyperbolic sine of a complex angle  
cexp1 compute the complex exponential of a complex number  
clog compute the complex logarithm of a complex number

Function Prototypes:

```
complex cipow(complex a, int p);  
complex crpow(complex a, float p);  
complex rcpow(float a, complex p);  
complex ccpow (complex a, complex p)  
complex ccos(complex a);  
complex csin(complex a);  
complex ccosh(complex a);  
complex csinh(complex a);  
complex cexp1(complex a);  
complex clog(complex a);
```

Credits:

Dave Hale, original version in C++  
Gabriel Alvarez, translation to C

COMPLEXFD - Subroutines to perform operations on double complex numbers.  
This set of functions complement the one in complexd.c  
of the CWP library

dcipow raise a double complex number to an integer power  
dcrpow raise a double complex number to a real power  
rdcpow raise a real number to a double complex power  
dcdcpow raise a double complex number to a double complex power  
dccos compute the double complex cosine of a double complex angle  
dcsin compute the double complex sine of a double complex angle  
dccosh compute the double complex hyperbolic cosine of a double complex angle  
dcsinh compute the double complex hyperbolic sine of a double complex angle  
dcexp1 compute the double complex exponential of a double complex number  
dclog compute the double complex logarithm of a double complex number

Function Prototypes:

```
dcomplex dcipow(dcomplex a, int p);  
dcomplex dcrpow(dcomplex a, float p);  
dcomplex rdcpow(float a, dcomplex p);  
dcomplex dcdcpow (dcomplex a, dcomplex p)  
dcomplex dccos(dcomplex a);  
dcomplex dcsin(dcomplex a);  
dcomplex dccosh(dcomplex a);  
dcomplex dcsinh(dcomplex a);  
dcomplex dcexp1(dcomplex a);  
dcomplex dclog(dcomplex a);
```

Credits:

Dave Hale, original version in C++  
Gabriel Alvarez, translation to C

CONVOLUTION - Compute  $z = x$  convolved with  $y$

conv compute the convolution of two input vector arrays

Input:

lx length of x array  
ifx sample index of first x  
x array[lx] to be convolved with y  
ly length of y array  
ify sample index of first y  
y array[ly] with which x is to be convolved  
lz length of z array  
ifz sample index of first z

Output:

z array[lz] containing x convolved with y

Function Prototype:

```
void conv (int lx, int ifx, float *x, int ly, int ify, float *y,  
int lz, int ifz, float *z);
```

Notes:

The operation  $z = x$  convolved with  $y$  is defined to be

$$z[i] = \sum_{j=ifx}^{ifx+lx-1} x[j]*y[i-j] \quad ; \quad i = ifz, \dots, ifz+lz-1$$

The  $x$  samples are contained in  $x[0]$ ,  $x[1]$ , ...,  $x[lx-1]$ ; likewise for the  $y$  and  $z$  samples. The sample indices of the first  $x$ ,  $y$ , and  $z$  values determine the location of the origin for each array. For example, if  $z$  is to be a weighted average of the nearest 5 samples of  $y$ , one might use

```
...  
x[0] = x[1] = x[2] = x[3] = x[4] = 1.0/5.0;  
conv(5,-2,x,lx,0,y,ly,0,z);  
...
```

In this example, the filter  $x$  is symmetric, with index of first sample = -2.

This function is optimized for architectures that can simultaneously perform a multiply, add, and one load from memory; e.g., the IBM RISC System/6000. Because, for each value of  $i$ , it accumulates the convolution sum  $z[i]$  in a scalar, this function is not likely to be optimal for vector architectures.

Author: Dave Hale, Colorado School of Mines, 11/23/91

## CUBICSPLINE - Functions to compute CUBIC SPLINE interpolation coefficients

`cakima` compute cubic spline coefficients via Akima's method  
(continuous 1st derivatives, only)  
`cmonot` compute cubic spline coefficients via the Fritsch-Carlson method  
(continuous 1st derivatives, only)  
`csplin` compute cubic spline coefficients for interpolation  
(continuous 1st and 2nd derivatives)

`chermite` compute cubic spline coefficients via Hermite Polynomial  
(continuous 1st derivatives only)

### Function Prototypes:

```
void cakima (int n, float x[], float y[], float yd[][4]);
void cmonot (int n, float x[], float y[], float yd[][4]);
void csplin (int n, float x[], float y[], float yd[][4]);
void chermite (int n, float x[], float y[], float yd[][4]);
```

### Input:

`n` number of samples  
`x` array[n] of monotonically increasing or decreasing abscissae  
`y` array[n] of ordinates

### Output:

`yd` array[n][4] of cubic interpolation coefficients (see notes)

### Notes:

The computed cubic spline coefficients are as follows:

```
yd[i][0] = y(x[i])    (the value of y at x = x[i])
yd[i][1] = y'(x[i])   (the 1st derivative of y at x = x[i])
yd[i][2] = y''(x[i])  (the 2nd derivative of y at x = x[i])
yd[i][3] = y'''(x[i]) (the 3rd derivative of y at x = x[i])
```

To evaluate  $y(x)$  for  $x$  between  $x[i]$  and  $x[i+1]$  and  $h = x - x[i]$ , use the computed coefficients as follows:

$$y(x) = yd[i][0] + h * (yd[i][1] + h * (yd[i][2] / 2.0 + h * yd[i][3] / 6.0))$$

Akima's method provides continuous 1st derivatives, but 2nd and 3rd derivatives are discontinuous. Akima's method is not linear, in that the interpolation of the sum of two functions is not the same as the sum of the interpolations.

The Fritsch-Carlson method yields continuous 1st derivatives, but 2nd and 3rd derivatives are discontinuous. The method will yield a

monotonic interpolant for monotonic data. 1st derivatives are set to zero wherever first divided differences change sign.

The method used by "csplin" yields continuous 1st and 2nd derivatives.

References:

See Akima, H., 1970, A new method for interpolation and smooth curve fitting based on local procedures, Journal of the ACM, v. 17, n. 4, p. 589-602.

For more information, see Fritsch, F. N., and Carlson, R. E., 1980, Monotone piecewise cubic interpolation: SIAM J. Numer. Anal., v. 17, n. 2, p. 238-246.

Also, see the book by Kahaner, D., Moler, C., and Nash, S., 1989, Numerical Methods and Software, Prentice Hall. This function was derived from SUBROUTINE PCHEZ contained on the diskette that comes with the book.

For more general information on spline functions of all types see the book by: Greville, T.N.E, 1969, Theory and Applications of Spline Functions, Academic Press.

Author: Dave Hale, Colorado School of Mines c. 1989, 1990, 1991

DBLAS - Double precision Basic Linear Algebra subroutines  
(adapted from LINPACK FORTRAN):

idamax return index of element with maximum absolute value  
dasum return sum of absolute values  
daxpy compute  $y[i] = a*x[i]+y[i]$   
dcopy copy  $x[i]$  to  $y[i]$  (i.e., set  $y[i] = x[i]$ )  
ddot return sum of  $x[i]*y[i]$  (i.e., return the dot product of  $x$  and  $y$ )  
dnrm2 return square root of sum of squares of  $x[i]$   
dscal compute  $x[i] = a*x[i]$   
dswap swap  $x[i]$  and  $y[i]$

Function Prototypes:

```
int idamax (int n, double *sx, int incx);
double dasum (int n, double *sx, int incx);
void daxpy (int n, double sa, double *sx, int incx, double *sy, int incy);
void dcopy (int n, double *sx, int incx, double *sy, int incy);
double ddot (int n, double *sx, int incx, double *sy, int incy);
double dnrm2 (int n, double *sx, int incx);
void dscal (int n, double sa, double *sx, int incx);
void dswap (int n, double *sx, int incx, double *sy, int incy);
```

idamax:

Input:

n number of elements in array  
sx array[n] of elements  
incx increment between elements

Returned:

index of element with maximum absolute value (idamax)

dasum:

Input:

n number of elements in array  
sx array[n] of elements  
incx increment between elements

Returned:

sum of absolute values (dasum)

daxpy:

Input:

n number of elements in arrays

sa the scalar multiplier  
sx array[n] of elements to be scaled and added  
incx increment between elements of sx  
sy array[n] of elements to be added  
incy increment between elements of sy

Output:  
sy array[n] of accumulated elements

dcopy:  
Input:  
n number of elements in arrays  
sx array[n] of elements to be copied  
incx increment between elements of sx  
incy increment between elements of sy

Output:  
sy array[n] of copied elements

ddot:  
Input:  
n number of elements in arrays  
sx array[n] of elements  
incx increment between elements of sx  
sy array[n] of elements  
incy increment between elements of sy

Returned: dot product of the two arrays

dnorm2:  
Input:  
n number of elements in array  
sx array[n] of elements  
incx increment between elements

Returned: square root of sum of squares of x[i]

dscal:  
Input:  
n number of elements in array  
sa the scalar multiplier  
sx array[n] of elements  
incx increment between elements

Output:

sx array[n] of scaled elements

Author: Dave Hale, Colorado School of Mines, 10/01/89

DGE - Double precision Gaussian Elimination matrix subroutines adapted from LINPACK FORTRAN:

dgefa Gaussian elimination to obtain the LU factorization of a matrix.  
dgeco Gaussian elimination to obtain the LU factorization and condition number of a matrix.  
dgesl Solve linear system  $Ax = b$  or  $A'x = b$  after LU factorization.

Function Prototypes:

```
void dgefa (double **a, int n, int *ipvt, int *info);  
void dgeco (double **a, int n, int *ipvt, double *rcond, double *z);  
void dgesl (double **a, int n, int *ipvt, double *b, int job);
```

dgfa:

Input:

a matrix[n][n] to be factored (see notes below)  
n dimension of a

Output:

a matrix[n][n] factored (see notes below)  
ipvt indices of pivot permutations (see notes below)  
info index of last zero pivot (or -1 if no zero pivots)

dgeco:

Input:

a matrix[n][n] to be factored (see notes below)  
n dimension of a

Output:

a matrix[n][n] factored (see notes below)  
ipvt indices of pivot permutations (see notes below)  
rcond reciprocal of condition number (see notes below)

Workspace:

z array[n]

dgesl:

Input:

a matrix[n][n] that has been LU factored (see notes below)  
n dimension of a  
ipvt indices of pivot permutations (see notes below)  
b right-hand-side vector[n]  
job =0 to solve  $Ax = b$

=1 to solve  $A'x = b$

Output:

b solution vector[n]

Notes:

These functions were adapted from LINPACK FORTRAN. Because two-dimensional arrays cannot be declared with variable dimensions in C, the matrix a is actually a pointer to an array of pointers to floats, as declared above and used below.

Elements of a are stored as follows:

```
a[0][0]   a[1][0]   a[2][0]   ... a[n-1][0]
a[0][1]   a[1][1]   a[2][1]   ... a[n-1][1]
a[0][2]   a[1][2]   a[2][2]   ... a[n-1][2]
.
.
.
.
a[0][n-1] a[1][n-1] a[2][n-1] ... a[n-1][n-1]
```

Both the factored matrix a and the pivot indices ipvt are required to solve linear systems of equations via dgesl.

dgeco:

Given the reciprocal of the condition number, rcond, and the double epsilon, DBL\_EPSILON, the number of significant decimal digits, nsdd, in the solution of a linear system of equations may be estimated by:  
 $nsdd = (\text{int})\log_{10}(rcond/DBL\_EPSILON)$

Author: Dave Hale, Colorado School of Mines, 1989

PFAFFT - Functions to perform Prime Factor (PFA) FFT's, in place

npfa\_d return valid n for complex-to-complex PFA  
npfar\_d return valid n for real-to-complex/complex-to-real PFA  
npfao\_d return optimal n for complex-to-complex PFA  
npfaro\_d return optimal n for real-to-complex/complex-to-real PFA  
pfacc\_d 1D PFA complex to complex  
pfacr\_d 1D PFA complex to real  
pfarc\_d 1D PFA real to complex  
pfamcc\_d multiple PFA complex to real  
pfa2cc\_d 2D PFA complex to complex  
pfa2cr\_d 2D PFA complex to real  
pfa2rc\_d 2D PFA real to complex

Function Prototypes:

```
int npfa_d (int nmin);
int npfao_d (int nmin, int nmax);
int npfar_d (int nmin);
int npfaro_d (int nmin, int nmax);
void pfacc_d (int isign, int n, real_complex z[]);
void pfacr_d (int isign, int n, real_complex cz[], real rz[]);
void pfarc_d (int isign, int n, real rz[], real_complex cz[]);
void pfamcc_d (int isign, int n, int nt, int k, int kt, real_complex z[]);
void pfa2cc_d (int isign, int idim, int n1, int n2, real_complex z[]);
void pfa2cr_d (int isign, int idim, int n1, int n2, real_complex cz[], real rz[]);
void pfa2rc_d (int isign, int idim, int n1, int n2, real rz[], real_complex cz[]);
```

npfa\_d:

Input:

nmin lower bound on returned value (see notes below)

Returned: valid n for prime factor fft

npfao\_d

Input:

nmin lower bound on returned value (see notes below)

nmax desired (but not guaranteed) upper bound on returned value

Returned: valid n for prime factor fft

npfar\_d

Input:

nmin lower bound on returned value

Returned: valid n for real-to-real\_complex/real\_complex-to-real prime factor fft

npfaro\_d:

Input:

nmin lower bound on returned value

nmax desired (but not guaranteed) upper bound on returned value

Returned: valid n for real-to-real\_complex/real\_complex-to-real prime factor fft

pfacc\_d:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform (see notes below)

z array[n] of real\_complex numbers to be transformed in place

Output:

z array[n] of real\_complex numbers transformed

pfacr\_d:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform (see notes below)

cz array[n/2+1] of real\_complex values (may be equivalenced to rz)

Output:

rz array[n] of real values (may be equivalenced to cz)

pfarc\_d:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform; must be even (see notes below)

rz array[n] of real values (may be equivalenced to cz)

Output:

cz array[n/2+1] of real\_complex values (may be equivalenced to rz)

pfamcc\_d:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n number of real\_complex elements per transform (see notes below)

nt number of transforms

k stride in real\_complex elements within transforms

kt            stride in real\_complex elements between transforms  
z            array of real\_complex elements to be transformed in place

Output:  
z array of real\_complex elements transformed

pfa2cc\_d:

Input:

isign        sign of isign is the sign of exponent in fourier kernel  
idim        dimension to transform, either 1 or 2 (see notes)  
n1        1st (fast) dimension of array to be transformed (see notes)  
n2        2nd (slow) dimension of array to be transformed (see notes)  
z        array[n2][n1] of real\_complex elements to be transformed in place

Output:  
z array[n2][n1] of real\_complex elements transformed

pfa2cr\_d:

Input:

isign        sign of isign is the sign of exponent in fourier kernel  
idim        dimension to transform, which must be either 1 or 2 (see notes)  
n1        1st (fast) dimension of array to be transformed (see notes)  
n2        2nd (slow) dimension of array to be transformed (see notes)  
cz        array of real\_complex values (may be equivalenced to rz)

Output:  
rz        array of real values (may be equivalenced to cz)

pfa2rc\_d:

Input:

isign        sign of isign is the sign of exponent in fourier kernel  
idim        dimension to transform, which must be either 1 or 2 (see notes)  
n1        1st (fast) dimension of array to be transformed (see notes)  
n2        2nd (slow) dimension of array to be transformed (see notes)  
rz        array of real values (may be equivalenced to cz)

Output:  
cz        array of real\_complex values (may be equivalenced to rz)

Notes:

Table of valid n and cost for prime factor fft. For each n, cost was estimated to be the inverse of the number of ffts done in 1 sec on an IBM RISC System/6000 Model 320H, by Dave Hale, 08/04/91.

(Redone by Jack Cohen for 15 sec to rebuild NTAB table on advice of David and Gregory Chudnovsky, 05/03/94).

Cost estimates are least accurate for very small n. An alternative method for estimating cost would be to count multiplies and adds, but this method fails to account for the overlapping of multiplies and adds that is possible on some computers, such as the IBM RS/6000 family.

npfa\_d:

The returned n will be composed of mutually prime factors from the set {2,3,4,5,7,8,9,11,13,16}. Because n cannot exceed 720720 = 5\*7\*9\*11\*13\*16, 720720 is returned if nmin exceeds 720720.

npfao\_d:

The returned n will be composed of mutually prime factors from the set {2,3,4,5,7,8,9,11,13,16}. Because n cannot exceed 720720 = 5\*7\*9\*11\*13\*16, 720720 is returned if nmin exceeds 720720. If nmin does not exceed 720720, then the returned n will not be less than nmin. The optimal n is chosen to minimize the estimated cost of performing the fft, while satisfying the constraint, if possible, that n not exceed nmax.

npfar and npfaro:

Current implemenations of real-to-real\_complex and real\_complex-to-real prime factor ffts require that the transform length n be even and that n/2 be a valid length for a real\_complex-to-real\_complex prime factor fft. The value returned by npfar satisfies these conditions. Also, see notes for npfa.

pfacc:

n must be factorable into mutually prime factors taken from the set {2,3,4,5,7,8,9,11,13,16}. in other words,  
 $n = 2^{**p} * 3^{**q} * 5^{**r} * 7^{**s} * 11^{**t} * 13^{**u}$

where

$0 \leq p \leq 4$ ,  $0 \leq q \leq 2$ ,  $0 \leq r,s,t,u \leq 1$

is required for pfa to yield meaningful results. this restriction implies that n is restricted to the range  
 $1 \leq n \leq 720720 (= 5*7*9*11*13*16)$

pfacr:

Because pfacr uses pfacc to do most of the work, n must be even and n/2 must be a valid length for pfacc. The simplest way to obtain a valid n is via  $n = npfar(nmin)$ . A more optimal n can be obtained with npfaro.

`pfarc`:

Because `pfarc` uses `pfacc` to do most of the work, `n` must be even and `n/2` must be a valid length for `pfacc`. The simplest way to obtain a valid `n` is via `n = npfar(nmin)`. A more optimal `n` can be obtained with `npfaro`.

`pfamcc`:

To perform a two-dimensional transform of an `n1` by `n2` `real_complex` array (assuming that both `n1` and `n2` are valid "n"), stored with `n1` fast and `n2` slow:

```
    pfamcc(isign,n1,n2,1,n1,z); (to transform 1st dimension)
    pfamcc(isign,n2,n1,n1,1,z); (to transform 2nd dimension)
```

`pfa2cc`:

Only one (either the 1st or 2nd) dimension of the 2-D array is transformed.

If `idim` equals 1, then `n2` transforms of `n1` `real_complex` elements are performed; else, if `idim` equals 2, then `n1` transforms of `n2` `real_complex` elements are performed.

Although `z` appears in the argument list as a one-dimensional array, `z` may be viewed as an `n1` by `n2` two-dimensional array: `z[n2][n1]`.

Valid `n` is computed via the "np" subroutines.

To perform a two-dimensional transform of an `n1` by `n2` `real_complex` array (assuming that both `n1` and `n2` are valid "n"), stored with `n1` fast and `n2` slow: `pfa2cc(isign,1,n1,n2,z)`; `pfa2cc(isign,2,n1,n2,z)`;

`pfa2cr`:

If `idim` equals 1, then `n2` transforms of `n1/2+1` `real_complex` elements to `n1` real elements are performed; else, if `idim` equals 2, then `n1` transforms of `n2/2+1` `real_complex` elements to `n2` real elements are performed.

Although `rz` appears in the argument list as a one-dimensional array, `rz` may be viewed as an `n1` by `n2` two-dimensional array: `rz[n2][n1]`. Likewise, depending on `idim`, `cz` may be viewed as either an `n1/2+1` by `n2` or an `n1` by `n2/2+1` two-dimensional array of `real_complex` elements.

Let `n` denote the transform length, either `n1` or `n2`, depending on `idim`. Because `pfa2rc` uses `pfa2cc` to do most of the work, `n` must be even and `n/2` must be a valid length for `pfa2cc`. The simplest way to

obtain a valid  $n$  is via  $n = \text{npfar}(\text{nmin})$ . A more optimal  $n$  can be obtained with `npfaro`.

`pfa2rc`:

If `idim` equals 1, then  $n_2$  transforms of  $n_1$  real elements to  $n_1/2+1$  real\_complex elements are performed; else, if `idim` equals 2, then  $n_1$  transforms of  $n_2$  real elements to  $n_2/2+1$  real\_complex elements are performed.

Although `rz` appears in the argument list as a one-dimensional array, `rz` may be viewed as an  $n_1$  by  $n_2$  two-dimensional array: `rz[n2][n1]`. Likewise, depending on `idim`, `cz` may be viewed as either an  $n_1/2+1$  by  $n_2$  or an  $n_1$  by  $n_2/2+1$  two-dimensional array of real\_complex elements.

Let  $n$  denote the transform length, either  $n_1$  or  $n_2$ , depending on `idim`. Because `pfa2rc` uses `pfa2cc` to do most of the work,  $n$  must be even and  $n/2$  must be a valid length for `pfa2cc`. The simplest way to obtain a valid  $n$  is via  $n = \text{npfar}(\text{nmin})$ . A more optimal  $n$  can be obtained with `npfaro`.

References:

Temperton, C., 1985, Implementation of a self-sorting in-place prime factor fft algorithm: *Journal of Computational Physics*, v. 58, p. 283-299.

Temperton, C., 1988, A new set of minimum-add rotated rotated dft modules: *Journal of Computational Physics*, v. 75, p. 190-198.

Press et al, 1988, *Numerical Recipes in C*, p. 417.

Author: Dave Hale, Colorado School of Mines, 04/27/89

Revised by Baoniu Han to handle double precision. 12/14/98

CWP\_Exit - exit subroutine for CWP/SU codes

FRANNOR - functions to generate a pseudo-random float normally distributed with  $N(0,1)$ ; i.e., with zero mean and unit variance.

frannor return a normally distributed random float  
srannor seed random number generator for normal distribution

Function Prototypes:

```
float frannor (void);  
void srannor (int seed);
```

frannor:

Input: (none)

Returned: normally distributed random float

srannor:

Input:

seed different seeds yield different sequences of random numbers.

Notes:

Adapted from subroutine rnor in Kahaner, Moler and Nash (1988) which in turn was based on an algorithm by Marsaglia and Tsang (1984).

References:

Numerical Methods and Software", D.

Kahaner, C. Moler, S. Nash, Prentice Hall, 1988.

Marsaglia G. and Tsang, W. W., 1984,

A fast, easily implemented method for sampling from decreasing or symmetric unimodal density functions: SIAM J. Sci. Stat. Comput., v. 5, no. 2, p. 349-359.

Author: Dave Hale, Colorado School of Mines, 01/21/89

FRANUNI - Functions to generate a pseudo-random float uniformly distributed on [0,1); i.e., between 0.0 (inclusive) and 1.0 (exclusive)

franuni return a random float  
sranuni seed random number generator

Function Prototypes:  
float franuni (void);  
void sranuni (int seed);

franuni:  
Input: (none)  
Returned: pseudo-random float

sranuni:  
seed different seeds yield different sequences of random numbers.

Notes:  
Adapted from subroutine uni in Kahaner, Moler, and Nash (1988).  
This book references a set of unpublished notes by  
Marsaglia.

According to the reference, this random  
number generator "passes all known tests and has a period that is ...  
approximately  $10^{19}$ ".

References:  
Numerical Methods and Software", D. Kahaner, C. Moler, S. Nash,  
Prentice Hall, 1988.

Marsaglia G., "Comments on the perfect uniform random number generator  
Unpublished notes, Wash S. U.

Author: Dave Hale, Colorado School of Mines, 12/30/89

## HANKEL - Functions to compute discrete Hankel transforms

`hankelalloc` allocate and return a pointer to a Hankel transformer

`hankelfree` free a Hankel transformer

`hankel0` compute the zeroth-order Hankel transform

`hankel1` compute the first-order Hankel transform

### Function Prototypes:

```
void *hankelalloc (int nfft);
```

```
void hankelfree (void *ht);
```

```
void hankel0 (void *ht, float f[], float h[]);
```

```
void hankel1 (void *ht, float f[], float h[]);
```

### `hankelalloc`:

Input:

`nfft` valid length for real to complex fft (see notes below)

Returned:

pointer to Hankel transformer

### `hankelfree`:

Input:

`ht` pointer to Hankel transformer (as returned by `hankelalloc`)

### `hankel0`:

Input:

`ht` pointer to Hankel transformer (as returned by `hankelalloc`)

`f` array[`nfft/2+1`] to be transformed

Output:

`h` array[`nfft/2+1`] transformed

### `hankel1`:

Input:

`ht` pointer to Hankel transformer (as returned by `hankelalloc`)

`f` array[`nfft/2+1`] to be transformed

Output:

`h` array[`nfft/2+1`] transformed

### Notes:

The zeroth-order Hankel transform is defined by:

$$h_0(k) = \int_0^{\infty} dr \, r \, j_0(k*r) f(r)$$

where  $j_0$  denotes the zeroth-order Bessel function.

The first-order Hankel transform is defined by:

$$h_1(k) = \int_0^{\infty} dr \, r \, j_1(k*r) f(r)$$

where  $j_1$  denotes the first-order Bessel function.

The Hankel transform is its own inverse.

The Hankel transform is computed by an Abel transform followed by a Fourier transform.

References:

Hansen, E. W., 1985, Fast Hankel transform algorithm: IEEE Trans. on Acoustics, Speech and Signal Processing, v. ASSP-33, n. 3, p. 666-671. (Beware of several errors in the equations in this paper!)

Authors: Dave Hale, Colorado School of Mines, 06/04/90

HILBERT - Compute Hilbert transform y of x

hilbert compute the Hilbert transform

Function Prototype:

```
void hilbert (int n, float x[], float y[]);
```

Input:

n length of x and y

x array[n] to be Hilbert transformed

Output:

y array[n] containing Hilbert transform of x

Notes:

The Hilbert transform is computed by convolving x with a windowed (approximate) version of the ideal Hilbert transformer.

Author: Dave Hale, Colorado School of Mines, 06/02/89

HOLBERG1D - Compute coefficients of Holberg's 1st derivative filter

holberg1d compute the coefficients of Holberg's 1st derivative filter

Function Prototype:

```
void holberg1d (float e, int n, float d[]);
```

Input:

e maximum relative error in group velocity

n number of coefficients in filter (must be 2, 4, 6, or 8)

Output:

d array[n] of coefficients

Notes:

Coefficients are output in a form suitable for convolution. The derivative is centered halfway between coefficients  $d[n/2-1]$  and  $d[n/2]$ .

Coefficients are computed via the power series method of Kindelan et al., 1990, On the construction and efficiency of staggered numerical differentiators for the wave equation: *Geophysics* 55, 107-110. See also, Holberg, 1987, Computational aspects of the choice of operator and sampling interval for numerical differentiation in large-scale simulation of wave phenomena: *Geophys. Prosp.*, 35, 629-655

Reference:

Kindelan et al., 1990,

On the construction and efficiency of staggered numerical differentiators for the wave equation: *Geophysics* 55, 107-110.

See also, Holberg, 1987, Computational aspects of the choice of operator and sampling interval for numerical differentiation in large-scale simulation of wave phenomena: *Geophys. Prosp.*, 35, 629-655

Author: Dave Hale, Colorado School of Mines, 06/06/91

INTCUB - evaluate  $y(x)$ ,  $y'(x)$ ,  $y''(x)$ , ... via piecewise cubic interpolation

intcub evaluate  $y(x)$ ,  $y'(x)$ ,  $y''(x)$ , ... via piecewise spline interpolation

Function Prototype:

```
void intcub (int nderiv, int nin, float xin[], float ydin[][4],
```

Input:

nderiv =0 if  $y(x)$  desired; =1 if  $y'(x)$  desired, ...

nin length of xin and ydin arrays

xin array[nin] of monotonically increasing or decreasing x values

ydin array[nin][4] of  $y(x)$ ,  $y'(x)$ ,  $y''(x)$ , and  $y'''(x)$

nout length of xout and yout arrays

xout array[nout] of x values at which to evaluate  $y(x)$ ,  $y'(x)$ , ...

Output:

yout array[nout] of  $y(x)$ ,  $y'(x)$ , ... values

Notes:

xin values must be monotonically increasing or decreasing.

Extrapolation of the function  $y(x)$  for xout values outside the range spanned by the xin values is performed using the derivatives in ydin[0][0:3] or ydin[nin-1][0:3], depending on whether xout is closest to xin[0] or xin[nin-1], respectively.

Reference:

See: Greville, T. N., Theory and Application of Spline Functions, Academic Press for a general discussion of spline functions.

Author: Dave Hale, Colorado School of Mines, 06/02/89

INTL2B - bilinear interpolation of a 2-D array of bytes

intl2b bilinear interpolation of a 2-D array of bytes

Function Prototype:

```
void intl2b (int nxin, float dxin, float fxin,  
int nyin, float dyin, float fyin, unsigned char *zin,  
int nxout, float dxout, float fxout,  
int nyout, float dyout, float fyout, unsigned char *zout);
```

Input:

nxin number of x samples input (fast dimension of zin)  
dxin x sampling interval input  
fxin first x sample input  
nyin number of y samples input (slow dimension of zin)  
dyin y sampling interval input  
fyin first y sample input  
zin array[nyin][nxin] of input samples (see notes)  
nxout number of x samples output (fast dimension of zout)  
dxout x sampling interval output  
fxout first x sample output  
nyout number of y samples output (slow dimension of zout)  
dyout y sampling interval output  
fyout first y sample output

Output:

zout array[nyout][nxout] of output samples (see notes)

Notes:

The arrays zin and zout must be passed as pointers to the first element of a two-dimensional contiguous array of unsigned char values.

Constant extrapolation of zin is used to compute zout for output x and y outside the range of input x and y.

For efficiency, this function builds a table of interpolation coefficients pre-multiplied by byte values. To keep the table reasonably small, the interpolation does not distinguish between x and y values that differ by less than  $dxin/ICMAX$  and  $dyin/ICMAX$ , respectively, where  $ICMAX$  is a parameter defined above.

Author: Dave Hale, Colorado School of Mines, c. 1989-1991.

INTLINC - evaluate complex  $y(x)$  via linear interpolation of  $y(x[0])$ ,  $y(x[1])$ , ...

Function Prototype:

```
void intlinc (int nin, float xin[], complex yin[], complex yinl, complex yinr,
int nout, float xout[], complex yout[]);
```

Input:

nin length of xin and yin arrays

xin array[nin] of monotonically increasing or decreasing x values

yin array[nin] of input  $y(x)$  values

yinl value used to extrapolate  $y(x)$  to left of input yin values

yinr value used to extrapolate  $y(x)$  to right of input yin values

nout length of xout and yout arrays

xout array[nout] of x values at which to evaluate  $y(x)$

Output:

yout array[nout] of linearly interpolated  $y(x)$  values

Notes:

xin values must be monotonically increasing or decreasing.

Extrapolation of the function  $y(x)$  for xout values outside the range spanned by the xin values is performed as follows:

For monotonically increasing xin values,

yout=yinl if  $xout < xin[0]$ , and yout=yinr if  $xout > xin[nin-1]$ .

For monotonically decreasing xin values,

yout=yinl if  $xout > xin[0]$ , and yout=yinr if  $xout < xin[nin-1]$ .

If  $nin==1$ , then the monotonically increasing case is used.

/

INTLIN - evaluate  $y(x)$  via linear interpolation of  $y(x[0])$ ,  $y(x[1])$ , ...

intlin evaluate  $y(x)$  via linear interpolation of  $y(x[0])$ ,  $y(x[1])$ , ...

Function Prototype:

```
void intlin (int nin, float xin[], float yin[], float yinl, float yinr,
int nout, float xout[], float yout[]);
```

Input:

nin length of xin and yin arrays

xin array[nin] of monotonically increasing or decreasing x values

yin array[nin] of input  $y(x)$  values

yinl value used to extrapolate  $y(x)$  to left of input yin values

yinr value used to extrapolate  $y(x)$  to right of input yin values

nout length of xout and yout arrays

xout array[nout] of x values at which to evaluate  $y(x)$

Output:

yout array[nout] of linearly interpolated  $y(x)$  values

Notes:

xin values must be monotonically increasing or decreasing.

Extrapolation of the function  $y(x)$  for xout values outside the range spanned by the xin values is performed as follows:

For monotonically increasing xin values,

yout=yinl if  $xout < xin[0]$ , and yout=yinr if  $xout > xin[nin-1]$ .

For monotonically decreasing xin values,

yout=yinl if  $xout > xin[0]$ , and yout=yinr if  $xout < xin[nin-1]$ .

If  $nin==1$ , then the monotonically increasing case is used.

Author: Dave Hale, Colorado School of Mines, 06/02/89

INTSINC8 - Functions to interpolate uniformly-sampled data via 8-coeff. sinc approximations:

ints8c interpolation of a uniformly-sampled complex function  $y(x)$  via an 8-coefficient sinc approximation.

ints8r Interpolation of a uniformly-sampled real function  $y(x)$  via a table of 8-coefficient sinc approximations

Function Prototypes:

```
void ints8c (int nxin, float dxin, float fxin, complex yin[],
             complex yinl, complex yinr, int nxout, float xout[], complex yout[]);
void ints8r (int nxin, float dxin, float fxin, float yin[],
             float yinl, float yinr, int nxout, float xout[], float yout[]);
```

Input:

nxin number of x values at which  $y(x)$  is input  
dxin x sampling interval for input  $y(x)$   
fxin x value of first sample input  
yin array[nxin] of input  $y(x)$  values:  $yin[0] = y(fxin)$ , etc.  
yinl value used to extrapolate yin values to left of  $yin[0]$   
yinr value used to extrapolate yin values to right of  $yin[nxin-1]$   
nxout number of x values a which  $y(x)$  is output  
xout array[nxout] of x values at which  $y(x)$  is output

Output:

yout array[nxout] of output  $y(x)$ :  $yout[0] = y(xout[0])$ , etc.

Notes:

Because extrapolation of the input function  $y(x)$  is defined by the left and right values yinl and yinr, the xout values are not restricted to lie within the range of sample locations defined by nxin, dxin, and fxin.

The maximum error for frequencies less than 0.6 nyquist is less than one percent.

Author: Dave Hale, Colorado School of Mines, 06/02/89

INTTABLE8 - Interpolation of a uniformly-sampled complex function  $y(x)$  via a table of 8-coefficient interpolators

intt8c interpolation of a uniformly-sampled complex function  $y(x)$  via a table of 8-coefficient interpolators  
intt8r interpolation of a uniformly-sampled real function  $y(x)$  via a table of 8-coefficient interpolators

Function Prototype:

```
void intt8c (int ntable, float table[][8],
int nxin, float dxin, float fxin, complex yin[],
complex yinl, complex yinr, int nxout, float xout[], complex yout[]);
void intt8r (int ntable, float table[][8],
int nxin, float dxin, float fxin, float yin[],
float yinl, float yinr, int nxout, float xout[], float yout[]);
```

Input:

ntable number of tabulated interpolation operators;  $ntable \geq 2$   
table array of tabulated 8-point interpolation operators  
nxin number of x values at which  $y(x)$  is input  
dxin x sampling interval for input  $y(x)$   
fxin x value of first sample input  
yin array of input  $y(x)$  values:  $yin[0] = y(fxin)$ , etc.  
yinl value used to extrapolate yin values to left of  $yin[0]$   
yinr value used to extrapolate yin values to right of  $yin[nxin-1]$   
nxout number of x values at which  $y(x)$  is output  
xout array of x values at which  $y(x)$  is output

Output:

yout array of output  $y(x)$  values:  $yout[0] = y(xout[0])$ , etc.

NOTES:

ntable must not be less than 2.

The table of interpolation operators must be as follows:

Let  $d$  be the distance, expressed as a fraction of  $dxin$ , from a particular  $xout$  value to the sampled location  $xin$  just to the left of  $xout$ . Then, for  $d = 0.0$ ,

```
table[0][0:7] = 0.0, 0.0, 0.0, 1.0, 0.0, 0.0, 0.0, 0.0
```

are the weights applied to the 8 input samples nearest  $xout$ .

Likewise, for  $d = 1.0$ ,

```
table[ntable-1][0:7] = 0.0, 0.0, 0.0, 0.0, 1.0, 0.0, 0.0, 0.0
```

are the weights applied to the 8 input samples nearest  $x_{out}$ . In general, for  $d = (\text{float})itable/(\text{float})(ntable-1)$ , `table[itable][0:7]` are the weights applied to the 8 input samples nearest  $x_{out}$ . If the actual sample distance  $d$  does not exactly equal one of the values for which interpolators are tabulated, then the interpolator corresponding to the nearest value of  $d$  is used.

Because extrapolation of the input function  $y(x)$  is defined by the left and right values  $y_{inl}$  and  $y_{inr}$ , the  $x_{out}$  values are not restricted to lie within the range of sample locations defined by  $n_{xin}$ ,  $d_{xin}$ , and  $f_{xin}$ .

AUTHOR: Dave Hale, Colorado School of Mines, 06/02/89

LINEAR\_REGRESSION - Compute linear regression of (y1,y2,...,yn) against (x1,x2,...,xn)

Function Prototype:

```
void linear_regression(float *y, float *x, int n, float coeff[4]);
```

Input:

y array of y values

x array of x values

n length of y and x arrays

Output:

coeff[4] where:

coeff[0] slope of best fit line

coeff[1] intercept of best fit line

coeff[2] correlation coefficient of fit (1 = perfect) [dimensionless]

coeff[3] standard error of fit (0 = perfect) [dimensions of y]

Notes:

y(x)

```

|      * .      fit is y(x) = a x + b
|      .
|      . *
| * .
| . *
|----- x

```

$$a = \frac{n \text{ Sum}[x*y] - \text{Sum}[x]*\text{Sum}[y]}{n \text{ Sum}[x*x] - \text{Sum}[x]*\text{Sum}[x]}$$

$$b = \frac{\text{Sum}[y] - a*\text{Sum}[x]}{n}$$

cc = std definition

se = std definition

Author: Chris Liner, UTulsa, 11/16/03

MKDIFF - Make an n-th order DIFFerentiator via Taylor's series method.

mkdiff make discrete Taylor series approximation to n'th derivative.

Function Prototype:

```
void mkdiff (int n, float a, float h, int l, int m, float d[]);
```

Input:

n order of desired derivative (n>=0 && n<=m-1 is required)

a fractional distance from integer sampling index (see notes)

h sampling interval

l sampling index of first coefficient (see notes below)

m sampling index of last coefficient (see notes below)

Output:

d array[m-l+1] of coefficients for n'th order differentiator

Notes:

The abscissae x of a sampled function f(x) can always be expressed as  $x = (j+a)*h$ , where j is an integer, a is a fraction, and h is the sampling interval. To approximate the n'th order derivative  $fn(x)$  of the sampled function f(x) at  $x = (j+a)*h$ , use the m-l+1 coefficients in the output array d[] as follows:

$$fn(x) = d[0]*f(j-l) + d[1]*f(j-l-1) + \dots + d[m-l]*f(j-m)$$

i.e., convolve the coefficients in d with the samples in f.

m-l+1 (the number of coefficients) must not be greater than the NCMAX parameter specified below.

For best approximations,

when n is even, use a = 0.0, l = -m

when n is odd, use a = 0.5, l = -m-1

Author: Dave Hale, Colorado School of Mines, 06/02/89

MKHDIFF - Compute filter approximating the bandlimited Half-DIFFerentiator.

mkhdiff - Compute filter approximating the bandlimited half-differentiator.

Function Prototype:

```
void mkhdiff (float h, int l, float d[]);
```

Input:

h sampling interval

l half-length of half-differentiator (length = 1+2\*l is odd)

Output:

d array[1+2\*l] of coefficients for half-differentiator

Notes:

The half-differentiator is defined by

$$d[l+j] = \int_{-\pi}^{\pi} \sqrt{1/h}/(2\pi) * \text{integral } dw \sqrt{-iw} * \exp(-iwj)$$
$$= \int_0^{\pi} \sqrt{2/h}/(2\pi) * \text{integral } dw \sqrt{w} * (\cos(wj) - \sin(wj))$$

for  $j = -l, -l+1, \dots, l$ .

An alternative definition is that  $f'(j) = d(j)*d(j)*f(j)$ , where  $f'(j)$  denotes the derivative of a sampled function  $f(j)$  and  $*$  denotes a convolution sum.

The half-derivative  $g(j)$  of  $f(j)$  may be computed by the following sum:

$$g(j) = d[0]*f(j+1) + d[1]*f(j+1-1) + \dots + d[2*l]*f(j-1)$$

The integral over frequency is evaluated numerically using Simpson's method. Although the Filon method of numerical integration is more appropriate for this integral, the truncation of  $d[l+j]$  for  $|j| > l$  is probably the greatest source of error. In any case,  $d[l+j]$  is cosine-tapered to reduce these truncation errors.

Author: Dave Hale, Colorado School of Mines, 06/02/89

MKSINC - Compute least-squares optimal sinc interpolation coefficients.

mksinc Compute least-squares optimal sinc interpolation coefficients.

Function Prototype:

```
void mksinc (float d, int lsinc, float sinc[]);
```

Input:

d fractional distance to interpolation point;  $0.0 \leq d \leq 1.0$

lsinc length of sinc approximation;  $lsinc \% 2 == 0$  and  $lsinc \leq 20$

Output:

sinc array[lsinc] containing interpolation coefficients

Notes:

The coefficients are a least-squares-best approximation to the ideal sinc function for frequencies from zero up to a computed maximum frequency. For a given interpolator length, lsinc, mksinc computes the maximum frequency, fmax (expressed as a fraction of the nyquist frequency), using the following empirically derived relation (from a Western Geophysical Technical Memorandum by Ken Lerner):

$$fmax = \min(0.066 + 0.265 * \log(lsinc), 1.0)$$

Note that fmax increases as lsinc increases, up to a maximum of 1.0. Use the coefficients to interpolate a uniformly-sampled function y(i) as follows:

$$y(i+d) = \sum_{j=0}^{lsinc-1} sinc[j] * y(i+j+1-lsinc/2)$$

Interpolation error is greatest for  $d=0.5$ , but for frequencies less than fmax, the error should be less than 1.0 percent.

Author: Dave Hale, Colorado School of Mines, 06/02/89

MNEWT - Solve non-linear system of equations  $f(x) = 0$  via Newton's method

mnewt Solve non-linear system of equations  $f(x) = 0$  via Newton's method

Function Prototype:

```
int mnewt (int maxiter, float ftol, float dxtol, int n, float *x, void *aux,  
void (*fdfdx)(int n, float *x, float *f, float **dfdx, void *aux));
```

Input:

maxiter maximum number of iterations

ftol converged when sum of absolute values of  $f$  less than ftol

dxtol converged when sum of absolute values of  $dx$  less than dxtol

$n$  number of equations

$x$  array[ $n$ ] containing initial guess of solution

aux pointer to auxiliary parameters to be passed to fdfdx

fdfdx pointer to function to evaluate  $f(x)$  and  $f'(x)$

Output:

$x$  array[ $n$ ] containing solution

Returned: number of iterations; -1 if failed to converge in maxiter

Input to the user-supplied function fdfdx:

$n$  number of equations

$x$  array[ $n$ ] of  $x_0, x_1, \dots$

aux pointer to auxiliary variables required by fdfdx.

Output from the user-supplied function fdfdx:

$f$  array[ $n$ ] of  $f_0(x), f_1(x), \dots$

dfdx array[ $n$ ][ $n$ ] of  $f'(x)$ ;  $dfdx[j][i] = df_i/dx_j$

Author: Dave Hale, Colorado School of Mines, 06/06/91

PFAFFT - Functions to perform Prime Factor (PFA) FFT's, in place

npfa return valid n for complex-to-complex PFA  
npfar return valid n for real-to-complex/complex-to-real PFA  
npfao return optimal n for complex-to-complex PFA  
npfaro return optimal n for real-to-complex/complex-to-real PFA  
pfacc 1D PFA complex to complex  
pfacr 1D PFA complex to real  
pfarc 1D PFA real to complex  
pfamcc multiple PFA complex to real  
pfa2cc 2D PFA complex to complex  
pfa2cr 2D PFA complex to real  
pfa2rc 2D PFA real to complex

Function Prototypes:

```
int npfa (int nmin);
int npfao (int nmin, int nmax);
int npfar (int nmin);
int npfaro (int nmin, int nmax);
void pfacc (int isign, int n, complex z[]);
void pfacr (int isign, int n, complex cz[], float rz[]);
void pfarc (int isign, int n, float rz[], complex cz[]);
void pfamcc (int isign, int n, int nt, int k, int kt, complex z[]);
void pfa2cc (int isign, int idim, int n1, int n2, complex z[]);
void pfa2cr (int isign, int idim, int n1, int n2, complex cz[], float rz[]);
void pfa2rc (int isign, int idim, int n1, int n2, float rz[], complex cz[]);
```

npfa:

Input:

nmin lower bound on returned value (see notes below)

Returned: valid n for prime factor fft

npfao

Input:

nmin lower bound on returned value (see notes below)

nmax desired (but not guaranteed) upper bound on returned value

Returned: valid n for prime factor fft

npfar

Input:

nmin lower bound on returned value

Returned: valid n for real-to-complex/complex-to-real prime factor fft

npfarc:

Input:

nmin lower bound on returned value

nmax desired (but not guaranteed) upper bound on returned value

Returned: valid n for real-to-complex/complex-to-real prime factor fft

pfacc:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform (see notes below)

z array[n] of complex numbers to be transformed in place

Output:

z array[n] of complex numbers transformed

pfacr:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform (see notes below)

cz array[n/2+1] of complex values (may be equivalenced to rz)

Output:

rz array[n] of real values (may be equivalenced to cz)

pfarc:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform; must be even (see notes below)

rz array[n] of real values (may be equivalenced to cz)

Output:

cz array[n/2+1] of complex values (may be equivalenced to rz)

pfamcc:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n number of complex elements per transform (see notes below)

nt number of transforms

k stride in complex elements within transforms

kt            stride in complex elements between transforms  
z            array of complex elements to be transformed in place

Output:  
z array of complex elements transformed

pfa2cc:

Input:

isign        sign of isign is the sign of exponent in fourier kernel  
idim        dimension to transform, either 1 or 2 (see notes)  
n1          1st (fast) dimension of array to be transformed (see notes)  
n2          2nd (slow) dimension of array to be transformed (see notes)  
z            array[n2][n1] of complex elements to be transformed in place

Output:  
z array[n2][n1] of complex elements transformed

pfa2cr:

Input:

isign        sign of isign is the sign of exponent in fourier kernel  
idim        dimension to transform, which must be either 1 or 2 (see notes)  
n1          1st (fast) dimension of array to be transformed (see notes)  
n2          2nd (slow) dimension of array to be transformed (see notes)  
cz          array of complex values (may be equivalenced to rz)

Output:  
rz          array of real values (may be equivalenced to cz)

pfa2rc:

Input:

isign        sign of isign is the sign of exponent in fourier kernel  
idim        dimension to transform, which must be either 1 or 2 (see notes)  
n1          1st (fast) dimension of array to be transformed (see notes)  
n2          2nd (slow) dimension of array to be transformed (see notes)  
rz          array of real values (may be equivalenced to cz)

Output:  
cz          array of complex values (may be equivalenced to rz)

Notes:

Table of valid n and cost for prime factor fft. For each n, cost was estimated to be the inverse of the number of ffts done in 1 sec on an IBM RISC System/6000 Model 320H, by Dave Hale, 08/04/91.

(Redone by Jack Cohen for 15 sec to rebuild NTAB table on advice of David and Gregory Chudnovsky, 05/03/94).

Cost estimates are least accurate for very small  $n$ . An alternative method for estimating cost would be to count multiplies and adds, but this method fails to account for the overlapping of multiplies and adds that is possible on some computers, such as the IBM RS/6000 family.

npfa:

The returned  $n$  will be composed of mutually prime factors from the set  $\{2,3,4,5,7,8,9,11,13,16\}$ . Because  $n$  cannot exceed  $720720 = 5*7*9*11*13*16$ ,  $720720$  is returned if  $nmin$  exceeds  $720720$ .

npfao:

The returned  $n$  will be composed of mutually prime factors from the set  $\{2,3,4,5,7,8,9,11,13,16\}$ . Because  $n$  cannot exceed  $720720 = 5*7*9*11*13*16$ ,  $720720$  is returned if  $nmin$  exceeds  $720720$ . If  $nmin$  does not exceed  $720720$ , then the returned  $n$  will not be less than  $nmin$ . The optimal  $n$  is chosen to minimize the estimated cost of performing the fft, while satisfying the constraint, if possible, that  $n$  not exceed  $nmax$ .

npfar and npfaro:

Current implemenations of real-to-complex and complex-to-real prime factor ffts require that the transform length  $n$  be even and that  $n/2$  be a valid length for a complex-to-complex prime factor fft. The value returned by npfar satisfies these conditions. Also, see notes for npfa.

pfacc:

$n$  must be factorable into mutually prime factors taken from the set  $\{2,3,4,5,7,8,9,11,13,16\}$ . in other words,  
 $n = 2^{**p} * 3^{**q} * 5^{**r} * 7^{**s} * 11^{**t} * 13^{**u}$

where

$0 \leq p \leq 4$ ,  $0 \leq q \leq 2$ ,  $0 \leq r,s,t,u \leq 1$

is required for pfa to yield meaningful results. this restriction implies that  $n$  is restricted to the range  
 $1 \leq n \leq 720720 (= 5*7*9*11*13*16)$

pfacr:

Because pfacr uses pfacc to do most of the work,  $n$  must be even and  $n/2$  must be a valid length for pfacc. The simplest way to obtain a valid  $n$  is via  $n = npfar(nmin)$ . A more optimal  $n$  can be obtained with npfaro.

`pfarc`:

Because `pfarc` uses `pfacc` to do most of the work, `n` must be even and `n/2` must be a valid length for `pfacc`. The simplest way to obtain a valid `n` is via `n = npfar(nmin)`. A more optimal `n` can be obtained with `npfaro`.

`pfamcc`:

To perform a two-dimensional transform of an `n1` by `n2` complex array (assuming that both `n1` and `n2` are valid "n"), stored with `n1` fast and `n2` slow:

```
    pfamcc(isign,n1,n2,1,n1,z); (to transform 1st dimension)
    pfamcc(isign,n2,n1,n1,1,z); (to transform 2nd dimension)
```

`pfa2cc`:

Only one (either the 1st or 2nd) dimension of the 2-D array is transformed.

If `idim` equals 1, then `n2` transforms of `n1` complex elements are performed; else, if `idim` equals 2, then `n1` transforms of `n2` complex elements are performed.

Although `z` appears in the argument list as a one-dimensional array, `z` may be viewed as an `n1` by `n2` two-dimensional array: `z[n2][n1]`.

Valid `n` is computed via the "np" subroutines.

To perform a two-dimensional transform of an `n1` by `n2` complex array (assuming that both `n1` and `n2` are valid "n"), stored with `n1` fast and `n2` slow: `pfa2cc(isign,1,n1,n2,z)`; `pfa2cc(isign,2,n1,n2,z)`;

`pfa2cr`:

If `idim` equals 1, then `n2` transforms of `n1/2+1` complex elements to `n1` real elements are performed; else, if `idim` equals 2, then `n1` transforms of `n2/2+1` complex elements to `n2` real elements are performed.

Although `rz` appears in the argument list as a one-dimensional array, `rz` may be viewed as an `n1` by `n2` two-dimensional array: `rz[n2][n1]`. Likewise, depending on `idim`, `cz` may be viewed as either an `n1/2+1` by `n2` or an `n1` by `n2/2+1` two-dimensional array of complex elements.

Let `n` denote the transform length, either `n1` or `n2`, depending on `idim`. Because `pfa2rc` uses `pfa2cc` to do most of the work, `n` must be even and `n/2` must be a valid length for `pfa2cc`. The simplest way to

obtain a valid  $n$  is via  $n = \text{npfar}(\text{nmin})$ . A more optimal  $n$  can be obtained with `npfaro`.

`pfa2rc`:

If `idim` equals 1, then  $n2$  transforms of  $n1$  real elements to  $n1/2+1$  complex elements are performed; else, if `idim` equals 2, then  $n1$  transforms of  $n2$  real elements to  $n2/2+1$  complex elements are performed.

Although `rz` appears in the argument list as a one-dimensional array, `rz` may be viewed as an  $n1$  by  $n2$  two-dimensional array: `rz[n2][n1]`. Likewise, depending on `idim`, `cz` may be viewed as either an  $n1/2+1$  by  $n2$  or an  $n1$  by  $n2/2+1$  two-dimensional array of complex elements.

Let  $n$  denote the transform length, either  $n1$  or  $n2$ , depending on `idim`. Because `pfa2rc` uses `pfa2cc` to do most of the work,  $n$  must be even and  $n/2$  must be a valid length for `pfa2cc`. The simplest way to obtain a valid  $n$  is via  $n = \text{npfar}(\text{nmin})$ . A more optimal  $n$  can be obtained with `npfaro`.

References:

Temperton, C., 1985, Implementation of a self-sorting in-place prime factor fft algorithm: *Journal of Computational Physics*, v. 58, p. 283-299.

Temperton, C., 1988, A new set of minimum-add rotated rotated dft modules: *Journal of Computational Physics*, v. 75, p. 190-198.

Differ significantly from Press et al, 1988, *Numerical Recipes in C*, p. 417.

Author: Dave Hale, Colorado School of Mines, 04/27/89

POLAR - Functions to map data in rectangular coordinates to polar and vice versa

recttopolar convert a function  $p(x,y)$  to a function  $q(a,r)$

polartorect convert a function  $q(a,r)$  to a function  $p(x,y)$

Function Prototypes:

```
void recttopolar ( int nx, float dx, float fx, int ny, float dy, float fy,
float **p, int na, float da, float fa, int nr,
float dr, float fr, float **q);
```

```
void polartorect ( int na, float da, float fa, int nr, float dr, float fr,
float **q, int nx, float dx, float fx, int ny,
float dy, float fy, float **p)
```

recttopolar:

Input:

nx number of x samples

dx x sampling interval

fx first x sample

ny number of y samples

dy y sampling interval

fy first y sample

p array[ny][nx] containing samples of  $p(x,y)$

na number of a samples

da a sampling interval

fa first a sample

nr number of r samples

dr r sampling interval

fr first r sample

Output:

q array[nr][na] containing samples of  $q(a,r)$

polartorect:

Input:

na number of a samples

da a sampling interval

fa first a sample

nr number of r samples

dr r sampling interval

fr first r sample

nx number of x samples

dx x sampling interval

fx first x sample

ny number of y samples  
dy y sampling interval  
fy first y sample  
q array[nr][na] containing samples of  $q(a,r)$

Output:  
p array[ny][nx] containing samples of  $p(x,y)$

Notes:  
The polar angle  $a$  is measured in radians,  
 $x = r \cdot \cos(a)$  and  $y = r \cdot \sin(a)$ .

recttopolar:  
Linear extrapolation is used to determine the value of  $p(x,y)$  for  
 $x$  and  $y$  coordinates not in the range corresponding to  $n_x$ ,  $dx$ , ....

polartorect:  
Linear extrapolation is used to determine the value of  $q(a,r)$  for  
 $a$  and  $r$  coordinates not in the range corresponding to  $n_a$ ,  $da$ , ....

Author: Dave Hale, Colorado School of Mines, 06/15/90

PRINTERPLOT - Functions to make a printer plot of a 1-dimensional array

pp1d printer plot of 1d array  
ppplot1 printer plot of 1d array

Function Prototypes:

```
void pp1d (FILE *fp, char *title, int lx, int ifx, float x[]);  
void ppplot1 (FILE *fp, char *title, int nx, float ax[]);
```

pp1d:

Input:

fp file pointer for output (e.g., stdout, stderr, etc.)  
title title of plot  
lx length of x  
ifx index of first x  
x array[lx] to be plotted

ppplot1:

Input:

fp file pointer for printed output (e.g., stdout, stderr, etc.)  
title title of plot  
nx number of x values to be plotted  
ax array[nx] of x values

Notes:

Are two subroutines to do this really necessary?

Author: Dave Hale, Colorado School of Mines, 06/02/89

QUEST - Functions to ESTimate Quantiles:

quest returns estimate - use when entire array is in memory  
questalloc returns quantile estimator - use before questupdate  
questupdate updates and returns current estimate - use for large  
numbers of floats, too big to fit in memory at one time  
questfree frees quantile estimator

quest:

Input:

p quantile to be estimated ( $0.0 \leq p \leq 1.0$  is required)

n number of samples in array x ( $n \geq 5$  is required)

x array[n] of floats

Returned: the estimate of a specified quantile

questalloc:

Input:

p quantile to be estimated ( $0.0 \leq p \leq 1.0$  is required)

n number of samples in array x ( $n \geq 5$  is required)

x array[n] of floats

Returned: pointer to a quantile estimator

questupdate:

Input:

q pointer to quantile estimator (as returned by questalloc)

n number of samples in array x

x array[n] of floats

Returned: quantile estimate

questfree:

q pointer to quantile estimator (as returned by questalloc)

Notes:

quest:

The estimate should approach the sample quantile in the limit of large n.

The estimate is most accurate for cumulative distribution functions that are smooth in the neighborhood of the quantile specified by p.

This function is an implementation of the algorithm published by

Jain and Chlamtac (1985).

questalloc:

This function must be called before calling function questupdate.

See also notes in questupdate.

questupdate:

The estimate should approach the sample quantile in the limit of large n.

The estimate is most accurate for cumulative distribution functions that are smooth in the neighborhood of the quantile specified by p.

This function is an implementation of the algorithm published by Jain, R. and Chlamtac, I., 1985, The PP algorithm for dynamic calculation of quantiles and histograms without storing observations: Comm. ACM, v. 28, n. 10.

Reference:

Jain, R. and Chlamtac, I., 1985, The PP algorithm for dynamic calculation of quantiles and histograms without storing observations: Comm. ACM, v. 28, n. 10.

Author: Dave Hale, Colorado School of Mines, 05/07/89

RESSINC8 - Functions to resample uniformly-sampled data via 8-coefficient sinc approximations:

ress8c resample a uniformly-sampled complex function via 8-coeff. sinc approx.  
ress8r resample a uniformly-sampled real function via 8-coeff. sinc approx.

Function Prototypes:

```
void ress8r (int nxin, float dxin, float fxin, float yin[],
float yinl, float yinr,
int nxout, float dxout, float fxout, float yout[]);
void ress8c (int nxin, float dxin, float fxin, complex yin[],
complex yinl, complex yinr,
int nxout, float dxout, float fxout, complex yout[]);
```

Input:

nxin number of x values at which y(x) is input  
dxin x sampling interval for input y(x)  
fxin x value of first sample input  
yin array[nxin] of input y(x) values: yin[0] = y(fxin), etc.  
yinl value used to extrapolate yin values to left of yin[0]  
yinr value used to extrapolate yin values to right of yin[nxin-1]  
nxout number of x values at which y(x) is output  
dxout x sampling interval for output y(x)  
fxout x value of first sample output

Output:

yout array[nxout] of output y(x) values: yout[0] = y(fxout), etc.

Notes:

Because extrapolation of the input function y(x) is defined by the left and right values yinl and yinr, the output x values defined by nxout, dxout, and fxout are not restricted to lie within the range of input x values defined by nxin, dxin, and fxin.

The maximum error for frequencies less than 0.6 nyquist is less than one percent.

Author: Dave Hale, Colorado School of Mines, 06/06/90

RFWTVA - Rasterize a Float array as Wiggle-Trace-Variable-Area.

rfwtva rasterize a float array as wiggle-trace-variable-area.

Function Prototype:

```
void rfwtva (int n, float z[], float zmin, float zmax, float zbase,
int yzmin, int yzmax, int xfirst, int xlast,
int wiggle, int nbpr, unsigned char *bits, int endian);
```

Input:

n number of samples in array to rasterize

z array[n] to rasterize

zmin z values below zmin will be clipped

zmax z values above zmax will be clipped

zbase z values between zbase and zmax will be filled (see notes)

yzmin horizontal raster coordinate corresponding to zmin

yzmax horizontal raster coordinate corresponding to zmax

xfirst vertical raster coordinate of z[0] (see notes)

xlast vertical raster coordinate of z[n-1] (see notes)

wiggle =0 for no wiggle (VA only); =1 for wiggle (with VA)

wiggle 2<=wiggle<=5 for solid/grey coloring of VA option

shade of grey: wiggle=2 light grey, wiggle=5 black

nbpr number of bytes per row of bits

bits pointer to first (top,left) byte in image

endian byte order =1 big endian =0 little endian

Output:

bits pointer to first (top,left) byte in image

Notes:

The raster coordinate of the (top,left) bit in the image is (0,0).

In other words, x increases downward and y increases to the right.

Raster scan lines run from left to right, and from top to bottom.

Therefore, xfirst, xlast, yzmin, and yzmax should not be less than 0.

Likewise, yzmin and yzmax should not be greater than nbpr\*8-1, and

care should be taken to ensure that xfirst and xlast do not cause bits to be set outside (off the bottom) of the image.

Variable area fill is performed on the right-hand (increasing y) side of the wiggle. If yzmin is greater than yzmax, then z values between zmin will be plotted to the right of zmax, and z values between zbase and zmin are filled. Swapping yzmin and yzmax is an easy way to reverse the polarity of a wiggle.

The variable "endian" must have a value of 1 or 0. If this is not a case an error is returned.

Author: Dave Hale, Colorado School of Mines, 07/01/89

MODIFIED: Paul Michaels, Boise State University, 29 December 2000

Added solid/grey shading scheme, wiggle $\geq$ 2 option for peaks/troughs

RFWTVAIN - Rasterize a Float array as Wiggle-Trace-Variable-Area, with 8 point sinc INTERpolation.

rfwtvaint rasterize a float array as wiggle-trace-variable-area, and apply sinc interpolation for display purposes.

Function Prototype:

```
void rfwtvaint (int n, float z[], float zmin, float zmax, float zbase,
int yzmin, int yzmax, int xfirst, int xlast,
int wiggle, int nbpr, unsigned char *bits, int endian);
```

Input:

n number of samples in array to rasterize  
z array[n] to rasterize  
zmin z values below zmin will be clipped  
zmax z values above zmax will be clipped  
zbase z values between zbase and zmax will be filled (see notes)  
yzmin horizontal raster coordinate corresponding to zmin  
yzmax horizontal raster coordinate corresponding to zmax  
xfirst vertical raster coordinate of z[0] (see notes)  
xlast vertical raster coordinate of z[n-1] (see notes)  
wiggle =0 for no wiggle (VA only); =1 for wiggle (with VA)  
          wiggle 2<=wiggle<=5 for solid/grey coloring of VA option  
          shade of grey: wiggle=2 light grey, wiggle=5 black  
nbpr number of bytes per row of bits  
bits pointer to first (top,left) byte in image  
endian byte order =1 big endian =0 little endian

Output:

bits pointer to first (top,left) byte in image

Notes:

The raster coordinate of the (top,left) bit in the image is (0,0). In other words, x increases downward and y increases to the right. Raster scan lines run from left to right, and from top to bottom. Therefore, xfirst, xlast, yzmin, and yzmax should not be less than 0. Likewise, yzmin and yzmax should not be greater than nbpr\*8-1, and care should be taken to ensure that xfirst and xlast do not cause bits to be set outside (off the bottom) of the image.

Variable area fill is performed on the right-hand (increasing y) side of the wiggle. If yzmin is greater than yzmax, then z values between zmin will be plotted to the right of zmax, and z values between zbase

and zmin are filled. Swapping yzmin and yzmax is an easy way to reverse the polarity of a wiggle.

The variable "endian" must have a value of 1 or 0. If this is not a case an error is returned.

The interpolation is by the 8 point sinc interpolation routine s8r.

Author: Dave Hale, Colorado School of Mines, 07/01/89

Memorial University of Newfoundland: Tony Kocurko, Sept 1995.

Added sinc interpolation.

MODIFIED: Paul Michaels, Boise State University, 29 December 2000

added solid/grey color scheme for peaks/troughs wiggle=2 option

SBLAS - Single precision Basic Linear Algebra Subroutines  
(adapted from LINPACK FORTRAN):

isamax return index of element with maximum absolute value  
sasum return sum of absolute values  
saxpy compute  $y[i] = a*x[i]+y[i]$   
scopy copy  $x[i]$  to  $y[i]$  (i.e., set  $y[i] = x[i]$ )  
sdot return sum of  $x[i]*y[i]$  (i.e., return the dot product of  $x$  and  $y$ )  
snrm2 return square root of sum of squares of  $x[i]$   
sscal compute  $x[i] = a*x[i]$   
sswap swap  $x[i]$  and  $y[i]$

Function Prototypes:

```
int isamax (int n, float *sx, int incx);  
float sasum (int n, float *sx, int incx);  
void saxpy (int n, float sa, float *sx, int incx, float *sy, int incy);  
void scopy (int n, float *sx, int incx, float *sy, int incy);  
float sdot (int n, float *sx, int incx, float *sy, int incy);  
float snrm2 (int n, float *sx, int incx);  
void sscal (int n, float sa, float *sx, int incx);  
void sswap (int n, float *sx, int incx, float *sy, int incy);
```

isamax:

Input:

$n$  number of elements in array  
 $sx$  array[ $n$ ] of elements  
 $incx$  increment between elements

Returned: index of element with maximum absolute value

sasum:

Input:

$n$  number of elements in array  
 $sx$  array[ $n$ ] of elements  
 $incx$  increment between elements

Returned: sum of absolute values

saxpy:

Input:

$n$  number of elements in arrays  
 $sa$  the scalar multiplier  
 $sx$  array[ $n$ ] of elements to be scaled and added

incx increment between elements of sx  
sy array[n] of elements to be added  
incy increment between elements of sy

Output:  
sy array[n] of accumulated elements

scopy:  
Input:  
n number of elements in arrays  
sx array[n] of elements to be copied  
incx increment between elements of sx  
incy increment between elements of sy

Output:  
sy array[n] of copied elements

sdot:  
Input:  
n number of elements in arrays  
sx array[n] of elements  
incx increment between elements of sx  
sy array[n] of elements  
incy increment between elements of sy

Returned: dot product of the two arrays

snrm2  
Input:  
n number of elements in array  
sx array[n] of elements  
incx increment between elements

Returned: square root of sum of squares of x[i]

sscal:  
Input:  
n number of elements in array  
sa the scalar multiplier  
sx array[n] of elements  
incx increment between elements

Output:

sx array[n] of scaled elements

sswap:

Input:

n number of elements in arrays

sx array[n] of elements

incx increment between elements of sx

sy array[n] of elements

incy increment between elements of sy

Output:

sx array[n] of swapped elements

sy array[n] of swapped elements

Notes:

Adapted from Linpack Fortran.

snrm2:

This simple version may cause overflow or underflow!

Author: Dave Hale, Colorado School of Mines, 10/01/89

SCAXIS - compute a readable scale for use in plotting axes

scaxis compute a readable scale for use in plotting axes

Function Prototype:

```
void scaxis (float x1, float x2, int *nxnum, float *dxnum, float *fxnum);
```

Input:

x1 first x value

x2 second x value

nxnum desired number of numbered values

Output:

nxnum number of numbered values

dxnum increment between numbered values (dxnum>0.0)

fxnum first numbered value

Notes:

scaxis attempts to honor the user-specified nxnum. However, nxnum will be modified if necessary for readability. Also, fxnum and nxnum will be adjusted to compensate for roundoff error; in particular, fxnum will not be less than xmin-eps, and fxnum+(nxnum-1)\*dxnum will not be greater than xmax+eps, where eps = 0.0001\*(xmax-xmin). xmin is the minimum of x1 and x2. xmax is the maximum of x1 and x2.

Author: Dave Hale, Colorado School of Mines, 01/13/89

SGA - Single precision general matrix functions adapted from LINPACK FORTRAN:

sgefa Gaussian elimination to obtain the LU factorization of a matrix.

sgeco Gaussian elimination to obtain the LU factorization and condition number of a matrix.

sgesl Solve linear system  $Ax = b$  or  $A'x = b$  after LU factorization.

Function Prototypes:

```
void sgefa (float **a, int n, int *ipvt, int *info);
```

```
void sgeco (float **a, int n, int *ipvt, float *rcond, float *z);
```

```
void sgesl (float **a, int n, int *ipvt, float *b, int job);
```

sgefa:

Input:

a matrix[n][n] to be factored (see notes below)

n dimension of a

Output:

a matrix[n][n] factored (see notes below)

ipvt indices of pivot permutations (see notes below)

info index of last zero pivot (or -1 if no zero pivots)

sgeco:

Input:

a matrix[n][n] to be factored (see notes below)

n dimension of a

Output:

a matrix[n][n] factored (see notes below)

ipvt indices of pivot permutations (see notes below)

rcond reciprocal condition number (see notes below)

Workspace:

z array[n]

sgesl

Input:

a matrix[n][n] that has been LU factored (see notes below)

n dimension of a

ipvt indices of pivot permutations (see notes below)

b right-hand-side vector[n]

job =0 to solve  $Ax = b$

=1 to solve  $A'x = b$

Output:

b solution vector[n]

Notes:

These functions were adapted from LINPACK FORTRAN. Because two-dimensional arrays cannot be declared with variable dimensions in C, the matrix a is actually a pointer to an array of pointers to floats, as declared above and used below.

Elements of a are stored as follows:

```
a[0][0]   a[1][0]   a[2][0]   ... a[n-1][0]
a[0][1]   a[1][1]   a[2][1]   ... a[n-1][1]
a[0][2]   a[1][2]   a[2][2]   ... a[n-1][2]
.
.
.
.
a[0][n-1] a[1][n-1] a[2][n-1] ... a[n-1][n-1]
```

Both the factored matrix a and the pivot indices ipvt are required to solve linear systems of equations via sgesl.

sgeco:

Given the reciprocal of the condition number, rcond, and the float epsilon, FLT\_EPSILON, the number of significant decimal digits, nsdd, in the solution of a linear system of equations may be estimated by:  
nsdd = (int)log10(rcond/FLT\_EPSILON)

This function was adapted from LINPACK FORTRAN. Because two-dimensional arrays cannot be declared with variable dimensions in C, the matrix a is actually a pointer to an array of pointers to floats, as declared above and used below.

Author: Dave Hale, Colorado School of Mines, 10/01/89

SHFS8R - Shift a uniformly-sampled real-valued function  $y(x)$  via a table of 8-coefficient sinc approximations.

shfs8r shift a uniformly-sampled real function via a table of 8-coeff. sinc approximations.

Function Prototypes:

```
void shfs8r (float dx, int nxin, float fxin, float yin[],
float yinl, float yinr, int nxout, float fxout, float yout[]);
```

Input:

dx x sampling interval for both input and output  $y(x)$   
nxin number of x values at which  $y(x)$  is input  
fxin x value of first sample input  
yin array[nxin] of input  $y(x)$  values:  $yin[0] = y(fxin)$ , etc.  
yinl value used to extrapolate yin values to left of  $yin[0]$   
yinr value used to extrapolate yin values to right of  $yin[nxin-1]$   
nxout number of x values a which  $y(x)$  is output  
fxout x value of first sample output

Output:

yout array[nxout] of output  $y(x)$  values:  $yout[0] = y(fxout)$ , etc.

Notes:

Because extrapolation of the input function  $y(x)$  is defined by the left and right values yinl and yinr, the output samples defined by dx, nxout, and fxout are not restricted to lie within the range of input sample locations defined by dx, nxin, and fxin.

The maximum error for frequencies less than  $0.6 \cdot nyquist$  is less than one percent.

Author: Dave Hale, Colorado School of Mines, 06/02/89

SINC - Return SINC(x) for as floats or as doubles

fsinc return float value of sinc(x) for x input as a float

dsinc return double precision sinc(x) for double precision x

Function Prototype:

```
float fsinc (float x);
```

```
double dsinc (double x);
```

Input:

x value at which to evaluate sinc(x)

Returned: sinc(x)

Notes:

$$\text{sinc}(x) = \sin(\text{PI}*x)/(\text{PI}*x)$$

Author: Dave Hale, Colorado School of Mines, 06/02/89

**SORT** - Functions to sort arrays of data or arrays of indices

**hpsort** sort an array of floats by the heap sort method

**qkisort** sort an array of indices `i[]` so that

`a[i[0]] <= a[i[1]] <= ... <= a[i[n-1]]`

uses the "quick sort" method

**qkifind** partially sort an array of indices `i[]` so that the

index `i[m]` has the value it would have if the entire

array of indices were sorted such that

`a[i[0]] <= a[i[1]] <= ... <= a[i[n-1]]`

uses the "quick sort" method

**qksort** sort an array of floats such that `a[0] <= a[1] <= ... <= a[n-1]`

uses the "quick sort" method

**qkfind** partially sort an array of floats so that the element `a[m]` has the value it would have if the entire array were sorted

such that `a[0] <= a[1] <= ... <= a[n-1]`

uses the "quick sort" method

Function Prototypes:

```
void hpsort (int n, float a[]);
```

```
void qkisort (int n, float a[], int i[]);
```

```
void qkifind (int m, int n, float a[], int i[]);
```

```
void qksort (int n, float a[]);
```

```
void qkfind (int m, int n, float a[]);
```

**hpsort:**

Input:

`n` number of elements in `a`

`a` array[`n`] to be sorted

Output:

`a` array[`n`] sorted

**qkisort:**

Input:

`n` number of elements in array `a`

`a` array[`n`] elements

`i` array[`n`] indices to be sorted

Output:

`i` array[`n`] indices sorted

**qkifind:**

Input:

m index of element to be found  
n number of elements in array a  
a array[n] elements  
i array[n] indices to be partially sorted

Output:

i array[n] indices partially sorted sorted

qksort:

Input:

n number of elements in array a  
a array[n] containing elements to be sorted

Output:

a array[n] containing sorted elements

qkfind:

Input:

m index of element to be found  
n number of elements in array a  
a array[n] to be partially sorted

Output:

a array[n] partially sorted

Notes:

hpsort:

The heap sort algorithm is, at worst,  $N \log_2 N$ , and in most cases is 20% faster. Adapted from Standish.

qkisort, qkifind, qksort, qkfind:

n must be less than  $2^{\text{NSTACK}}$ , where NSTACK is defined above.

qkisort:

This function is adapted from procedure quicksort by Hoare, C.A.R., 1961, Communications of the ACM, v. 4, p. 321; the main difference is that recursion is accomplished explicitly via a stack array for efficiency; also, a simple insertion sort is used to sort subarrays too small to be partitioned efficiently.

qkifind:

This function is adapted from procedure find by  
Hoare, C.A.R., 1961, Communications of the ACM, v. 4, p. 321.

qksort:

This function is adapted from procedure quicksort by  
Hoare, C.A.R., 1961, Communications of the ACM, v. 4, p. 321;  
the main difference is that recursion is accomplished  
explicitly via a stack array for efficiency; also, a simple  
insertion sort is used to sort subarrays too small to be  
partitioned efficiently.

qkfind:

This function is adapted from procedure find by Hoare 1961.

Reference:

hpsort:

Standish, T. A., Data Structure Techniques, p. 91.  
See also Press, W. A., et al., Numerical Recipes in C.

quick sort:

Hoare, C.A.R., 1961, Communications of the ACM, v. 4, p. 321.

Author: Dave Hale, Colorado School of Mines, 12/26/89

SQR - Single precision QR decomposition functions adapted from LINPACK FORTRAN:

sqrdc Compute QR decomposition of a matrix.

sqrsl Use QR decomposition to solve for coordinate transformations, projections, and least squares solutions.

sqrst Solve under-determined or over-determined least squares problems, with a user-specified tolerance.

Function Prototypes:

```
void sqrdc (float **x, int n, int p, float *qraux, int *jpvt,
float *work, int job);
```

```
void sqrsl (float **x, int n, int k, float *qraux,
float *y, float *qy, float *qty,
```

```
float *b, float *rsd, float *xb, int job, int *info);
```

```
void sqrst (float **x, int n, int p, float *y, float tol,
```

```
float *b, float *rsd, int *k,
```

```
int *jpvt, float *qraux, float *work);
```

sqrdc:

Input:

x matrix[p][n] to decompose (see notes below)

n number of rows in the matrix x

p number of columns in the matrix x

jpvt array[p] controlling the pivot columns (see notes below)

job =0 for no pivoting;

=1 for pivoting

Output:

x matrix[p][n] decomposed (see notes below)

qraux array[p] containing information required to recover the orthogonal part of the decomposition

jpvt array[p] with jpvt[k] containing the index of the original matrix that has been interchanged into the k-th column, if pivoting is requested.

Workspace:

work array[p] of workspace

sqrsl:

Input:

x matrix[p][n] containing output of sqrdc.

n number of rows in the matrix xk; same as in sqrdc.

k number of columns in the matrix xk; k must not be greater

than  $\text{MIN}(n,p)$ , where  $p$  is the same as in `sqrdc`.  
`qraux` array[ $p$ ] containing auxiliary output from `sqrdc`.  
`y` array[ $n$ ] to be manipulated by `sqrsl`.  
`job` specifies what is to be computed. `job` has the decimal  
 expansion ABCDE, with the following meaning:  
 if A  $\neq$  0, compute `qy`.  
 if B, C, D, or E  $\neq$  0, compute `qty`.  
 if C  $\neq$  0, compute `b`.  
 if D  $\neq$  0, compute `rsd`.  
 if E  $\neq$  0, compute `xb`.  
 Note that a request to compute `b`, `rsd`, or `xb` automatically  
 triggers the computation of `qty`, for which an array must  
 be provided.

Output:

`qy` array[ $n$ ] containing  $Qy$ , if its computation has been  
 requested.  
`qty` array[ $n$ ] containing  $Q'y$ , if its computation has  
 been requested. Here  $Q'$  denotes the transpose of  $Q$ .  
`b` array[ $k$ ] containing solution of the least squares problem:  
 minimize  $\text{norm2}(y - xk*b)$ ,  
 if its computation has been requested. (Note that if  
 pivoting was requested in `sqrdc`, the  $j$ -th component of  
`b` will be associated with column `jpvt[j]` of the original  
 matrix `x` that was input into `sqrdc`.)  
`rsd` array[ $n$ ] containing the least squares residual  $y - xk*b$ ,  
 if its computation has been requested. `rsd` is also the  
 orthogonal projection of `y` onto the orthogonal complement  
 of the column space of `xk`.  
`xb` array[ $n$ ] containing the least squares approximation  $xk*b$ ,  
 if its computation has been requested. `xb` is also the  
 orthogonal projection of `y` onto the column space of `x`.  
`info` = 0 unless the computation of `b` has been requested and  $R$   
 is exactly singular. In this case, `info` is the index of  
 the first zero diagonal element of  $R$  and `b` is left  
 unaltered.

`sqrst`:

Input:

`x` matrix[ $p$ ][ $n$ ] of coefficients (`x` is destroyed by `sqrst`.)  
`n` number of rows in the matrix `x` (number of observations)  
`p` number of columns in the matrix `x` (number of parameters)  
`y` array[ $n$ ] containing right-hand-side (observations)

tol relative tolerance used to determine the subset of columns of x included in the solution. If tol is zero, a full complement of the MIN(n,p) columns is used. If tol is non-zero, the problem should be scaled so that all the elements of X have roughly the same absolute accuracy eps. Then a reasonable value for tol is roughly eps divided by the magnitude of the largest element.

Output:

x matrix[p][n] containing output of sqrdc  
b array[p] containing the solution (parameters); components corresponding to columns not used are set to zero.  
rsd array[n] of residuals  $y - Xb$   
k number of columns of x used in the solution  
jpvt array[p] containing pivot information from sqrdc.  
qraux array[p] containing auxiliary information from sqrdc.

Workspace:

work array[p] of workspace.

Notes:

!!! WARNING !!!

These functions have many options, not all of which have been tested!  
(Dave Hale, 12/31/89)

This function was adapted from LINPACK FORTRAN. Because two-dimensional arrays cannot be declared with variable dimensions in C, the matrix x is actually a pointer to an array of pointers to floats, as declared above and used below.

Elements of x are stored as follows:

```
x[0][0]    x[1][0]    x[2][0]    ... x[p-1][0]
x[0][1]    x[1][1]    x[2][1]    ... x[p-1][1]
x[0][2]    x[1][2]    x[2][2]    ... x[p-1][2]
.          .          .          .
.          .          .          .
.          .          .          .
.          .          .          .
x[0][n-1]  x[1][n-1]  x[2][n-1]  ... x[p-1][n-1]
```

sqrdc:

Uses Householder transformations to compute the QR decomposition of an n by p

matrix  $x$ . Column pivoting based on the 2-norms of the reduced columns may be performed at the user's option.

After decomposition,  $x$  contains in its upper triangular matrix  $R$  of the QR decomposition. Below its diagonal  $x$  contains information from which the orthogonal part of the decomposition can be recovered. Note that if pivoting has been requested, the decomposition is not that of the original matrix  $x$  but that of  $x$  with its columns permuted as described by  $jpvt$ .

The selection of pivot columns is controlled by  $jpvt$  as follows.

The  $k$ -th column  $x[k]$  of  $x$  is placed in one of three classes according to the value of  $jpvt[k]$ .

if  $jpvt[k] > 0$ , then  $x[k]$  is an initial column.

if  $jpvt[k] == 0$ , then  $x[k]$  is a free column.

if  $jpvt[k] < 0$ , then  $x[k]$  is a final column.

Before the decomposition is computed, initial columns are moved to the beginning of the array  $x$  and final columns to the end. Both initial and final columns are frozen in place during the computation and only free columns are moved. At the  $k$ -th stage of the reduction, if  $x[k]$  is occupied by a free column it is interchanged with the free column of largest reduced norm.  $jpvt$  is not referenced if  $job == 0$ .

`sqrsl:`

Uses the output of `sqrdc` to compute coordinate transformations, projections, and least squares solutions. For  $k \leq \text{MIN}(n,p)$ , let  $x_k$  be the matrix

$x_k = (x[jpvt[0]], x[jpvt[1]], \dots, x[jpvt[k-1]])$

formed from columns  $jpvt[0], jpvt[1], \dots, jpvt[k-1]$  of the original

$n$  by  $p$  matrix  $x$  that was input to `sqrdc`. (If no pivoting was done,  $x_k$

consists of the first  $k$  columns of  $x$  in their original order.) `sqrdc`

produces a factored orthogonal matrix  $Q$  and an upper triangular matrix  $R$  such that

$x_k = Q * (R)$

(0)

This information is contained in coded form in the arrays  $x$  and `qraux`.

The parameters `qy`, `qty`, `b`, `rsd`, and `xb` are not referenced if their computation is not requested and in this case can be replaced by NULL pointers in the calling program. To save storage, the user may in some cases use the same array for different parameters in the calling sequence. A frequently occurring example is when one wishes to compute any of `b`, `rsd`, or `xb` and does not need `y` or `qty`. In this case one may equivalence `y`, `qty`, and one of `b`, `rsd`, or `xb`, while providing separate arrays for anything else that is to be computed. Thus the calling

sequence

```
sqrsl(x,n,k,qraux,y,NULL,y,b,y,NULL,110,&info)
```

will result in the computation of b and rsd, with rsd overwriting y. More generally, each item in the following list contains groups of permissible equivalences for a single calling sequence.

1. (y,qty,b) (rsd) (xb) (qy)
2. (y,qty,rsd) (b) (xb) (qy)
3. (y,qty,xb) (b) (rsd) (qy)
4. (y,qy) (qty,b) (rsd) (xb)
5. (y,qy) (qty,rsd) (b) (xb)
6. (y,qy) (qty,xb) (b) (rsd)

In any group the value returned in the array allocated to the group corresponds to the last member of the group.

sqrst:

Computes least squares solutions to the system

$Xb = y$

which may be either under-determined or over-determined. The user may supply a tolerance to limit the columns of X used in computing the solution. In effect, a set of columns with a condition number approximately bounded by  $1/\text{tol}$  is used, the other components of b being set to zero.

On return, the arrays x, jpvt, and qraux contain the usual output from sqrdc, so that the QR decomposition of x with pivoting is fully available to the user. In particular, columns jpvt[0], jpvt[1], ..., jpvt[k-1] were used in the solution, and the condition number associated with those columns is estimated by  $\text{ABS}(x[0][0]/x[k-1][k-1])$ .

Author: Dave Hale, Colorado School of Mines, 12/29/89

STOEP - Functions to solve a symmetric Toeplitz linear system of equations  
 $Rf=g$  for  $f$

stoepd solve a symmetric Toeplitz system - doubles  
stoepf solve a symmetric Toeplitz system - floats

Function Prototypes:

```
void stoepd (int n, double r[], double g[], double f[], double a[]);  
void stoepf (int n, float r[], float g[], float f[], float a[]);
```

Input:

$n$  dimension of system  
 $r$  array[ $n$ ] of top row of Toeplitz matrix  
 $g$  array[ $n$ ] of right-hand-side column vector

Output:

$f$  array[ $n$ ] of solution (left-hand-side) column vector  
 $a$  array[ $n$ ] of solution to  $Ra=v$  (Claerbout, FGDP, p. 57)

Notes:

These routines do NOT solve the case when the main diagonal is zero, it just silently returns.

The left column of the Toeplitz matrix is assumed to be equal to the top row (as specified in  $r$ ); i.e., the Toeplitz matrix is assumed symmetric.

Author: Dave Hale, Colorado School of Mines, 06/02/89

STRSTUFF -- STRing manuplation subs

cwp\_strdup - duplicate a string

strchop - chop off the tail end of a string "s" after a "," returning  
the front part of "s" as "t".

cwp\_strrev - reverse a string

Input:

char \*str input string

Output:

none

Returns:

char \* duplicated string

Notes:

This local definition of strdup is necessary because some systems  
do not have it.

Author: John Stockwell, Spring 2000.

SWAPBYTE - Functions to SWAP the BYTE order of binary data

swap\_short\_2 swap a short integer  
swap\_u\_short\_2 swap an unsigned short integer  
swap\_int\_4 swap a 4 byte integer  
swap\_u\_int\_4 swap an unsigned integer  
swap\_long\_4 swap a long integer  
swap\_u\_long\_4 swap an unsigned long integer  
swap\_float\_4 swap a float  
swap\_double\_8 swap a double

Function Prototypes:

```
void swap_short_2(short *tni2);  
void swap_u_short_2(unsigned short *tni2);  
void swap_int_4(int *tni4);  
void swap_u_int_4(unsigned int *tni4);  
void swap_long_4(long *tni4);  
void swap_u_long_4(unsigned long *tni4);  
void swap_float_4(float *tnf4);  
void swap_double_8(double *tndd8);
```

Notes:

These routines are necessary for reversing the byte order of binary data for transportation between big-endian and little-endian machines. Examples of big-endian machines are IBM RS6000, SUN, NeXT. Examples of little endian machines are PC's and DEC.

These routines have been tested with PC data and run on PC's running several PC versions of UNIX, but have not been tested on DEC.

Also, the number appended to the name of the routine refers to the number of bytes that the item is assumed to be.

Authors: Jens Hartmann, Institut fur Geophysik, Hamburg, Jun 1993  
John Stockwell, CWP, Colorado School of Mines, Jan 1994

SYMMEIGEN - Functions solving the eigenvalue problem for symmetric matrices  
 eig\_jacobi - find eigenvalues and corresponding eigenvectors via  
           the jacobi algorithm for symmetric matrices  
 sort\_eigenvalues - sort eigenvalues and corresponding eigenvectors  
 in descending order

Function Prototypes:

```

void eig_jacobi(float **a, float d[], float **v, int n);
void sort_eigenvalues(float d[], float **v, int n);
  (inspired by Press et. al., 1996)

```

Macro used internally

```

define ROTATE(a,i,j,k,l) g=a[i][j];h=a[k][l];a[i][j]=g-s*(h+g*tau);\
  a[k][l]=h+s*(g-h*tau);

```

```

void eig_jacobi(float **a, float d[], float **v, int n)
eig_jacobi - find eigenvalues and corresponding eigenvectors via
  the jacobi algorithm for symmetric matrices

```

Function Prototype:

```

void eig_jacobi(float **a, float d[], float **v, int n);
  (inspired by Press et. al., 1996)

```

```

{
  int j,iq,ip,i;
  float tresh,theta,tau,t,sm,s,h,g,c,*b,*z;

  /* allocate space temporarily
  b=alloc1float(n); b-=1;
  z=alloc1float(n); z-=1;

  /* initialize v to the identity matrix
  for (ip=1;ip<=n;ip++) {
    for (iq=1;iq<=n;iq++) v[ip][iq]=0.0;
    v[ip][ip]=1.0;
  }
  /* initialilize to the diagonal on matrix a
  for (ip=1;ip<=n;ip++) {
    b[ip]=d[ip]=a[ip][ip];
    z[ip]=0.0;
  }

  /* main iteration loop
  for (i=1;i<=50;i++) {

```

```

sm=0.0;
for (ip=1;ip<=n-1;ip++) {
    for (iq=ip+1;iq<=n;iq++)
        sm += fabs(a[ip][iq]);
}
/* normal return
if (sm == 0.0) {
    z+=1; free1float(z);
    b+=1; free1float(b);
    return;
}
/* tresh values for first 3 sweeps and thereafter
if (i < 4)
    tresh=0.2*sm/(n*n);
else
    tresh=0.0;
for (ip=1;ip<=n-1;ip++) {
    for (iq=ip+1;iq<=n;iq++) {
        g=100.0*fabs(a[ip][iq]);
        if (i > 4 && (float)(fabs(d[ip])+g) == (float)fabs(d[ip])
            && (float)(fabs(d[iq])+g) == (float)fabs(d[iq]))
            a[ip][iq]=0.0;
        else if (fabs(a[ip][iq]) > tresh) {
            h=d[iq]-d[ip];
            if ((float)(fabs(h)+g) == (float)fabs(h))
                t=(a[ip][iq])/h;
            else {
                theta=0.5*h/(a[ip][iq]);
                t=1.0/(fabs(theta)+sqrt(1.0+theta*theta));
                if (theta < 0.0) t = -t;
            }
            c=1.0/sqrt(1+t*t);
            s=t*c;
            tau=s/(1.0+c);
            h=t*a[ip][iq];
            z[ip] -= h;
            z[iq] += h;
            d[ip] -= h;
            d[iq] += h;
            a[ip][iq]=0.0;

            /* Jacobi rotations

```

```

        for (j=1;j<=ip-1;j++) {
            ROTATE(a,j,ip,j,iq)
        }
        for (j=ip+1;j<=iq-1;j++) {
            ROTATE(a,ip,j,j,iq)
        }
        for (j=iq+1;j<=n;j++) {
            ROTATE(a,ip,j,iq,j)
        }
        for (j=1;j<=n;j++) {
            ROTATE(v,j,ip,j,iq)
        }
    }
}
for (ip=1;ip<=n;ip++) {
    b[ip] += z[ip];
    d[ip]=b[ip];
    z[ip]=0.0;
}
}
/* this will not happen, hopefully
fprintf(stderr,"jacobi iteration does not converge\n");
}

```

void sort\_eigenvalues(float d[], float \*\*v, int n)  
sort\_eigenvalues - sort eigenvalues and corresponding eigenvectors  
in descending order

Function Prototypes:

```
void sort_eigenvalues(float d[], float **v, int n);
(inspired by Press et. al., 1996)
```

```
{
    int k,j,i;
    float p;

    for (i=1;i<n;i++) {
        p=d[k=i];
        for (j=i+1;j<=n;j++)
            if (d[j] >= p) p=d[k=j];
        if (k != i) {
            d[k]=d[i];

```

```
    d[i]=p;
    for (j=1;j<=n;j++) {
        p=v[j][i];
        v[j][i]=v[j][k];
        v[j][k]=p;
    }
}
}
```

TEMPORARY\_FILENAME - Creates a file name in a user-specified directory.

Function prototype:

```
char *temporary_filename(char *tempfile);
```

Input:

tempfile pointer to directory prefix string (eg. /usr/tmp/)

Output:

tempfile pointer to filename string (eg. /usr/tmp/1206aaa)

Notes:

temporary\_filename creates a file name by appending a sequence of numbers and letters (which is created by tmpnam) to the prefix string passed as its argument. On return the input argument points to the (now augmented) prefix string.

It is duty of the calling program to provide room for the augmented string. The resulting string is typically used as a name for a temporary file; in this case it is the calling program's job to make sure that the supplied prefix ends with a slash.

This routine was written to supplement the ANSI C function tmpnam which also creates a temporary filename, but within a fixed directory, usually the /tmp directory. Unfortunately, some /tmp directories are too small to hold typical seismic data sets, so this routine allows the user to specify a directory with sufficient capacity. Also note that on many systems, the tmpfile() call avoids this problem by simulating a temporary file with a memory buffer. However, this is not a panacea as the file size might exceed available memory and on some systems this call does actually create a file (again, usually in tmp).

Author: Jack K. Cohen, Colorado School of Mines, 12/12/95

TRIDIAGONAL - Functions to solve tridiagonal systems of equations  $Tu=r$  for  $u$ .

tridif Solve a tridiagonal system of equations (float version)  
tridid Solve a tridiagonal system of equations (double version)  
tripd Solve a positive definite, symmetric tridiagonal system  
tripp Solve an unsymmetric tridiagonal system that uses  
Gaussian elimination with partial pivoting

Function Prototypes:

```
void tridif (int n, float a[], float b[], float c[], float r[], float u[]);  
void tridid (int n, double a[], double b[], double c[], double r[], double u[]);  
void tripd (float *d, float *e, float *b, int n);  
void tripp(int n, float *d, float *e, float *c, float *b);
```

tridif, tridid:

Input:

n dimension of system  
a array[n] of lower sub-diagonal of T (a[0] ignored)  
b array[n] of diagonal of T  
c array[n] of upper super-diagonal of T (c[n-1] ignored)  
r array[n] of right-hand-side column vector

Output:

u array[n] of solution (left-hand-side) column vector

tripd:

Input:

d array[n], the diagonal of A  
e array[n], the superdiagonal of A  
b array[n], the rhs column vector of  $Ax=b$

Output:

b b is overwritten with the solution to  $Ax=b$

tripp:

Input:

d diagonal vector of matrix  
e upper-diagonal vector of matrix  
c lower-diagonal vector of matrix  
b right-hand vector  
n dimension of matrix

Output:

b solution vector

Notes:

For example, a tridiagonal system of dimension 4 is specified as:

$$\begin{array}{cccc|ccc} |b[0] & c[0] & 0 & 0 & | & |u[0]| & |r[0]| \\ |a[1] & b[1] & c[1] & 0 & | & |u[1]| & = & |r[1]| \\ | 0 & a[2] & b[2] & c[2] & | & |u[2]| & |r[2]| \\ | 0 & 0 & a[3] & b[3] & | & |u[3]| & |r[3]| \end{array}$$

The tridiagonal matrix is assumed to be non-singular.

tripd:

Given an n-by-n symmetric, tridiagonal, positive definite matrix A and n-vector b, following algorithm overwrites b with the solution to  $Ax = b$

Authors: tridif, tridid: Dave Hale, Colorado School of Mines, 10/03/89

tripd, tripp: Zhenyue Liu, Colorado School of Mines, 1992-1993

VANDERMONDE - Functions to solve Vandermonde system of equations  $Vx=b$

vanded solve Vandermonde system of doubles

vandef solve Vandermonde system of floats

Function Prototypes:

```
void vanded (int n, double v[], double b[], double x[]);
```

```
void vandef (int n, float v[], float b[], float x[]);
```

Input:

n dimension of system

v array[n] of 2nd row of Vandermonde matrix (1st row is all ones)

b array[n] of right-hand-side column vector

Output:

x array[n] of solution column vector

Notes:

The arrays b and x may be equivalenced.

Reference:

Adapted from Algorithm 5.6-2 in Golub, G. H., and Van Loan, C. F., 1983, Matrix Computations, John-Hopkins University Press.

Author: Dave Hale, Colorado School of Mines, 06/02/89

WAVEFORMS    Subroutines to define some wavelets for modeling of seismic data

ricker1\_wavelet    Compute the time response of a source function as a Ricker wavelet with peak frequency "fpeak" Hz.

ricker2\_wavelet    Compute a Ricker wavelet with a given period, amplitude and distortion factor

akb\_wavelet        Compute the time response of a source function as a wavelet based on a wavelet used by Alford, Kelly, and Boore.

spike\_wavelet      Compute the time response of a source function as a spike.

unit\_wavelet        Compute the time response of a source function as a constant unit shift.

zero\_wavelet        Compute the time response of a source function as zero everywhere.

berlage\_wavelet    Compute the time response of a source function as a Berlage wavelet with peak frequency "fpeak" Hz, exponential decay factor "decay", time exponent "tn", and initial phase angle "ipa".

gaussian\_wavelet    Compute the time response of a source function as a Gaussian wavelet with peak frequency "fpeak" in Hz.

gaussderiv\_wavelet Compute the time response of a source function as a Gaussian first derivative wavelet with peak frequency "fpeak" in Hz.

Function Prototypes:

void ricker1\_wavelet (int nt, float dt, float fpeak, float \*wavelet);

void ricker2\_wavelet (int hlw, float dt, float period, float ampl, float distort, float \*wavelet);

void akb\_wavelet (int nt, float dt, float fpeak, float \*wavelet);

void spike\_wavelet (int nt, int tindex, float \*wavelet);

void unit\_wavelet (int nt, float \*wavelet);

void zero\_wavelet (int nt, float \*wavelet);

void berlage\_wavelet (int nt, float dt, float fpeak, float ampl, float tn,

```
        float decay, float ipa, float *wavelet);  
void gaussian_wavelet (int nt, float dt, float fpeak, float *wavelet);  
void gaussderiv_wavelet (int nt, float dt, float fpeak, float *wavelet);
```

Authors: Tong Fei, Ken Lerner

Author: Nils Maercklin, February 2007

XCOR - Compute  $z = x$  cross-correlated with  $y$

xcor compute  $z = x$  cross-correlated with  $y$

Function Prototype:

```
void xcor (int lx, int ifx, float *x, int ly, int ify, float *y ,
int lz, int ifz, float *z);
```

Input:

lx length of x array  
ifx sample index of first x  
x array[lx] to be cross-correlated with y  
ly length of y array  
ify sample index of first y  
y array[ly] with which x is to be cross-correlated  
lz length of z array  
ifz sample index of first z

Output:

z array[lz] containing x cross-correlated with y

Notes:

See notes for convolution function conv().

The operation "x cross correlated with y" is defined to be:

$$z[i] = \sum_{j=ifx}^{ifx+lx-1} x[j]*y[i+j] \quad ; \quad i = ifz, \dots, ifz+lz-1$$

This function performs cross-correlation by

- (1) reversing the samples in the x array while copying them to a temporary array, and
- (2) calling function conv() with ifx set to  $1-ifx-lx$ .

Assuming that the overhead of reversing the samples in x is negligible, this method enables cross-correlation to be performed as efficiently as convolution, while reducing the amount of code that must be optimized and maintained.

Author: Dave Hale, Colorado School of Mines, 11/23/91

XINDEX - determine index of x with respect to an array of x values

xindex determine index of x with respect to an array of x values

Input:

nx number of x values in array ax

ax array[nx] of monotonically increasing or decreasing x values

x the value for which index is to be determined

index index determined previously (used to begin search)

Output:

index for monotonically increasing ax values, the largest index

for which  $ax[index] \leq x$ , except  $index=0$  if  $ax[0] > x$ ;

for monotonically decreasing ax values, the largest index

for which  $ax[index] \geq x$ , except  $index=0$  if  $ax[0] < x$

Notes:

This function is designed to be particularly efficient when called repeatedly for slightly changing x values; in such cases, the index returned from one call should be used in the next.

Author: Dave Hale, Colorado School of Mines, 12/25/89

YCLIP - Clip a function  $y(x)$  defined by linear interpolation of the uniformly sampled values:  $y(fx)$ ,  $y(fx+dx)$ , ...,  $y(fx+(nx-1)*dx)$ . Returns the number of samples in the clipped function.

yclip clip a function  $y(x)$  defined by linear interpolation of uniformly sampled values

Function Prototype:

```
int yclip (int nx, float dx, float fx, float y[], float ymin, float ymax, float xc[], float yc[]);
```

Input:

nx number of x (and y) values

dx x sampling interval

fx first x

y array[nx] of uniformly sampled  $y(x)$  values

ymin minimum y value; must not be greater than ymax

ymax maximum y value; must not be less than ymin

Output:

xc array[?] of x values for clipped  $y(x)$

yc array[?] of y values for clipped  $y(x)$

Returned: number of samples in output arrays xc and yc

Notes:

The output arrays xc and yc should contain space  $2*nx$  values, which is the maximum possible number (nc) of xc and yc returned.

Author: Dave Hale, Colorado School of Mines, 07/03/89

YXTOXY - Compute a regularly-sampled, monotonically increasing function  $x(y)$  from a regularly-sampled, monotonically increasing function  $y(x)$  by inverse linear interpolation.

yxtoxy compute a regularly sampled function  $x(y)$  from a regularly sampled, monotonically increasing function  $y(x)$

Function Prototype:

```
void yxtoxy (int nx, float dx, float fx, float y[],
int ny, float dy, float fy, float xylo, float xyhi, float x[]);
```

Input:

nx number of samples of  $y(x)$

dx x sampling interval;  $dx > 0.0$  is required

fx first x

y array[nx] of  $y(x)$  values;  $y[0] < y[1] < \dots < y[nx-1]$  required

ny number of samples of  $x(y)$

dy y sampling interval;  $dy > 0.0$  is required

fy first y

xylo x value assigned to  $x(y)$  when y is less than smallest  $y(x)$

xyhi x value assigned to  $x(y)$  when y is greater than largest  $y(x)$

Output:

x array[ny] of  $x(y)$  values

Notes:

User must ensure that:

(1)  $dx > 0.0$  &&  $dy > 0.0$

(2)  $y[0] < y[1] < \dots < y[nx-1]$

Author: Dave Hale, Colorado School of Mines, 06/02/89

ZASC - routine to translate ncharacters from ebcdic to ascii

zasc - convert n characters from ebcdic to ascii format

Input:

nchar number of characters to be translated

ainput pointer to input characters

Output:

aoutput pointer to output characters

Function Prototype:

```
int zasc(char *ainput, char *aoutput, integer nchar);
```

Notes:

translated by f2c. Horribly inefficient, but little used

Author: Stew Levin of Mobil, 1997

ZEBC - routine to translate ncharacters from ascii to ebcdic

zebc - convert n characters from ascii to ebcdic format

Input:

nchar number of characters to be translated

ainput pointer to input characters

Output:

aoutput pointer to output characters

Function Prototype:

```
int zebc(char *ainput, char *aoutput, integer nchar);
```

Notes:

translated by f2c. Horribly inefficient, but little used

Author: Stew Levin of Mobil, 1997

CHECK - CHECK triangulated models

badModel bad Model flag  
checkVertexUse check Vertex Use  
checkEdgeUse check Edge Use  
checkFace check Face  
checkModel check Model

Function Prototypes:

```
void badModel(void);  
void checkVertexUse (VertexUse *vu);  
void checkEdgeUse (EdgeUse *eu);  
void checkFace (Face *f);  
void checkModel (Model *m);
```

checkVertexUse:

Input:

vu Pointer to VertexUse

checkEdgeUse:

Input:

eu pointer to EdgeUse

checkFace:

Input:

f pointer to Face

checkModel:

Input:

m pointer to Model

Notes: Routines for checking triangulated models.

Author: Dave Hale, Colorado School of Mines, 07/09/90

CIRCUM - define CIRCUMcircles for Delaunay triangulation

circum - compute center and radius-squared of circumcircle of 3 (x,y) locations

circumTri - compute center and radius-squared of circumcircle of triangular face

Function Prototypes:

```
void circum (float x1, float y1, float x2, float y2, float x3, float y3,  
float *xc, float *yc, float *rs);
```

```
void circumTri (Tri *t);
```

circum:

Input:

x1 x-coordinate of first point  
y1 y-coordinate of first point  
x2 x-coordinate of second point  
y2 y-coordinate of second point  
x3 x-coordinate of third point  
y3 y-coordinate of third point

Output:

xc pointer to x-coordinate of center of circumcircle  
yc pointer to y-coordinate of center of circumcircle  
rs pointer radius<sup>2</sup> of circumcircle

circumTri:

Input:

t Pointer to Tri

Returns:

xc x-coordinate of circumcircle  
yc y-coordinate of circumcircle  
rs radius<sup>2</sup> of circumcircle

Author: Dave Hale, Colorado School of Mines, Fall 1990.

COLINEAR - determine if edges or vertecies are COLINEAR in triangulated  
model

edgesColinear see whether or not two edges are colinear

vertexBetweenVertices determine whether or not a vertex is on a line  
between two other vertices

Function Prototypes:

```
int edgesColinear (Edge *e1, Edge *e2);
```

```
int vertexBetweenVertices (Vertex *v, Vertex *v1, Vertex *v2);
```

edgesColinear:

Input:

e1 pointer to first Edge

e2 pointer to second Edge

Returns: (int)

1 if colinear

vertexBetweenVertices:

Input:

v pointer to first Vertex in question

v1 pointer to first reference Vertex

v2 pointer to second reference Vertex

Returns: integer

1 if v=v1 or v=v2 or if v is between v1 and v2

0 otherwise

Author: Dave Hale, Colorado School of Mines, Fall 1990.

CREATE - create model, boundary edge triangles, edge face, edge vertex, add a vertex

makeModel Make and return a pointer to a new model

makeBoundaryEdgeTri Create a boundary edge and triangle

makeEdgeFace Create an edge by connecting two vertices

makeEdgeVertex Create an edge connecting an existing vertex (v1) to a new vertex

addVertexToModel Add a vertex to model, and return pointer to new vertex

insideTriInModel return pointer to triangle in model containing specified (x,y) coordinates

Function Prototypes:

```
Model *makeModel (float xmin, float ymin, float xmax, float ymax);
```

```
void makeBoundaryEdgeTri (Vertex *v, Edge **enew, Tri **tnew);
```

```
void makeEdgeFace (Vertex *v1, Vertex *v2, Edge **enew, Face **fnew);
```

```
Vertex* addVertexToModel (Model *m, float x, float y);
```

```
Tri* insideTriInModel (Model *m, Tri *start, float x, float y);
```

makeModel:

Input:

xmin minimum x-coordinate

ymin minimum y-coordinate

xmax maximum x-coordinate

ymax maximum y-coordinate

Returns: pointer to a new Model

makeBoundaryEdgeTri:

Input:

v specified boundary Vertex

Output:

enew new boundary Edge

tnew new boundary triangle

Notes:

The specified vertex and the adjacent vertices on the boundary are assumed to be colinear. Therefore, the resulting boundary triangle has zero area, and is intended to enable deletion of the specified vertex from the boundary.

makeEdgeFace:

Input:

v1 First Vertex

v2 second Vertex

Output:

enew new Edge

fnew new Face

Notes:

The vertices must be adjacent to a single common face.

This face is closed off by the new edge, and a new edge and a new face are made and returned.

addVertexToModel:

Input:

m model

x x-coordinate of new vertex

y y-coordinate of new vertex

Notes:

If the new vertex is close to an existing vertex, this function returns NULL.

insideTriInModel:

Input:

m Model

start triangle to look at first (NULL to begin looking anywhere)

x x-coordinate

y y-coordinate

Notes:

Points on an edge of a triangle are assumed to be inside that triangle.

An edge may be used by two triangles, so two triangles may "contain" a point that lies on an edge. The first triangle found to contain the specified point is returned.

Author: Dave Hale, Colorado School of Mines, Fall 1990.

DELETE - DELETE vertex, model, edge, or boundary edge from triangulated model

deleteVertexFromModel Delete a vertex from model  
killModel Delete a model along with everything in it  
killEdge Delete an edge  
killBoundaryEdge Kill a boundary edge

Function Prototypes:

```
void deleteVertexFromModel (Model *m, Vertex *v);  
void killModel (Model *m);  
void killEdge (Edge *e, Face **fs);  
void killBoundaryEdge (Edge *e);
```

deleteVertexFromModel:

Input:

m pointer to Model  
v pointer to Vertex to be deleted

killModel:

Input:

m pointer to Model

killEdge:

Input:

e Edge to delete

Output:

fs surviving Face

killBoundaryEdge:

Input:

e boundary Edge

Notes:

Killing a boundary edge is typically done after a new boundary vertex is inserted on an existing boundary edge.

Author: Dave Hale, Colorado School of Mines, Fall 1990.

DTE - Distance to Edge

distanceToEdge - return distance to edge from specified (x,y) coordinates

Function Prototype:

```
float distanceToEdge (Edge *e, float x, float y);
```

distanceToEdge:

Input:

e edge to which distance is to be computed

x x-coordinate

y y-coordinate

Author: Dave Hale, Colorado School of Mines, 09/11/90

FIXEDGES - FIX or unFIX EDGES between vertices

fixEdgeBetweenVertices Fix edge(s) between vertices, creating new  
colinear edges as necessary.

unfixEdge unfix edge

fixEdgesBetweenVertices:

Input:

v1 pointer to first Vertex

v2 pointer to second Vertex

Returns:

0 if unable to fix edges

1 otherwise

unfixEdge:

Input:

e edge to be unfix

Returns:

0 if unable to unfix edge

1 otherwise

Author: Dave Hale, Colorado School of Mines, 06/04/91

INSIDE - Is a vertex or point inside a circum circle, etc. of a triangulated model

inCircum determine whether or not a vertex is inside a circum circle

inCircumTri determine whether or not a vertex is inside a circum circle of a triangle

in3Vertices determine whether or not a vertex is inside triangle (v1,v2,v3)

inTri determine whether or not a vertex is inside a triangle

Function Prototypes:

```
int inCircum (float x, float y, float xc, float yc, float rs);
```

```
int inCircumTri (float x, float y, Tri *t);
```

```
int in3Vertices (float x, float y, Vertex *v1, Vertex *v2, Vertex *v3);
```

```
int inTri (float x, float y, Tri *t);
```

inCircum:

Input:

x x-coordinate of vertex

y y-coordinate of vertex

xc x-coordinate of center of circumcircle

yc y-coordinate of center of circumcircle

rs radius<sup>2</sup> of circumcircle

Returns:

1 if x,y inside of circumcircle

0 otherwise

Notes:

A vertex exactly on the edge of a circumcircle is taken as being outside

inCircumTri:

Input:

x x-coordinate of vertex

y y-coordinate of vertex

t pointer to Tri

Returns:

1 if x,y inside of circumcircle of a triangle

0 otherwise

Notes:

A vertex exactly on the edge of a circumcircle is taken as being outside

in3Vertices:

Input:

x x-coordinate of vertex  
y y-coordinate of vertex  
v1 pointer to first Vertex  
v2 pointer to second Vertex  
v3 pointer to third Vertex

Returns:

1 if x,y inside of v1,v2,v3  
0 otherwise

Notes:

A vertex exactly on an edge of the triangle is taken as being inside

inTri:

Input:

x x-coordinate of vertex  
y y-coordinate of vertex  
t pointer to Tri

Returns:

1 if x,y inside a triangle  
0 otherwise

Notes:

A vertex exactly on the edge of a triangle is inside

Author: Dave Hale, Colorado School of Mines, 06/04/91

NEAREST - NEAREST edge or vertex in triangulated model

nearestEdgeInModel Return pointer to edge in model nearest to  
specified (x,y) coordinates

nearestVertexInModel Return pointer to vertex in model nearest  
to specified (x,y) coordinates

Function Prototypes:

Vertex\* nearestVertexInModel (Model \*m, Vertex \*start, float x, float y);

Edge\* nearestEdgeInModel (Model \*m, Edge \*start, float x, float y);

nearestEdgeInModel:

Input:

m model

start edge to look at first (NULL to begin looking anywhere)

x x-coordinate

y y-coordinate

Returns: pointer to nearest Edge

nearestVertexInModel:

Input:

m model

start vertex to look at first (NULL to begin looking anywhere)

x x-coordinate

y y-coordinate

Returns: pointer to nearest Vertex

Author: Dave Hale, Colorado School of Mines, Fall 1990

PROJECT - project to edge in triangulated model

projectToEdge - Project point with specified (x,y) coordinates to specified edge

Function Prototype:

```
void projectToEdge (Edge *e, float *x, float *y)
```

Input:

e edge to which point is to be projected

x x-coordinate before projection

y y-coordinate before projection

Output:

x x-coordinate after projection

y y-coordinate after projection

Author: Dave Hale, Colorado School of Mines, 09/11/90

READWRITE - READ or WRITE a triangulated model

readModel Read a model in the form produced by writeModel

writeModel Write a model to a file

Function Prototypes:

Model \*readModel (FILE \*fp);

void writeModel (Model \*m, FILE \*fp);

readModel:

Input:

fp file pointer to file containing model

writeModel:

Input:

m pointer to Model

fp file pointer

Author: Jack K. Cohen, Center for Wave Phenomena, 09/21/90

Modified: Dave Hale, Center for Wave Phenomena, 11/30/90

Converted representation of model from ascii to binary for speed.

Added code to read attributes.

Modified (writeModel): Craig Artley, Center for Wave Phenomena, 04/08/94

Corrected bug; previously the edgeuses and vertextuses of the exterior face were not written.