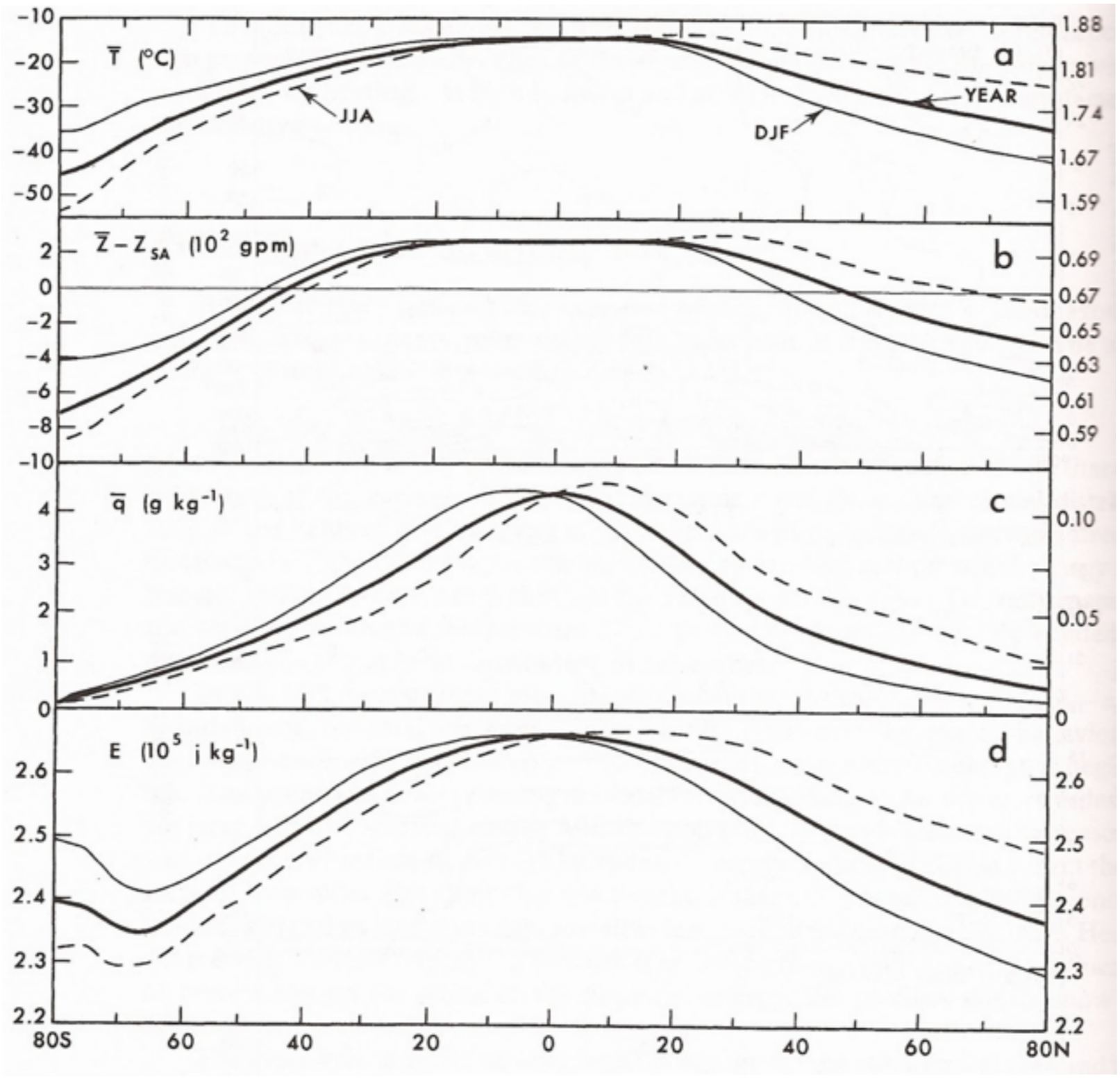
Energetics

Meridional distribution of energy (10^5 J kg^{-1})



Internal

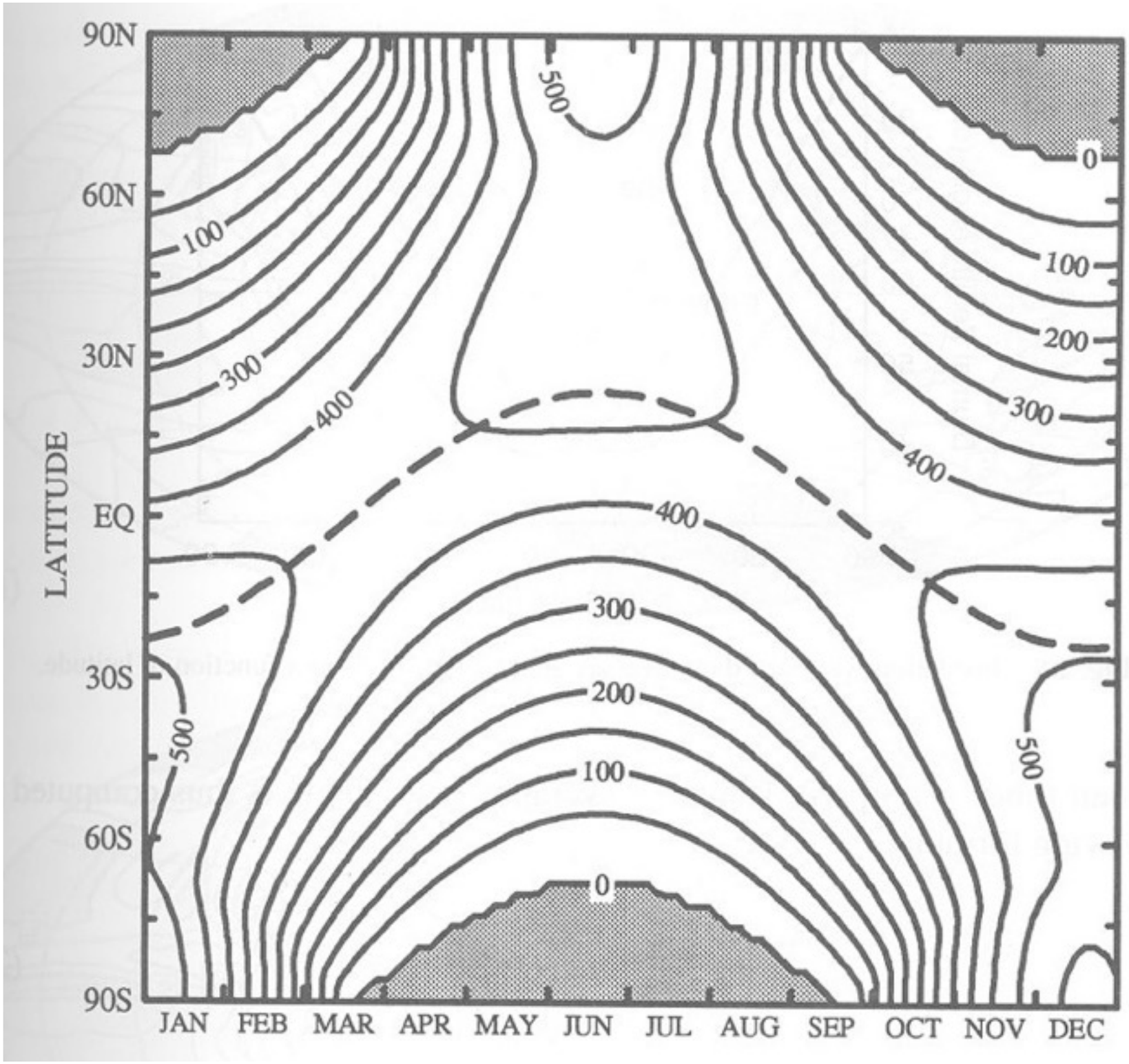
Potential

Latent

Total

(Peixoto and Oort, fig 13.3: Kinetic energy is order 150 J/kg)

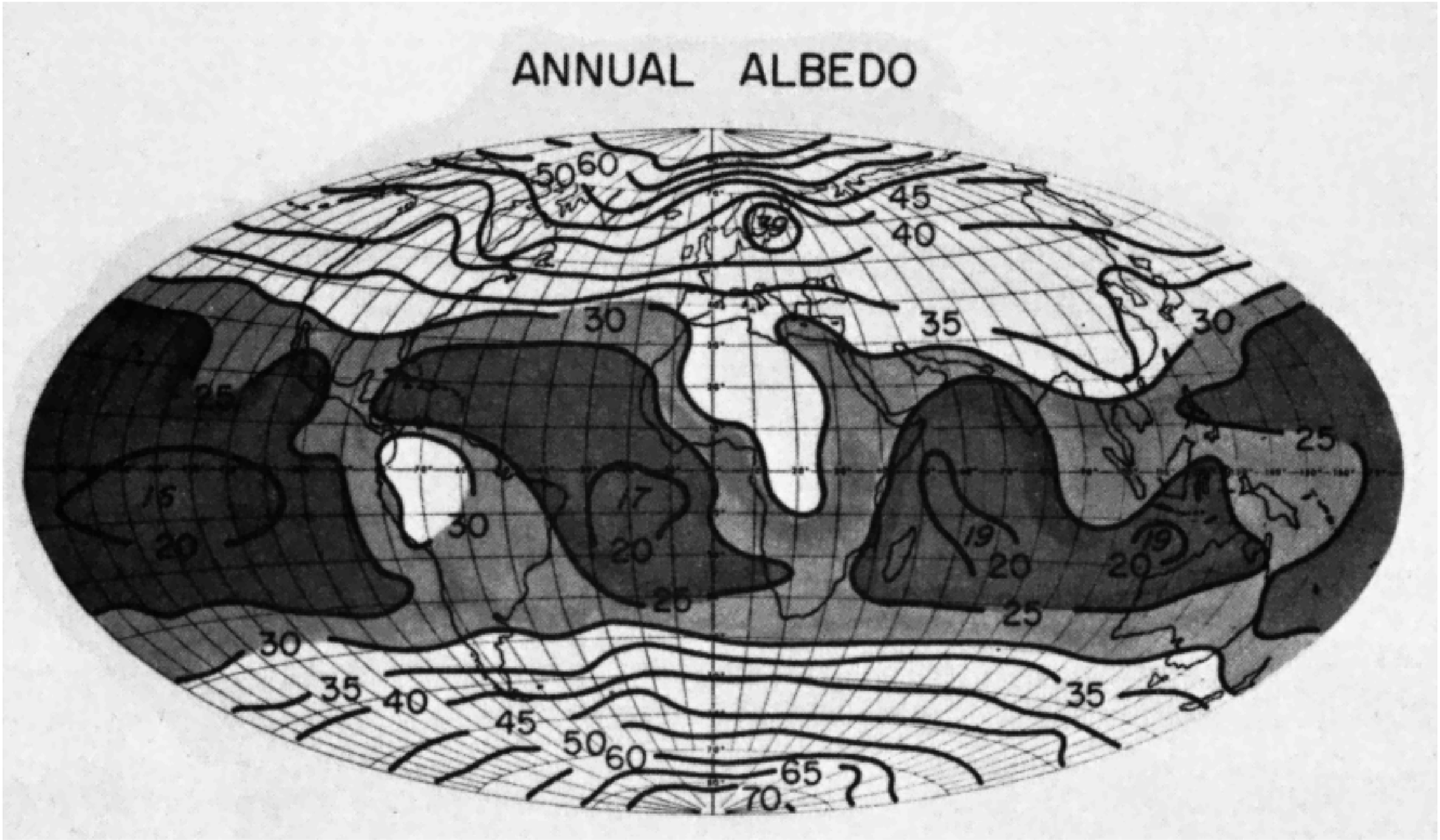
Daily-mean TOA insolation vs latitude and season



From Hartman, Physical Climatology

Albedos for different surfaces

Aerosols	Small but highly variable
Soil, rocks, vegetation	.1 to .3
Water	.02 to .2
Snow and ice	.6 to .8
Cb (clouds	~.9
Cu (clouds)	~.7
St (clouds)	~.5
Ci (clouds)	~.2
Rayleigh Scattering	~.05



(Stephens et al, JGR, 1981; from Fig. 6)

Planetary albedo very similar between hemispheres

Units: percent

	DJF	MAM	JJA	SON	Annual	error
Northern Hemisphere	30	33	31	29	31	
Southern Hemisphere	31	28	27	30	30	
Global	31	30	30	30	30	±1

Source: Stephens et al., 1981

Modern measurements show reflected shortwave essentially the same between NH and SH

($W\ m^{-2}$)	Northern Hemisphere	Southern Hemisphere	Difference
Reflected clear-sky solar radiation	55.5	49.5	6
Reflected solar radiation	99.5	99.6	-0.1

Hemispheric averages of time-mean TOA irradiances as measured by CERES-EBAF (2000-2005) from Voigt et al, J. Climate, 2013

Modern measurements show reflected shortwave essentially the same between NH and SH
Compensation by clouds must be involved. But why?

($W\ m^{-2}$)	Northern Hemisphere	Southern Hemisphere	Difference
Reflected clear-sky solar radiation	55.5	49.5	6
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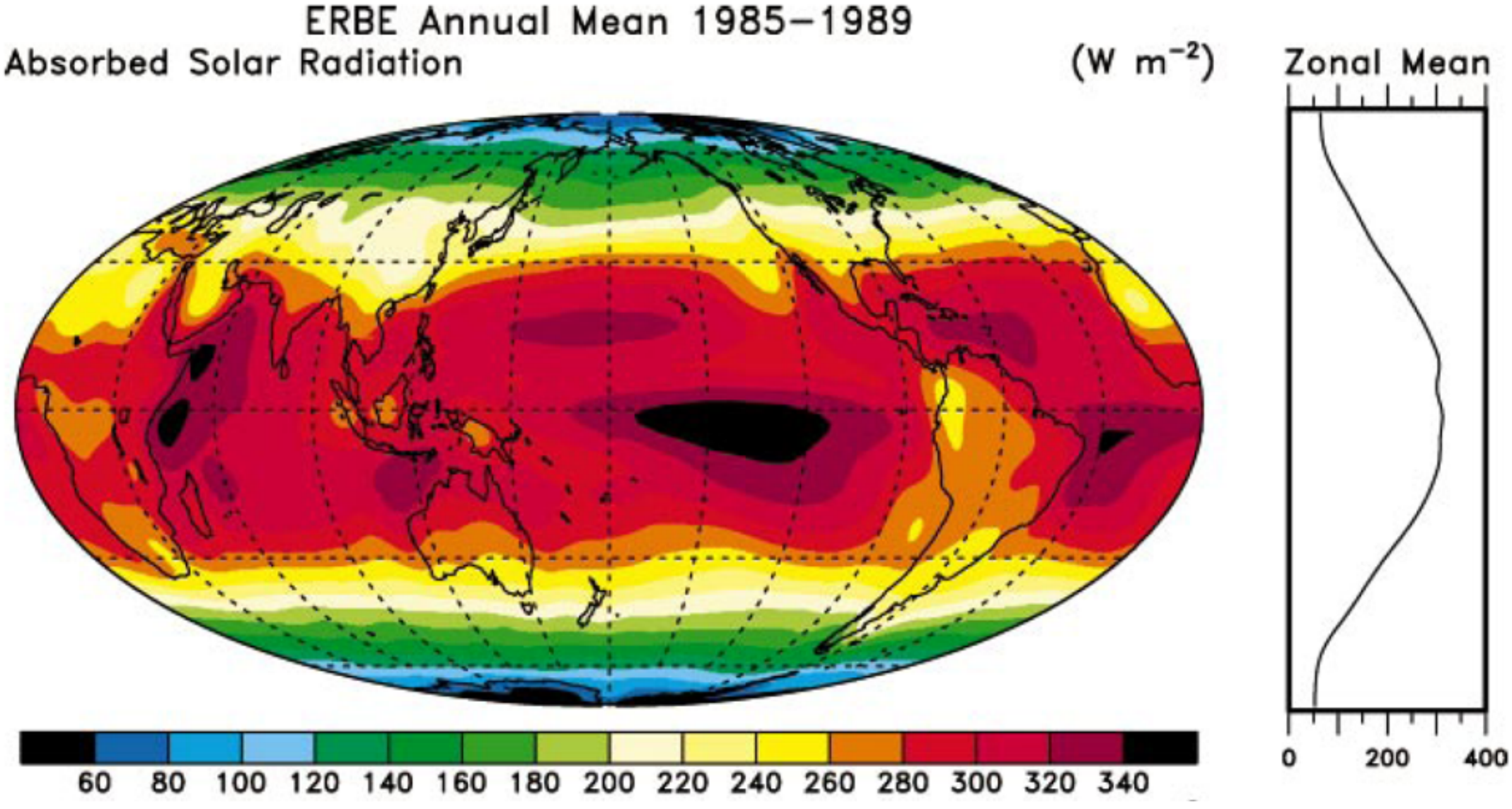
Hemispheric averages of time-mean TOA irradiances as measured by CERES-EBAF (2000-2005) from Voigt et al, J. Climate, 2013

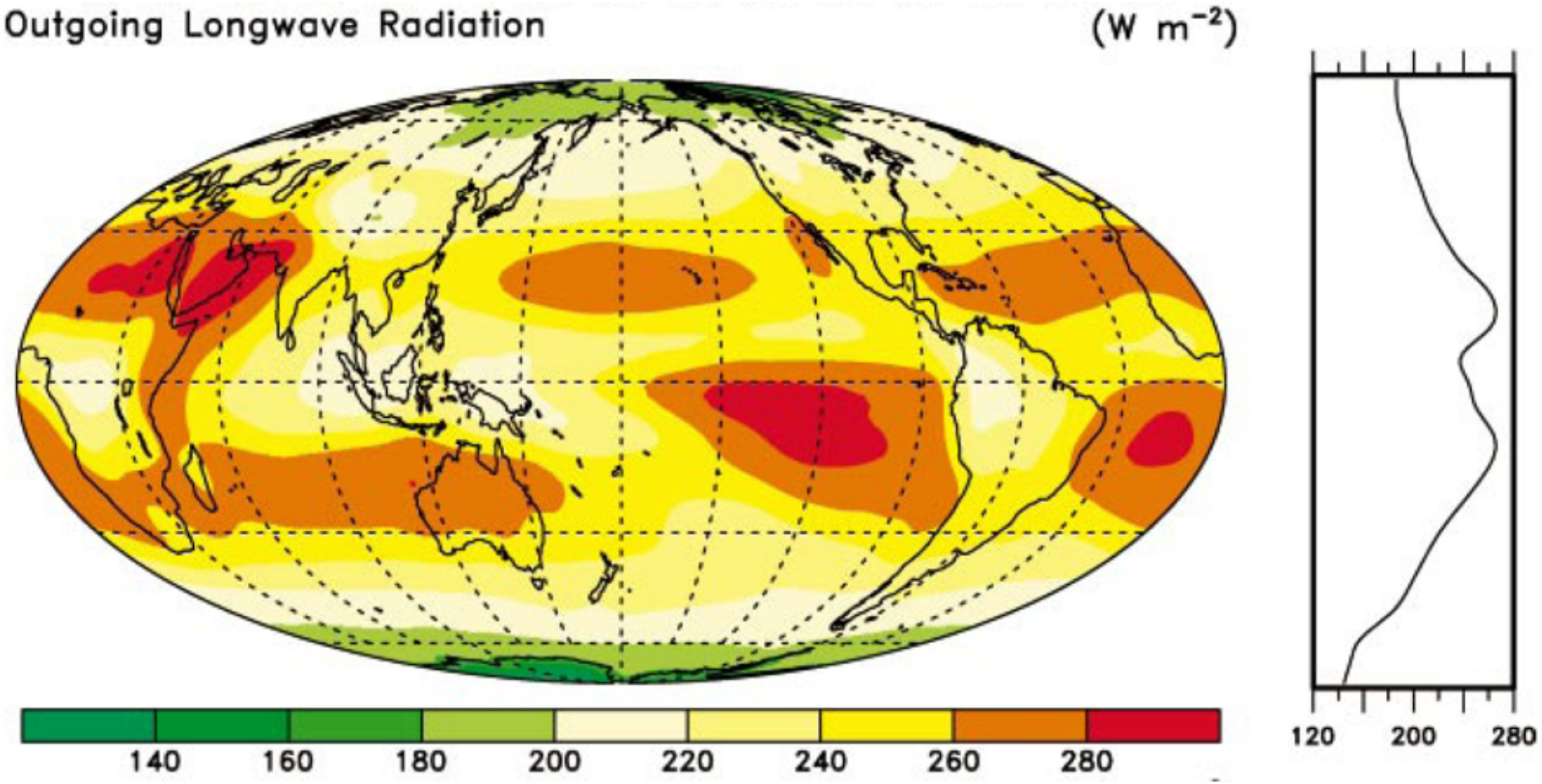
Absorbed solar radiation (W m^{-2})



Annualized mean TOA ERBE measurements for the period Feb 1985–Apr 1989

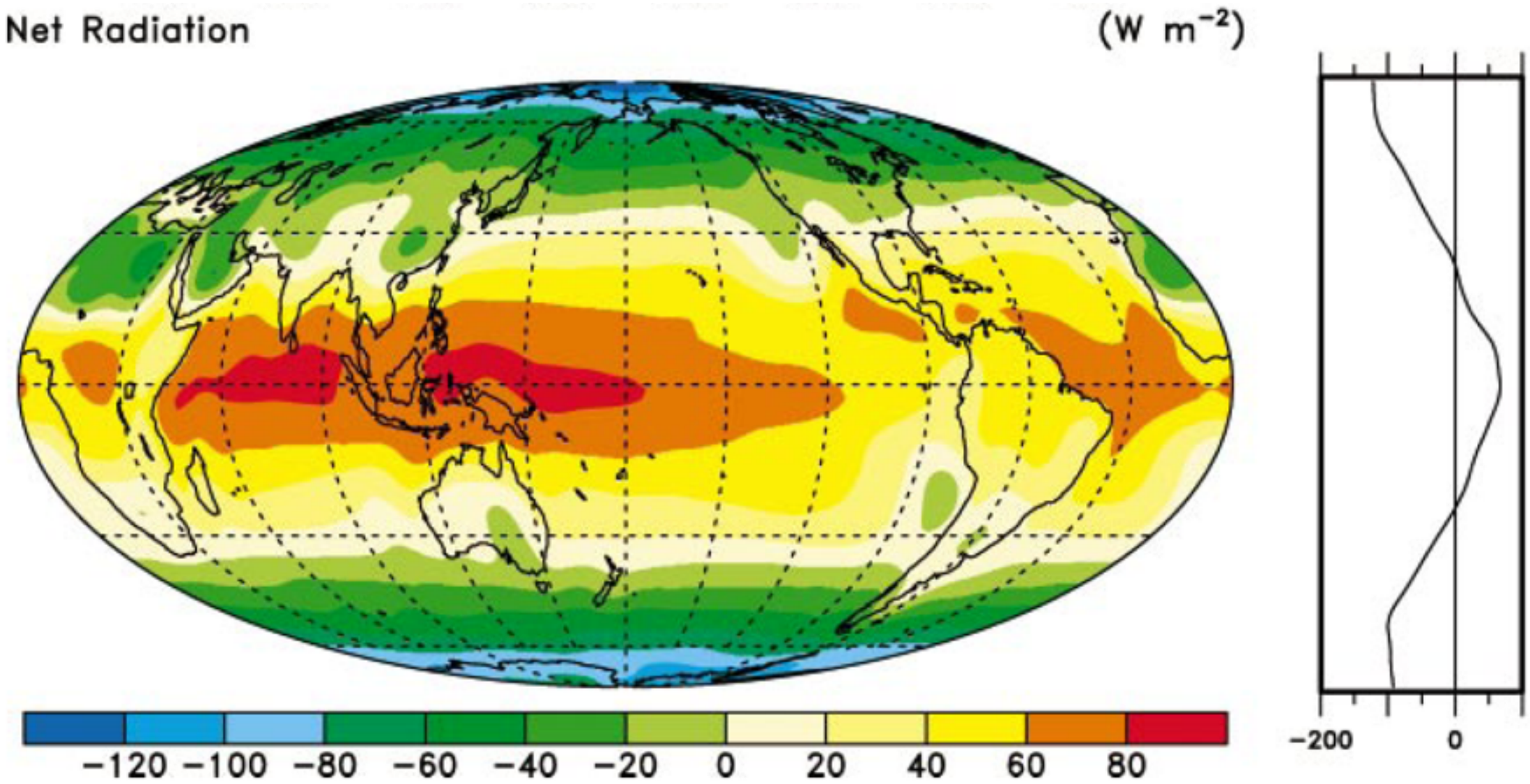
(Trenberth and Stepaniak, J. Climate 2003; Fig 2)

Outgoing Longwave Radiation ($W\ m^{-2}$)

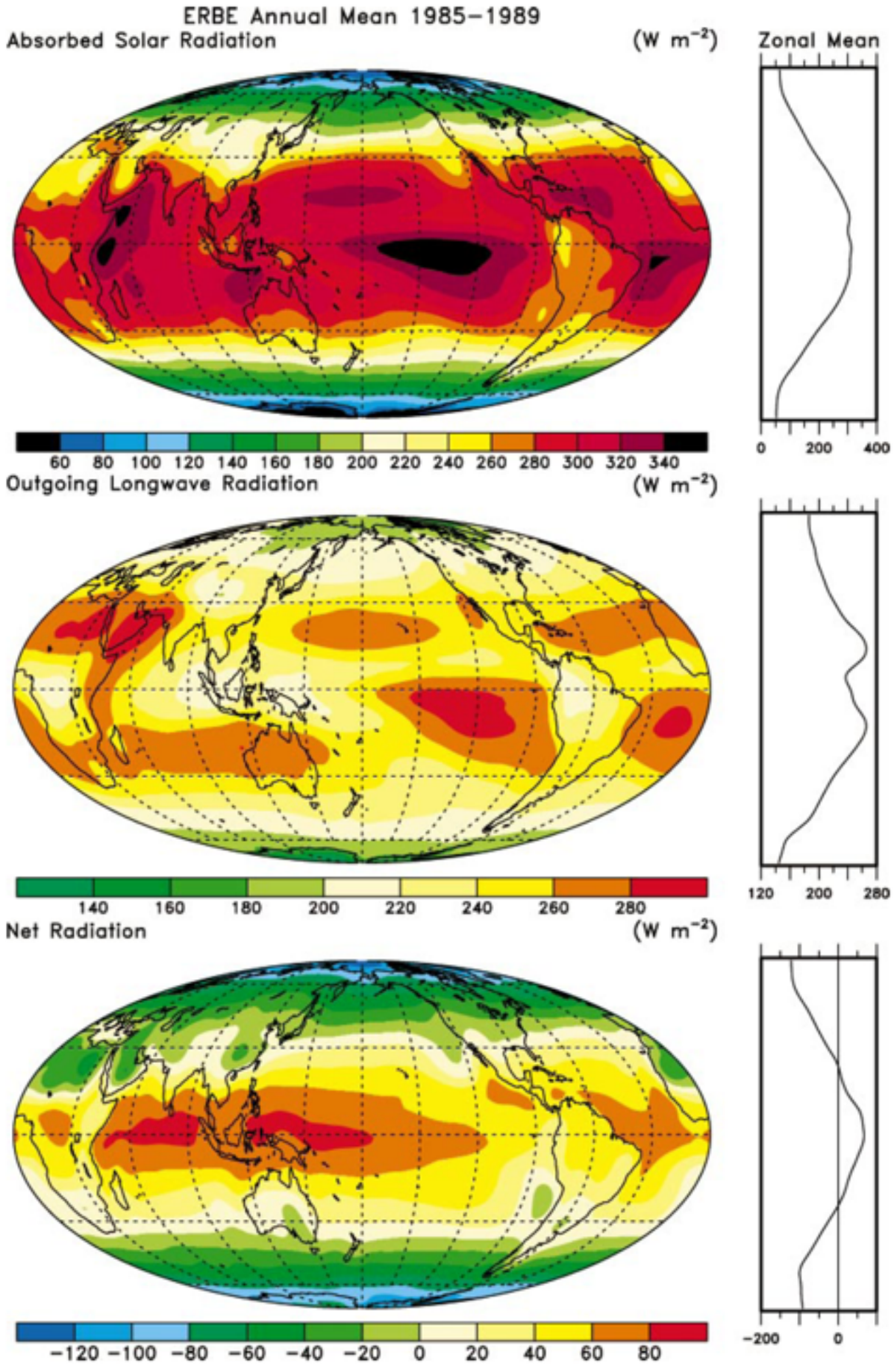


(Trenberth and Stepaniak, J. Climate 2003 Fig 2)

Net Radiation Absorbed (W m^{-2})



(Trenberth and Stepaniak, J. Climate 2003 Fig 2)

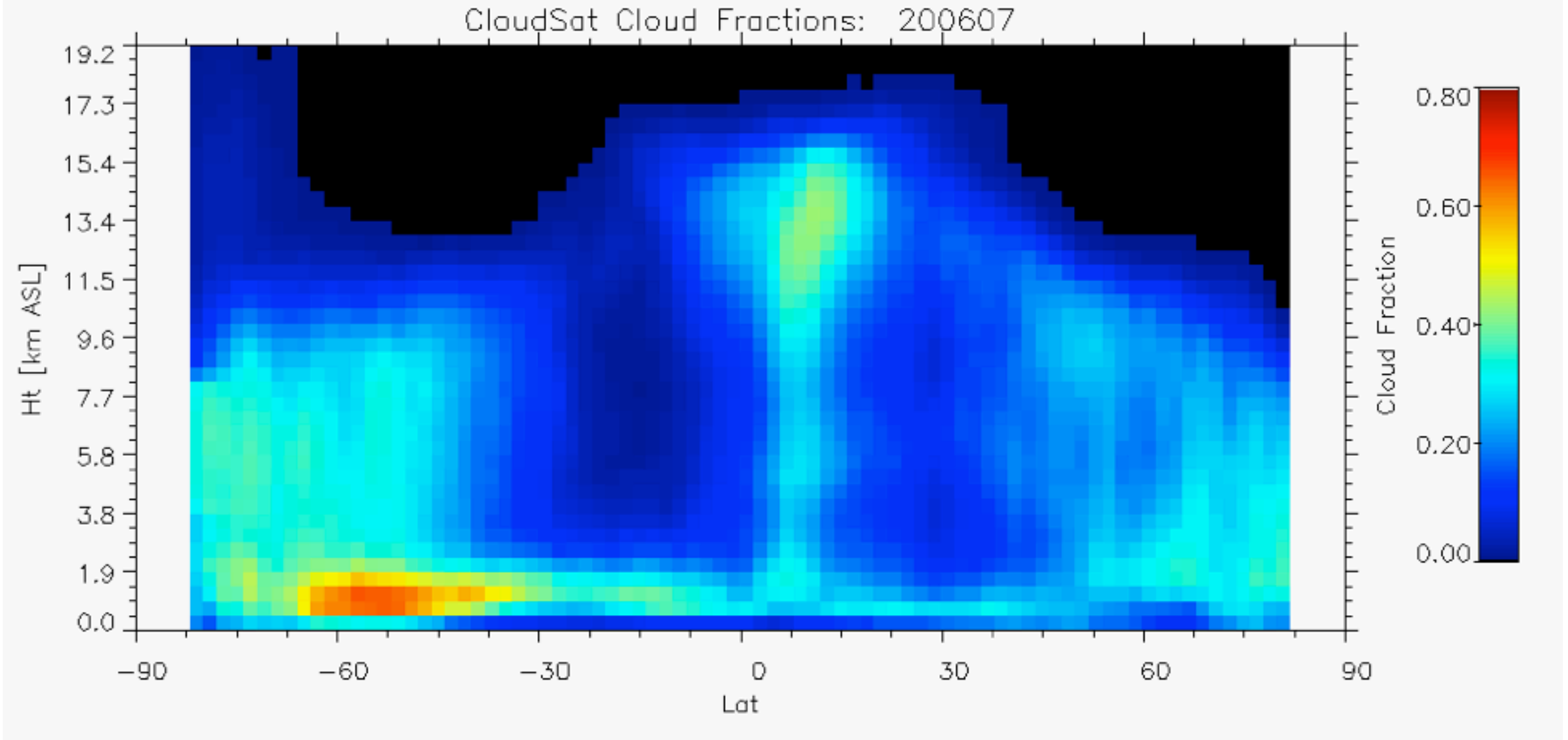


Absorbed Solar

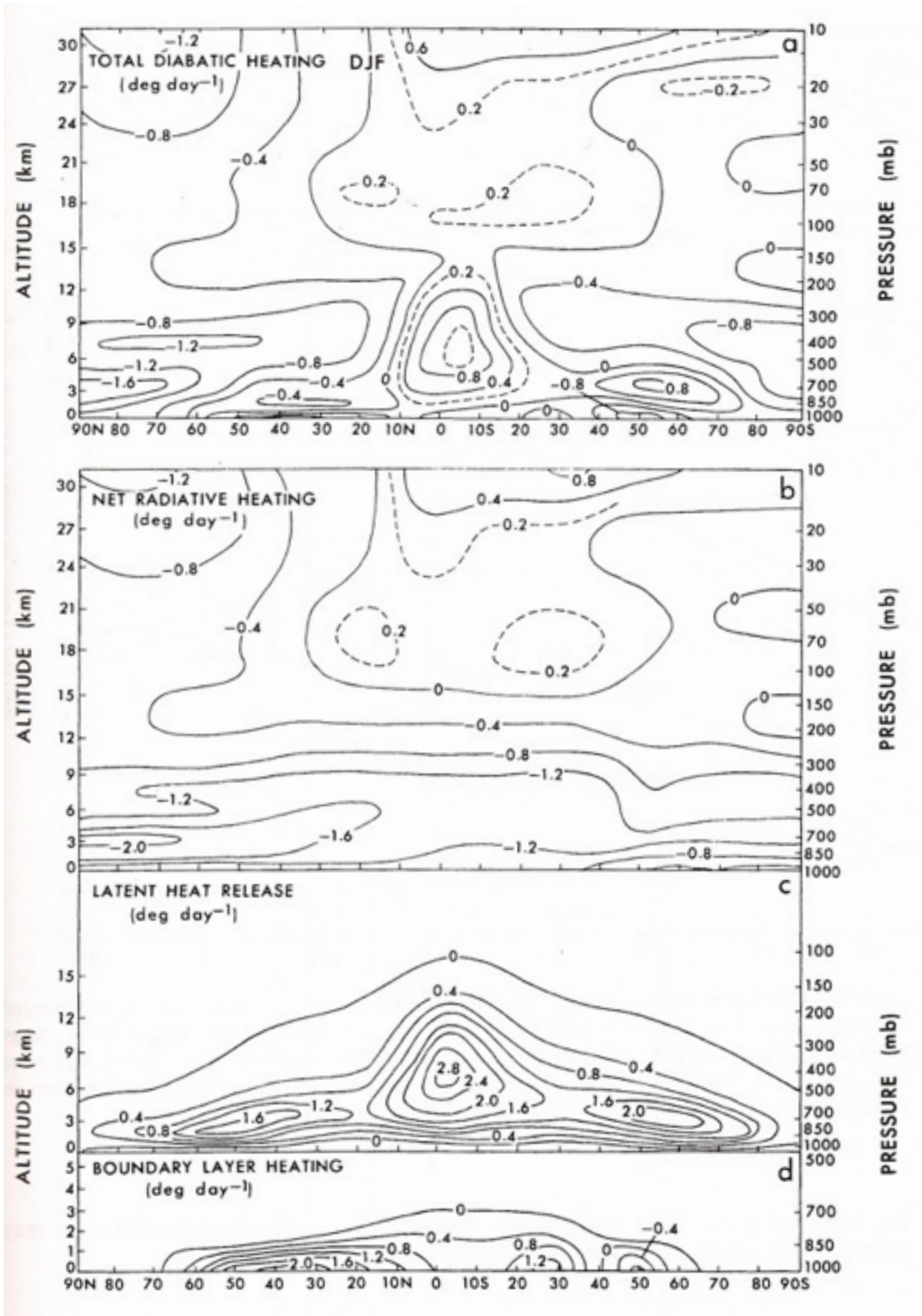
OLR

Net (Absorbed-OLR)

(Trenberth and Stepaniak, J. Climate 2003 Fig 2)


CloudSat Cloud Fractions: 200607
19.2
17.3
15.4
13.4
11.5
9.6
7.7
5.8
3.8
1.9
0.0
Ht [km ASL]
−90
−60
−30
0
30
60
90
Lat
0.80
0.60
0.40
0.20
0.00
Cloud Fraction

Diabatic heating in K day^{-1} (December to February)



Total

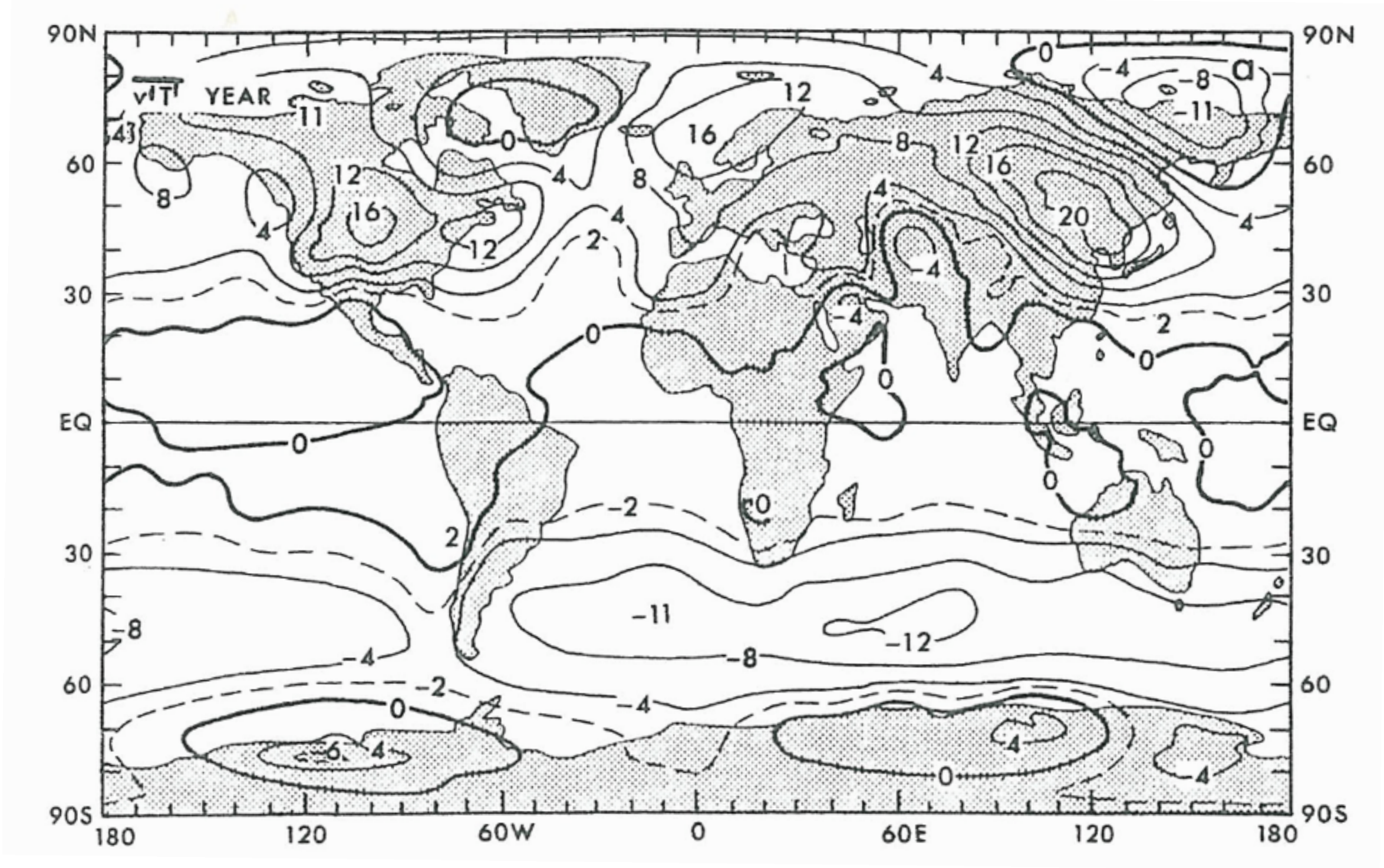
(Peixoto and Oort, fig 13.2)

Radiative

Latent

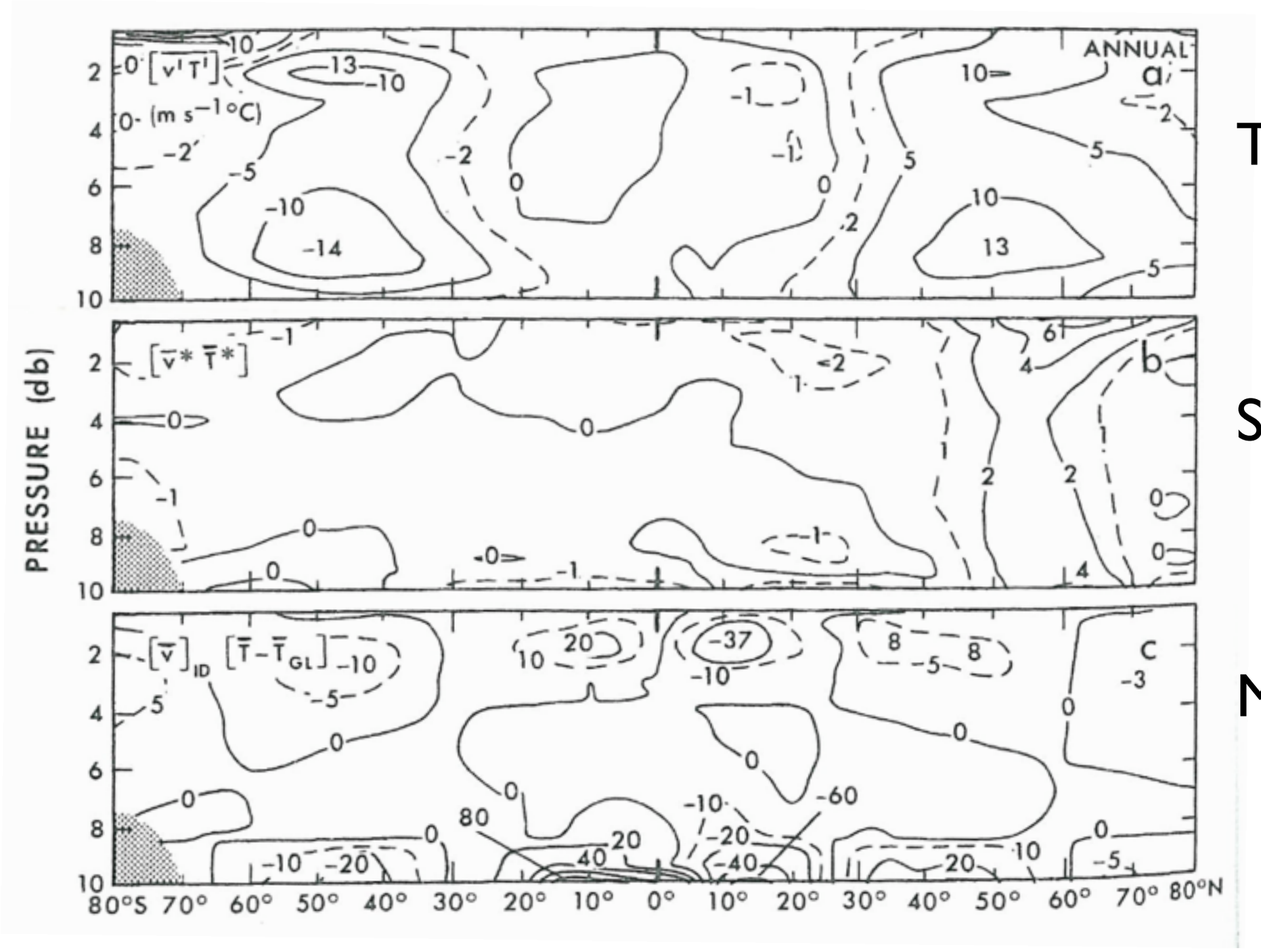
Boundary layer

Northward transport of sensible heat (K m s^{-1})



(Peixoto and Oort, fig 13.4)

Northward transport of sensible heat (K m s^{-1})



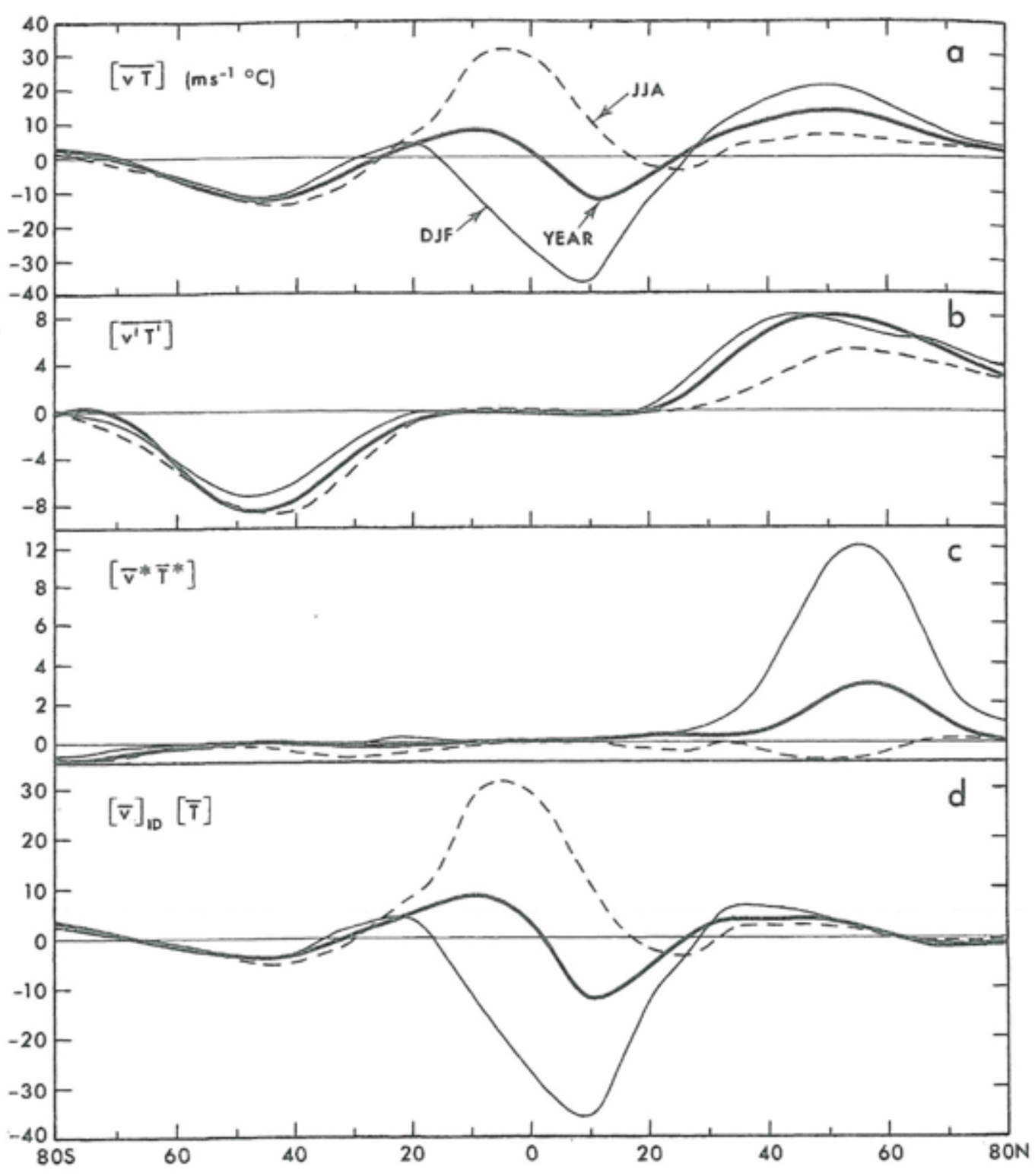
Transient

Stationary

Mean

(Peixoto and Oort, fig 13.5)

Northward transport of sensible heat (K m s^{-1})



Total

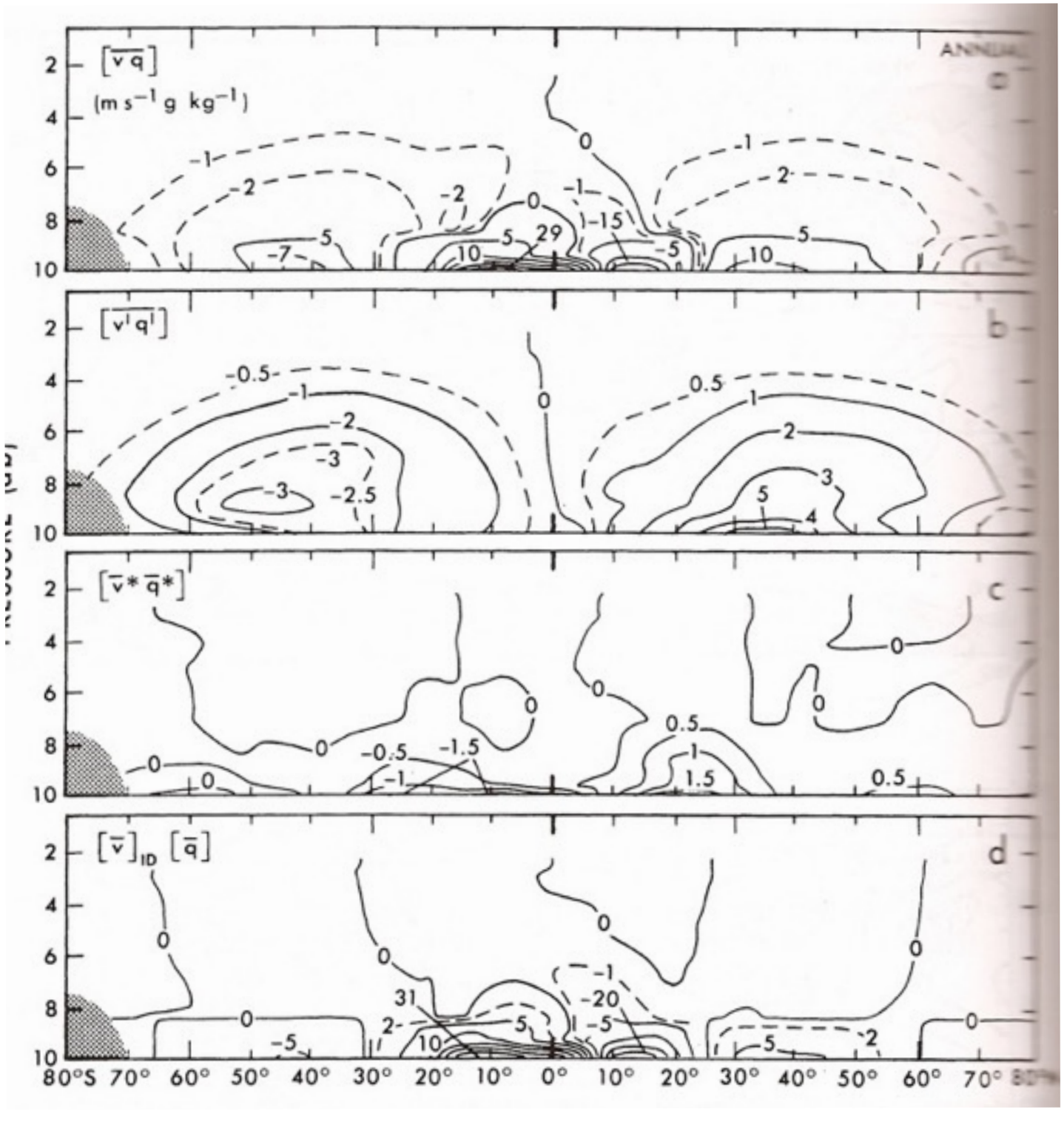
Transient

Stationary

Mean

(Peixoto and Oort, fig 13.6; multiply by 0.4 cos(lat) for PW)

Northward transport of latent heat (g kg^{-1} m s^{-1})



Total

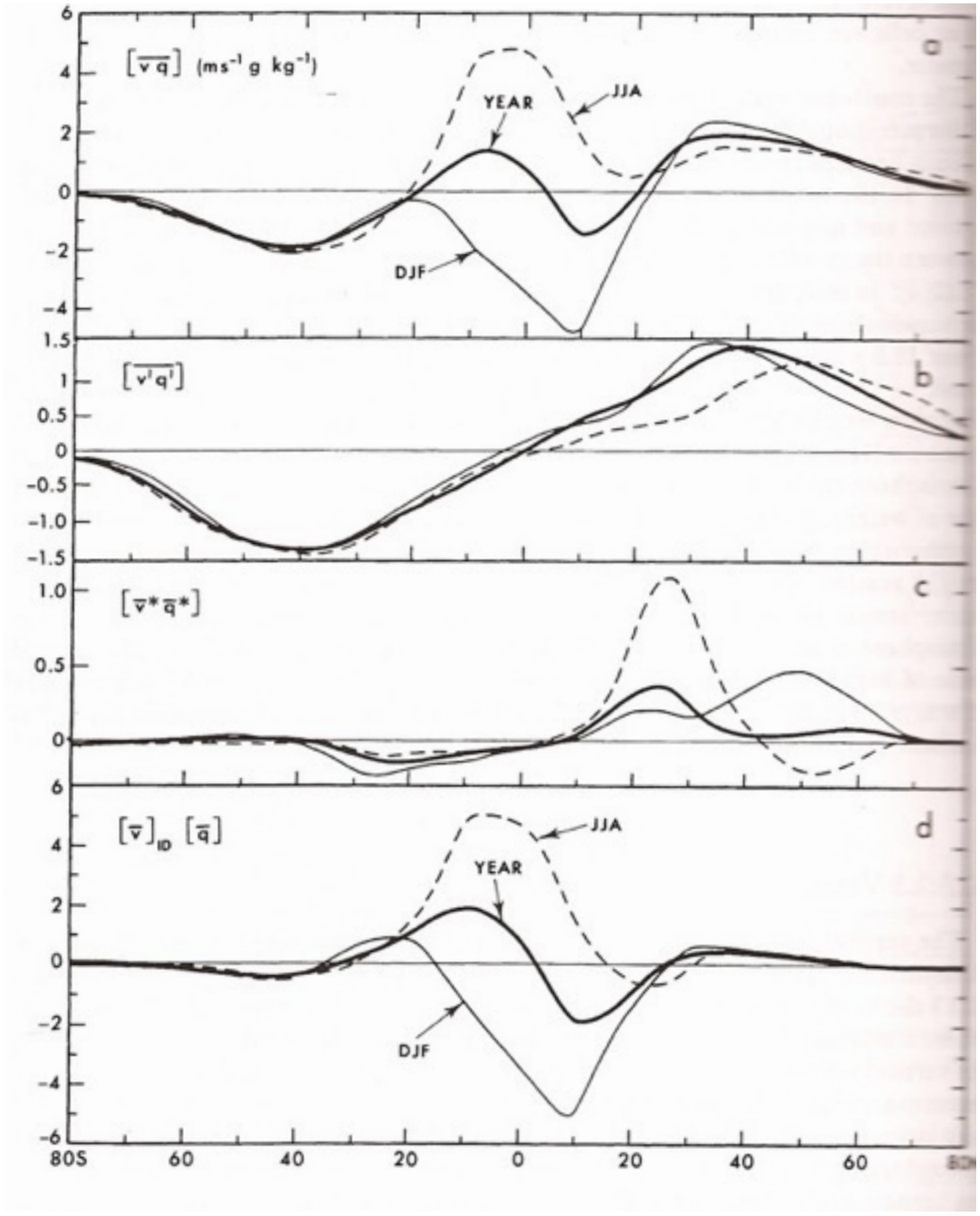
Transient

Stationary

Mean

(Peixoto and Oort, fig 12.11)

Northward transport of latent heat (g kg^{-1} m s^{-1})



Total

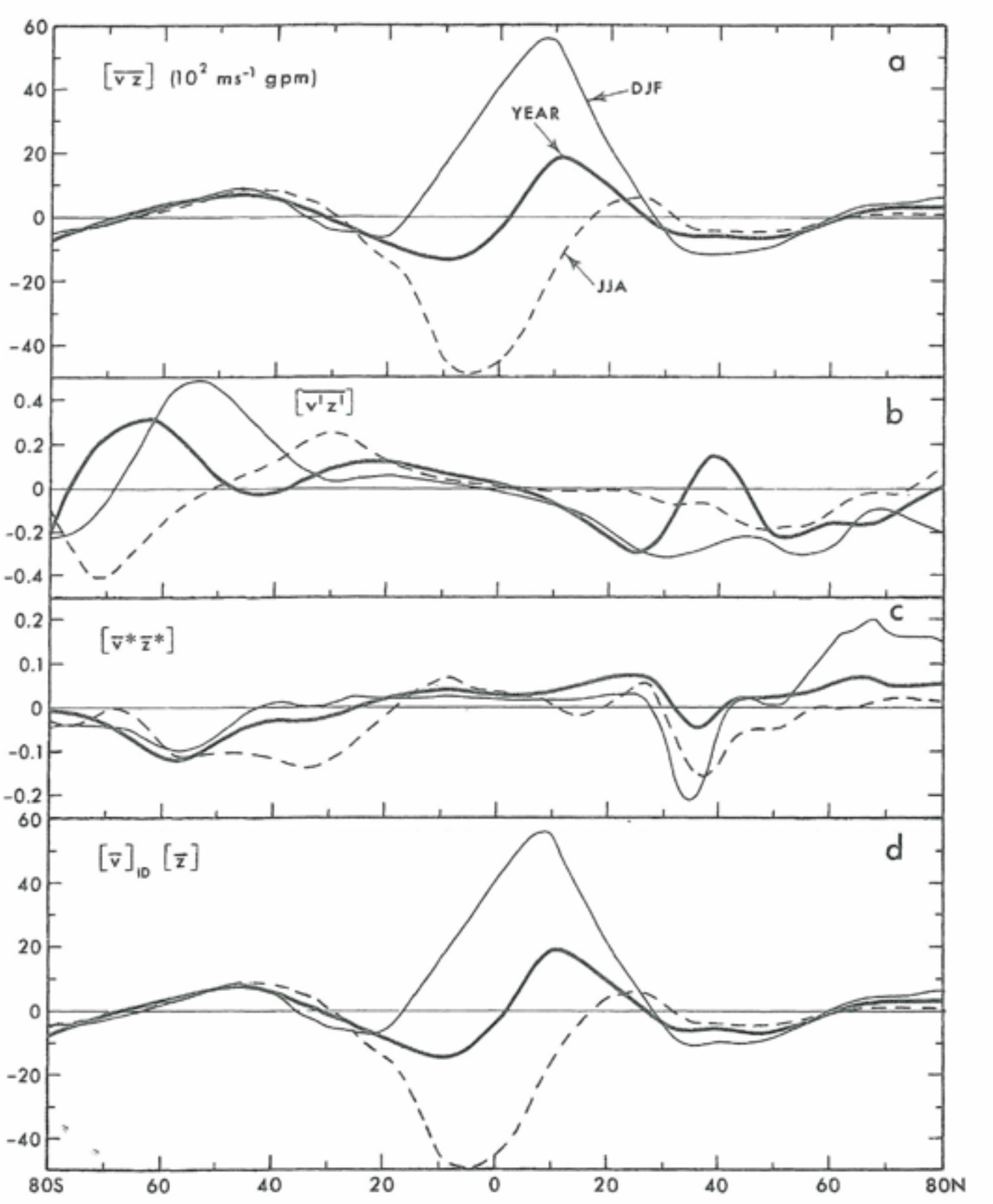
Transient

Stationary

Mean

(Peixoto and Oort, fig 12.12; energy conversion not the same)

Northward transport of potential energy (10^2 m^2 s^{-1})



Total

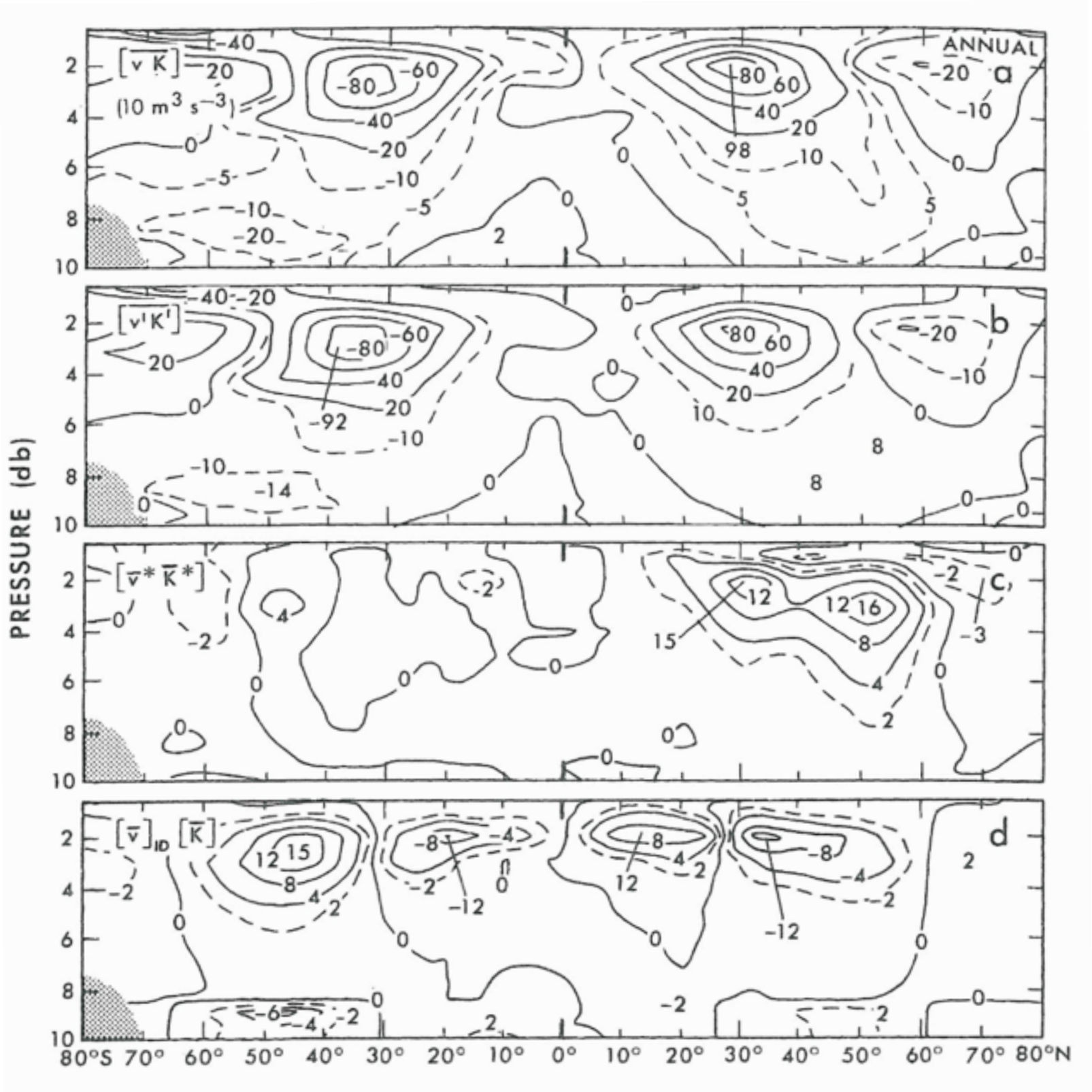
Transient

Stationary

Mean

(Peixoto and Oort, fig 13.7)

Northward transport of kinetic energy (10 m^3 s^{-1})



Total

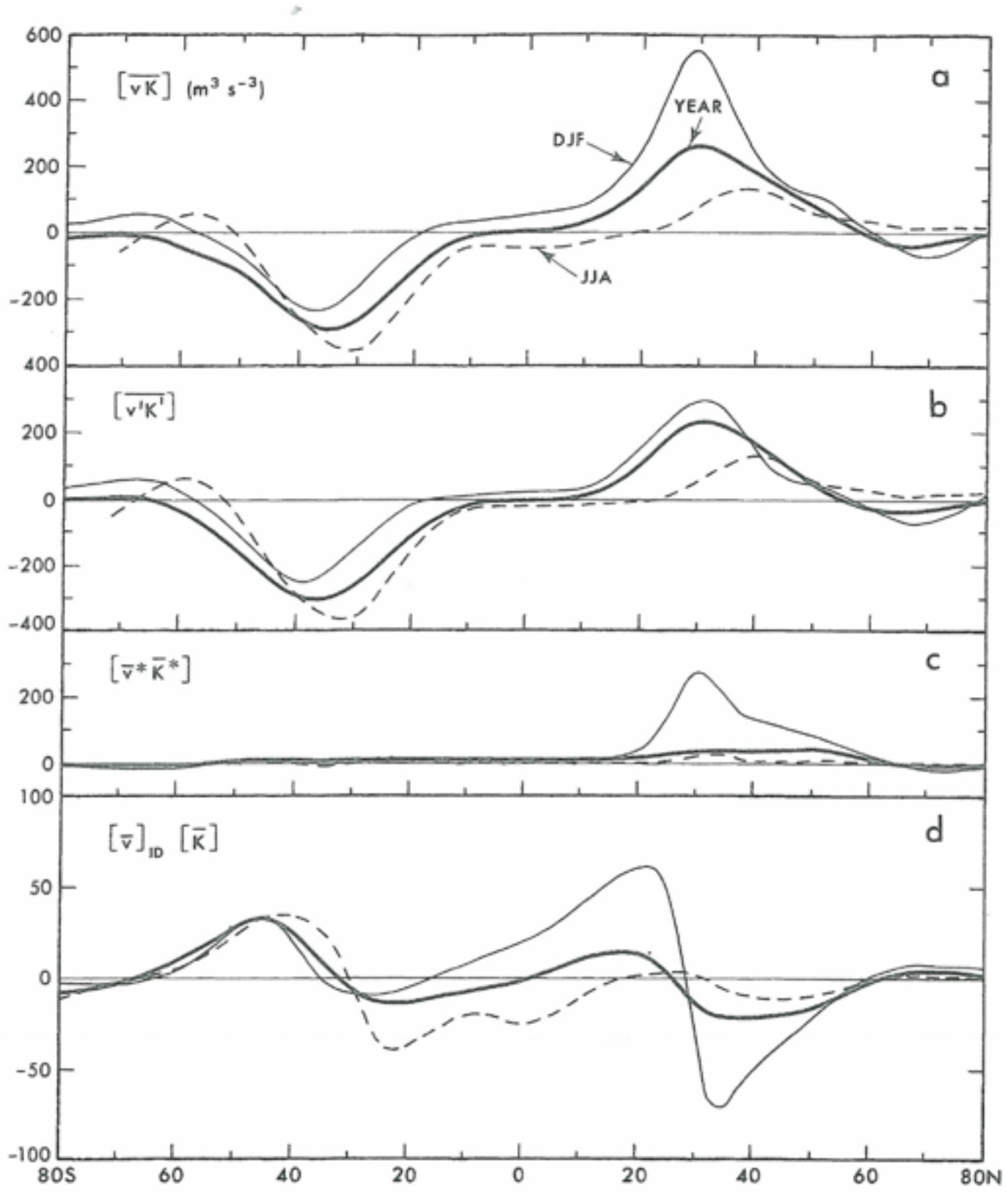
Transient

Stationary

Mean

(Peixoto and Oort, fig 13.8)

Northward transport of kinetic energy ($m^3\ s^{-1}$)



Total

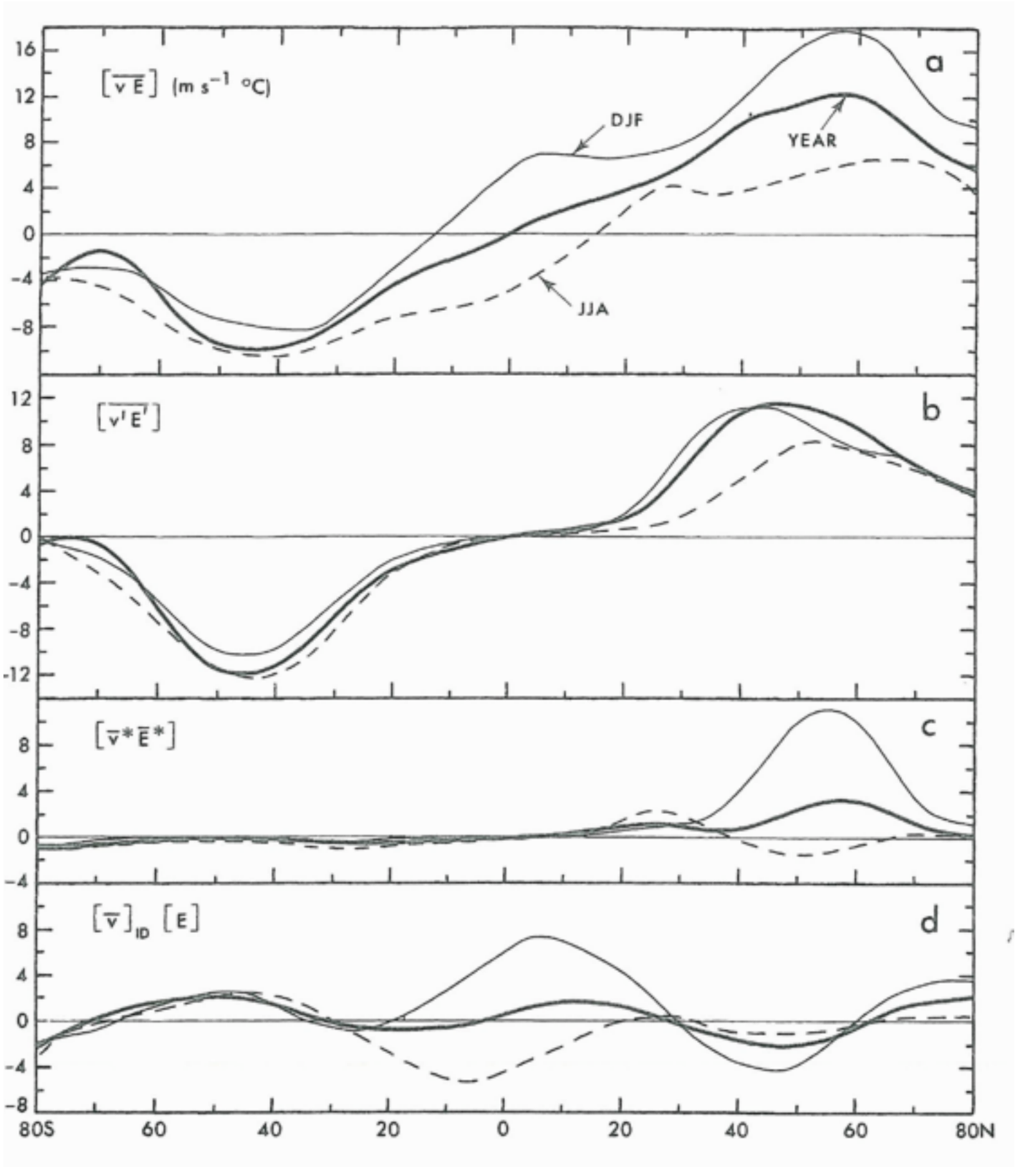
Transient

Stationary

Mean

(Peixoto and Oort, fig 13.9; 0.0004 cos(lat) for PW)

Northward transport of energy (K m s^{-1})



Total

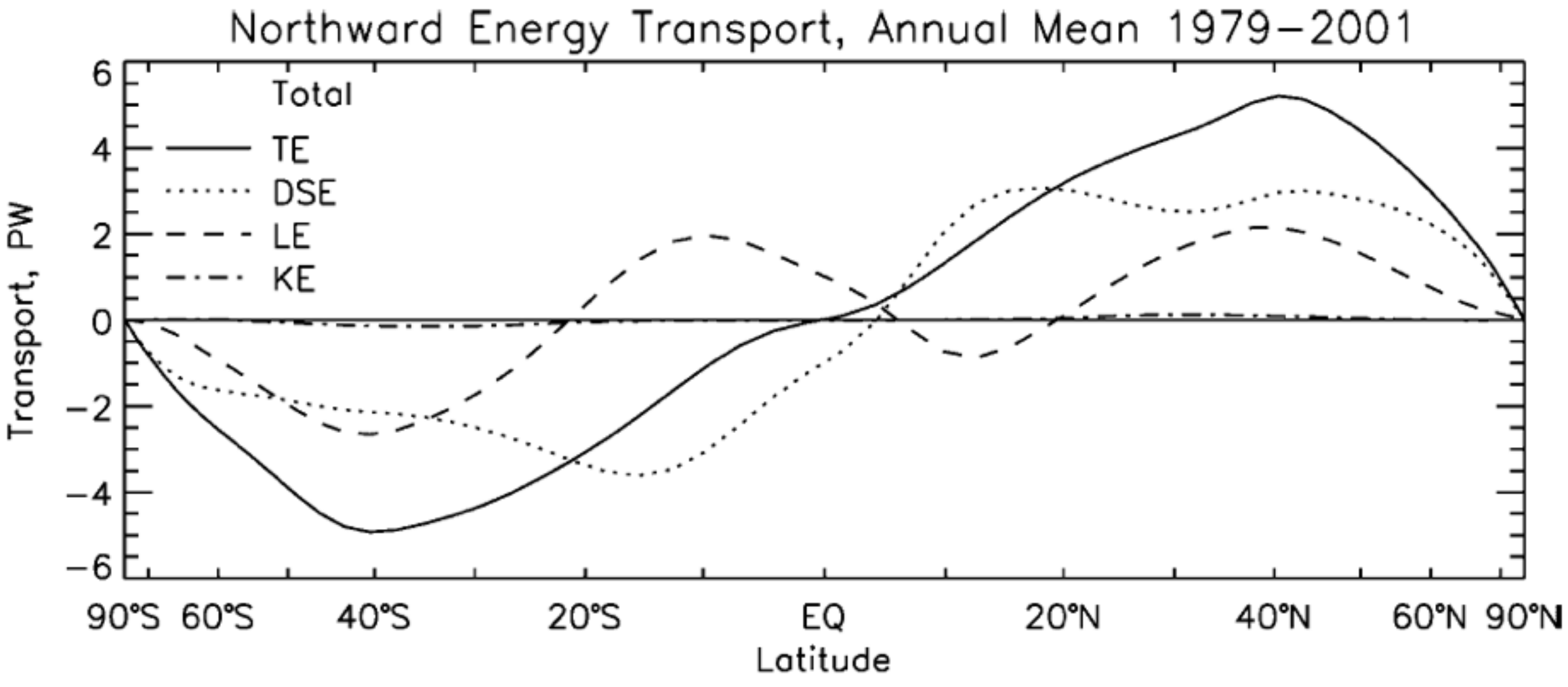
Transient

Stationary

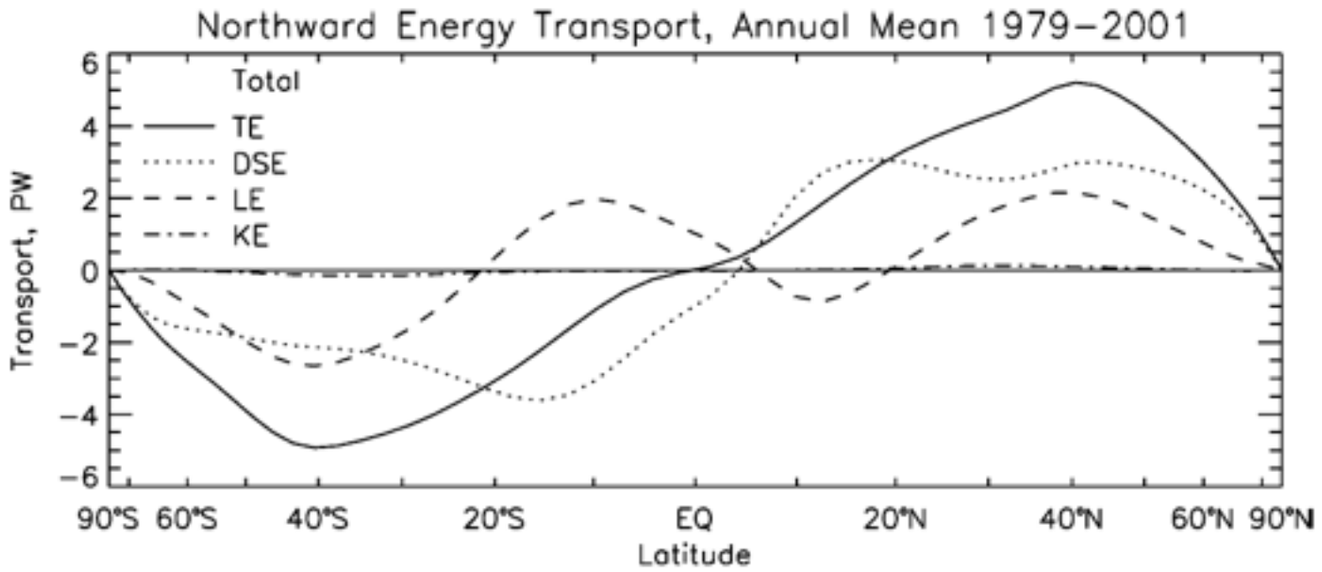
Mean

(Peixoto and Oort, fig 13.11)

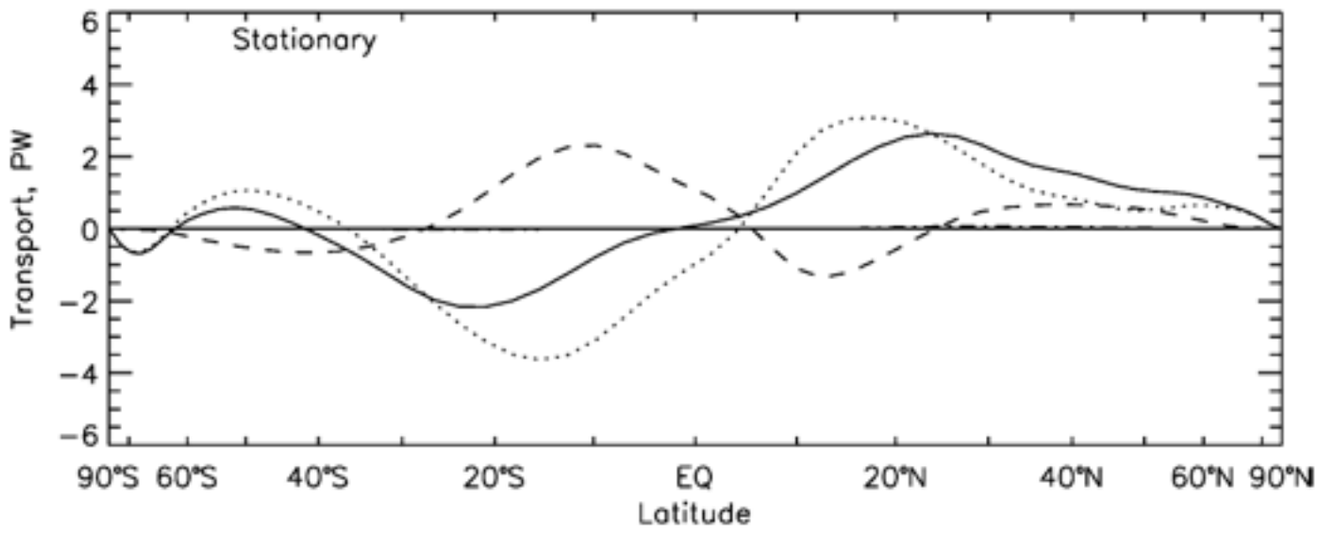
Energy transports from NCEP reanalysis; comparison of different components



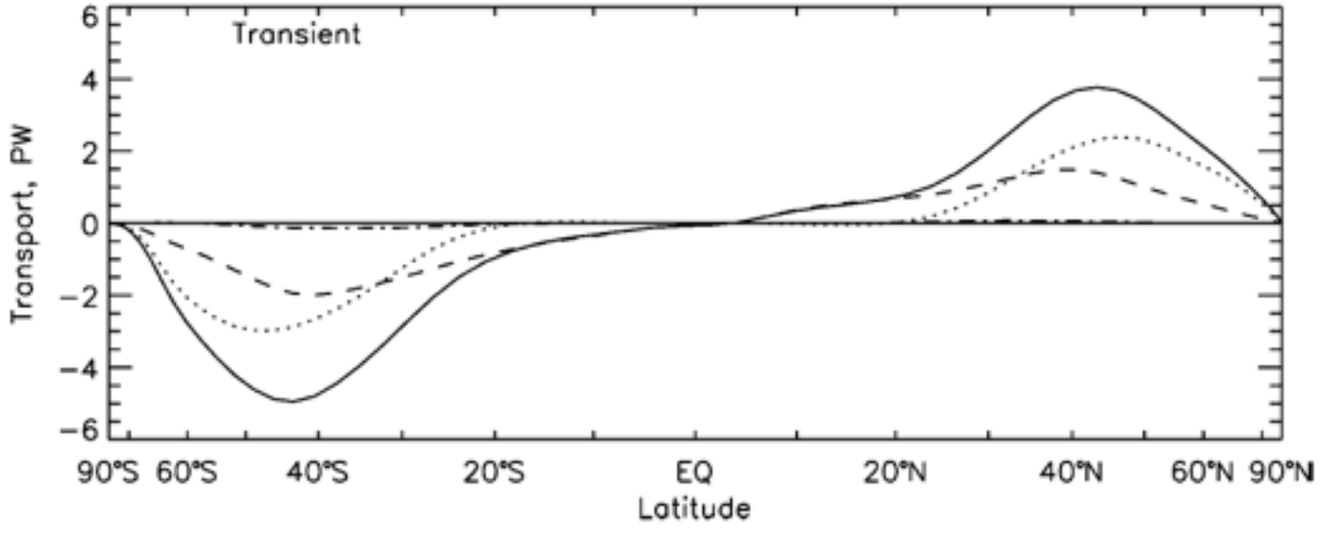
(Trenberth and Stepaniak, J. Climate pages 3691-3705, 2003 Fig 1)



Total



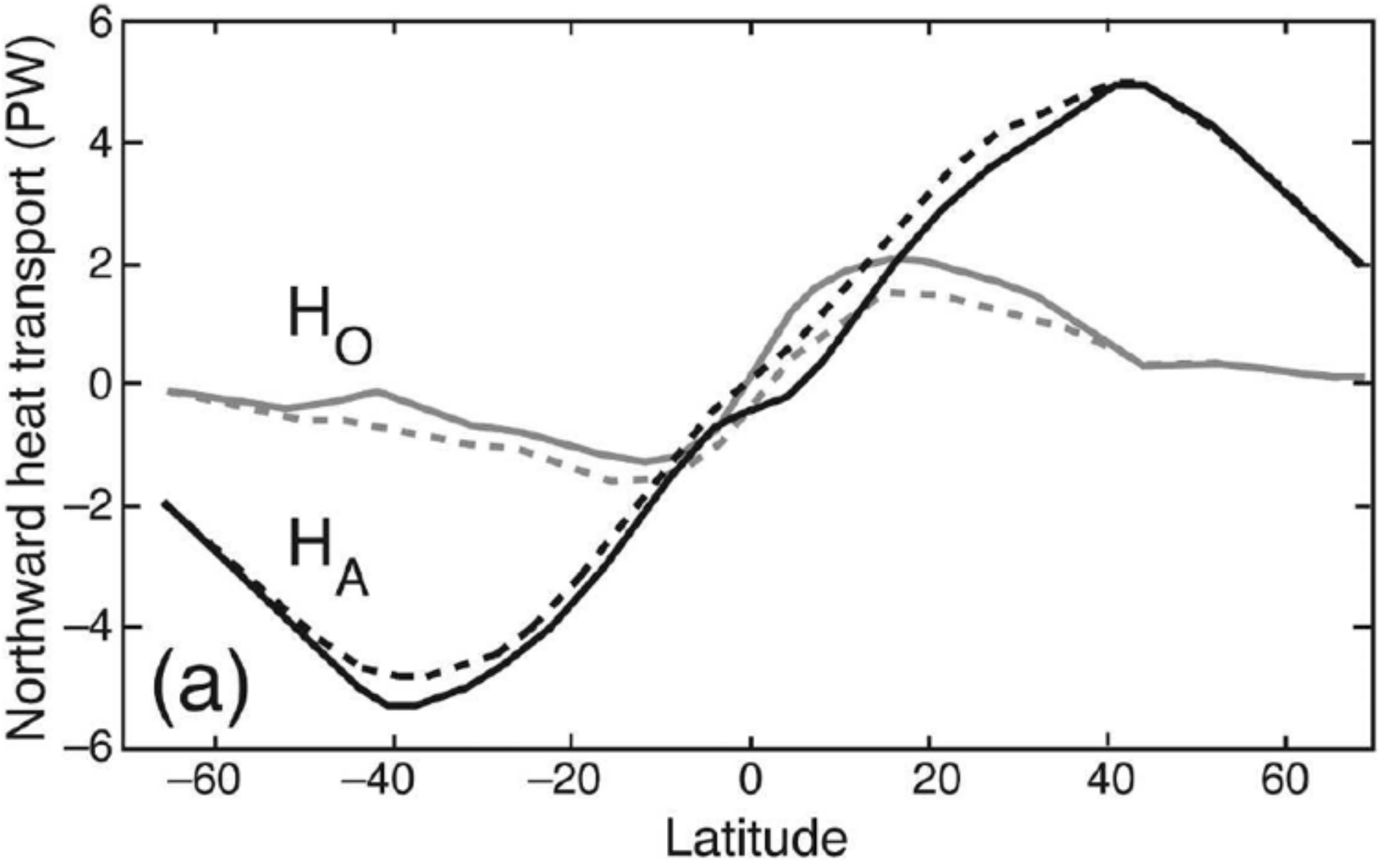
Covariance longer than monthly



Sub-monthly

(Trenberth and Stepaniak, J. Climate pages 3691-3705, 2003 Fig 1)

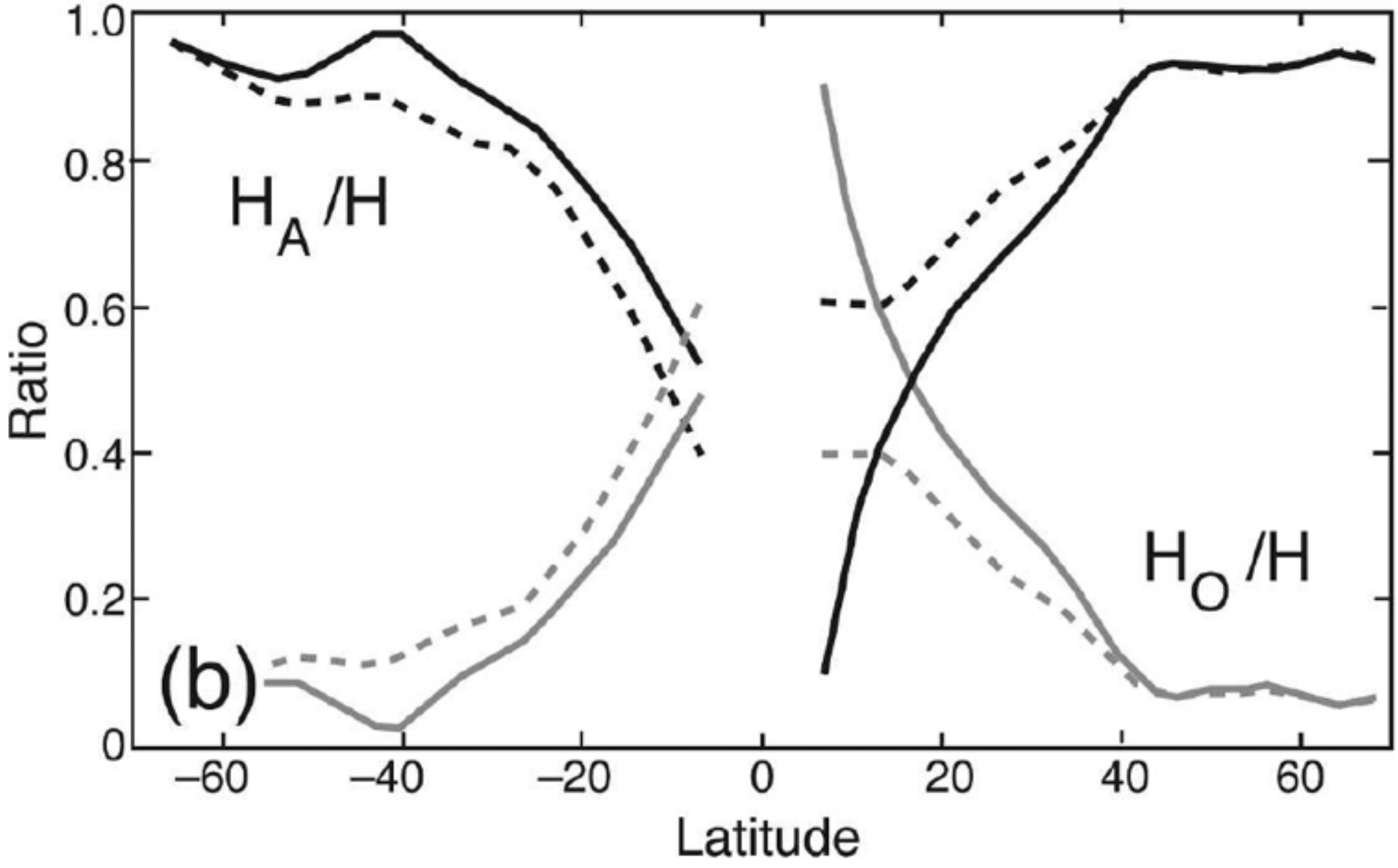
Northward energy transport: atmosphere and ocean (PW)



Dashed - NCEP
Solid - ERA15
Ocean implied from ERBE

(Czaja and Marshall, 2006 after Trenberth and Caron 2001)

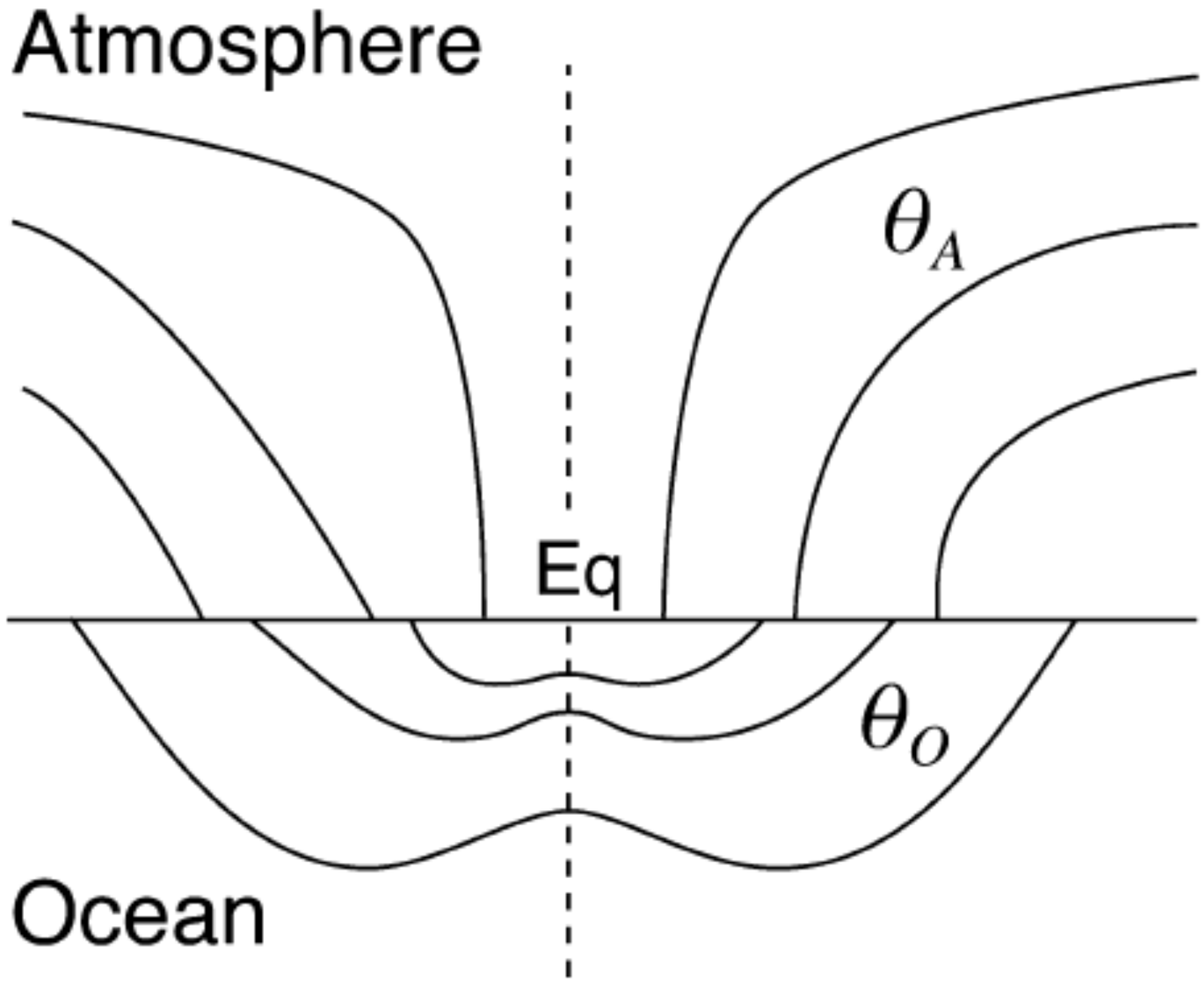
Northward energy transport: atmosphere and ocean (PW)



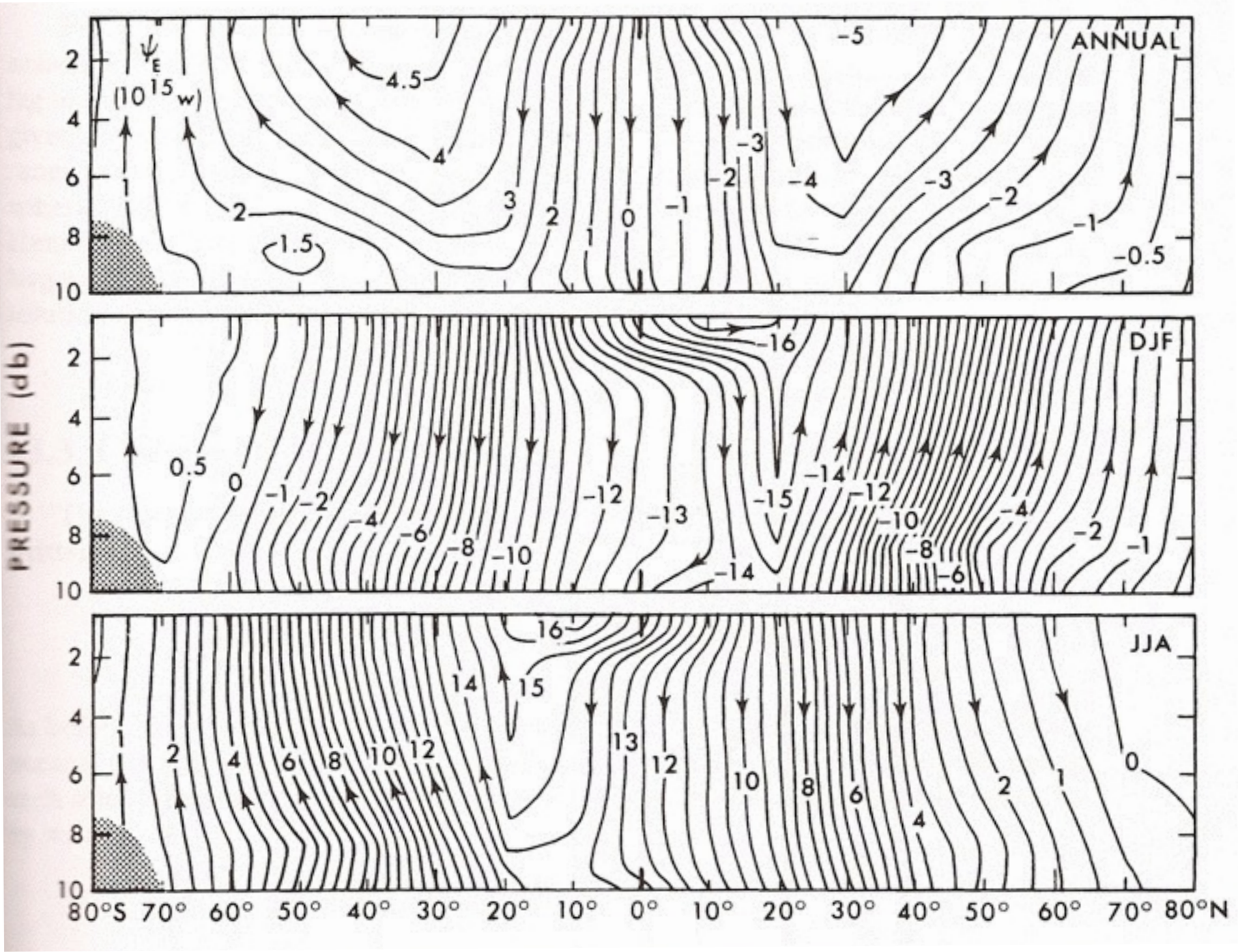
Dashed - NCEP
Solid - ERA15
Ocean implied from ERBE

(Czaja and Marshall, 2006 after Trenberth and Caron 2001)

Latitudes of greatest stratification differ in atmosphere and ocean



Energy transport streamfunction (PW)



Annual

DJF

JJA

(Peixoto and Oort, fig 13.15)