Intercontinental Transport of Toxic Air Pollutants: A Modeling Perspective

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Air Pollution Research: An Engineering Systems Approach

- Research Focus: Understanding how present and potential future human activities influence air pollution and its impacts, and informing more effective management
- Current Research Topics:
  - Transport and fate of toxic pollutants (e.g. mercury, POPs)
  - Health impacts of air pollution and climate
  - Science and policy of hazardous substance management
- Tools:
  - Atmospheric chemistry modeling
  - Economic and health impact modeling
  - Social science techniques

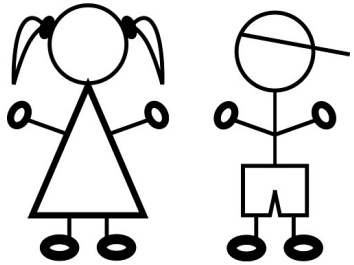
Framework for investigating air pollution impacts

Emissions of NOx, VOCs, SO2, BC, OC, GHGs, air toxics

Atmospheric modeling

Pollutant transport
Atmospheric chemistry
Climate interactions

Concentration of ozone, particulates, Toxic exposure



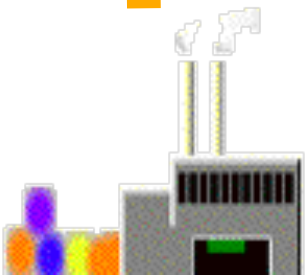
Population health impacts

Hospital visits
Mortalities (acute/chronic)
IQ deficits

Economic activities &
Policy choices

Economic modeling

Pollution controls
Technology changes



Integrated models & tools

Transport and Fate of Mercury: Science and Policy at Multiple Scales

Major anthropogenic source is stationary combustion (coal)

Ongoing U.S. efforts to regulate power sector emissions

Atmospheric transport and deposition leads to high fish methylmercury (uncertainties about atmospheric chemistry, processes)

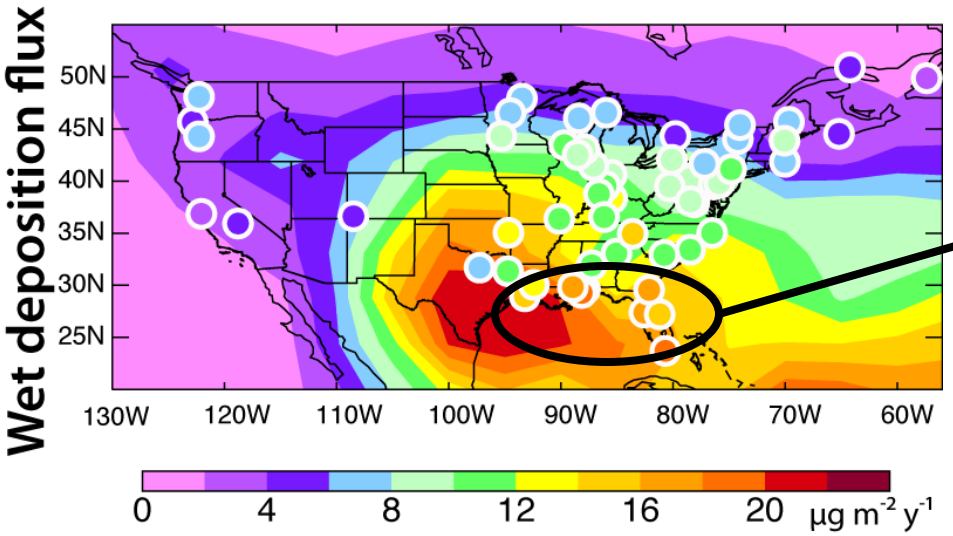
Particular concern in the Arctic environment due to contamination of traditional foods

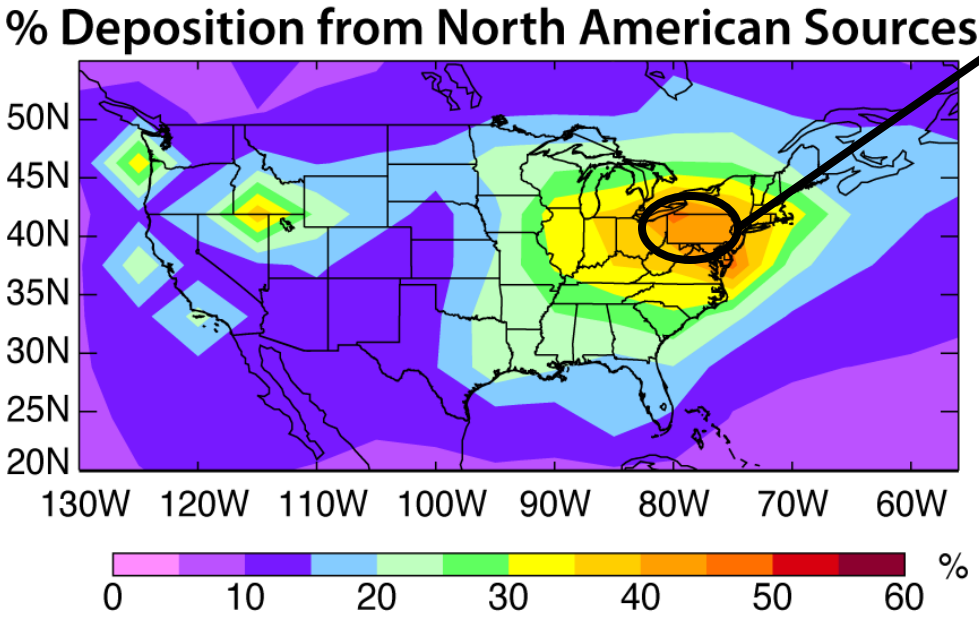
United Nations Environment Programme
Chemicals
UNEP Mercury Programme

Global treaty negotiations begin June 2010

Informing risk reduction policies at multiple scales

North American Contribution to Mercury Deposition





Southeast has highest wet deposition in the U.S., but mostly from non-US sources: this is due to rainout of mercury from higher altitudes in summertime

Up to 60% of deposition in Midwest/Northeast U.S. is from domestic sources

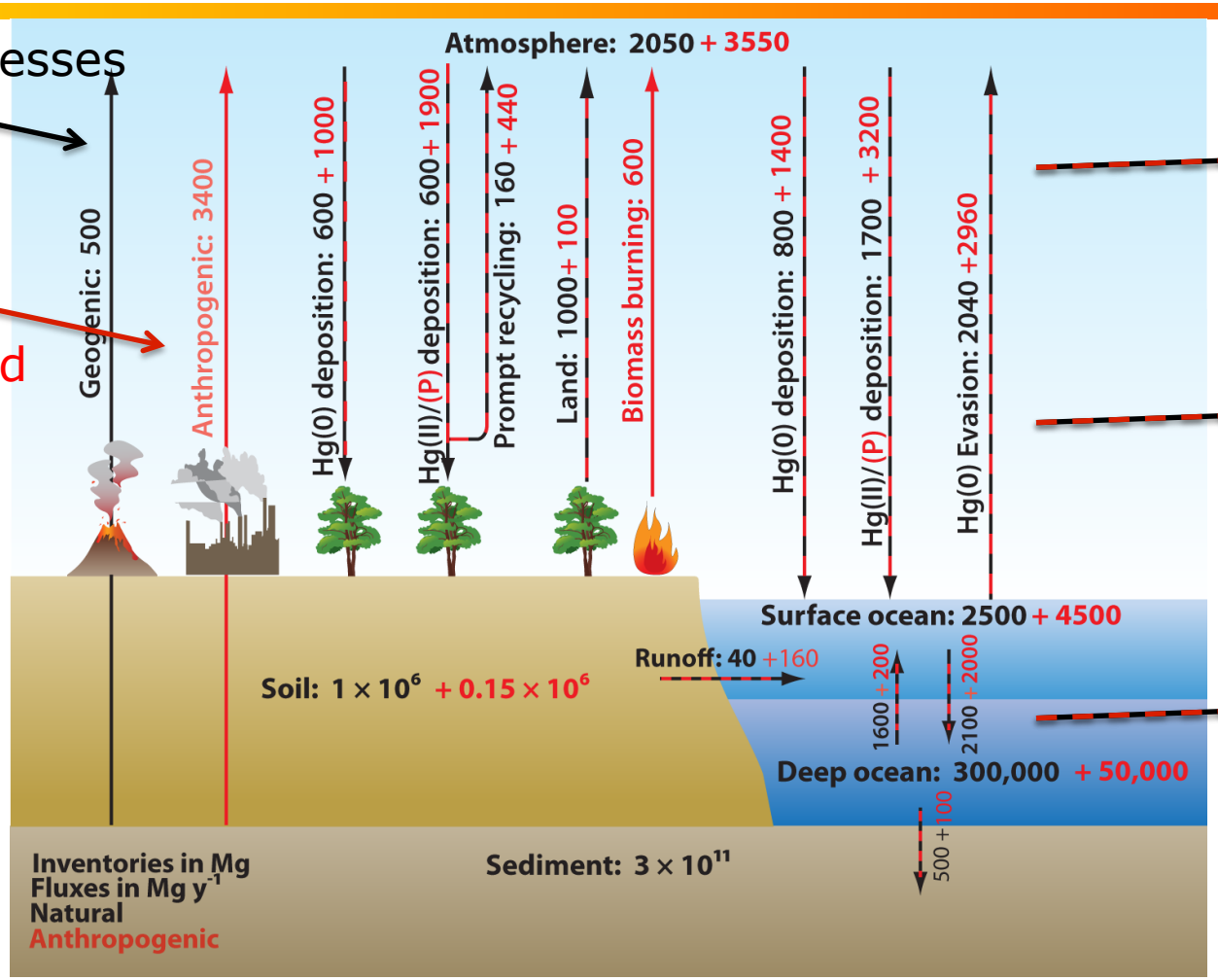
Policy implications:
Reducing deposition in both Midwest and Southeast will require policy actions on multiple political scales (national and global)

[*Selin & Jacob, Atmos. Env. 2008*]

Understanding Coupled Human-Natural Systems: Global Biogeochemical Cycle of Mercury

Natural Processes

Human activities and policy interactions



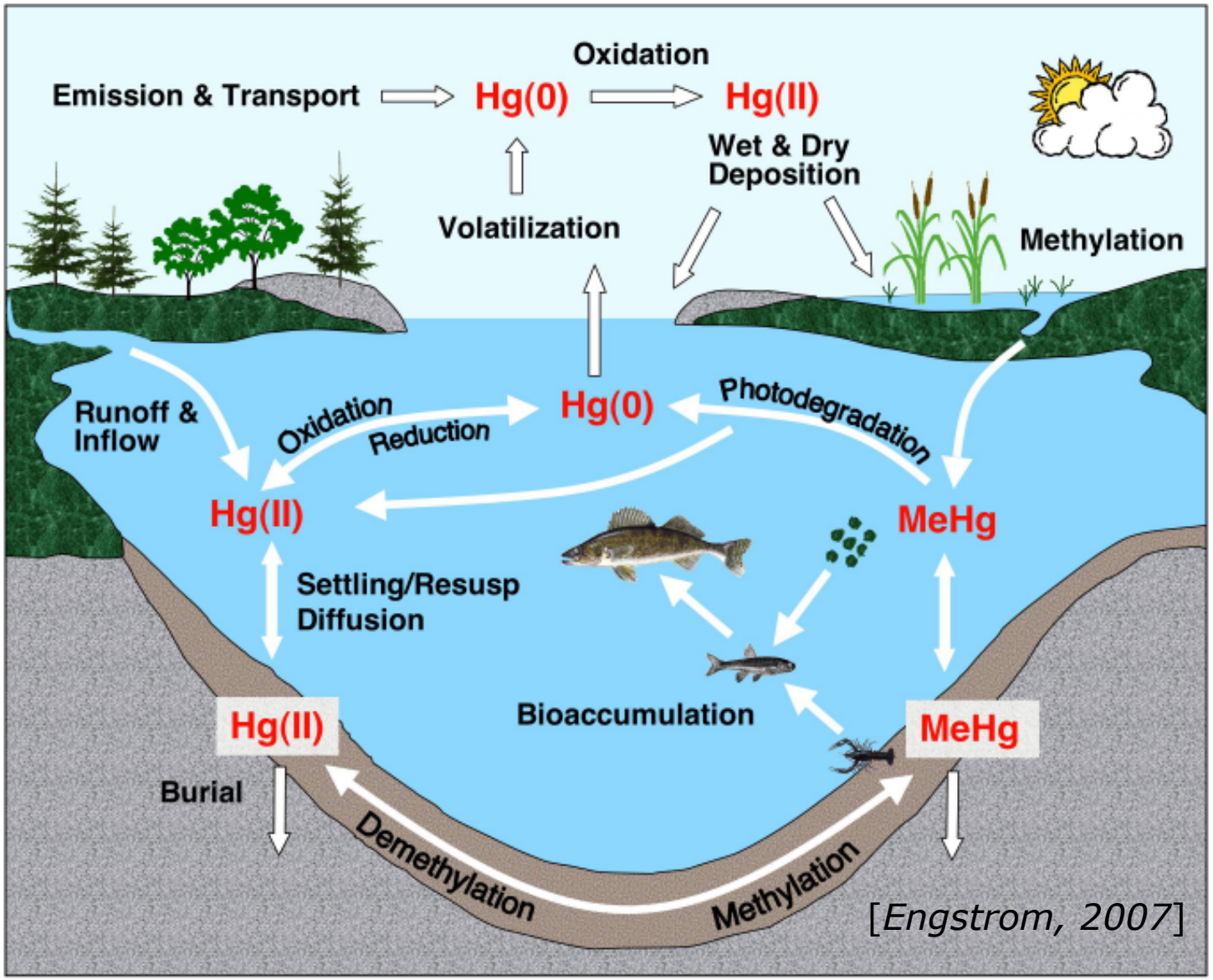
Coupled Human-Natural Interactions

Technical, policy and ecosystem uncertainty

Human and environment impacts

[*Selin, Ann. Rev. Env. Res., 2009*]

From Deposition to Fish Methylmercury

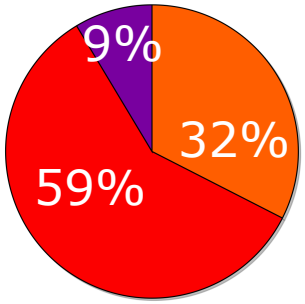


Freshwater Deposition and Source Attribution

How do sources affect fish methylmercury, and on what timescales?

Northeast U.S.

24.21 μg m^{-2} y^{-1}



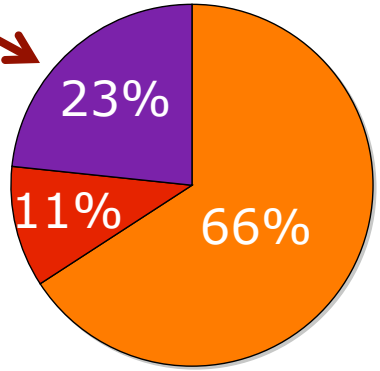
International Anthropogenic

Pre-industrial + Historical

N. American Anthropogenic

Southeast U.S.

34.08 μg m^{-2} y^{-1}



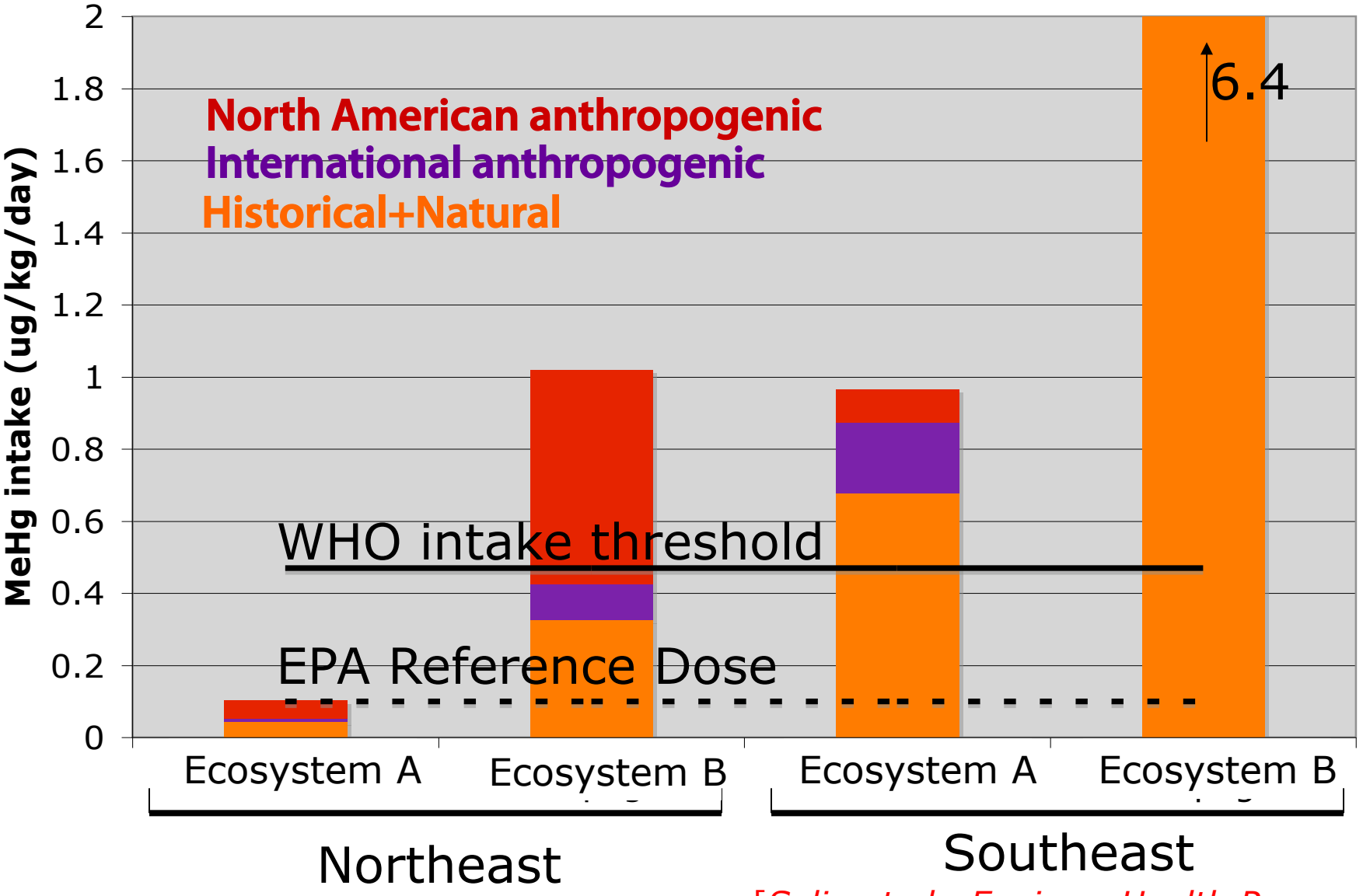
Lake, River, Watershed, and Aquatic food web models
[Knightes et al., 2009]

Policy and Timescale Analysis

[Selin et al., Environ. Health Persp., 2010]

Local Exposure from Freshwater Fish

2 x 100 g fish meals/week (60 kg person) @ t=40 y



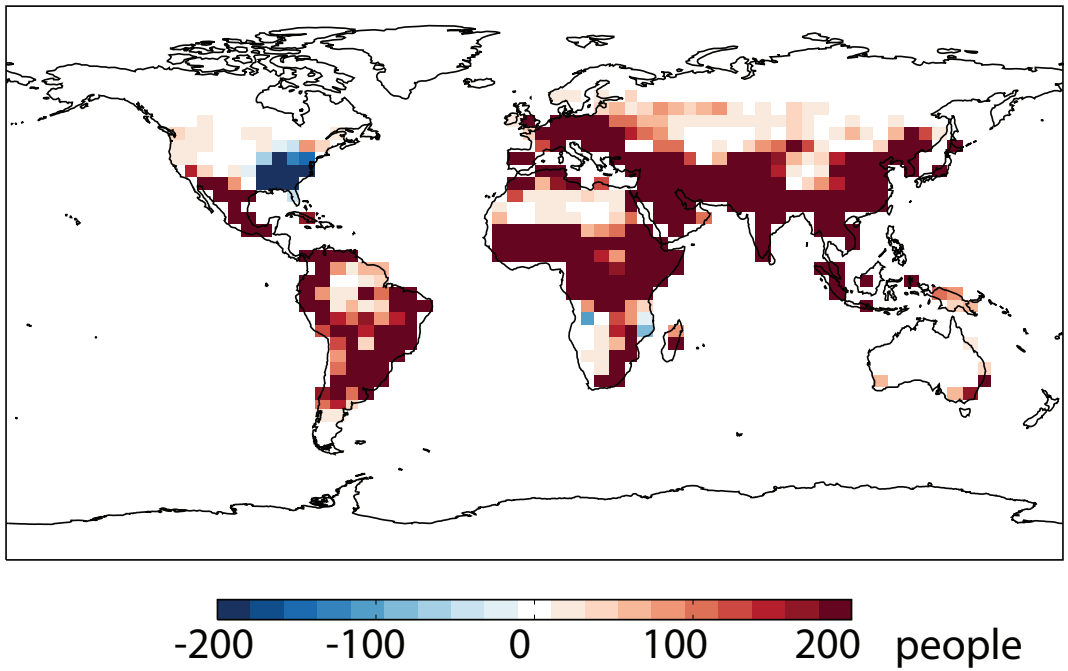
[*Selin et al., Environ. Health Persp.*, 2010]

Future Directions: Transport and Fate of Air Toxics

- ***Mercury:***
  - *Chemistry, Transport and Fate of Mercury*
- ***Persistent Organic Pollutants:***
  - *Transport and fate of PCBs, especially to the Arctic*
  - *Fate and transport of PAHs*
- ***Policy Analysis of Global Mercury Negotiations***
- ***Other potential research directions:***
  - *Vanadium, Nickel and particulate matter*
  - *Quantifying the economic impacts of mercury pollution*

Research Highlight #1: Global Health Impacts of Ozone Pollution in 2050

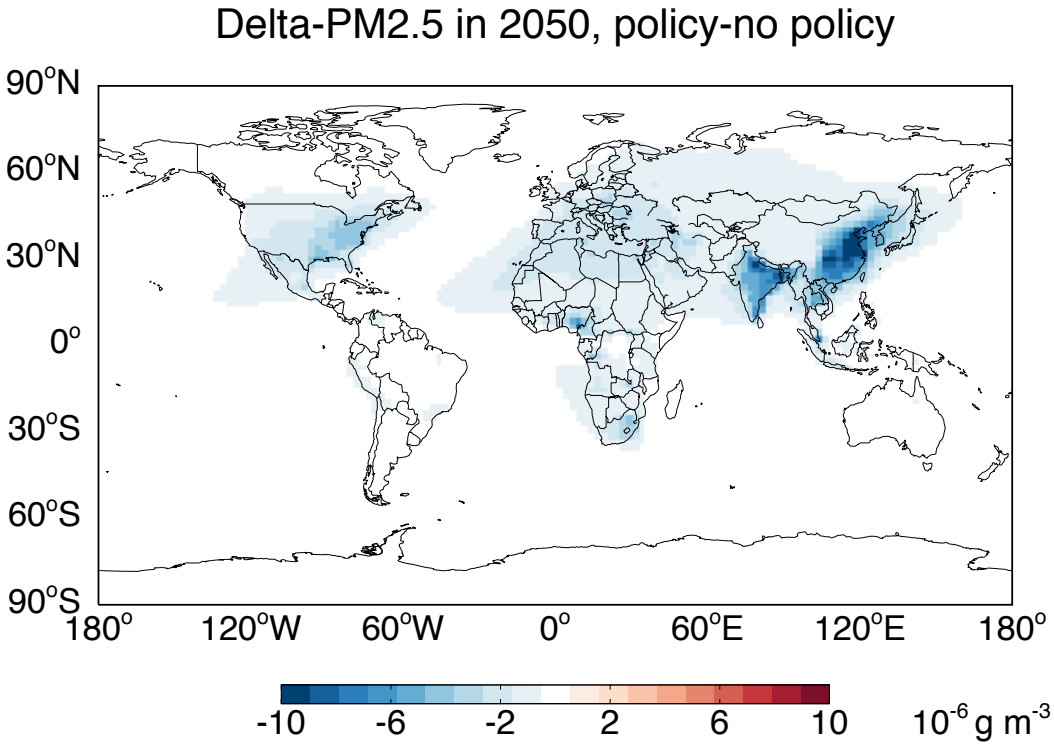
Projected Mortalities from Ozone Exposure, 2050



- Projected changes in annual mortalities from ozone air pollution from 2000-2050 due to projected climate and emissions changes
  - Reductions in the U.S. are due to more stringent policies to control ozone, while elsewhere, increased emissions lead to increased ozone.
  - Globally, we project over 800,000 additional mortalities.

[*Selin et al., Environ. Res. Lett., 2009*]

Research Highlight #2: Climate Policy Co-benefits for Air Pollution and Health



- Change in $PM_{2.5}$ due to co-benefits of climate policy (based on IGSM scenarios, Webster et al.)
  - Difference between 2050 reference and CO_2 stabilization at 450 ppm
  - Quantified benefits about 0.1% of global welfare in 2050 (compared with 7% global GDP cost of climate policy), but with regional variation

[*Selin et al., in prep*]

Future Directions: Air Pollution Health Impacts

- Impacts of transportation technologies on air quality, human health and the economy on global to local scales by 2050, with case study of Northeast U.S.
- Linking urban impacts into urban-scale integrated assessment modeling
- Using models, satellite information, and other data products to inform a decision-support framework for air pollution health impacts

The Selin Group 2010

- **Postdoc:**
  - Carey Friedman (PhD, URI): Transport and fate of persistent organic pollutants
  - Tammy Thompson (PhD, U. Texas): Regional-to-global atmospheric chemistry modeling
- **Doctoral Students:**
  - Rebecca Saari, ESD 1st yr: Future climate policy and air pollution health impacts
  - Katherine Saad, EAPS 1st yr: Climate-air pollution connections (co-supervised by R. Prinn, EAPS)
  - Leah Stokes, DUSP 1st yr: Mercury science-policy (primary advisor: L. Susskind, DUSP)
- **Master's students:**
  - Caleb Waugh (TPP 2nd year), air pollution from hybrid/electric vehicles (primary advisor: J. Reilly)
- **Undergraduates:**
  - Abby Koss (EAPS Junior): Persistent Organic Pollutants data analysis
  - Anastasia Maheras (EAPS Senior): Mercury data analysis