MERCURY IN THE ATMOSPHERE, BIOSPHERE, AND POLICY SPHERE:
Insights from Global Modeling

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MERCURY IN THE ENVIRONMENT: OUTLINE

1. Deposition to the United States results from a mix of local and global sources, depending on the location

2. Historical and present releases of mercury will continue to contribute to methylmercury exposure for decades and longer
GLOBAL BIOGEOCHEMICAL CYCLE OF MERCURY

MERCURY: ATMOSPHERIC CHEMISTRY

OH, O₃, Br, other halogens

Hg⁰
1.6 ng m⁻³
Atmospheric lifetime 0.5-2 y
Insoluble

Hg²⁺
1-100 pg m⁻³

in-cloud photoreduction

oxidation

reduction

Hg(P)

Wet and Dry Deposition
Soluble

Goal: Use combination of model and measurements to constrain mercury chemistry, transport, and deposition

Measurements: TGM=Total Gaseous Mercury, RGM=Reactive Gaseous Mercury
Up to 60% of deposition in the Midwest/Northeast U.S. is from domestic sources. Florida 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.

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

[Selin & Jacob, AE 2008]
FROM DEPOSITION TO FISH METHYLMERCURY

[Engstrom, 2007]
FRESHWATER DEPOSITION AND SOURCE ATTRIBUTION

How do sources affect fish methyl mercury, and on what timescales?

Northeast U.S. 24.21 µg m⁻² y⁻¹
- Pre-industrial + Historical: 59%
- N. American Anthropogenic: 32%
- International Anthropogenic: 9%

Southeast U.S. 34.08 µg m⁻² y⁻¹
- N. American Anthropogenic: 66%
- International Anthropogenic: 23%
- Pre-industrial + Historical: 11%

SERAFM: Lake model  WASP7: River model  WCS (MLM): Watershed loading  BASS: Aquatic food web

Policy and Timescale Analysis

[Selin et al., EHP, 2010]
Each ecosystem driven by present-day deposition for 40 years

Policy experiment: All Hg is “historical” at t=0. How is anthropogenic signal reflected in fish, and on what timescale?

Same deposition, but different ecosystem dynamics lead to very different source attributions (and concentrations) over time (watershed role)

Regional differences in deposition sources lead to different attributions in similar ecosystems

[Selin et al., EHP, 2010]
LOCAL EXPOSURE FROM FRESHWATER FISH

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

North American anthropogenic
International anthropogenic
Historical+Natural

WHO intake threshold
EPA Reference Dose

Ecosystem A
Ecosystem B
Ecosystem A
Ecosystem B

Northeast
Southeast

[Selin et al., EHP, 2010]
POPULATION-WIDE EXPOSURE FROM MARINE FISH

No mechanistic link (yet) from oceanic Hg concentration to fish methylmercury

Historical exposure could continue to increase, complicating policy decision-making

Different challenges on different scales (local to global)

Adaptation and mitigation necessary? (Learning lessons from other issue areas)

“current emissions” scenario
14-box ocean model: Sunderland and Mason, 2007

[Selin et al., EHP, 2010]
POLICY CHALLENGES ON MULTIPLE SCALES

GLOBAL:
Global Mercury Assessment (2002): sufficient evidence to warrant international action

REGIONAL:

U.S.:
Clean Air Mercury Rule: established “cap and trade” approach to regulating mercury from coal-fired power plants (2005), struck down by courts in 2008; new regulations expected fall 2010

Challenge: Inform effective policies that reduce risk at multiple scales (local to global)

[Selin and Selin, RECIEL, 2006]