Explaining Global Trends in Tropospheric Mercury using Global Modeling

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24 September 2012

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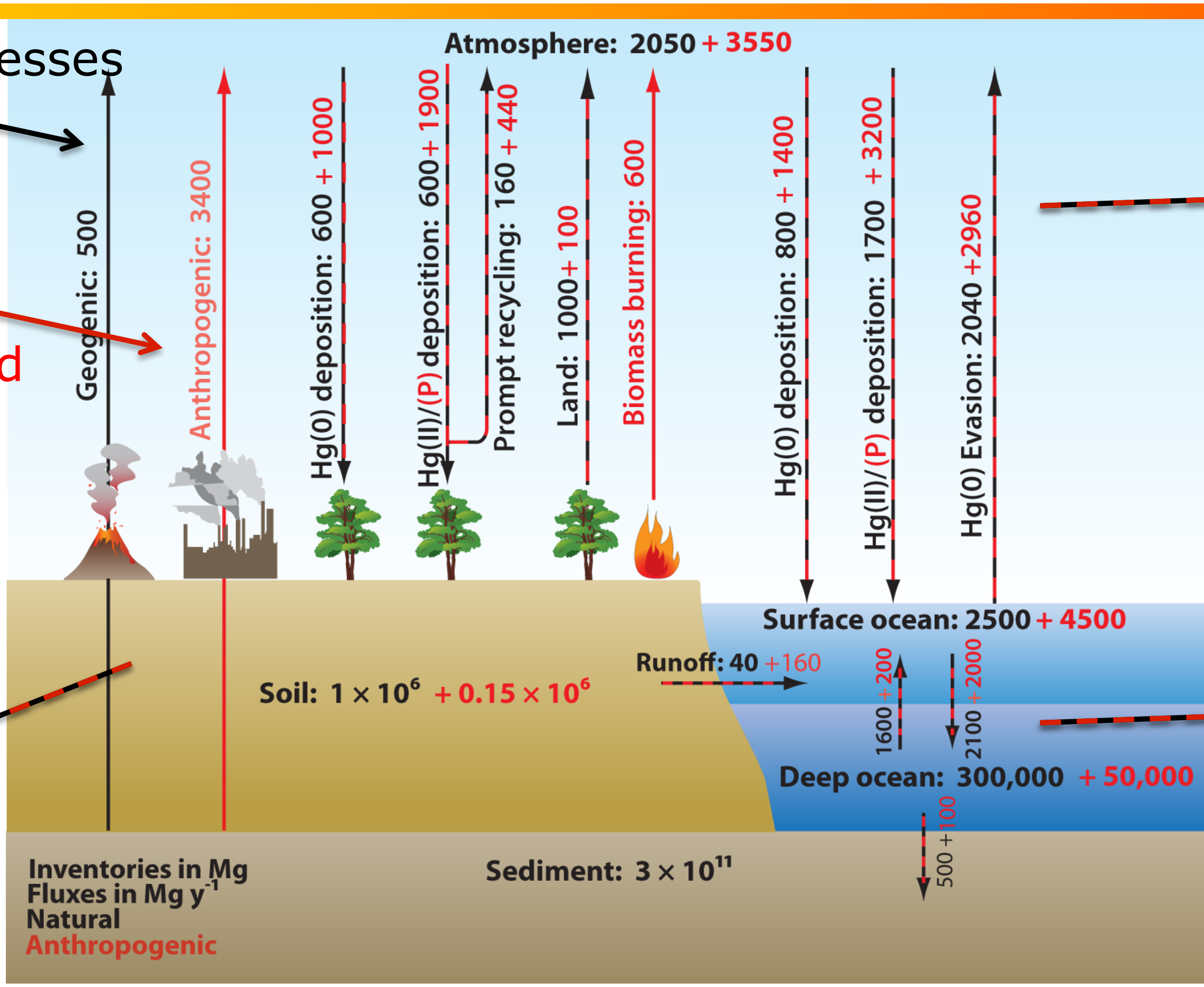
EAPS

Understanding the Present and Future Global Biogeochemical Cycle of Mercury

Natural Processes

Human activities and policy interactions

Soil lifetime: Role of Historic Mercury



Technical, policy and ecosystem uncertainty

Human and environment impacts

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

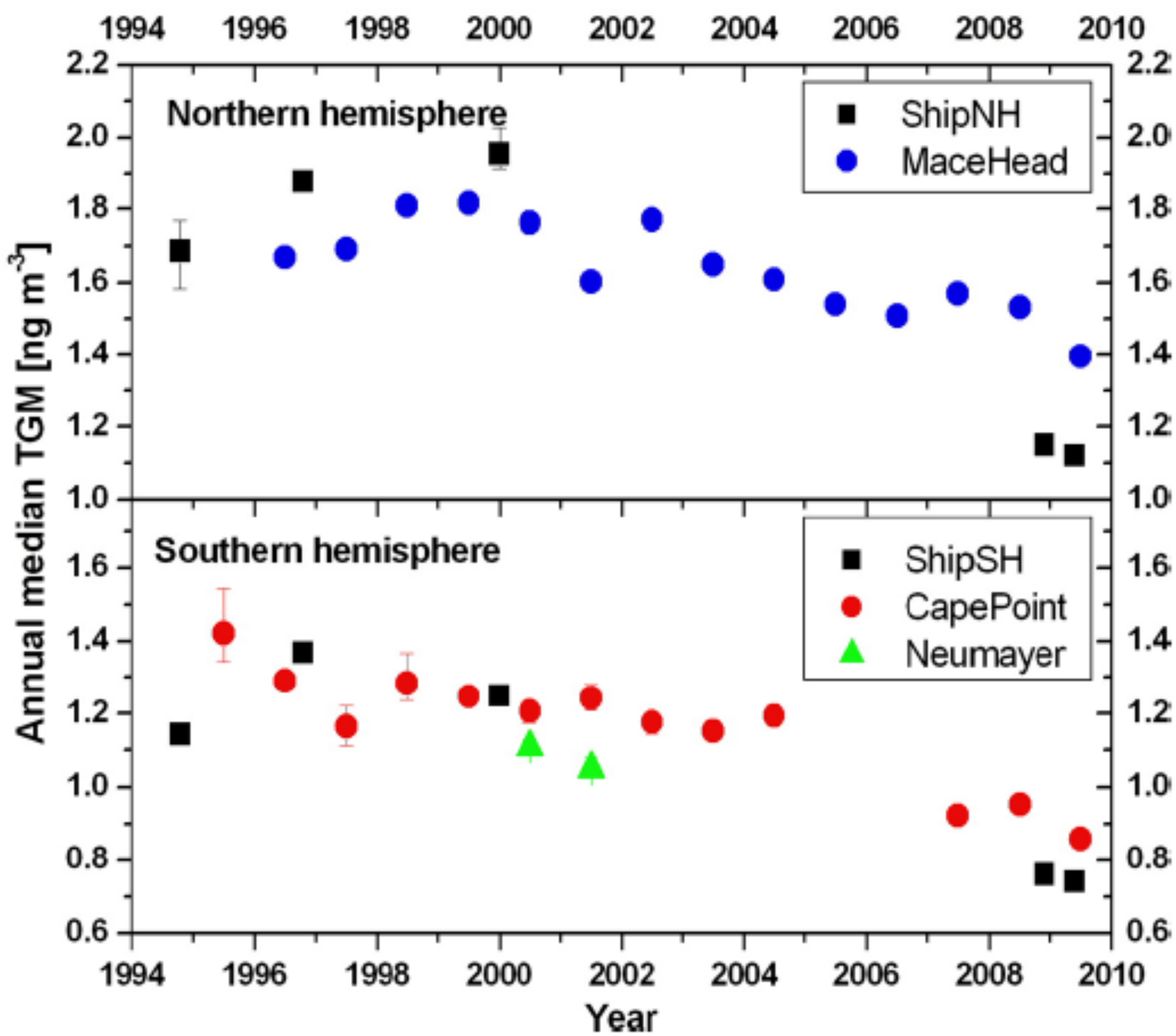
How to explain recent trends in Hg?

Slemr et al. (2011): 20% declines in atmospheric Mercury at Cape Point, Mace Head since 1995.

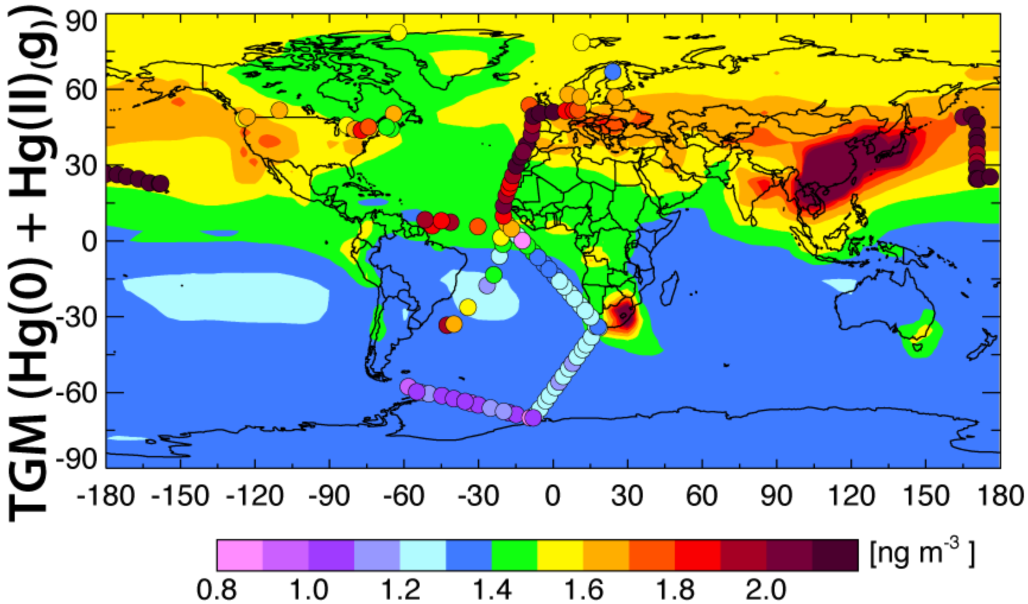
How to explain this?

Several possibilities:
-Change in emission
-ocean?
-Change in oxidation

Inverse methods show that cruise data provide limited quantitative constraint.



GEOS-Chem Global Mercury Model

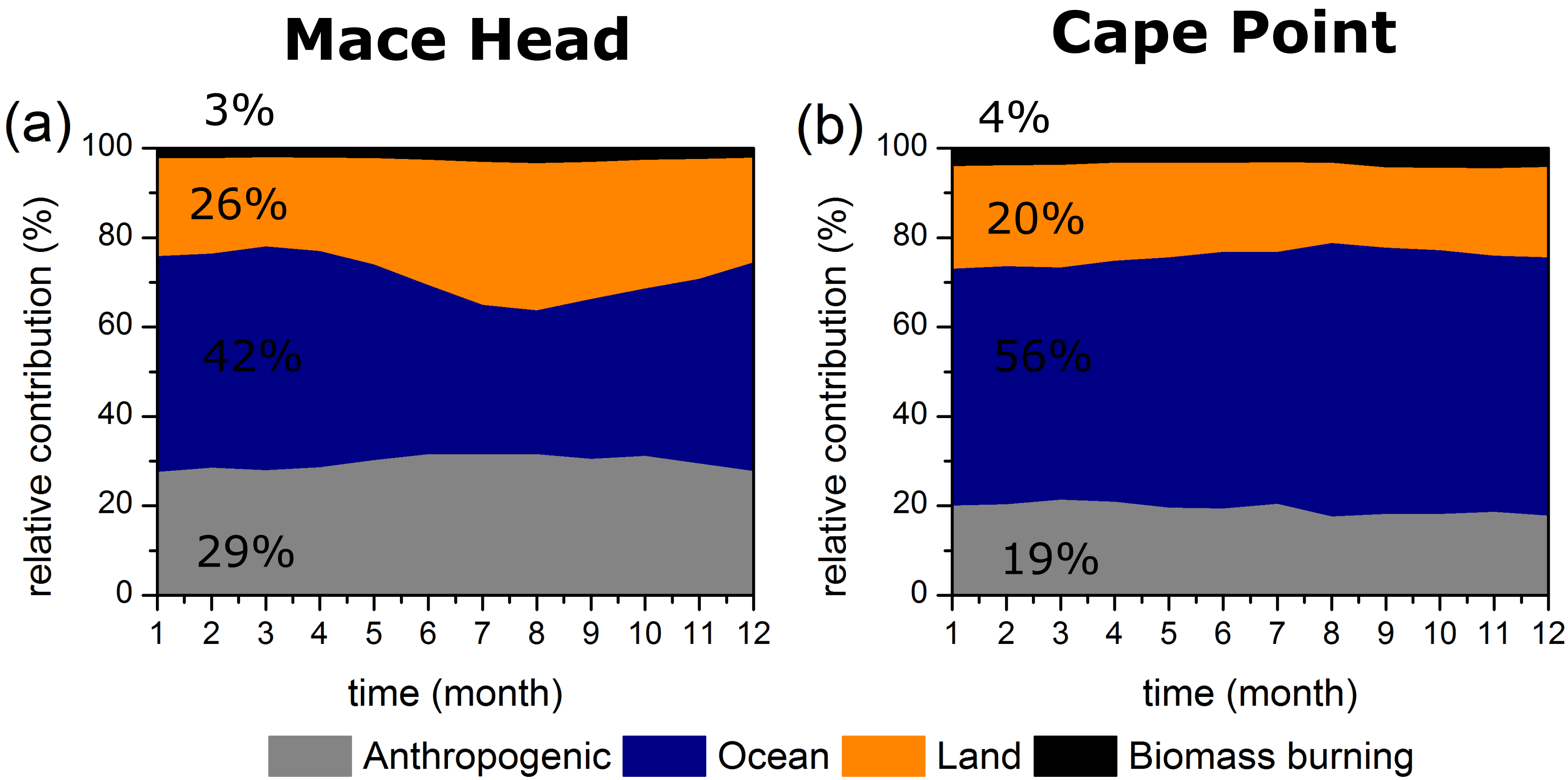


Global, 3D tropospheric chemistry model, 4x5 degree resolution, assimilated meteorology

[*Bey et al*., 2001]

Mercury simulation includes land-atmosphere-ocean coupling *(Selin et al., 2007, 2008; Strode et al., 2007; Holmes et al., 2010; Soerensen et al., 2010)*

What sources influence concentrations?

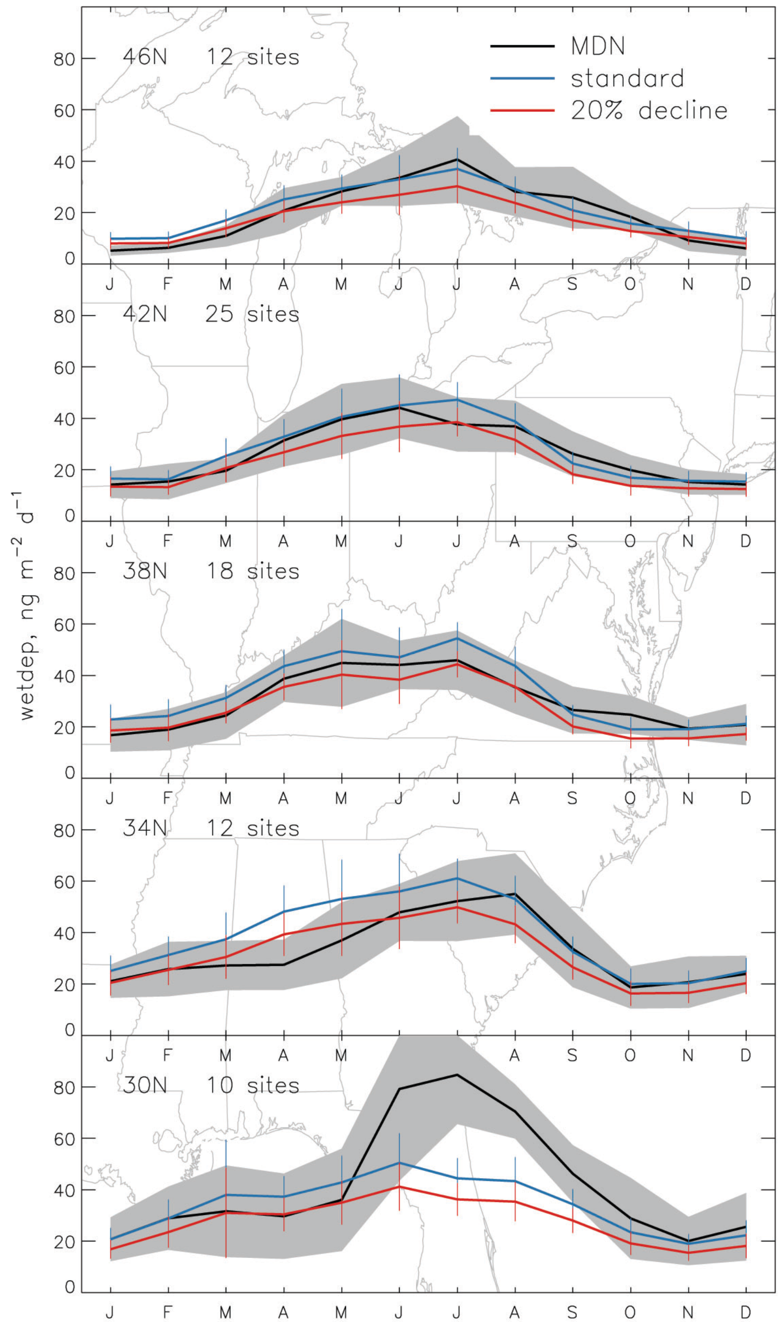


[Song and Selin, in prep]

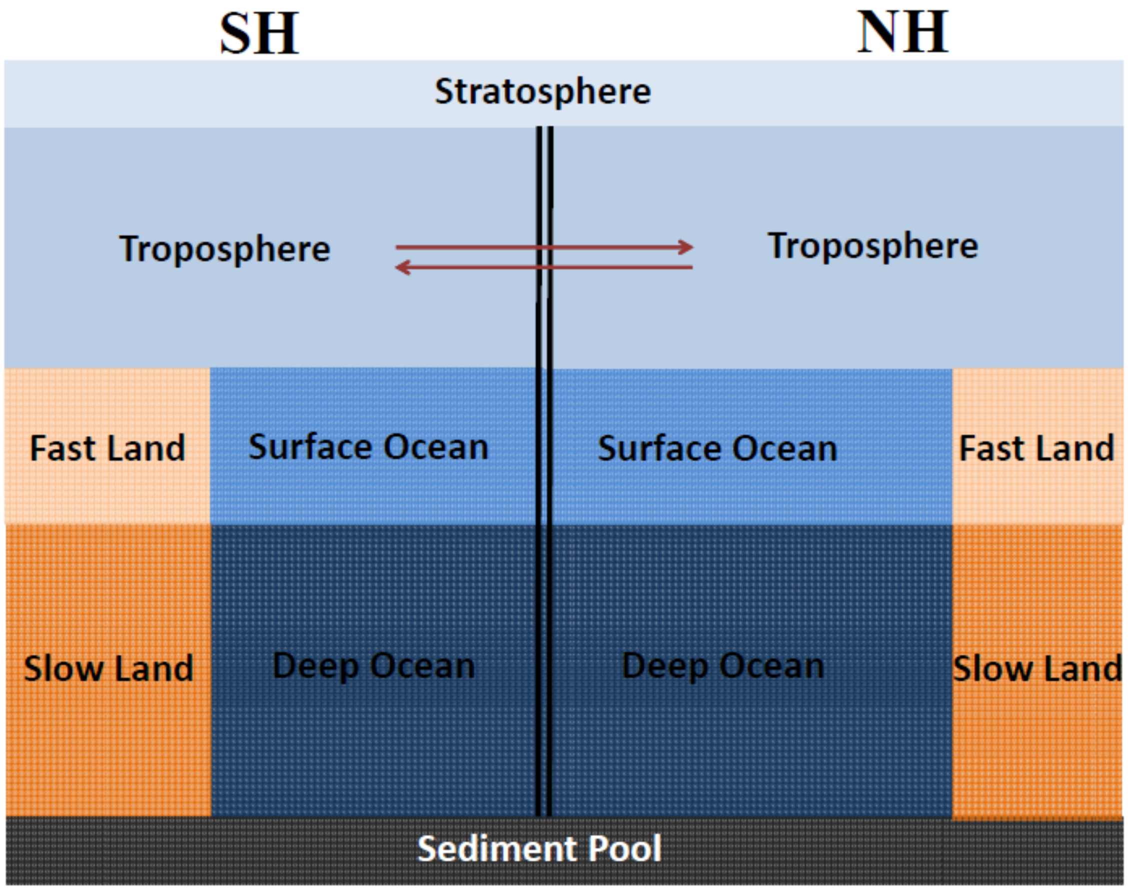
Wet deposition in E US

- **Decrease ocean/land/ anthropogenic emissions by 20%**
- **Average 1996-2009**
- **Mean wet deposition (ng m^{-2} d^{-1})**

1) standard: 30.9
2) 20% decline: 25.2



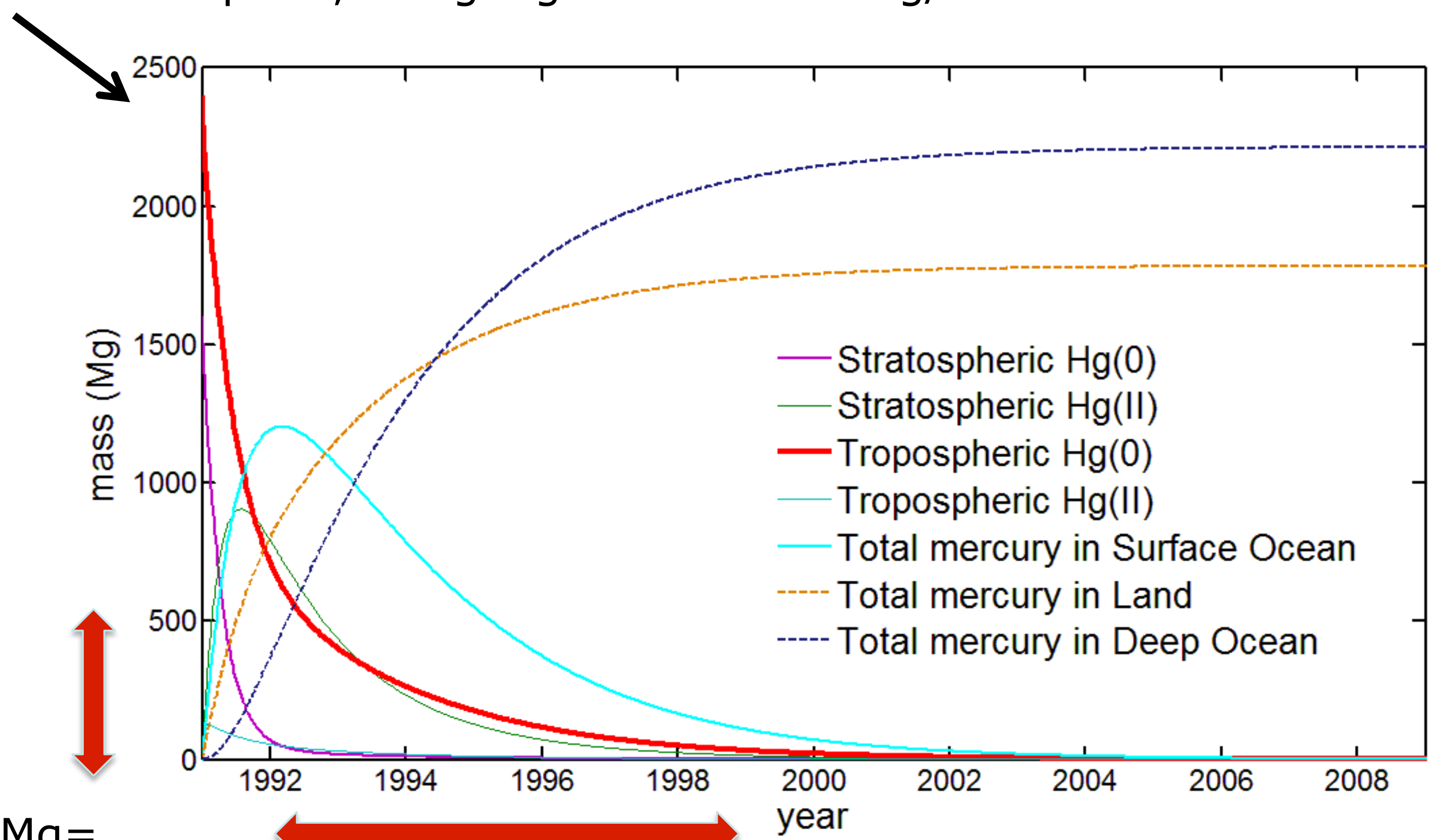
12-box Global Mercury Model



Focus on uncertainty in 3 parameters: anthropogenic emission, ocean evasion rate, oxidation rate

Interacting timescales complicate analysis

Pinatubo eruption, using high estimate of Hg/S ratio



500 Mg=
10% of total
tropospheric mass

Decrease over 7-8 years in troposphere

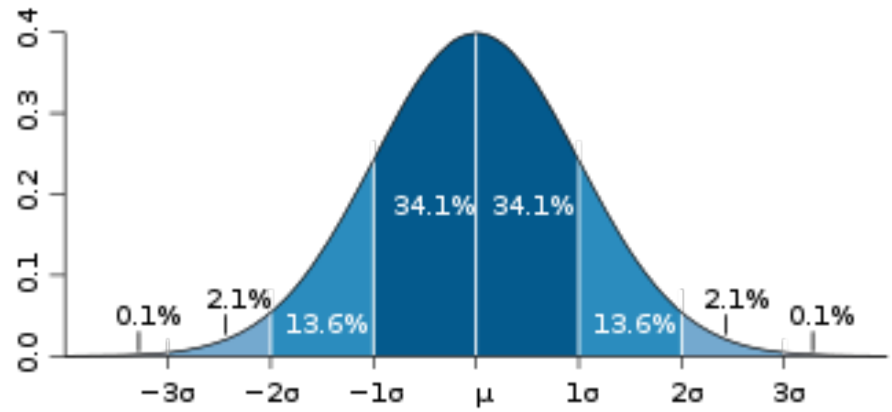
[Song and Selin in prep.]

Multi-factor analysis

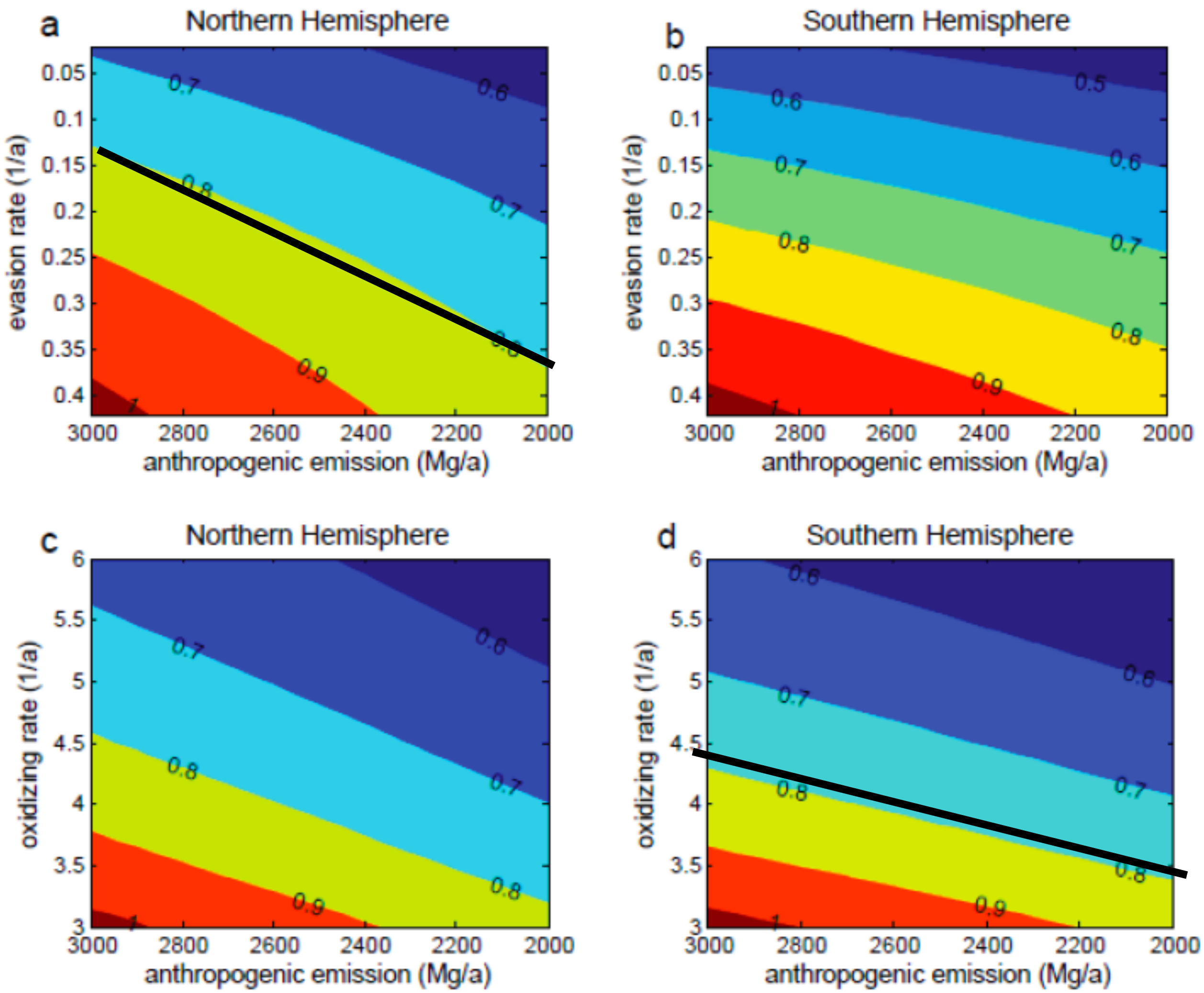
- **Multiple factors**
1) Anthropogenic emission
2) Ocean evasion
3) Atmospheric oxidizing rate ~ Lifetime

- **Constrain conditions**
1) $0.75 < N < 0.85$
2) $0.75 < S < 0.85$
3) $1.40 < N/S < 1.60$

- **2 Cases**
1) all $\sigma = 0.3$
2) $\sigma_1 = 0.3; \sigma_2 = 1.0; \sigma_3 = 1.0$

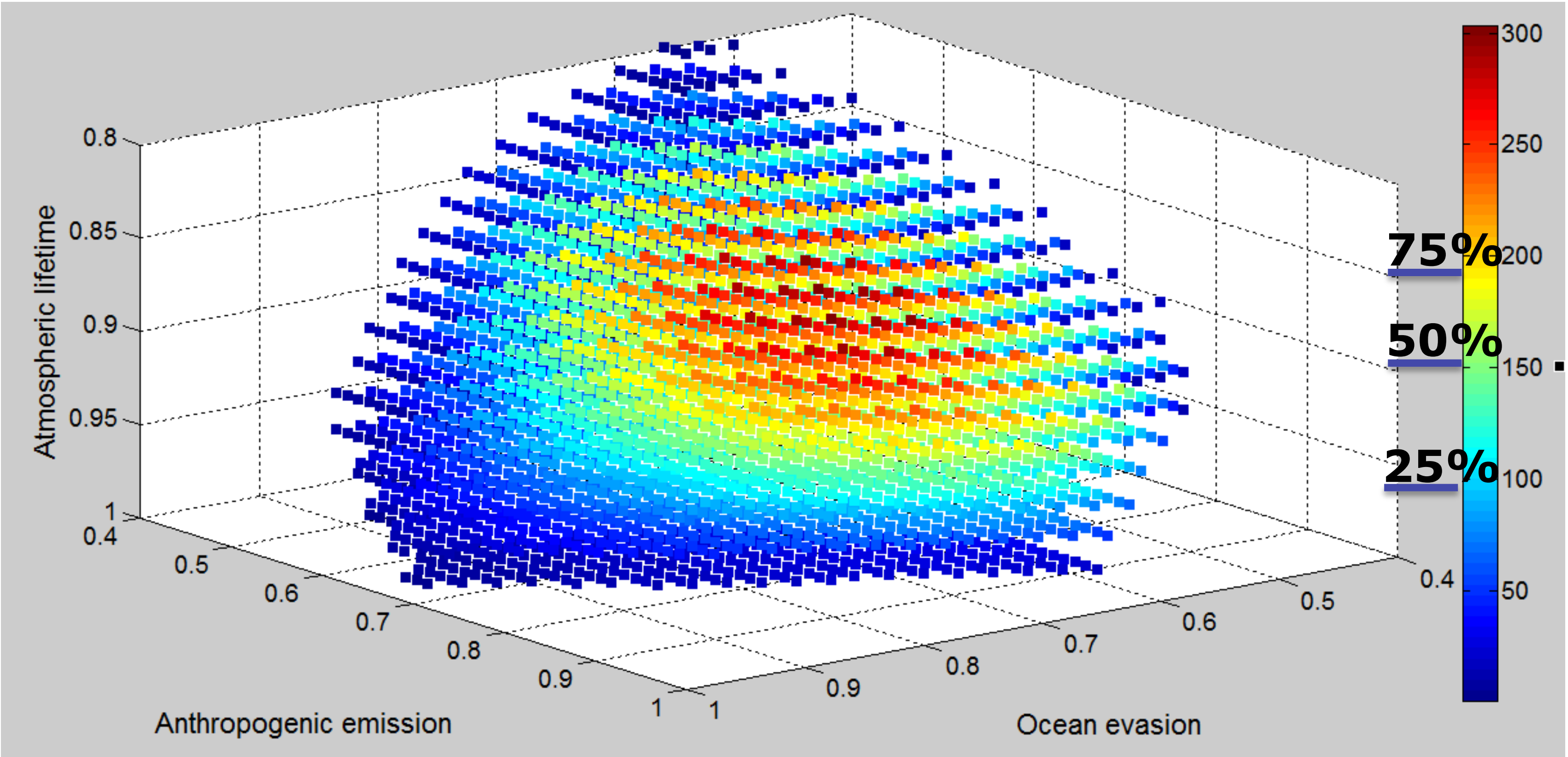


A combination of factors is most plausible

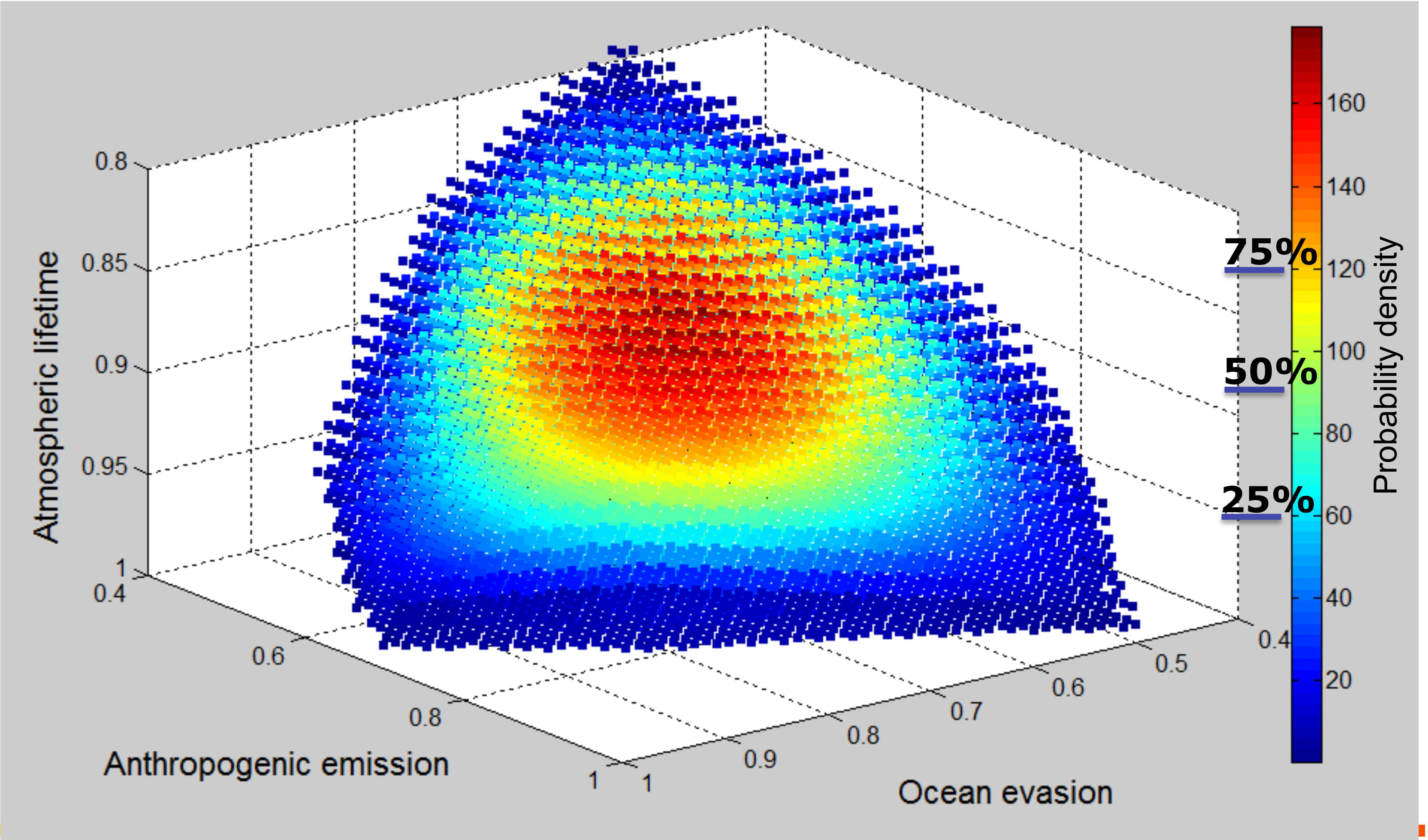


[Song and Selin, in prep]

Case 2: Standard deviation 30%

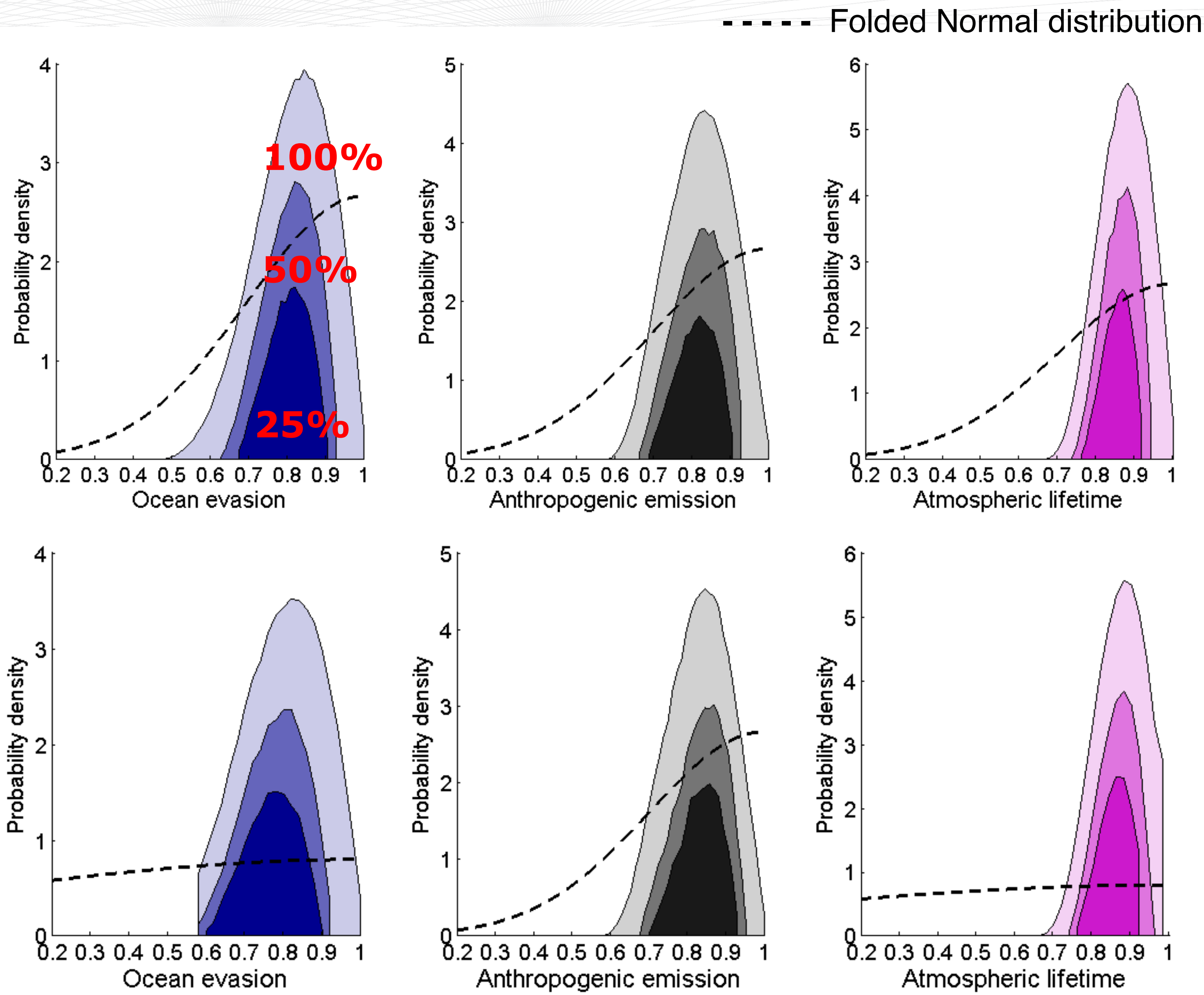


Case 1: Std Dev 100% for ocean, oxidation



Case 1

Case 2



Folded Normal distribution
100%
50%
25%
Probability density
Ocean evasion
Anthropogenic emission
Atmospheric lifetime
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Improving Knowledge of Policy Responses to Mercury Impacts

Research questions:

- ❑ How does scientific information inform global environmental policies?
- ❑ What are best practices for scientists and engineers to have an impact?

Negotiations for global mercury treaty began June 2010

Methods: Development of a "Mercury Game"– a negotiation simulation with dual goals:

- ❑ Understand the ways in which science is used in global policy
- ❑ Teach scientists and engineers about the process and how to participate

Play the game! http://mit.edu/mercurygame

You can download and play at home if you missed the short course yesterday!

With Leah Stokes, Lawrence Susskind