

What capabilities do we have for quantifying the relationship between atmospheric Hg deposition and human/biological mercury exposure?



**1. Emissions**



**2. Deposition**



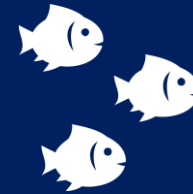
**3. Land**



**4. Ocean**



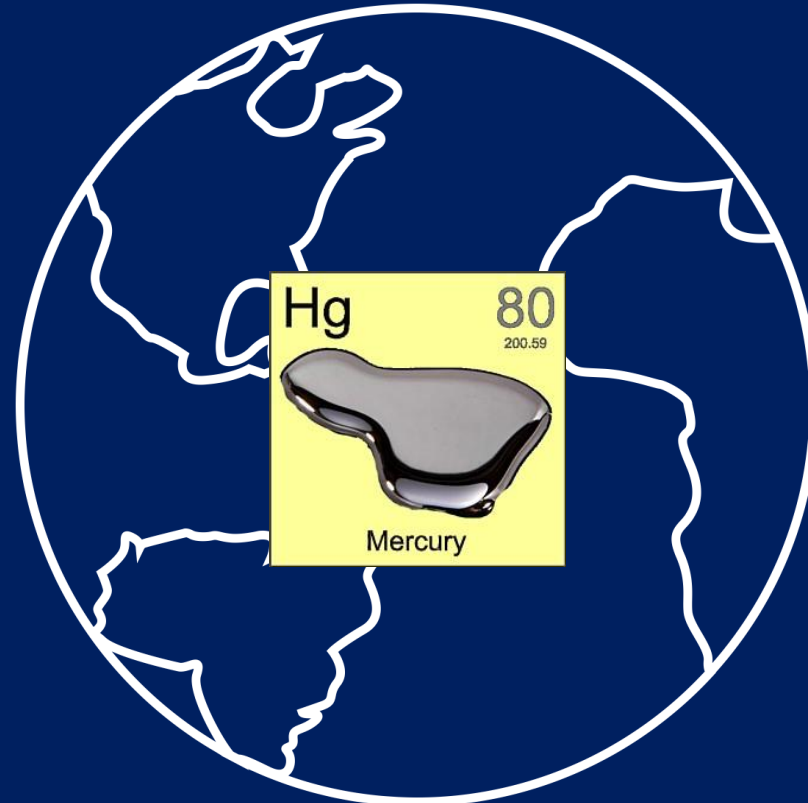
**5. Bioavailability**



**6. Food webs**

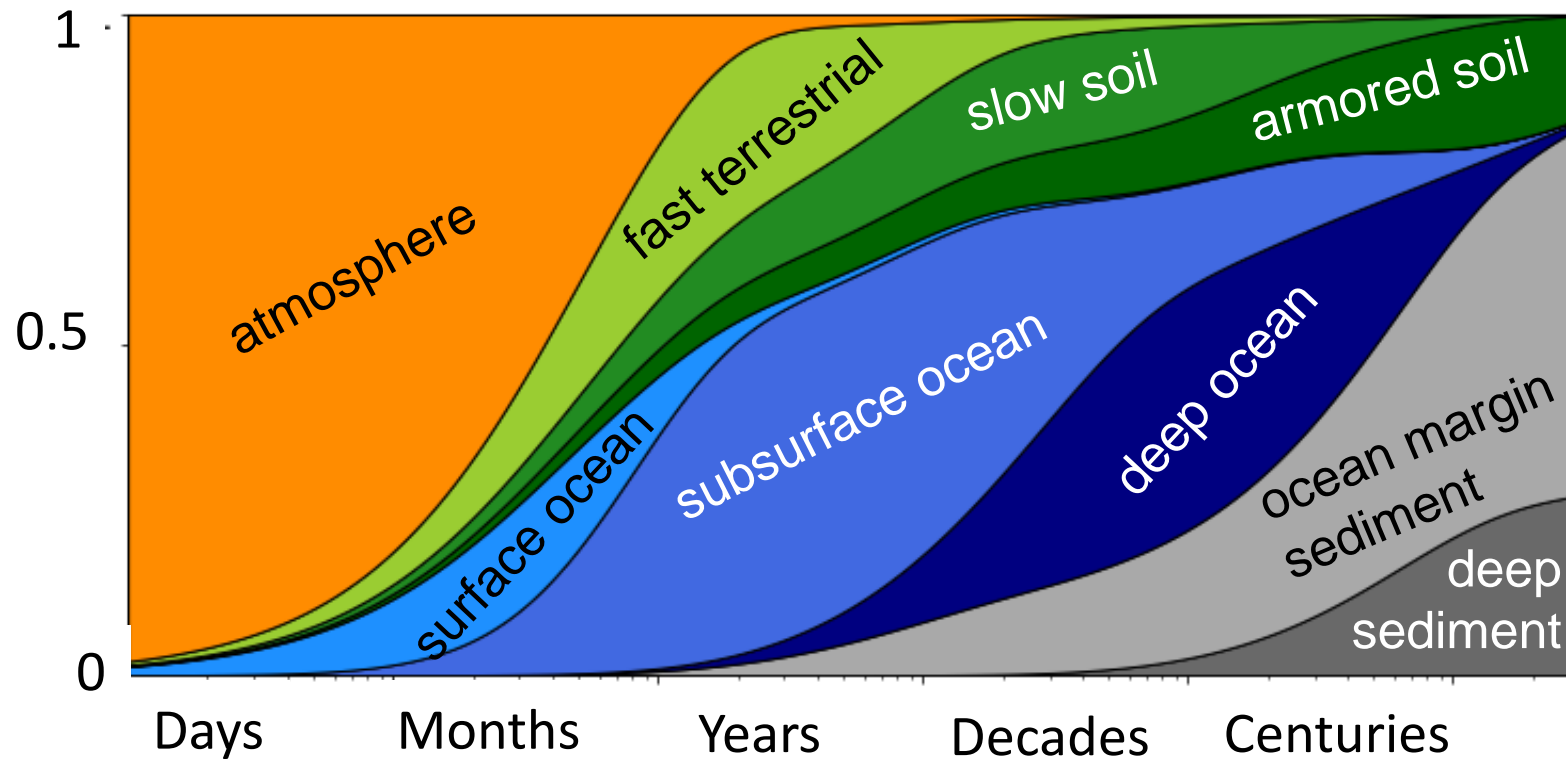


**7. Humans**



# Quantifying perturbations to the global Hg cycle requires that we understand their temporal evolution in different reservoirs

## Fate of a unit pulse of Hg to the atmosphere (eigenanalysis)



Time from initial perturbation

The lifetime of anthropogenic Hg in soils and the ocean ranges from years to millennia

# Global Biogeochemical Modeling (Harvard/MIT)



**GEOS-Chem (atmosphere)**

**North America**



Harvard  
(Sunderland/  
Jacob)



MIT  
(Selin)



Illinois  
(Horowitz)



UBC  
(Giang)



Holmes  
(FSU)

**China**



Nanjing U.  
(Y. Zhang)

**Australia**



Wollongong  
(Fisher)

**GTMM/  
CASA  
(terrestrial)**

**MITgcm with ecology  
(ocean)**

**LITHOSPHERE**

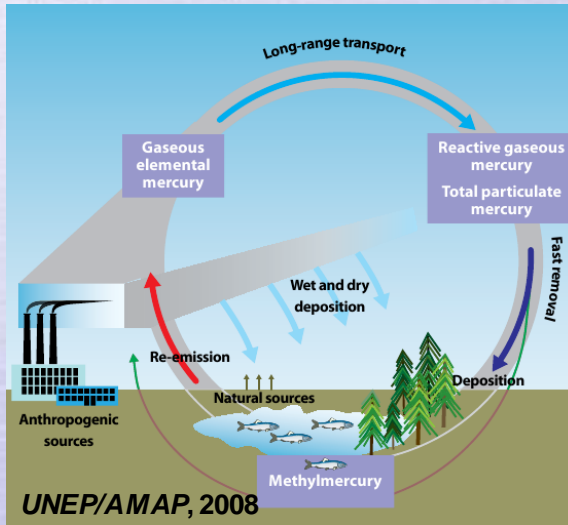


Biogeochemistry of  
Global Contaminants  
**HARVARD**

# Mercury multi-media modelling (GLEMOS)

## Initial development of multi-media modelling approach for Hg

### Hg cycling in the environment



Travnikov, MSC E  
(Russian Federation)

### Motivation:

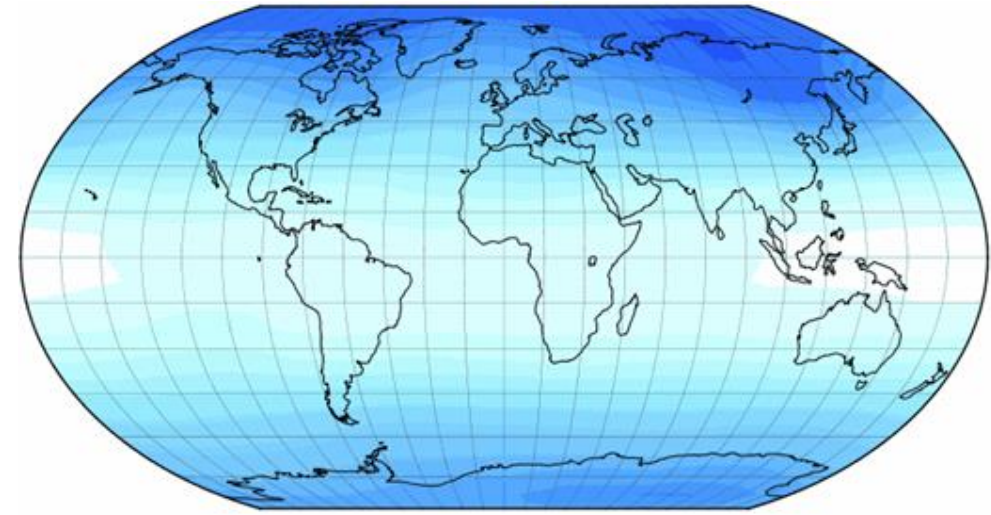
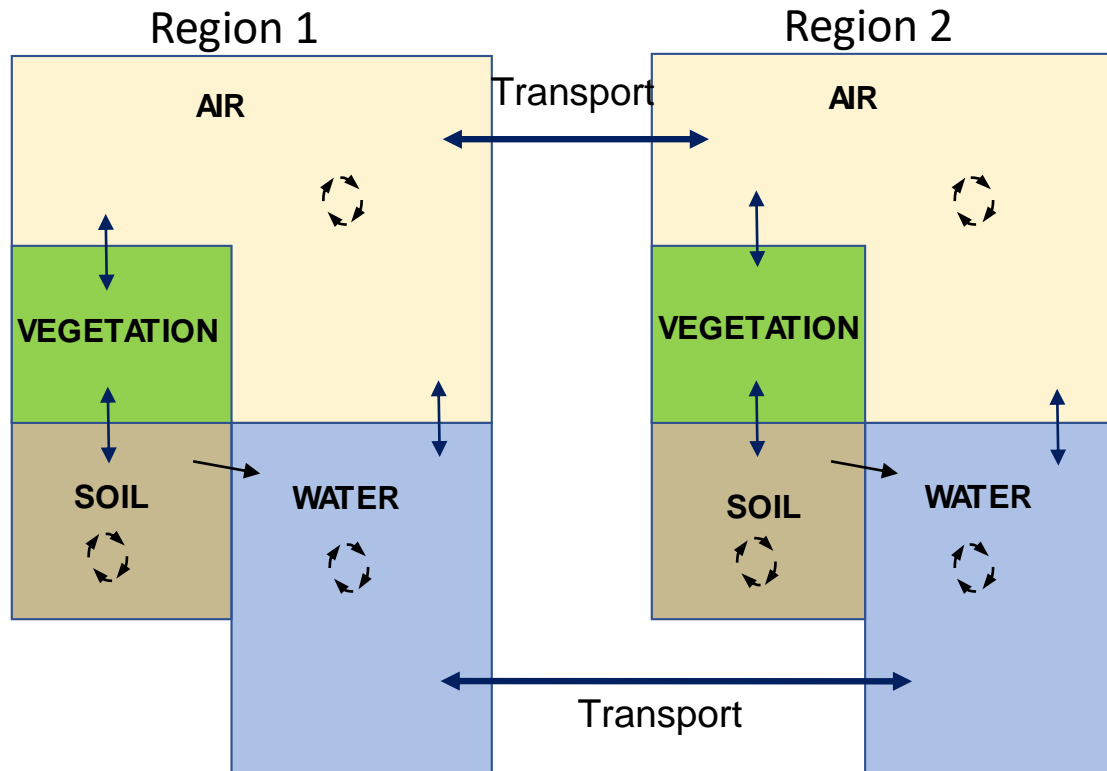
- Mercury easily cycles between the **atmosphere** and **water/soil/vegetation**
- **Legacy/natural sources** make up 65% of Hg deposition within EMEP
- **Delayed response** of Hg media content to emissions reduction

### On-going work:

- Development of **Hg media modules** for GLEMOS (ocean, soil, vegetation)
- Assessment of **long-term Hg accumulation** in media since pre-industrial times
- Evaluation against **observations**

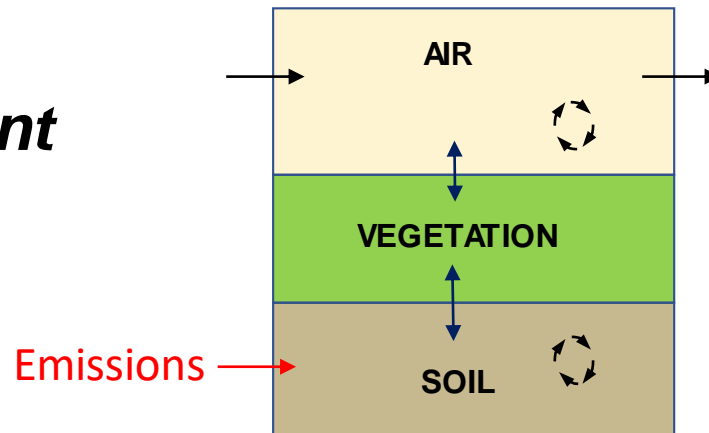
# WorM3: World Multimedia Mercury Model

Asif Qureshi et al. *Global Biogeochemical Cycles*.  
Doi: 10.1029/2011GB004068 (2011)



- Based on BETR-Global (global POPs modeling)
- Yearly-scale assessments
- $15^\circ \times 15^\circ \rightarrow 3.75^\circ \times 3.75^\circ$

## Variation: *Regional Assessment*



Asif Qureshi, K. Subhavana (2020)  
Multimedia Mercury Cycling in a Legacy Contaminated  
Tropical Montane Forest...Implications for Monitoring  
and Assessment of Future Contaminated Regions.  
*J. Hazard. Toxic Radioact. Waste*, 24(4): 05020002.

# MARINE MERCURY MODELING

## Current status and future plans

We developed a novel multi-compartment model for mercury cycling in the marine environment:

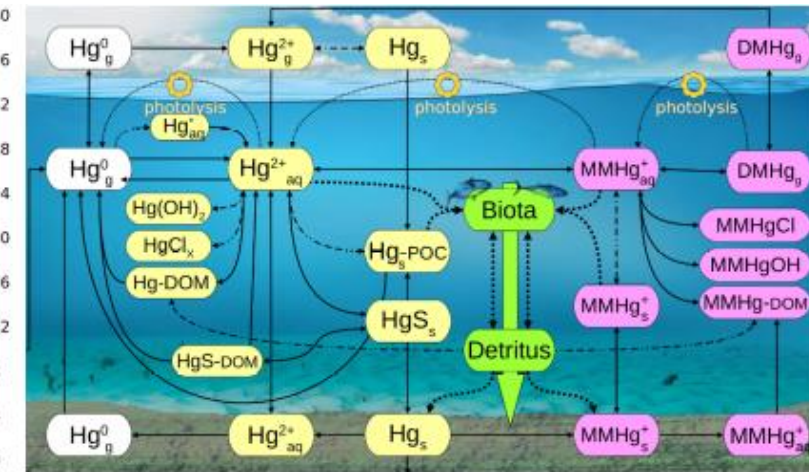
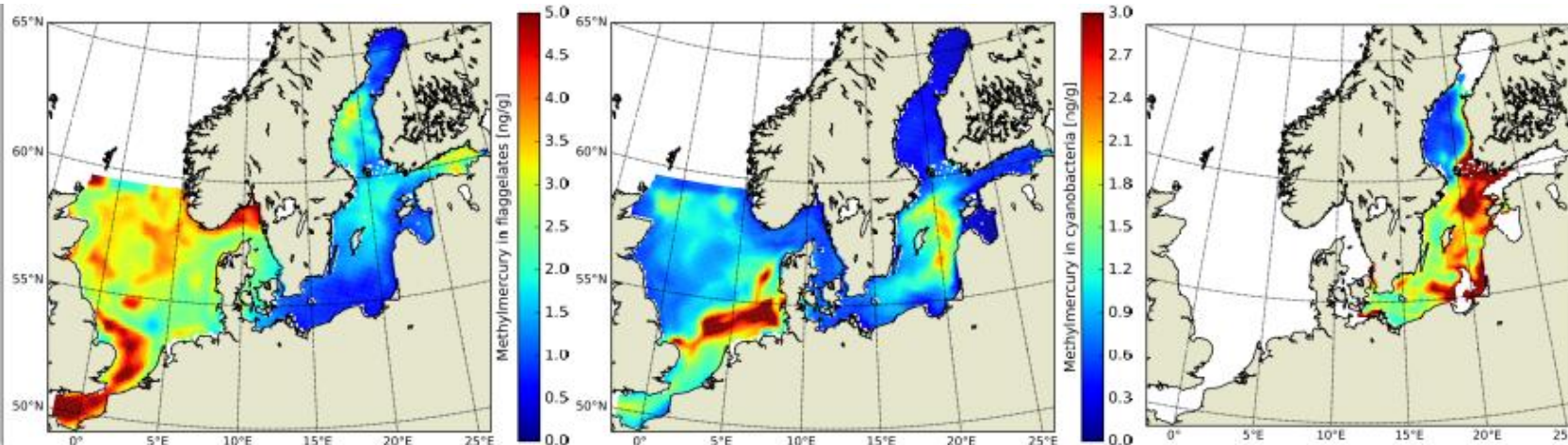
- Includes transport, transformation, and bio-accumulation of Hg and MeHg
- Generalized NPZD ecosystem model with 3 phytoplankton and 2 zooplankton species
- A simple closure term for higher trophic levels



Bieser (HMZ, Germany)

Future plans:

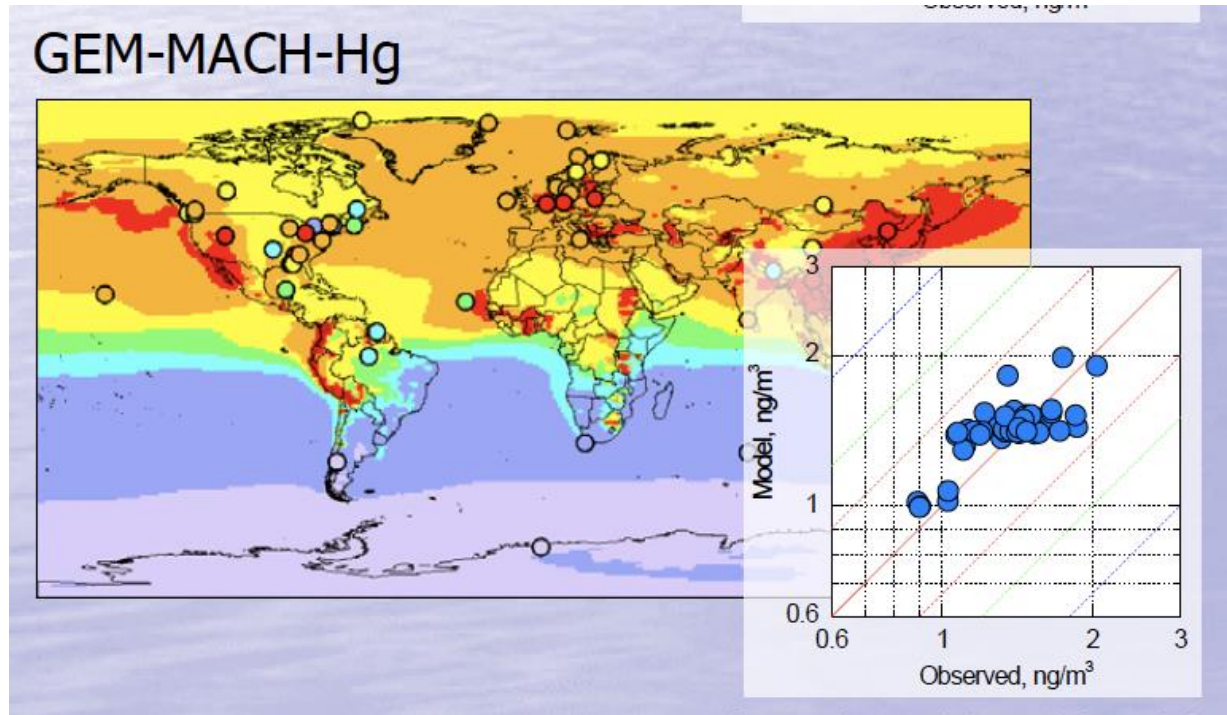
- Apply and evaluate the model for different ocean basins
- Include higher trophic levels (fish), fish migration, and more complex ecosystems
- Implement bacteria into the ecosystem to investigate biotic methylation processes



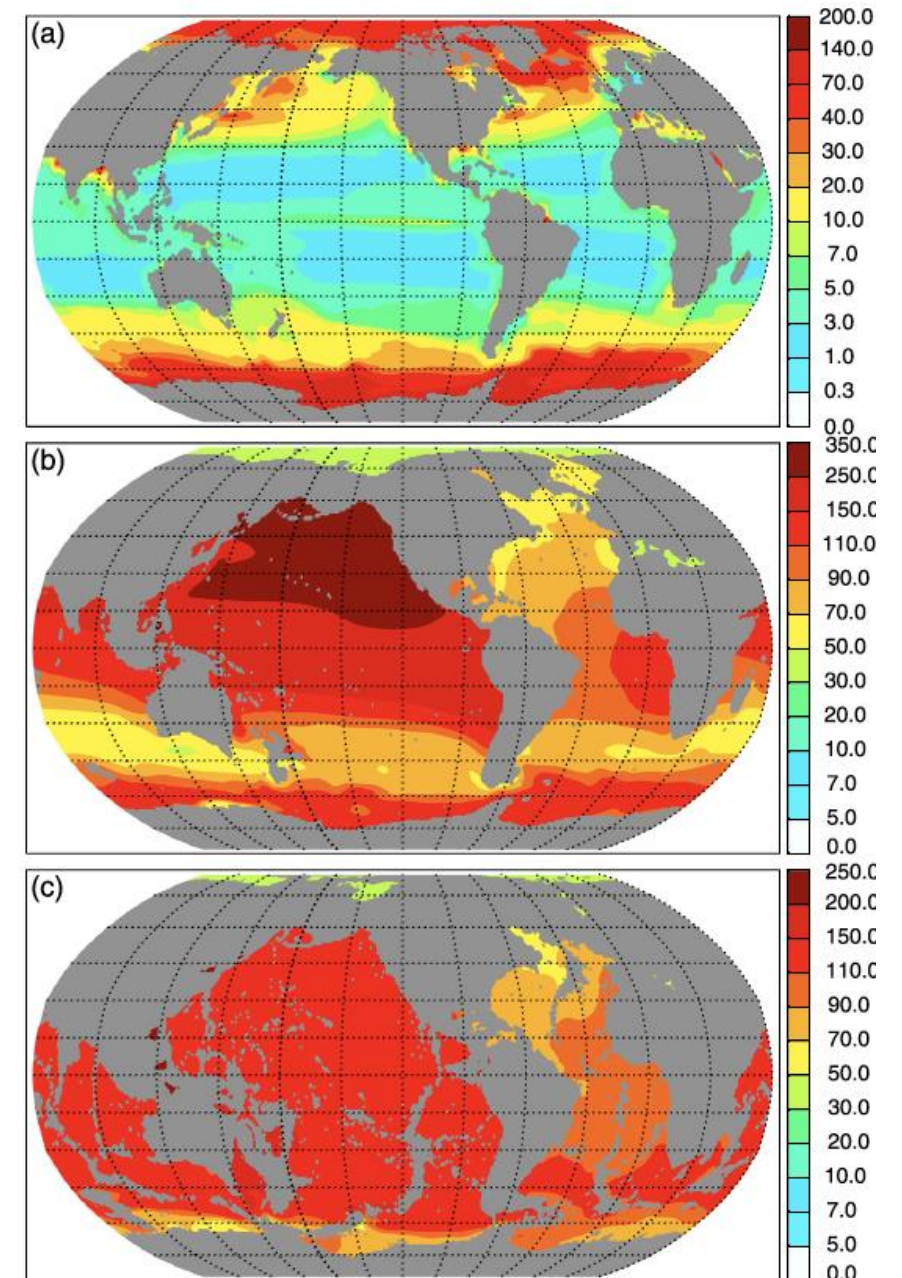
# GEM-MACH-Hg



Environment and Climate Change Canada (Dastoor)



Semeniuk and Dastoor, 2017, Global Biogeochemical Cycles



**Figure 4.** Horizontal slices of MeHg<sup>T</sup> concentration (fM) at various depths: (a) base of mixed layer, (b) 1033 m, and (c) 3257 m.

# Summary

- Emerging capability for global biogeochemical modeling for Hg in many countries
- Many examples in the peer-reviewed literature already
- Focus now is on marine, terrestrial modeling at the global scale
- Some large-scale studies linking to marine fish and ecosystem scale biotic endpoints
- Links to human populations in a meaningful way requires information on their consumption preferences