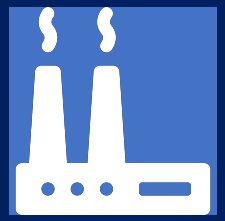
Multimedia modeling for Hg: What can we do between 2021-23?

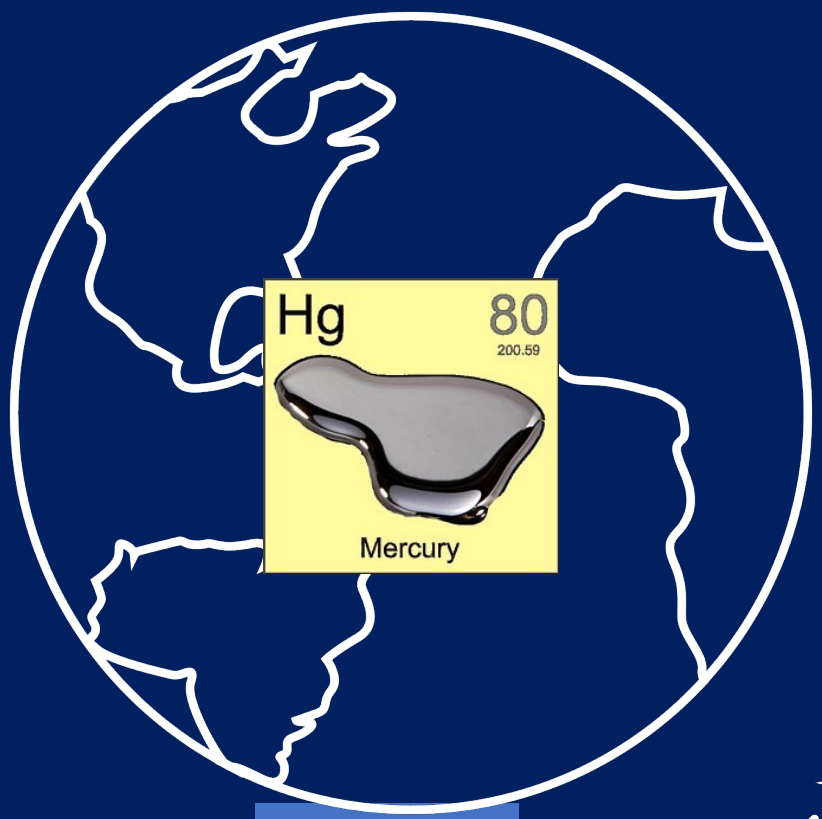
Proposal: Initial focus on comparison of contemporary terrestrial-atmospheric and atmospheric-oceanic exchanges



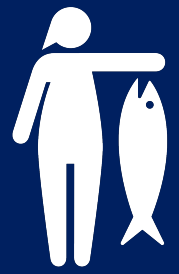
1. Emissions

2. Deposition

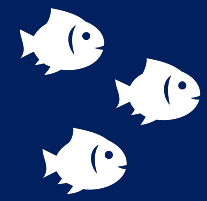
3. Land



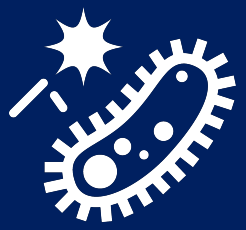
4. Ocean



7. Humans



6. Food webs



5. Bioavailability

Biogeochemistry of Global Contaminants
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Contemporary (ca. 2015) comparison of gross terrestrial and oceanic emissions by major regions to parallel atmospheric intercomparison

Available models and potential research groups (please suggest others)

USA:

GEOS-Chem (MIT, Selin)

MITgcm, GTMM (Harvard, Sunderland)

Canada:

GEM-MACH-Hg (ECCC, Dastoor)

Europe:

HERMES (?) (HZG, Bieser)

Russia:

GLEMOS (MSC E, Travnikov)

China:

MITgcm (Nanjing U., Zhang)

India:

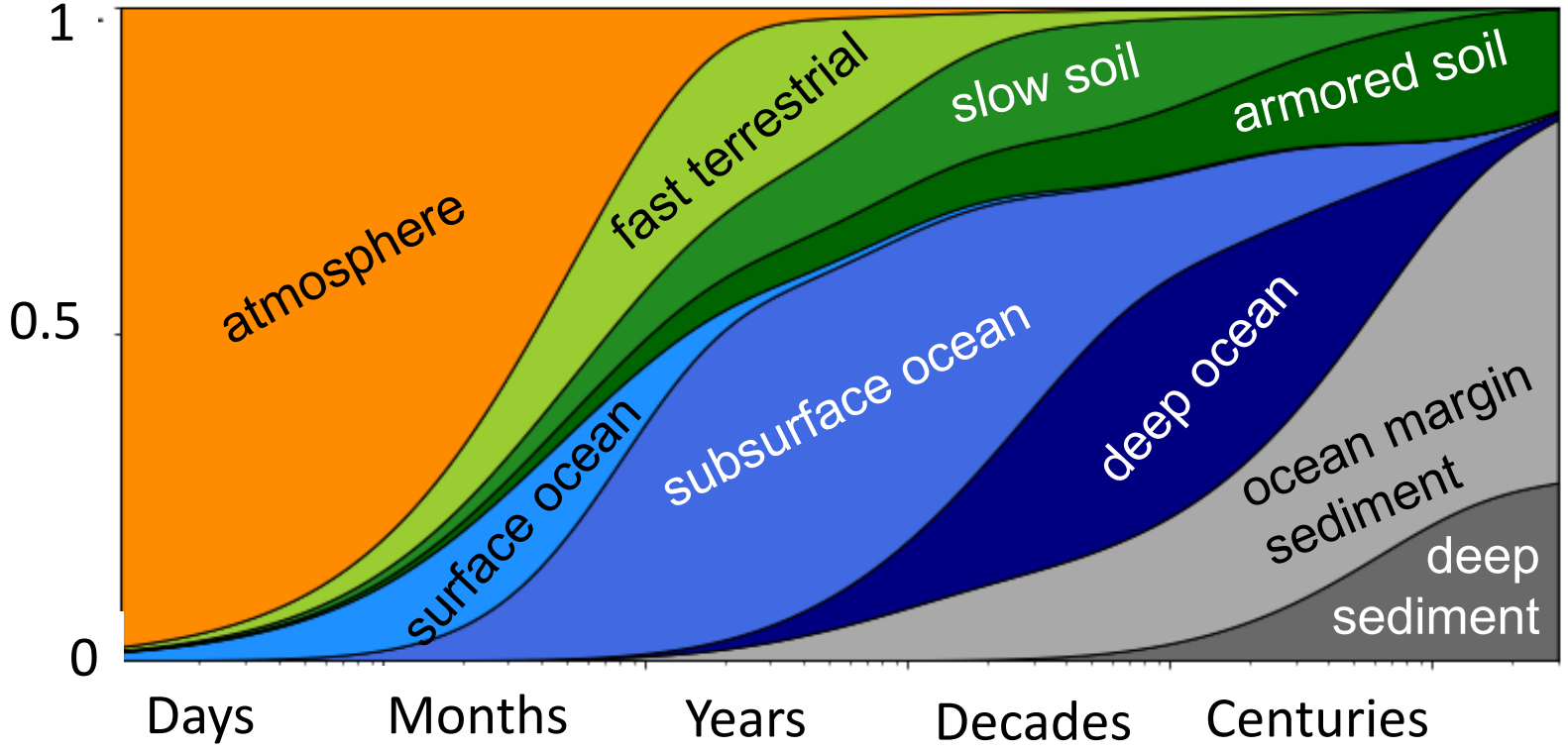
WorM3 (IIT, Qureshi)

Japan:

FATE-Hg (NIES, Suzuki)

For 30+ year simulation: Need to think about changes in legacy reservoirs

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



Biogeochemistry of Global Contaminants
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Time from initial perturbation

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

Amos et al., 2013; 2014; 2015

For longer simulations:
Need historical emissions & characterization of uncertainty

All-time emissions to the atmosphere, land and water

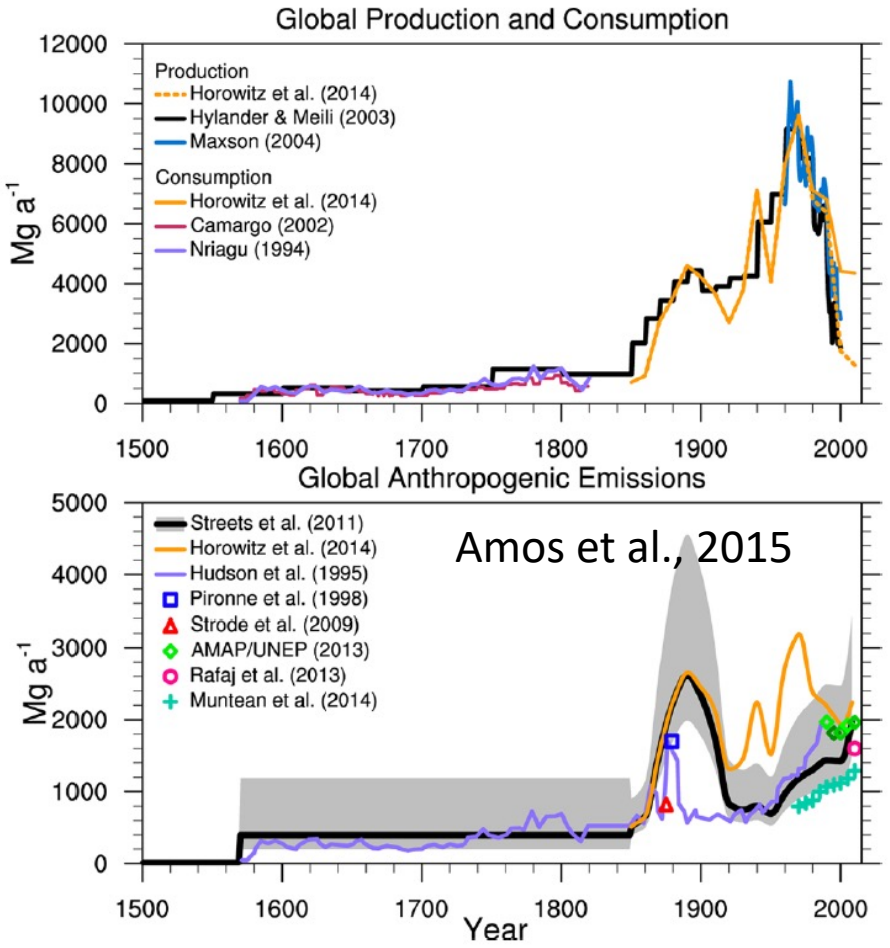
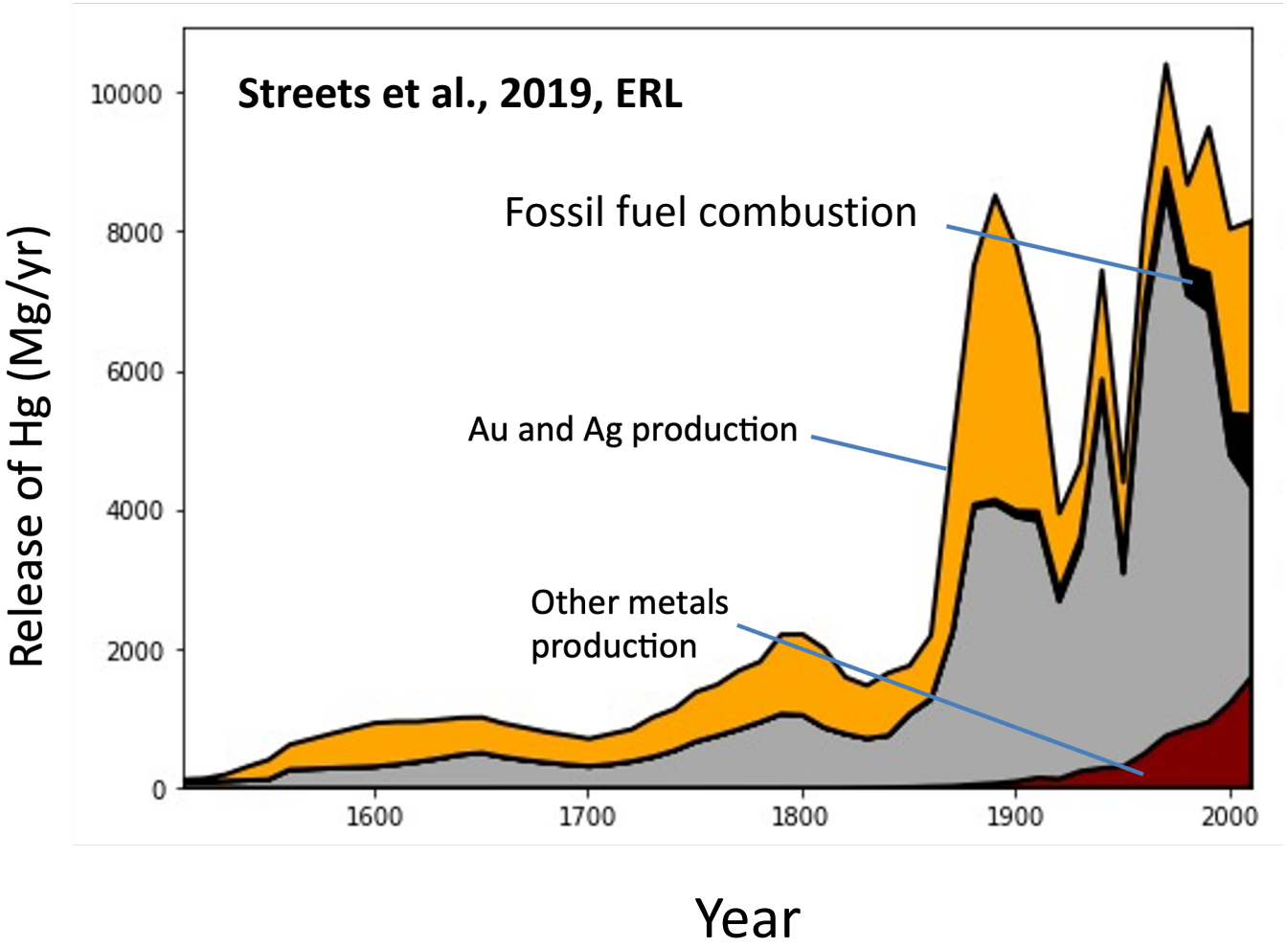


Figure 1. Published estimates of global Hg production and consumption (top panel) and primary anthropogenic emissions of Hg to the atmosphere (bottom panel).[19,20,22–25,27,28,121–123,125]



Plausible parameter space is greatly reduced in a fully coupled simulation

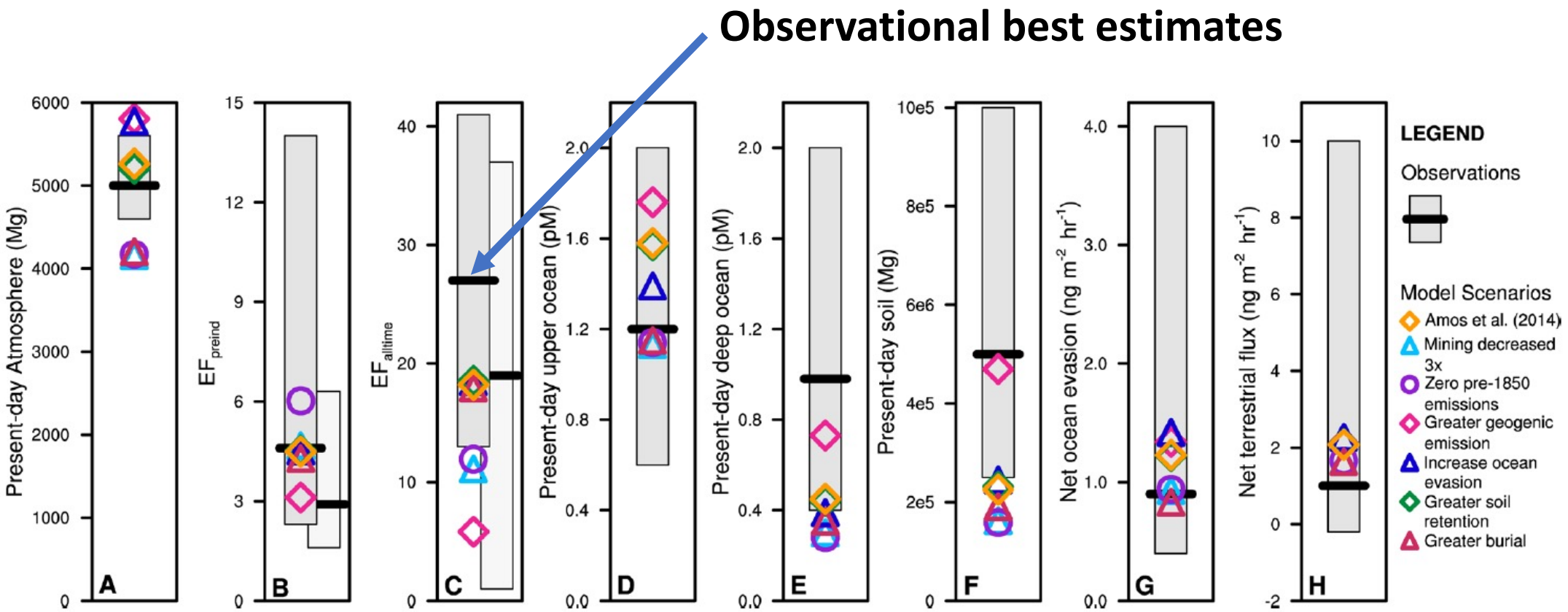


Figure 3. Observational constraints (gray bars) on model sensitivity simulations (symbols). Thick black horizontal lines indicate the observational mean or best estimate and median ±95% confidence intervals for panel B (see text). For panels B and C, EFs from peat are shown as the darker gray bar and lighter gray bar for lake sediments. Table 1 describes each model scenario. For archives, EF_{preind} = the ratio of mean Hg accumulation rate from the extended 20th century maximum ("20Cmax") relative to pre-industrial (1760 to 1880) and $EF_{alltime}$ is the ratio 20Cmax relative to pre-large-scale mining (3000 BC to 1550 AD). Model EFs are calculated from atmospheric deposition, and 20Cmax is taken as 1950 to 1975 based on peak emissions in Horowitz et al.[20] (Figure 1).

Amos et al., 2015

Summary

- Emerging capability for global biogeochemical modeling for Hg in many countries
- Many examples in the peer-reviewed literature
- Contemporary intercomparison of air-sea and atmospheric-terrestrial fluxes seems very doable in next two years
- Historical simulations and fully coupled modeling across groups would require more effort but offer the opportunity to reduce uncertainty in the global budget