Effects of ocean biogeochemistry on the fate of riverine mercury in the Arctic and global oceans

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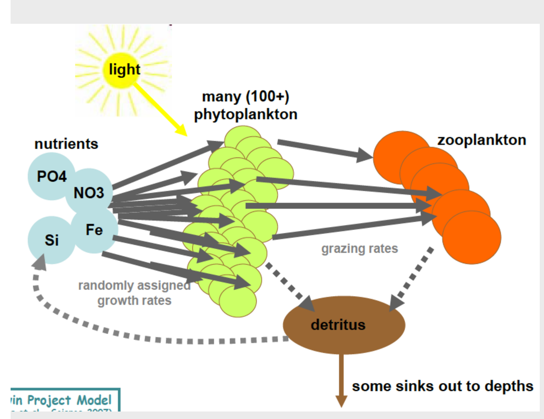
1. Introduction

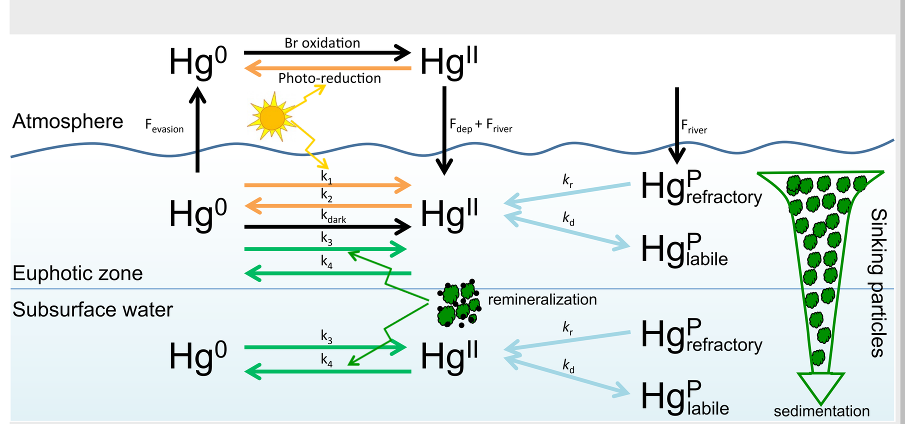
- Rivers discharge 28 ± 13 Mmol a^{-1} of Hg to the ocean, comparable to inputs from global atmospheric deposition (10 - 29 Mmol a^{-1}).
- Differences in the geochemical forms of Hg affect removal from the water column, redox processes, and bioavailability for methylation.
- Large spatial heterogeneity exists for riverine Hg discharge and its transport in the ocean.
- We use a 3-D model for oceanic Hg to investigate how ocean transport and interactions between Hg and natural organic matter affect the fate of river-derived Hg.
- We determine if the large observed summertime evasion from the Arctic Ocean can be reconciled with a smaller riverine source.

2. Model Description

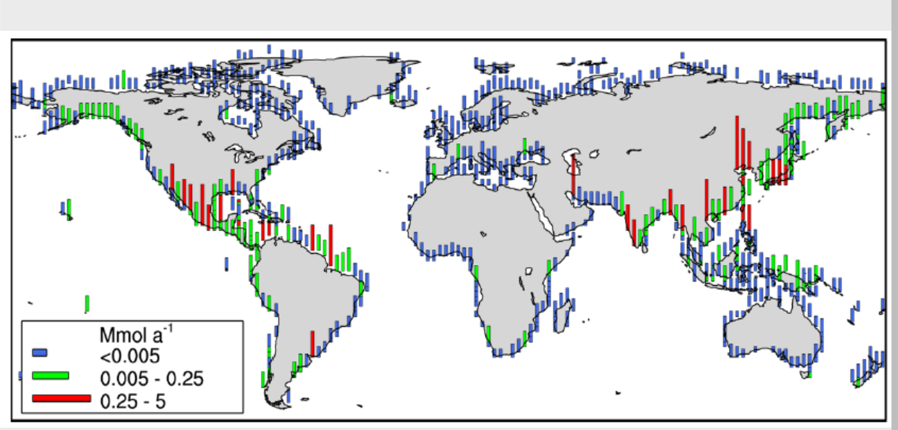
- A new oceanic Hg simulation with the MITgcm.
- 36 km resolution and 50 vertical layers for the Arctic Ocean.
- 1°×1° resolution and 23 vertical levels elsewhere.



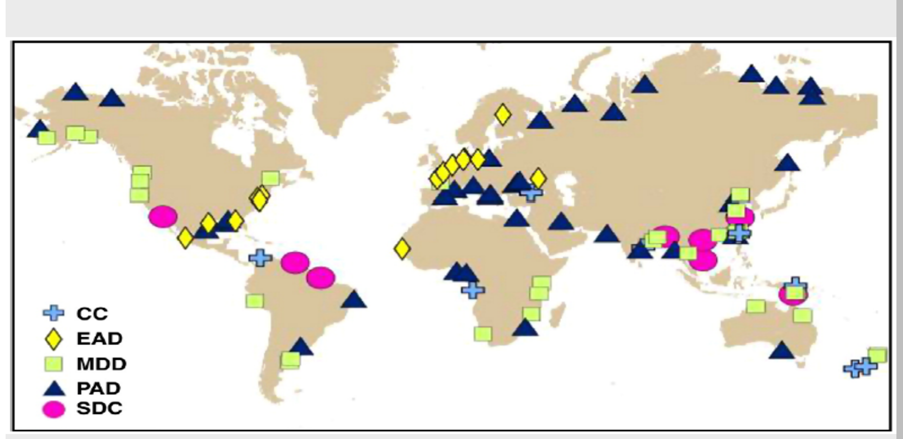
- Coupled with the biogeochemical cycle of organic carbon and associated marine plankton ecosystem (the DARWIN project; Dutkiewicz et al., 2009).



- Three forms of Hg: elemental Hg (Hg^0), divalent Hg (Hg^{II}) and particle-bound Hg (Hg^P).
- Divide Hg^P into labile and refractory pools.
- Hg biogeochemistry following Zhang et al. (2014).

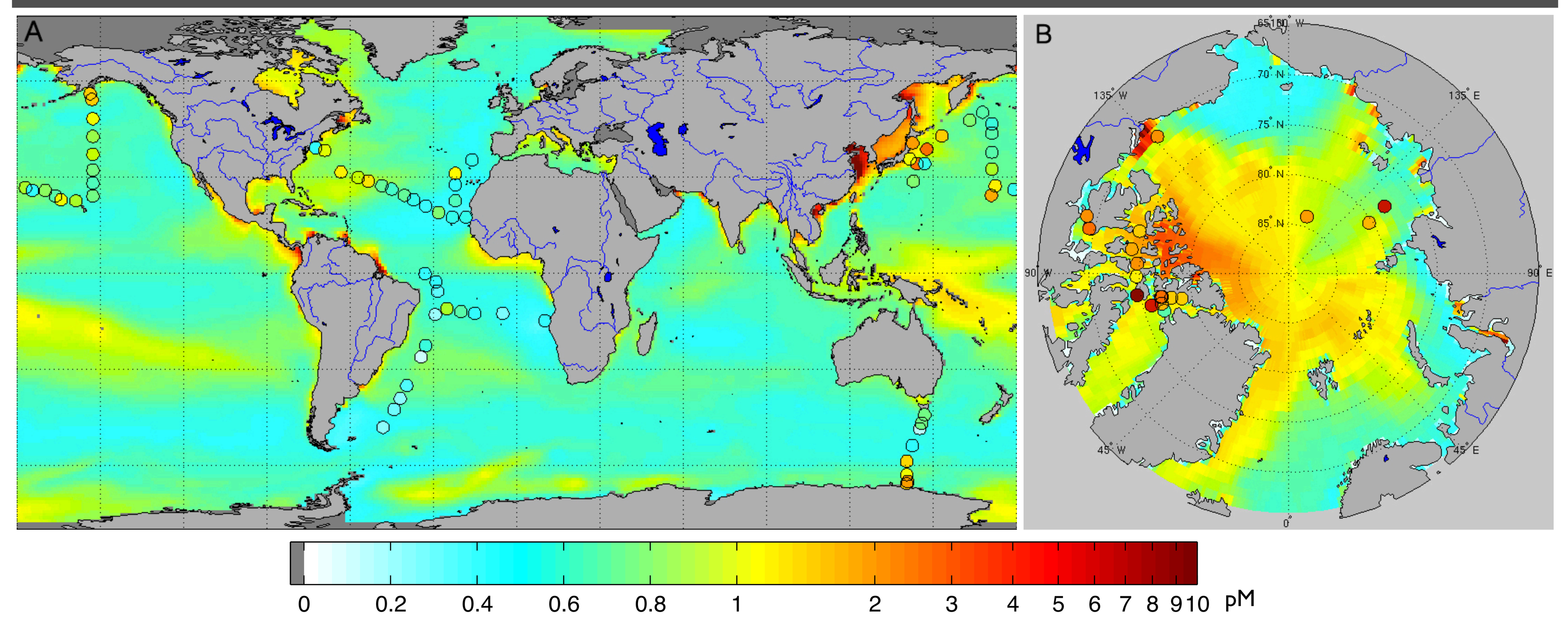


- Present-day river inputs based on Amos et al. (2014).
- Hg^{II}: 0.87±0.29 Mmol a^{-1}, Hg^P: 27±13 Mmol a^{-1}.
- Fraction of $Hg^P_{refractory}$ depends on suspended load (Blair and Aller, 2012).



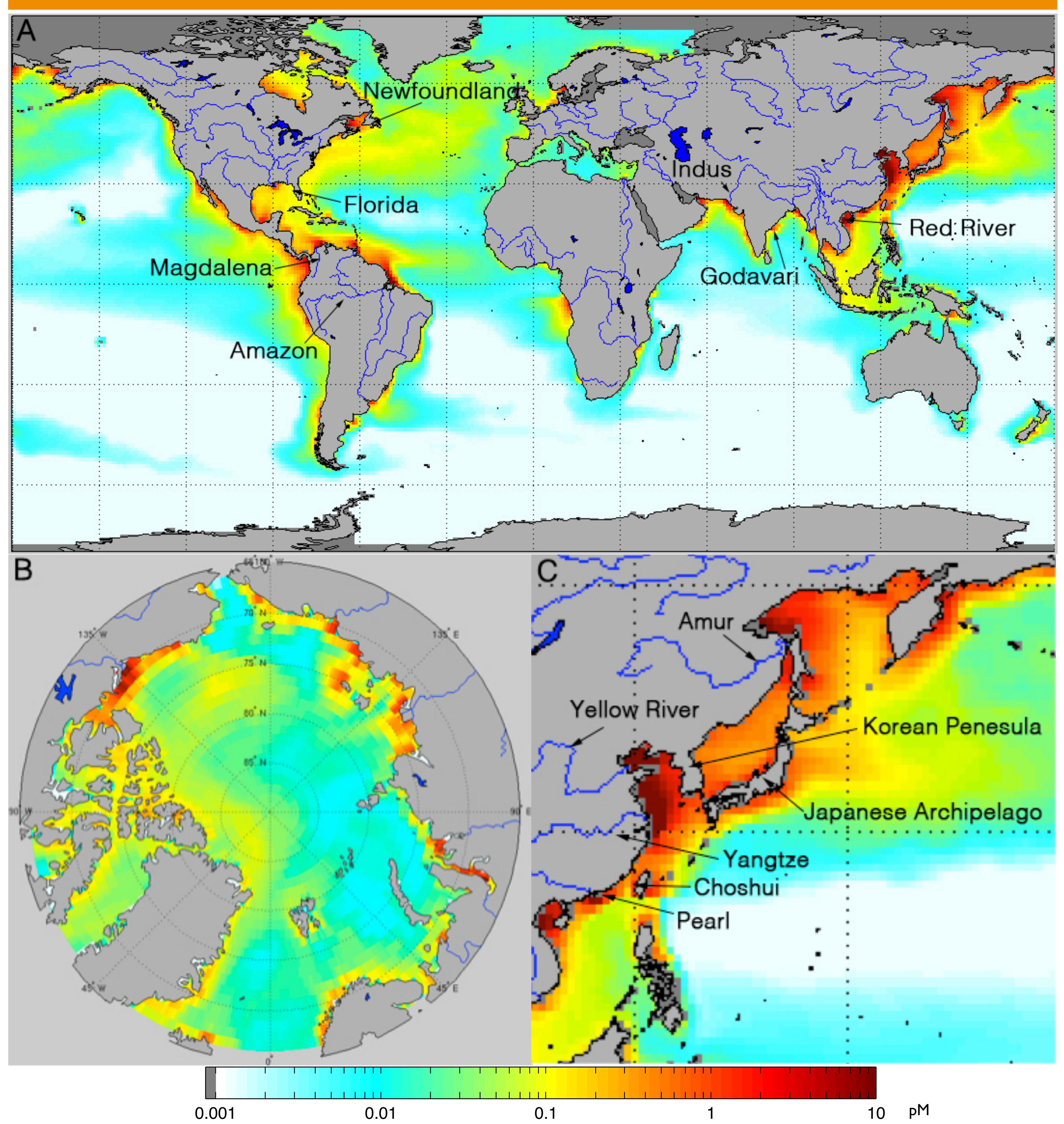
- Burial of riverine particles in estuarine sediments using the typology system developed by Walsh and Nittrouer (2009).
- Different fractions (10-60%) of sediment exported beyond the estuarine environment.

3. Model Evaluation



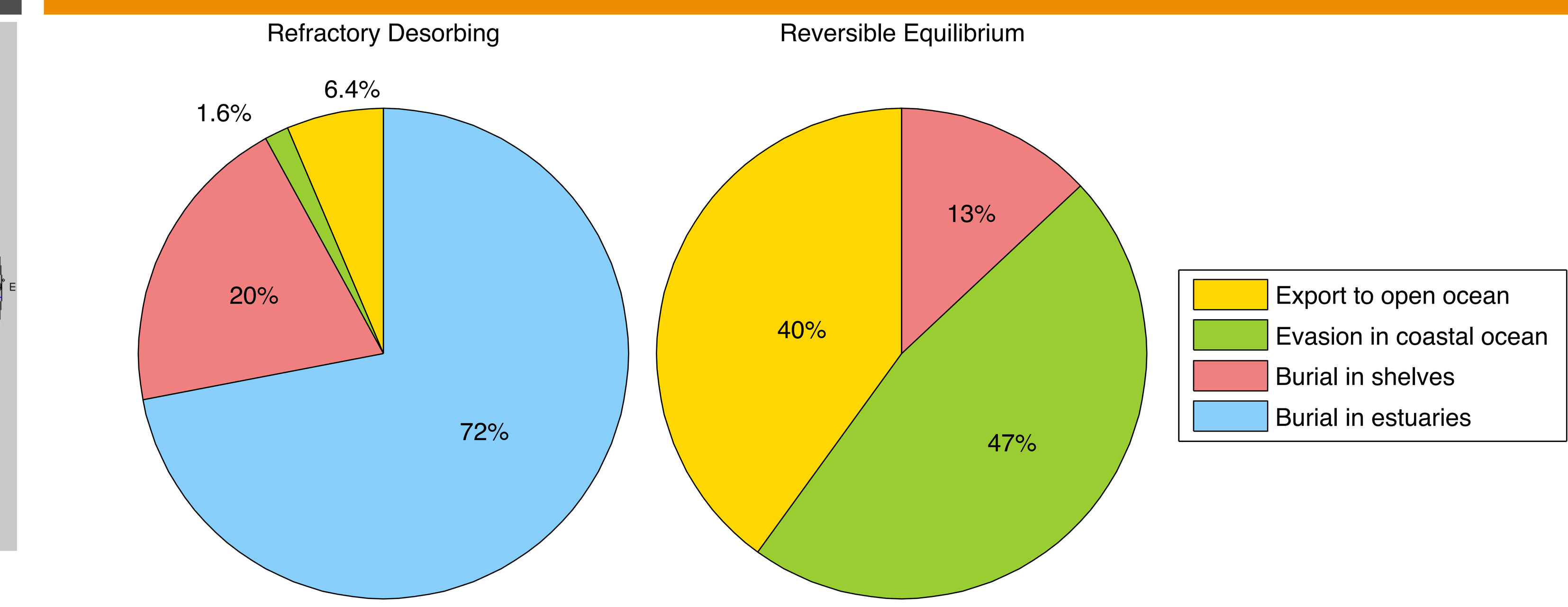
- The model reasonably reproduces observed spatial patterns of surface ocean total Hg concentrations.

5. River signal in the ocean



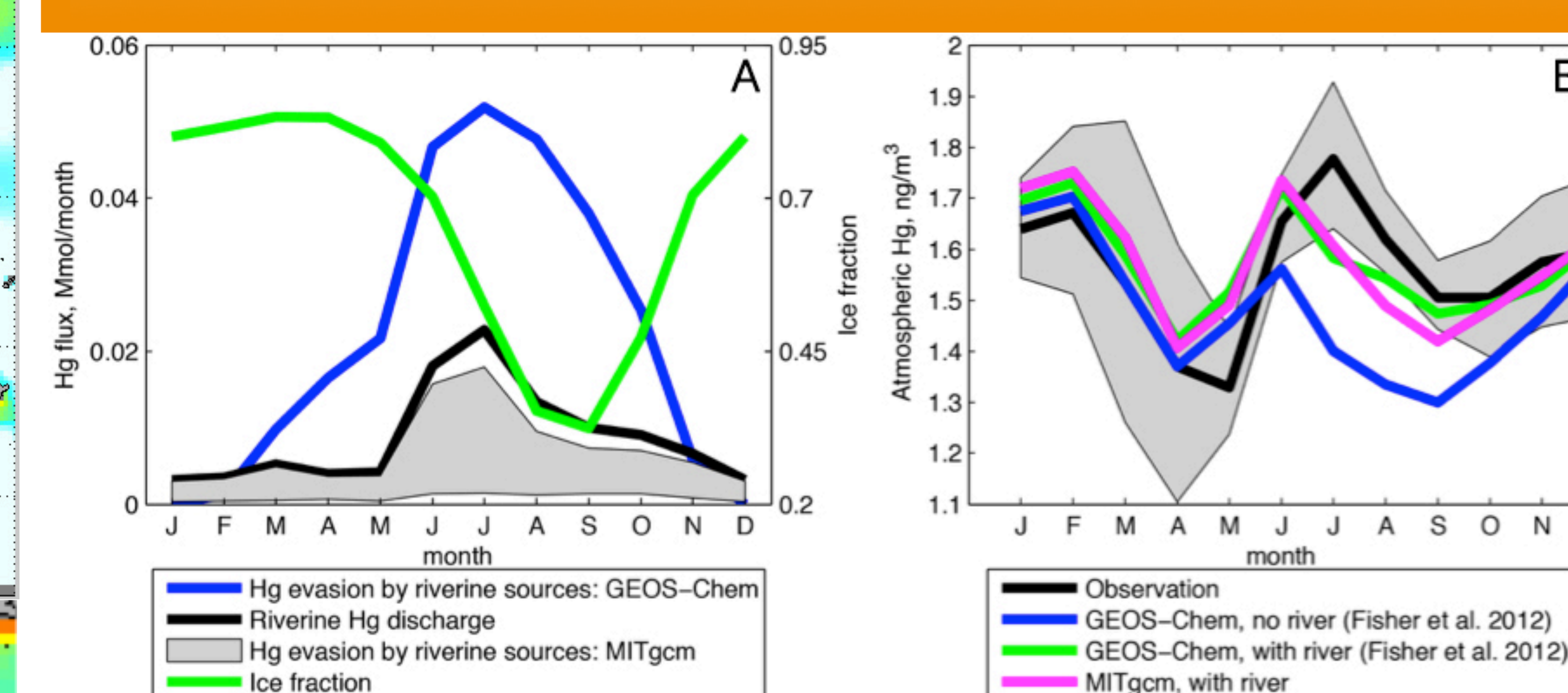
- The two largest contributors: Yellow and Yangtze Rivers (33% of global total). Little (2.6%) is exported due to blockage of landmass.
- Reach of river plumes is enhanced by the Gulf Stream and the Kuroshio (e.g. 25% is exported from North American rivers).
- Hg from Arctic rivers preferentially accumulates in the coastal regions.

4. Reactivity of riverine Hg



- The fate of riverine Hg is highly sensitive to the fraction of the Hg^P pool that is specified as refractory in nature.
- Mid- and low-latitude riverine Hg^P is dominant by refractory pool, otherwise, too high evasion unsupported by observations.
- Hg^P from Arctic rivers is more labile because of the much lower suspended load and faster remineralization.

6. Fate of Hg from Arctic rivers



- Sea-ice melting is accelerated by the heat of freshwater discharge originated from melting snow over land in May and June.
- Piston velocity is increased over ocean partially covered by sea ice due to enhanced shear-stress and convection driven turbulence.
- 0.23 Mmol a^{-1} of Hg is needed from circumpolar rivers to reproduce atmospheric observations. Close to the upper limit by Amos et al. (2014) (0.1 ± 0.06 Mmol a^{-1}), and the estimate by Dastoor and Durnford (2014) (0.25 Mmol a^{-1}) based on Hg:DOC ratios.

References

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