Investigation of long-term fate of mercury in the ocean using a new global model

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Introduction

- We have developed a new global model for mercury (FATE-Hg), which is based on a fully coupled atmosphere-ocean chemical transport model and low and high-order marine ecosystem models.
- FATE-Hg considers methylated mercury production in the open ocean seawater, bioconcentration, and food-web biomagnification from particle organic matter to fish.
- We performed a long-term simulation over three centuries with changes in anthropogenic emission since the Industrial Revolution.
- We investigated the long-term evolution of total mercury (THg) in the ocean and geographic THg sources in the upper ocean.

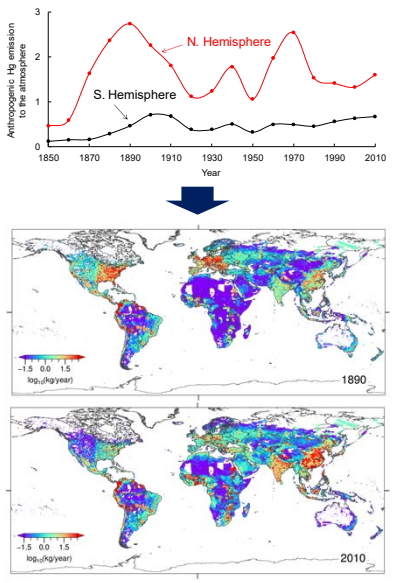
Results

- The simulated oceanic THg showed a phase lag of 5–10 years from the anthropogenic emission in the surface-intermediate oceans.
- Oceanic THg in 2010 was 410 Gg, which is 1.6–16.9 times higher than that estimated by the previous model.
- The estimated overall turnover time of oceanic THg was 320 years, which is significantly shorter than those estimated by previous model-based studies.
- North America (NA), Europe (EU), and East Asia are the dominant source regions in most ocean sections in the Northern Hemisphere, though the emissions from NA and EU have fall considerably since the 1970s.

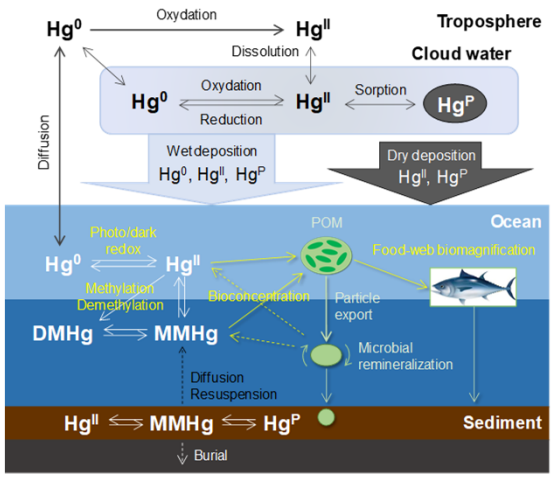
Global Multimedia Model (FATE-Hg)

- Simulates global biogeochemical cycles of Hg in and across the atmosphere, ocean, and biosphere using emission, climate, reactants, and satellite data.

Anthropogenic Emission [1,2]

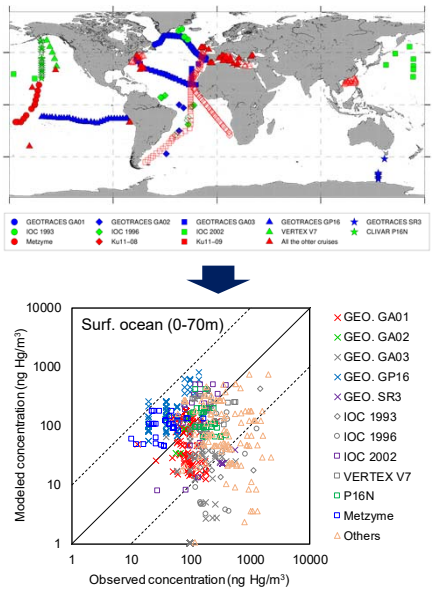


Modelled Hg Processes [2]

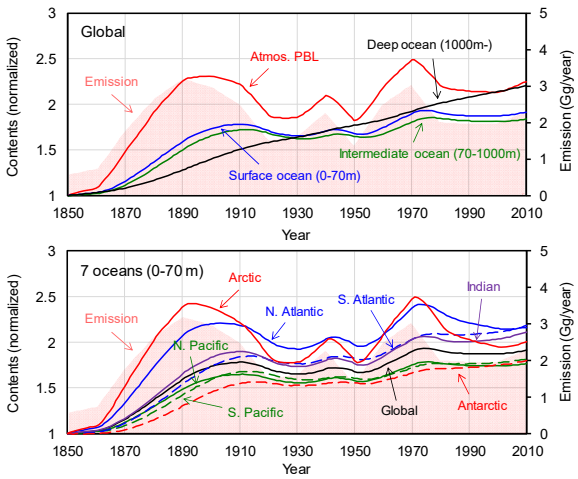


- Simulates 3D advection and diffusion, dry/wet depositions, gaseous exchange, transformations, bioconcentration, and food-web biomagnifiction.

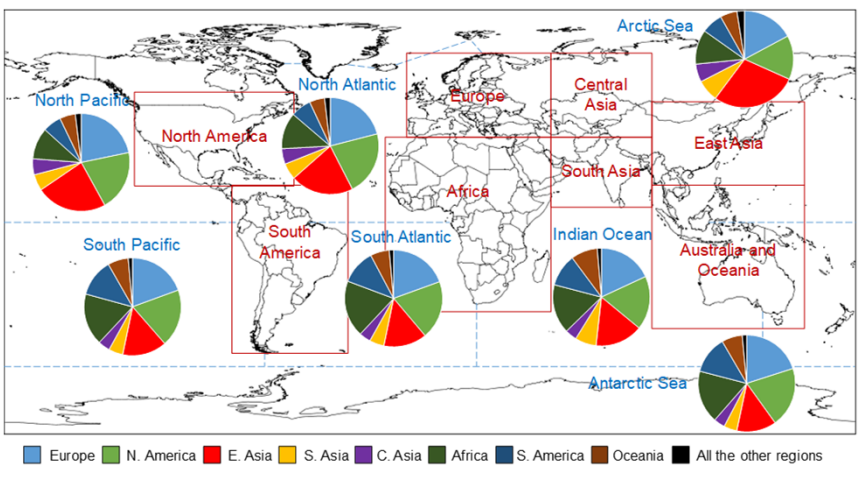
Validation (Oceanic THg) [2]



Long-term Variation of THg Contents [2]



Source Attribution of THg in the Ocean Mixed Layer



References: 1) Streets *et al.* (2017) *Environ. Sci. Technol.*, 51, 5969−5977.; 2) Kawai *et al.* (2020) *Enviorn. Model. Soft.*, 124, 104599.
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