Measurements and modeling of mercury in the ocean and air-sea exchange

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Background

Hg^0 measurements in the surface ocean

West Atlantic Ocean

September 2008
June 2009
September 2009
August 2010

Pacific Ocean

October 2011
Measurements (high temporal resolution)

Hg$^0$ in air: Tekran 2537A (5 min)

Hg$^0$ in water: Collected using a continuous sparging set-up with a high water/air flow ratio that ensured gas:water equilibrium. Method developed by Andersson et al. 2008. Equilibrium air concentrations determined every 5 minutes with a Tekran 2537A

Air-sea exchange: Calculated using Nightingale et al. (2000) flux parameterization for mean wind speeds

\[
Hg_{\text{flux}}^0 = K_W \left( Hg_{\text{aq}}^0 - \frac{Hg_{\text{air}}^0}{H'} \right)
\]

\[
K_W = A \times u_{10}^2 \left( \frac{Sc_{Hg}}{Sc_{CO}} \right)
\]
West Atlantic Ocean

Hg\textsuperscript{0}air

Air-sea exchange

Hg\textsuperscript{0}aq

Wind Speed

3-5 days
Subsurface input?

Mixed layer depth ~ 20-25 meters

Clearly temperature stratification:
- during cruise (Black)
- before cruise (Blue lines)
Atmospheric input?

Precipitation at Bermuda

August 2010 13 cm month prior 2 cm during cruise
June 2009 21 cm month prior 10 cm during cruise

Origin of air masses
Pacific Cruise 2011 (preliminary results)

- **Hg^0_{air}**
- **Hg^0_{aq}**

![Graph showing the concentration of Hg^0_{air} and Hg^0_{aq} vs. latitude.](image)
Pacific Cruise 2011 (preliminary results)

[Fitzgerald et al 1984; Kim and Fitzgerald 1986; Fitzgerald 1986]
Pacific Cruise 2011 (preliminary results)

\[ Hg^{0}_{\text{air}} \]

\[ Hg^{0}_{\text{aq}} \]

\[ \text{Jan-90} \]

\[ \text{Jun-84} \]

[Mason and Fitzgerald et al 1990; Kim and Fitzgerald 1984]
Pacific Cruise 2011 (preliminary results)

Figure 3: Hg concentration in the Atlantic surface waters near Gibraltar. How-ever, the decline during the northern hemispheric winter.

- Kuss et al., 2011

Further east, Hg concentration was high in the northern and southern spring seasons but higher in the tropics. Consistent with our data of May 2009, a relatively large influence of the African continent was observed in the equatorial region. This is supported by Figures 2d–f).

Kuss et al., 2011.

- Coquery and Cossa, 2008b; Kuss et al., 2003.

Also, the Hg concentration in the Atlantic surface waters near Gibraltar was determined by Sanemasa et al., 1975, to calculate H at various water temperatures.

HgHg \(Hg\) in the shallow layer of low salinity conditions favorable to Hg transformation. In this area, Hg was exposed to intense tropical solar radiation and thus to Hg along the transect was significantly higher in November 2008 (Figures 2a–d).

Kuss et al., 2011.

- Kuss et al., 2011.
GEOS-Chem global 3-D chemical transport model

Assimilated meteorology from NASA Goddard Earth Observing System (GEOS)

Horizontal resolution $4^\circ \times 5^\circ$, 48 vertical layers

**Atmospheric Hg$^0$, Hg$^{II}$ and HgP** [Selin et al. 2007]

**Br** is the atmospheric oxidant of Hg$^0$ [Holmes et al. 2010]

Associated surface **ocean model representing Hg$^0$, Hg$^{II}$ and HgP** [Soerensen et al. 2010]
Method: GEOS-Chem model

GEOS-Chem global 3-D chemical transport model

- atmosphere
- surface ocean
- subsurface water

- $\text{Hg}^0$ (net evasion)
- $\text{Hg}^{II}$ (deposition)
- $\text{Hg}^P$

- MLD: 10-670 m avg. 54 m

- Horizontal resolution 4°x5°

[Soerensen et al. 2010]
Results: 3 hour timeseries comparisons

September 2008 in the West Atlantic Ocean

Hg\textsubscript{aq} Flux Hg\textsubscript{air}

Aqueous Hg\textsubscript{0}

Atmospheric Hg\textsubscript{0}
Results: 3 hour timeseries comparisons

September 2008 in the West Atlantic Ocean

Hg$_{aq}^0$

Flux

Hg$_{air}^0$

Hg$_{aq}^0$ flux

Green: model variables except for Wind Speed

Aqueous Hg$_0^0$

Atmospheric Hg$_0^0$
Perspectives

- Analyzing the presented data using the GEOS-Chem model
- Improving the current surface ocean representation by:
  - Adding lateral water flows
  - Adding river input
  - Adding MeHg in the chemical scheme

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