Determination of gaseous elemental mercury air-sea exchange in the Baltic Sea

ICOS Östergarnsholm

10 May – 20 June, 2017
Objectives

1. Quantify the Hg\(^0\) air-sea flux using the gas exchange model and micrometeorological methods

2. Compare Hg\(^0\) fluxes from coastal waters and the open sea

3. Investigate wind speed dependence of Hg\(^0\) gas transfer velocity
Gas exchange model

\[ F_{Hg^0} = K_w \left( \frac{GEM}{H^'} - DGM \right) \]

\( \Delta \) partial pressure \( Hg^0 \)

- \( C_{DGM} \)
- Ambient \( Hg^0 \)
- Sea surface temperature
- Wind speed
- Atmospheric pressure
- Salinity

mass transfer velocity between water and air

Nerentorp et al., 2017
Gradient-based methods

\[ F_{Hg^0} = - \frac{k \cdot u_* \cdot z}{\phi_h \left( \frac{Z}{L} \right)} \cdot \frac{\delta c_{Hg^0}}{\delta z} \]

\( Hg^0, CO_2, H_2O, \)

Temp, Humidity,

Solar rad.

\( Hg^0, CO_2, H_2O, \)

Temp, Humidity,

Solar rad.
Relaxed Eddy Accumulation (REA)

CSAT3 3-D Sonic at 10 m height

Open-sea sector: $80^\circ < WD < 160^\circ$

Coastal sector: $160^\circ < WD < 220^\circ$

Hg$^0$ flux
CO$_2$ flux
Sensible heat flux
Water vapour flux
Wind vector
Results: Dissolved gaseous $\text{Hg}^0$ and modeled $\text{Hg}^0$ flux

- Dissolved gaseous Hg
- Solar radiation

$\text{Hg}^0$ flux and $\text{Hg}^0$ aq supersaturation

blue: open sea conditions for wind direction 80° - 160°
red: coastal conditions for wind direction 160° - 220°
**Results:**

1) Hg$^0$ flux derived from the model and measurements (mean; 10th and 90th percentile):

- Gas exchange model: 0.6 (0.1 – 1.3) ng m$^{-2}$ h$^{-1}$
- Aerodynamic gradient: 0.5 (-3.8 – 5.6) ng m$^{-2}$ h$^{-1}$ (coastal sector)
- Relaxed eddy accumulation: 0.6 (-45 - 40) ng m$^{-2}$ h$^{-1}$ (coastal sector)

2) Hg$^0$ emission from open sea sector (mean = 6.3 ng m$^{-2}$ h$^{-1}$) larger than from coastal sector (mean = 0.6 ng m$^{-2}$ h$^{-1}$).

3) Micrometeorological measurements indicated a stronger wind speed dependence of the Hg$^0$ transfer velocity compared to the Standard Model (Nightingale et al., 2000) which appears to coincide with whitecap formation in the open sea flux footprint (wind speed > 5 m s$^{-1}$).

**References:**
