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

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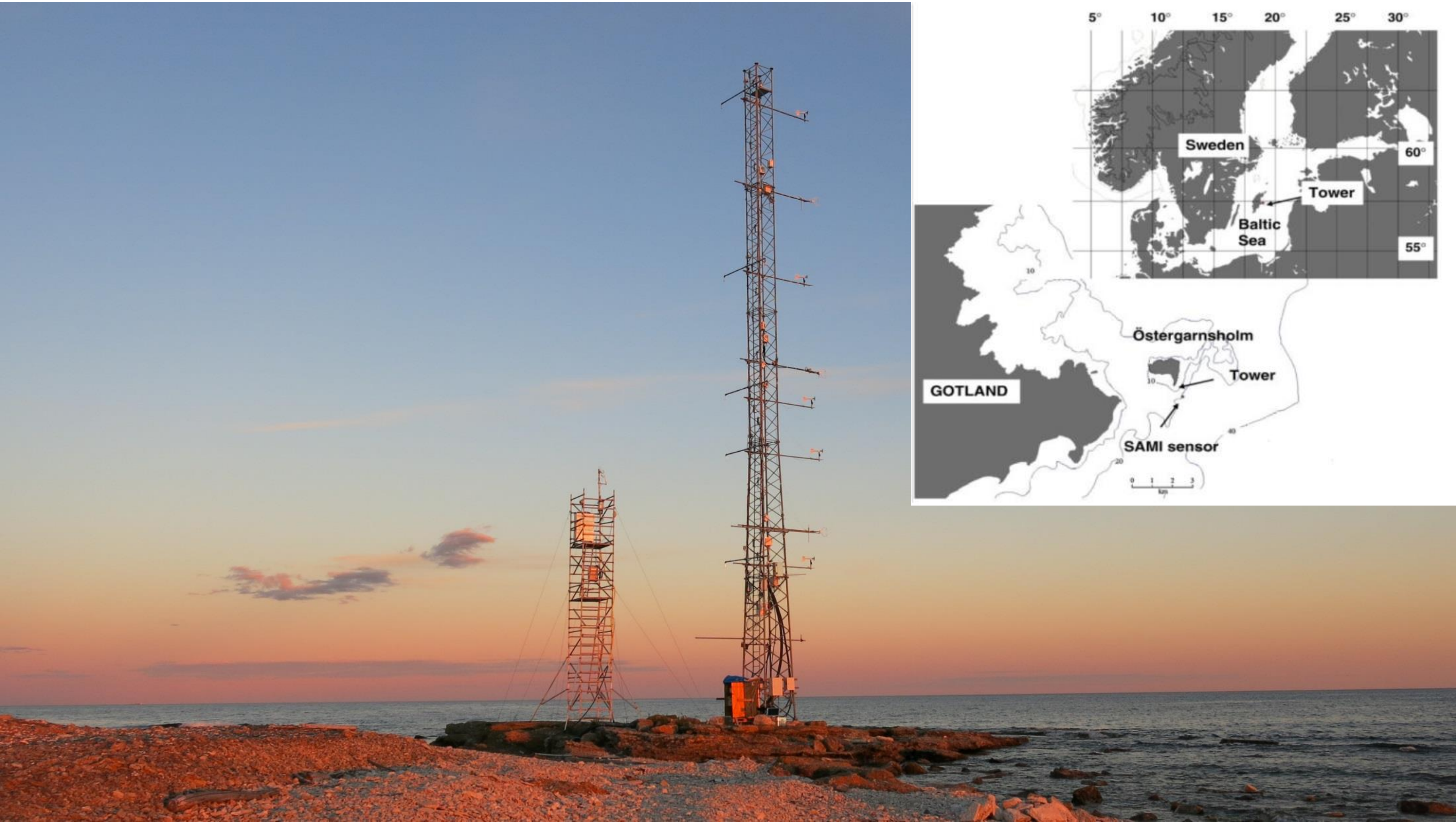
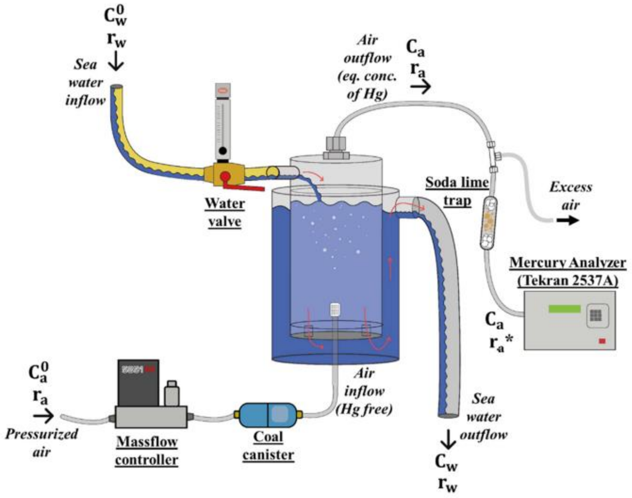
ICOS Östergarnsholm



10 May – 20 June, 2017

Objectives

Automatic continuous equilibrium system



Micrometeorological techniques

(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**

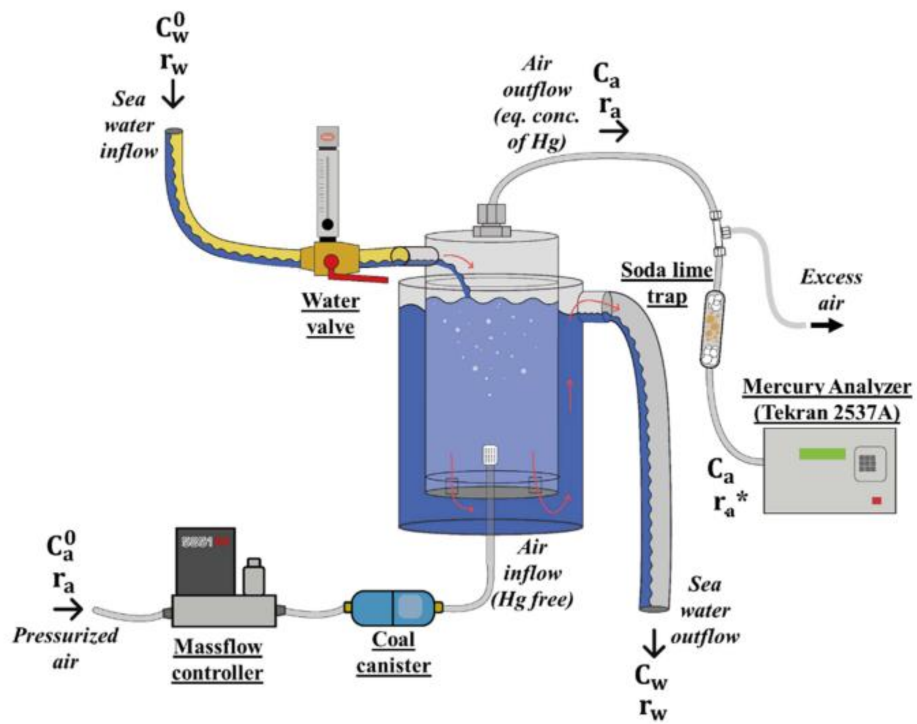
Gas exchange model

Δ partial pressure Hg^0

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

mass transfer velocity between water and air

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



Nerentorp et al., 2017

Gradient-based methods

29 m

Hg^0 , CO_2 , H_20, Temp, Humidity, Solar rad.

7 m

Hg^0 , CO_2 , H_20, Temp, Humidity, Solar rad.

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

Relaxed Eddy Accumulation (REA)

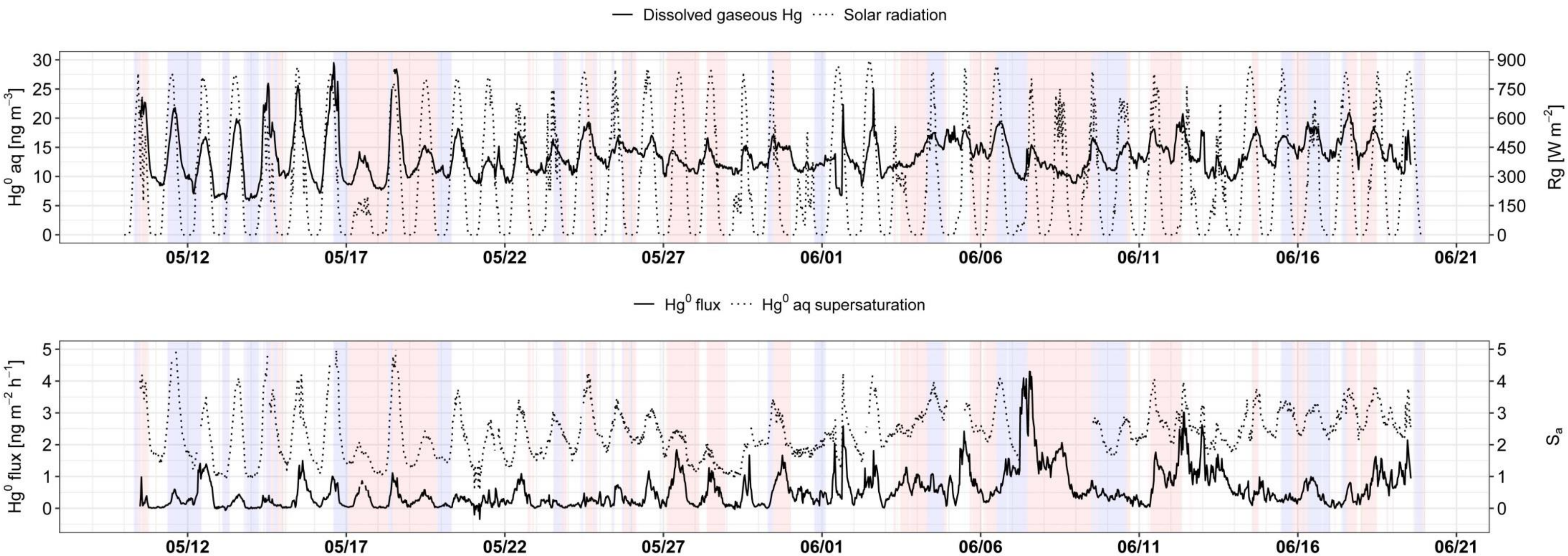
CSAT3 3-D Sonic at 10 m height

Open-sea sector: 80° < WD < 160°
Coastal sector: 160° < WD < 220°

10 m

Hg^0 flux
CO_2 flux
Sensible heat flux
Water vapour flux
Wind vector

Results: Dissolved gaseous Hg^0 and modeled Hg^0 flux



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:

I. Nerentorp Mastromonaco, M.G., Gårdfeldt, K., Wängberg, I., 2017. Seasonal and spatial evasion of mercury from the western Mediterranean Sea. Marine Chemistry, The role of oceans in the global mercury observing systems 193, 34–43.

II. Nightingale, P.D., Malin, G., Law, C.S., Watson, A.J., Liss, P.S., Liddicoat, M.I., Boutin, J., Upstill-Goddard, R., 2000. In situ evaluation of air-sea gas exchange parameterizations using novel conservative and volatile tracers. *Global Biogeochemical Cycles* 14, 373 - 387.