Measurement and Parameterization of Air-Sea Gas Transfer

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Concerns about CO₂ accumulation in the atmosphere and increased understanding of biogeochemical feedbacks at the ocean interface lead us to develop methods for measuring and parameterizing air-sea gas exchange over the open ocean.

The air-sea flux of a gas (x) can be measured directly on a ship by the eddy covariance method and can be expressed in terms of a transfer coefficient ($k_x$):

\[ \text{Flux} = w'x' = k_x \alpha \Delta X \]

- $w'$ = turbulent vertical velocity
- $x'$ = fluctuations of species in air
- $\alpha$ = solubility
- $k_x$ = transfer velocity
- $\Delta X$ = air-sea concentration gradient

Open ocean covariance gas flux observation requires methods for removing ship motion effects from the turbulence measurements and improvement to fast response gas instrumentation.

Collaborations with researchers from Columbia U. (McGillis; closed-path CO₂), U. Hawaii (Huebert; mass spec DMS), U. Colorado (Helmig; chemiluminescence O₃), and others have led to significant instrument improvement and other technical advances.

Simple wind speed parameterizations of the gas transfer velocity ($k_x$) have been developed from shipboard flux observations, but these relationships ignore important forcing physics and species solubility.

Fairall et al. (2002; Boundary-Layer Meteorol., 96) introduced a publicly-available parameterization of $k_x$ (the NOAA/COARE model) which considers the effects of other meteorological (stress, stability, etc) and oceanic variables (surface current, waves, bubbles, etc) as well as species solubility on the gas transfer.

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Open ocean expeditions are undertaken to measure gas fluxes by the covariance technique; these observations ($w'x'$), along with air and sea surface gas concentrations ($\Delta X$) are used to find $k_x$.

Above: NOAA/COARE model (blue) compared to GasEx-98 covariance CO₂ flux observations (red)

Below: NOAA/COARE compared with bin-average ozone flux observations (blue)

Comparison of NOAA/COARE with CO₂ (top panel) and DMS (bottom panel) covariance observations.