Measurement and Parameterization of Air-Sea Gas Transfer

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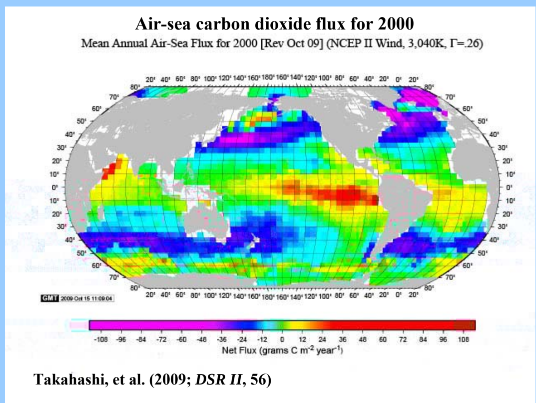
Concerns about CO_2 accumulation in the atmosphere and increased understanding of biogeochemical feedbacks at the ocean interface lead us to develop methods for measuring and parameterizing air-sea gas exchange over the open ocean



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)

$$Flux = \overline{w'x'} = k_x \alpha_x \Delta X$$

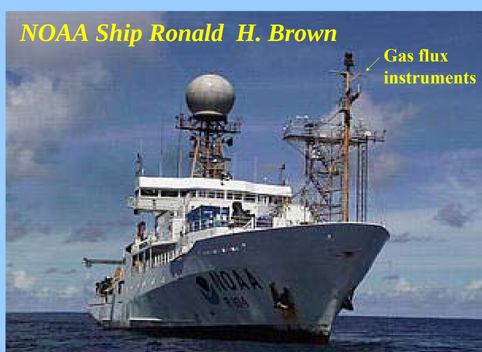
w' = turbulent vertical velocity

x' = fluctuations of species in air

α_x = solubility

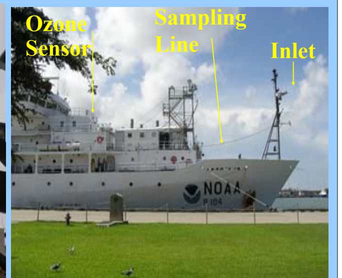
k_x = transfer velocity

ΔX = air - sea concentration gradient

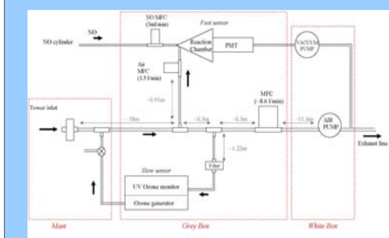


Open ocean expeditions are undertaken to measure gas fluxes by the covariance technique; these observations ($\overline{w'x'}$), along with air and sea surface gas concentrations (ΔX) are used to find k_x

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

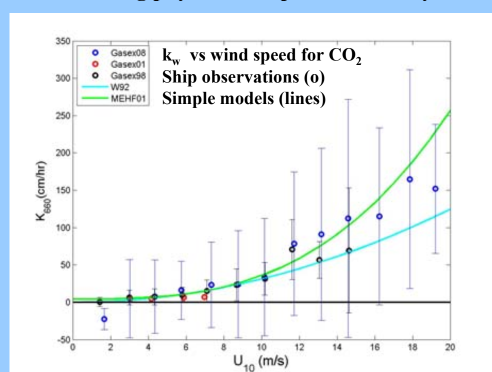


Collaborations with researchers from Columbia U. (McGillis; closed-path CO_2), U. Hawaii (Huebert; mass spec DMS), U. Colorado (Helmig; chemiluminescence O_3), and others have led to significant instrument improvement and other technical advances

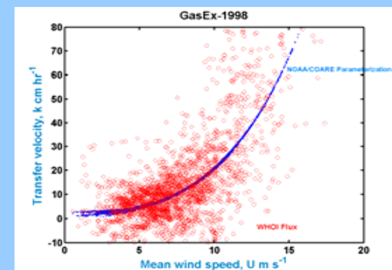


Schematic of the Univ of Colorado INSTAAR fast ozone sensor

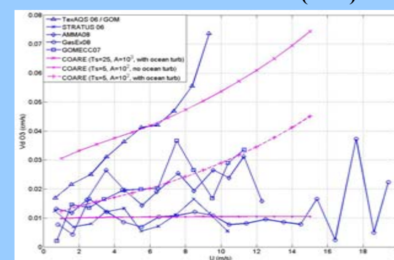
Simple wind speed parameterizations of the gas transfer velocity (k_x) have been developed from shipboard flux observations, but these relationships ignore important forcing physics and species solubility



Fairall et al. (2002; *Boundary-Layer Meteorol.*, 96) introduced a publically-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



Above: NOAA/COARE model (blue) compared to GasEx-98 covariance CO_2 flux observations (red)
Below: NOAA/COARE compared with bin-average ozone flux observations (blue)



Comparison of NOAA/COARE with CO_2 (top panel) and DMS (bottom panel) covariance observations