Improvement to a Micrometeorologically-Based Air-Sea Gas Transfer Parameterization

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Scientific Research Theme: Regional Processes

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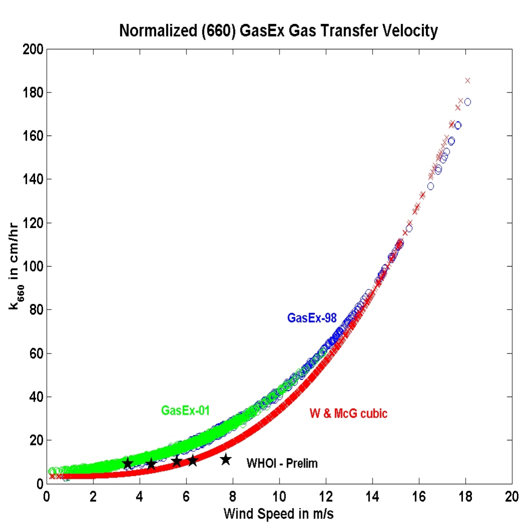
Scientific Impact: Improved parameterization of air-sea gas transfer which can be incorporated into larger scale models for more accurate forecasting of carbon dioxide sequestration.

Reference: Fairall, Hare, Edson, and McGillis, 2000: Parameterization and Micrometeorological Measurement of Air-Sea Gas Transfer, *Boundary-Layer Meteorology*, v96, pp 63-105.

Large uncertainties in the extent of carbon dioxide transfer between the atmosphere and ocean have prevented us from accurately quantifying how the increasing atmospheric CO_2 burden is partitioned between the ocean and terrestrial biosphere, which limits our ability to accurately predict future atmospheric CO_2 levels. The need for accurate predictive models of air-sea gas flux has prompted a number of field experiments in recent years, including the NOAA-sponsored GasEx-1998 and GasEx-2001 cruises, where the experimental emphasis was placed on making accurate direct covariance measurements of gas fluxes within the context of an accurately measured environment. Air-sea gas transfer is driven by complex physical processes within the lower marine atmosphere, in the upper oceanic boundary layer, and at the sea surface, and improvements to small-scale gas transfer parameterizations can only be realized through comprehensive measurement strategies such as those accomplished in the GasEx cruises.



The CO_2 gas flux (***F***) can be expressed quite simply: $F = k\ (\alpha_w\, fCO_{2w} + \alpha_s\, fCO_{2a})$, where ***k*** is the gas transfer velocity, α is the gas solubility in the water (***w***) or at the surface (***s***), and fCO_2 is the fugacity of carbon dioxide in the water (***w***) and air (***a***). The transfer velocity is conceptually similar to a dimensional "transfer coefficient" in the traditional bulk model context.

The Fairall et al (2000) gas transfer parameterization has a basis in the Toga Coare bulk flux parameterization for heat and momentum fluxes and expresses the gas flux (or transfer velocity) in terms of the matching of turbulent and molecular dissipative properties at both sides of the interface. Additional considerations have been applied for the effects of higher wind regimes (modulation by wave effects, breaking waves, and bubble enhancement of gas transfer). Currently, we are working toward refining these high wind adjustments in order to reproduce the gas flux observations from the cruise data sets. Additional work is underway to investigate the effect of the thermal structure of the near surface water (cool-skin and warm-layer effects) on the modeled transfer velocity.

The figure shows the gas transfer velocity (***k***) estimated from the Fairall parameter-rization (normalized to an arbitrary Schmidt number) from the two GasEx cruise datasets along with the simple Wanninkhof and McGillis cubic wind-speed dependent relationship and preliminary direct CO_2 flux measurements from GasEx-2001.