SCOTT D. MILLER **FALL 2004**

RESEARCH STATEMENT

My interest is in using micrometeorology to address outstanding questions of exchange between the atmosphere and land or water surfaces. Four projects, both continuing and new, demonstrate the use of direct flux measurements to address important science questions: 1) the flux of dimethylsulfide, acetone and carbon dioxide over the open ocean and the relative importance of air- and water-side resistance to gas exchange; 2) the effect of selective logging on carbon dioxide, water vapor and energy exchange above a tropical rainforest; 3) the physics of momentum and energy exchange above deep ocean waves; and 4) the role of carbon dioxide evasion from rivers in the Amazon basin in the regional carbon budget. This broad range of topics has required collaborations with physical and chemical oceanographers, ecologists, hydrologists, and meteorologists. The measurements have been made using commercially available instruments in novel configurations, and, more recently, incorporating new trace gas measurements. A short overview and highlights of these projects are given below.

Ocean-Atmosphere Exchange of DMS, Acetone, and Carbon Dioxide (with Eric Saltzman)

The goal of this recently funded research is to improve our understanding of air-sea gas transfer and to obtain direct air-sea flux estimates for carbon dioxide, dimethylsulfide, and acetone. These gases are each of unique biogeochemical interest: 1) carbon dioxide for its importance as a greenhouse gas, 2) dimethylsulfide for its role as a precursor for tropospheric sulfate aerosol and cloud condensation nuclei, and 3) acetone for its impact on tropospheric photochemistry as a precursor of free tropospheric HOx. Dimethylsulfide and acetone measurements will be made using a chemical ionization mass spectrometer in development at UC Irvine. These measurements are state-of-the-art, as currently there are no published direct measurements of these gas fluxes over the ocean. The wide range of solubilities of these three gases will allow us to partition the piston velocity into its air- and water-side resistances. Our results will provide a test of the current models of air-sea exchange relating transfer velocities to environmental parameters, reduce uncertainties in large-scale budgets of these gases, and ultimately improve model predictions for their cycling on short and long time scales.

Selective Logging in Tropical Forest (Post-doc with Mike Goulden)

Selective logging represents a significant component of land use change in the tropics, affecting an estimated 10,000 km^2 yr^{-1}. The goal of this ongoing research is to measure the effect of selective logging on carbon dioxide, water vapor and energy exchange above a tropical rain forest. We began eddy covariance measurements above a tropical rainforest in Brazil in 2000; the forest was selectively logged in 2001. We used the year of data prior to logging to report how primary, undisturbed forest functions with respect to carbon dioxide and energy exchange (Miller et al. 2004, Goulden et al. 2004, Rocha et al. 2004, Saleska et al. 2003). Comparison of pre- and post-logging data is being used to quantify the logging effect on carbon, water, and energy cycling. Integration of the carbon flux measurements suggests that the logging is followed by a loss of carbon to the atmosphere as slash left by logging decomposes, and that forest carbon cycling returns to pre-logging levels rapidly (~1 year after selective logging).

Marine Boundary Layers (PhD with Carl Friehe, Tihomir Hristov, Jim Edson)

Global climate simulations have found that uncertainties in ocean surface fluxes cause large uncertainties in model output. The goal of this research is to improve our understanding of the physics of air-sea momentum and energy exchange above deep ocean waves, and the effect of waves on flux-profile relationships. Platform motion and flow distortion have resulted in a lack of turbulence profile measurements immediately above deep ocean waves. We made measurements of the wind profile (12 levels) and wind turbulence profile (4 levels) within 20 meters of the mean ocean surface from the unique platform R/P FLIP (Miller et al. 1997). We used data processing to extract the relatively small wave-induced wind components and compared their structure to classical theories of wind-wave growth (Hristov et al. 1998, 2003). A remarkable feature of this data set is momentum flux divergence during high wind and wave conditions that appears to be caused by interaction with the wave field (Miller et al in preparation for submission to JPO). This result has important implications for our understanding of the over-ocean drag coefficient, and may help explain why models of storm surge require enhanced drag coefficients to match measured surge (Miller et al. in preparation for submission to GRL).

River-Atmosphere Exchange of Carbon Dioxide in the Amazon Basin

The goal of these measurements is to test recent reports suggesting large gas evasion rates of carbon dioxide from the Amazon River and its tributaries to the atmosphere. These reported gas transfer rates were estimated using air-water gas transfer coefficients derived from floating chamber and ocean measurements. We mounted an eddy covariance system on a small riverboat and measured the flux of carbon dioxide and water vapor from two rivers (and connected lakes) near Santarem, Para, with widely different carbon dioxide concentrations. Preliminary calculations indicate that the calculated gas transfer velocity agrees with some ocean-based parameterizations.

In summary, these projects represent a spectrum of scientifically interesting questions and utilizations of direct flux measurements, including fundamental physics of surface exchange, improvement of parameterizations, integration of flux to calculate net exchange, partition of gas exchange into air- and water-side components, and testing of published indirect flux estimates with direct measurements. This research has involved many collaborations and the development of new instrumentation for the measurement of fluxes of important trace gas species.