High Resolution Climate Data From Research and Volunteer Observing Ships

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Project Summary

Direct covariance air-sea flux measurements are performed on several oceanic cruises each year, and ESRL has developed a roving standard flux measuring system to be deployed on research vessels on an opportunistic basis. This latter task promotes high-quality climate observations from UNOLS and NOAA research vessel fleet and from NOAA Flux Reference Buoys. Currently, climate data from 31 research vessels are archived at the Shipboard Automated Meteorological and Oceanographic Systems (SAMOS) at Florida State University. Flux Reference Bouy data are available at OceanSITES (http://www.oceansites.org/). Because buoys and most ships and satellites rely on bulk methods to estimate fluxes, another aspect of this project is the use of direct measurements to improve the NOAA/COARE bulk flux algorithm. A full suite of direct, inertial-dissipation, and bulk turbulent fluxes of sensible heat, latent heat, and momentum are measured along with IR and solar radiative fluxes, precipitation, and associated bulk meteorological properties. This effort represents a partial transition of research from the OGP CLIVAR programs to operations under the Climate Observations Division (COD). Cruises have been conducted on three NOAA ships, seven UNOLS ships, and one Coast Guard icebreaker to TAO buoys along the 95W and 110W, the PIRATA Northeast Extension (PNE), the Northwest Tropical Atlantic Station (NTAS) reference buoy, and the WHOI Hawaii Ocean Time Series Station (WHOTS) reference buoy.

The project development is the result of a NOAA-sponsored workshop on high-resolution marine measurements (Smith et al., 2003, *Report and Recommendations from the Workshop on High-Resolution Marine Meteorology*, COAPS Report 03-01, Florida State University, pp38) which identified three important issues with the planned NOAA air-sea observation system: 1) the need for a data quality assurance program to firmly establish that the observations meet the accuracy requirements, 2) the need for observations at high time resolution (about 1 minute) and, 3) the need to more efficiently utilize research vessels, including realizing their potential for the highest quality data and their potential to provide more direct and comprehensive observations. For seasonal time scales, the net air-sea flux (sum of 5 flux components) must be constrained within 10 Wm^{-2}. Buoys and VOS systems are required to operate virtually unattended for months, so considerations of practical issues (e.g., power availability, instrument ruggedness, safe access, etc.) are balanced against inherent sensor accuracy and optimal sensor placement. As discussed above, an important function of the *in situ* measurements is to provide validation data to improve NWP and satellite flux fields. High time resolution and more direct observations are invaluable for interpreting surface flux measurements and diagnosing the source of disagreements --such information can be provided by suitably equipped research vessels (R/V). Thus, the accuracy of buoy and VOS observations must be improved and supplemented with high-quality, high time resolution measurements from the US R/V fleet (which is presently under utilized). The necessity for both high time resolution and high accuracy places extreme demands on measurements because some sources of error (such as the effect of ship flow distortion on wind speed) tend to average out over a large sample. To accomplish this requires a careful

intercomparison program to provide traceability of buoy, VOS, and RV accuracy to a set of standards.

This project directly addresses the need for accurate measures of air-sea exchange in the *Program Plan for Building a Sustained Ocean Observing System for Climate* (Sections 5.2-5.4), and it is a joint effort by ESRL and Dr. Robert Weller of the Woods Hole Oceanographic Institution (WHOI). The ESRL Air-Sea Interaction Group website can be found athttp://www.esrl.noaa.gov/psd/psd3/air-sea/. ESRL also cooperates with Dr. Frank Bradley (CSIRO, Canberra Australia) on precipitation and radiative flux observations, Dr. Meghan Cronin (NOAA PMEL) on buoy-ship intercomparisons and climate variability analysis, and Dr. Wade McGillis (Univ. Columbia) on gas fluxes. A project website has been established (High Resolution Climate Observations http://www.esrl.noaa.gov/psd/psd3/air-sea/oceanobs/). An associated website (http://www.esrl.noaa.gov/psd/psd3/wgsf/) contains a handbook on best practices for flux measurements plus a database of high-resolution flux data. This work will be closely monitored by the WCRP Working Group on Surface Fluxes (WGSF) which is chaired by C. Fairall. This gives the project high visibility in the CLIVAR, GEWEX, and SOLAS programs. This project is managed in cooperation with JCOMM.

Users of the data from this project include numerous individual collaborators (J. Edson at UConn, B. Huebert at UHawaii, B. Ward at Galway, M. Bourassa at FSU, W. McGillis at LDEO, F. Bradley at CSIRO, M. Cronin at PMEL, R. Wanninkhof at AOML, R. Weller at WHOI, A. Beljaars at ECMWF) and many projects/programs worldwide (SAMOS, GOSUD, SeaFlux, USGCRP, WCRP, SOLAS, SURFA, OceanSites, CLIVAR, VOCALS, UNOLS, TAO). Specific applications include global model algorithm development and intercomparison, satellite product intercomparison, *in situ* (buoy and ship) intercomparison studies, application of the NOAA/COARE model for flux parameterization, and improved climate observation capabilities.