Spatial Variability in Surface Meteorology from a VOS and the ECMWF Model

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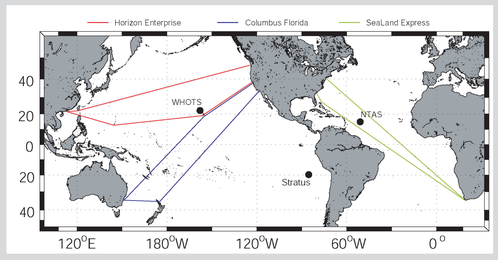
The Upper Ocean Processes Group at WHOI has adapted a suite of Air-Sea Interaction Meteorology (ASIMET) sensors for installation on Volunteer Observing Ships (VOS). These systems have been installed on 5 different VOS over the last several years, providing a wealth of data along repeated (or nearly repeated) tracks in the Atlantic and Pacific basins (see http://kuvasz.whoi.edu/vos/index.html). Among the goals of the VOS work is to assess the quality of numerical weather prediction models on a variety of spatial scales, as a complement to the time series assessment provided by Ocean Reference Stations. Our most extensive VOS data set comes from the container ship Horizon Enterprise, which crosses the North Pacific on an approximately 5-week schedule. In this presentation, we focus on the ~2400 mile segment between Oakland, California, and Honolulu, Hawaii. Surface meteorology from the VOS is compared with that from the ECMWF model for 29 transects during 2003 - 2006. Most variables show good agreement in the mean, but large standard deviations indicate shortcomings in of the ECMWF model on short spatial scales. Some variables do have notable mean differences, for example ECMWF wind speed is ~ 2 m/s less than VOS on average.

Background

Central to efforts to improve the predictability of climate is the need to understand the physics of how the atmosphere and ocean exchange heat, freshwater, and momentum and, in turn, to accurately represent that understanding in the models used to mak predictions. At present, over much of the globe, quantitative maps of air-sea fluxes, derived either from ship reports, numerical model analyses or satellites, have errors that are large compared to the size of climatically significant signals.

To address the need for accurate in-situ observations on broad spatial scales, the Upper Ocean Processes Group at WHOI has undertaken a program of observations using variations of the IMproved METeorology (IMET) sensor suite (ASIMET, AutoIMET) adapted for installation on Volunteer Observing Ships (VOS). These systems have been installed on 5 different VOS over the last 4 years, providing a wealth of data along repeated (or nearly repeated) tracks in the Atlantic and Pacific basins.



Schematic map of UOP VOS routes along with the location of UOP operated Ocean Reference Station moorings.

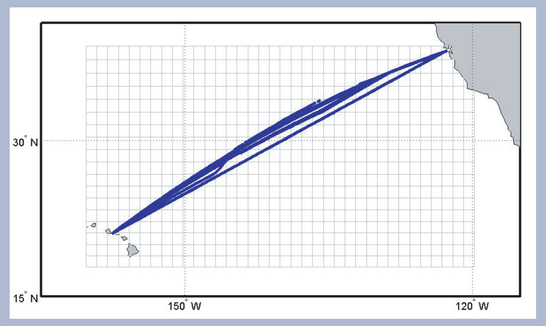
Observations made using IMET technology on long VOS routes that span the oceanbasins are essential to providing the accurate, in-situ surface meteorology needed to:

- Identify errors in existing climatological, model-based, and remotely-sensed surface meteorology and air-sea fluxes,
- Provide the motivation for improvements to existing flux parameterizations and algorithms,
- Provide the data needed to correct existing climatologies, and
- Validate new model codes and remote sensing methods.

Bow mast of the VOS Horizon Enterprise where IMET sensors are located.

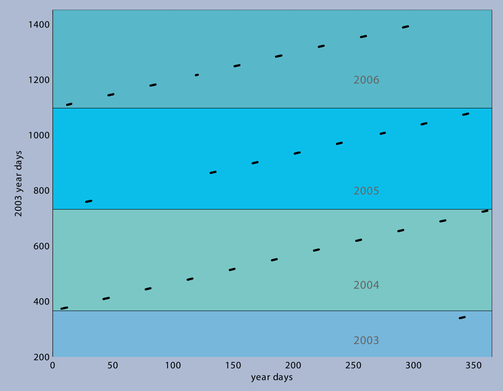
Data Set and Approach

Regional Coverage



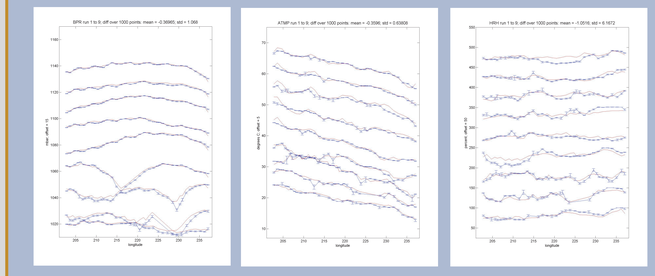
Ship tracks for the Honolulu to Oakland transects are shown along with ECMWF grid cells. The transects are along similar, but not identical, routes covering a distance of about 2400 miles. A typical transect passes through 34 ECMWF grid cells. VOS data are averaged within each cell and compared to the matching ECMWF variables as a function of distance along the track. The 29 available transits provide about 1000 VOS/ECMWF comparisons.

Temporal Coverage



From 2003 to 2006 there were 29 transits of the Horizon Enterprise between Honolulu and Oakland, plotted here as a "stack" of transit duration vs time of year. Each transit takes about 6 days to complete. A nominal 5 week repeat interval results in 10 transits in a "complete" year. The most complete seasonal coverage is from May - November (yeardays 120 - 330).

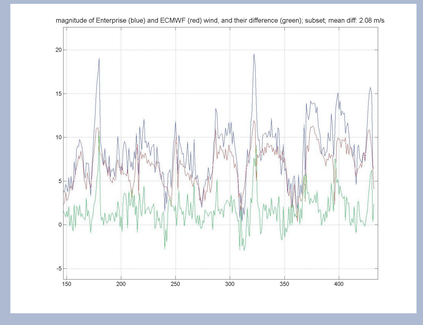
Sample Comparisons



Comparison of hourly averaged VOS variables (blue, with error bars) and ECMWF data (red) for the first 9 Honolulu-Oakland transits. Each transit spans about 6 days in time, and is plotted vs. longitude. The first transit of the group is shown at the bottom of the plot; an offset has been applied for successive transits.

- VOS BP (left) compares well with ECMWF, mean difference = 0.4 +/- 1.0 mb
- VOS AT (middle) also compares well with ECMWF, mean difference = 0.4 +/- 0.6 deg C. However, smaller scale structure is not captured by the model
- VOS RH (right) compares well with ECMWF in the mean (difference = 1 %), but shows significant variability on short spatial scales (std = 6%)

Wind speed comparison



Wind speed differences were of particular interest because addional transits (prior to 2003) were available but did not have absolute wind measurements, due to the lack of high resolution GPS data to perform the correction.

The ECMWF model winds capture the variabiltiy seen in the VOS winds reasonably well (std dev of difference ~2 m/s), albiet with some bias. The mean difference over all points is 2.1 m/s. The character of the comparison can be seen in the data subset shown above.

Summary

Between December 2003 and November 2006, the VOS Horizon Enterprise traveled 29 times from Honolulu Hawaii to Oakland, CA. In-situ meteorological data from these transits were compared with ECMWF model varibles. Each transit passed through about 34 ECMWF grid cells. VOS data were averaged to 1 hr and compared with ECMWF data for the appropriate grid cell during each ~6 day transit.

There are about 1000 comparisons overall between the roughly 1 degree square ECMWF grid cells and the hourly averages of VOS data as the ship passed through the grid. Most variables show good agreement in the mean, for example, mean BP and RH differences are about 0.4 mb and 0.4 deg C, respectively. Mean SST differences were quite small (less than 0.2 degrees), but we note that the ECMWF SST is derived from in-situ data sources. Most variables show notable differences on short spatial scales.

Wind vectors appear similar in both datasets, though ECMWF winds have a somewhat smaller amplitude (the mean difference between VOS and ECMWF winds is 2m/s). Note that VOS winds come from the top of the bow mast at a height of 29m, whereas ECMWF models winds at 10m height - the height difference could contribute to the observed difference. Since we lack good absolute VOS winds prior to Dec 2003 - because of the lack of high-resolution GPS fixes - this comparison to ECMWF winds suggests that we may be able to substitute ECMWF winds to calculate fluxes from the earlier VOS data.

Further Information

Descriptions and figures for the datasets are posted on the VOS web site http://uop.whoi.edu/vos.

Detailed technical information on the AutoIMET (VOS) and ASIMET systems is available at http://frodo.whoi.edu

Instrument design questions can be addressed to David Hosom at dhosom@whoi.edu

AutoIMET and ASIMET modules are available commercially from Star Engineering Inc of Foxboro, MA (508) 543 9144, attn: Mr. Bill Jobsky.

Acknowledgments

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