Application of altimetry measurements to observational and modeling studies of low-frequency upper ocean mass and heat circulation in the Tropical Pacific

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The focus of our investigation team is the utilization of Jason-1 altimeter data in support of monitoring, prediction, and process studies of interannual variability in the tropical Pacific Ocean with extensions to the Indian Ocean. Our team draws on individual, collective, and institutional strengths in altimeter data processing and analysis, tropical ocean modeling, ocean data assimilation, equatorial ocean theory, and basin-scale in-situ observations.

Specific research topics covered by our team include altimetry-based process studies of seasonal to interannual (i.e., El Niño) variability in the tropical Pacific Ocean, the variability of the Indo-Pacific warm pool system, assimilation and impact assessment of altimetry data and TAO/TRITON sea surface dynamic height topography into ocean model and coupled ocean-atmosphere prediction models, and analyses of equatorial wave dynamics via the joint analysis of Jason-1 and TAO/TRITON moored observations. Several of these research topics represent a broadening of our use of altimeter data in the tropical Pacific Ocean beyond our accomplishments during the pre-launch phase, three-year Prime, and Extended Mission of TOPEX/POSEIDON, and are in direct support of the objectives of the CLIVAR (Climate Variability and Predictability) program.

For example, in Ballabrera et al [2001] a reduced order Kalman filter is used to assimilate observed fields of the surface wind stress, sea surface temperature and sea level into the coupled ocean-atmosphere model of Zebiak and Cane.
The method projects the Kalman filter equations onto a subspace defined by the eigenvalue decomposition of the error forecast matrix, allowing its application to high dimensional systems.
The Zebiak and Cane model couples a linear, reduced-gravity ocean model with a single, vertical-mode atmospheric model.
The compatibility between the simplified physics of the model and each observed variable is studied separately and together. The results show the ability of the empirical orthogonal functions (EOFs) of the model to represent the simultaneous value of the wind stress, sea surface temperature (SST), and sea level, when the fields are limited to the latitude band 10°S – 10°N, and when the number of EOFs is greater than the number of statistical significant modes. Figure 1 shows an example of our research that isolates the individual and combined influences of SST, surface wind, and altimetric observations on El Niño forecast skill as measured by the Niño 3 SST index of the eastern equatorial Pacific.

In this first application of the Kalman filter to a coupled ocean-atmosphere prediction model, the sea level fields are assimilated in terms of the Kelvin and Rossby modes of the thermocline depth anomaly. An estimation of the error of these modes is derived from the projection of an estimation of the sea level error over such modes. The ability of the method to reconstruct the state of the equatorial Pacific and to predict its time evolution is shown. The method is quite robust for predictions up to six months, and able to predict the onset of the 1997 El Niño event fifteen months before its occurrence.

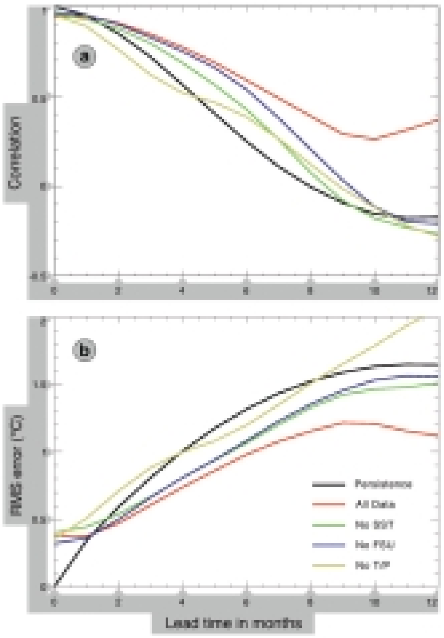

Figure 1: Correlation (a) and RMS Error (b) for coupled model predictions of Niño 3 using a reduced order Kalman filter for the assimilation, separately and together, of SST, FSU surface wind, and TOPEX/POSEIDON altimeter data, over a period January 1993-September 1998.

References

Ballabrera J., A.J. Busalacchi, R. Murtugudde, 2001: Application of a reduced order Kalman filter to assimilate sea level, sea surface temperature, and wind stress into a coupled atmosphere-ocean model: Impact on the prediction of El Niño. *J. Clim.* (in press).

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