WAVE MONITORING AND ANALYSIS IN THE PACIFIC

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Numerous activities are underway at CCAR to utilize TOPEX/POSEIDON data in operational and research projects. For example we are developing a nowcast/forecast general circulation model for the Gulf of Mexico which assimilates TOPEX/POSEIDON altimeter data. We place sea surface topography, wind and wave data on the WWW at three day intervals. The development of shallow water tide models is progressing, and we have various studies underway to analyze TOPEX/POSEIDON data for Kelvin and Rossby wave activity in the global oceans.

Some results of the wave studies are described briefly here. The first result is a comparison of theoretical and observed Rossby wave phase speed in the Pacific. The second result reports on a study to detect and monitor propagation of Kelvin waves along the Pacific coast of the American continent.

Long baroclinic Rossby waves are a mechanism by which mid-latitude oceans adjust at low frequencies to changes in wind forcing. A data assimilation technique has been developed for inverse modeling of long baroclinic Rossby waves based on simulated annealing and extended Kalman filtering of TOPEX altimeter data using a simple ocean model.

The model is a simple low-frequency quasi-geostrophic model with 1 1/2 layers. This limits the modeled sea surface height variation to changes caused by radiation of long (nondispersive) Rossby waves and Ekman pumping. An additional local seasonal heating and cooling term is introduced to account for the annual steric signal at mid to high latitudes. Initial values of the free parameters; reduced gravity, westward Rossby wave speed, amplitude and phase of seasonal heating, were predetermined by simulated annealing [Kirkpatrick et al., 1983] using a cost function based on a discretized form of the model. An extended Kalman filter, based on the model dynamics forced with '93-'95 wind stress anomalies, is applied with TOPEX/POSEIDON Sea Level Anomaly (SLA) data and the annealed parameter estimates.

Regions of free wave activity and Ekman pumping were identified by correlating the filtered Rossby wave and wind forced contribution to the time rate of change of the filtered SLA after removing the annealed estimate of the local heat flux. Phase speeds in regions of Rossby wave correlations greater than 85% are assumed to be associated with freely propagating waves. Comparison of filtered phase speeds at these points to those predicted by linear Rossby wave theory showed faster than expected propagation at high latitudes. Our results are in good agreement with estimates based on subjective filtering of TOPEX/POSEIDON data and hand tracking of wave crests and troughs [Chelton and Schlax, 1996]. A comparison of the estimated phase speed and theoretical phase speed is shown in the Figure 1. Analysis of the model results are currently being conducted to examine the underlying dynamics of the system.

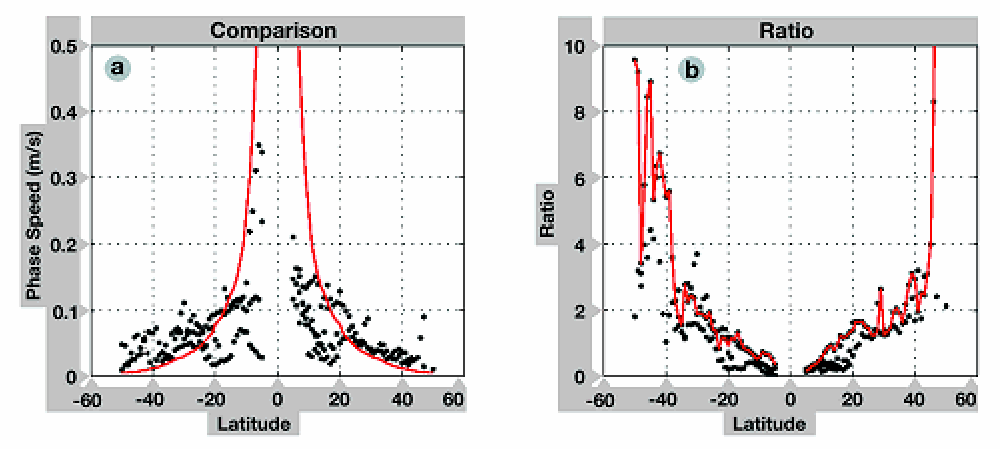

Figure 1

Comparison between (a) the estimated phase speed (in m/s) with the theoretical phase speed (solid line) and (b) their ratio with the mean calculated and plotted at each line of latitude (solid line)

Until recently, there has been little work on the detection and monitoring of meridional propagation of ENSO signals using altimetry. Observations of these signals are crucial to understanding the oceanographic teleconnection between equatorial ENSO signals and the mid-latitudes.

TOPEX data are collected at points across the equator and then along the 200 m isobaths in the northern and southern hemisphere Pacific ocean. The data is decomposed using a MSSA technique to extract and reconstruct signals at various frequency bands such as annual, interannual, seasonal, and intraseasonal.

Results show promise for the detection of poleward propagating ENSO signals in the intraseasonal frequency band in the northern and southern Pacific basins. To best highlight wave propagation, time-distance plots are analyzed. Figure 2 is a time-distance plot of the intraseasonal reconstruction in the equatorial and coastal Pacific regions. The lower portion of the plot is the equatorial and southern hemisphere. The upper portion is the equatorial (repeated) and northern hemisphere.

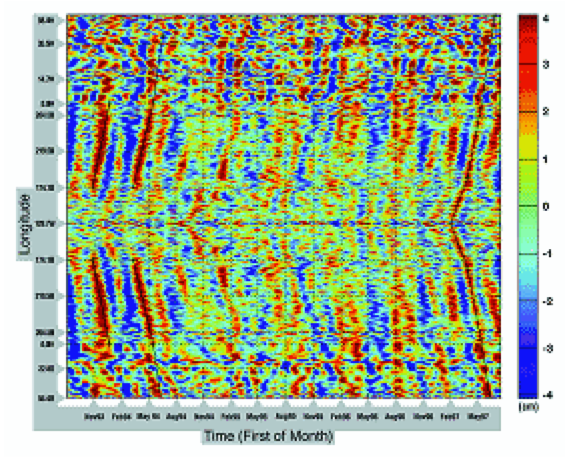

Figure 2

Longitude time distribution of the Sea Level Anomalies (in cm) in the equatorial. and coastal Pacific wave guides: reconstruction of the intraseasonal signal.

(163 Kb)

Many coastally propagating features in both the northern and southern hemispheres are evident during this time period and hemispherical differences are apparent in some cases. Note that once the waves impinge on the eastern boundary of the Pacific, the phase speed tends to increase (as evidenced by the change in the slope of the wavefront on the time-distance plot). Hemispherical differences are apparent in some cases, likely due to local forcing as there is no consistent pattern between hemispheres. Many coastally proon the eastern boundary of the Pacific, the phase speed tendspagating features in both the northern and southern hemispheres are evident during this time period and hemispherical differences are apparent in some cases. Note that once the waves impinge to increase (as evidenced by the change in the slope of the wavefront on the time-distance plot). Hemispherical differences are apparent in some cases, likely due to local forcing as there is no consistent pattern between hemispheres.

References :

- Kirkpatrick et al. , 1983, *Science, 220.*
- Chelton and Schlax, 1996, *Science, 272*, April 1996.