ANALYSIS OF TOPEX/POSEIDON DATA IN OCEAN CIRCULATION STUDIES

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We present analyses of large-scale sea-level variations at seasonal and interannual time-scales in three different oceans, using a combination of TOPEX/POSEIDON (T/P) data, satellite SSTs, and OGCMs. In the Indian Ocean, propagating semi-annual Rossby waves from 20-30°S are evident in both the T/P sea level anomalies and SSTs, and are important in carrying the large interannual variations from the eastern boundary into the ocean interior. In the Atlantic, surface heat fluxes have been inverted from T/P data via an OGCM, and could be used to improve those derived from meteorological models. Finally, in the Pacific, vertical baroclinic modes derived from an OGCM are used to estimate the first three baroclinic contributions to T/P sea level.

Rossby wave propagation in the south Indian Ocean

We have been investigating the south-east Indian Ocean boundary as a generation region for many westward propagating signals. Annual Rossby waves around 10°S are well documented, but there is also a broad range of westward propagating signals between 20-35°S with periods between 100-180 days, and spatial scales of around 500 km [Morrow and Birol, 1997]. These mesoscale features appear to originate at the eastern boundary, where instabilities in the density-driven coastal current generate a large amount of variability, in the form of meanders and separating eddies.

Whether these propagating features are generated by local or remote wind-forcing, or local separation of eddies is currently under investigation. Figure 1 shows that these westward propagating signals have distinct signatures in both dynamic height (measured from altimetry) and SST (from AVHRR). In particular, interannual variations at the eastern Indian boundary can be carried to the ocean interior. For example, altimetry and XBTs show a large warming event on the eastern Indian boundary around May, 1994, which propagates offshore. During the following summer the additional steric effect leads to a large-scale anomalous SST warming in the ocean interior around 90-110°E, lasting several months.

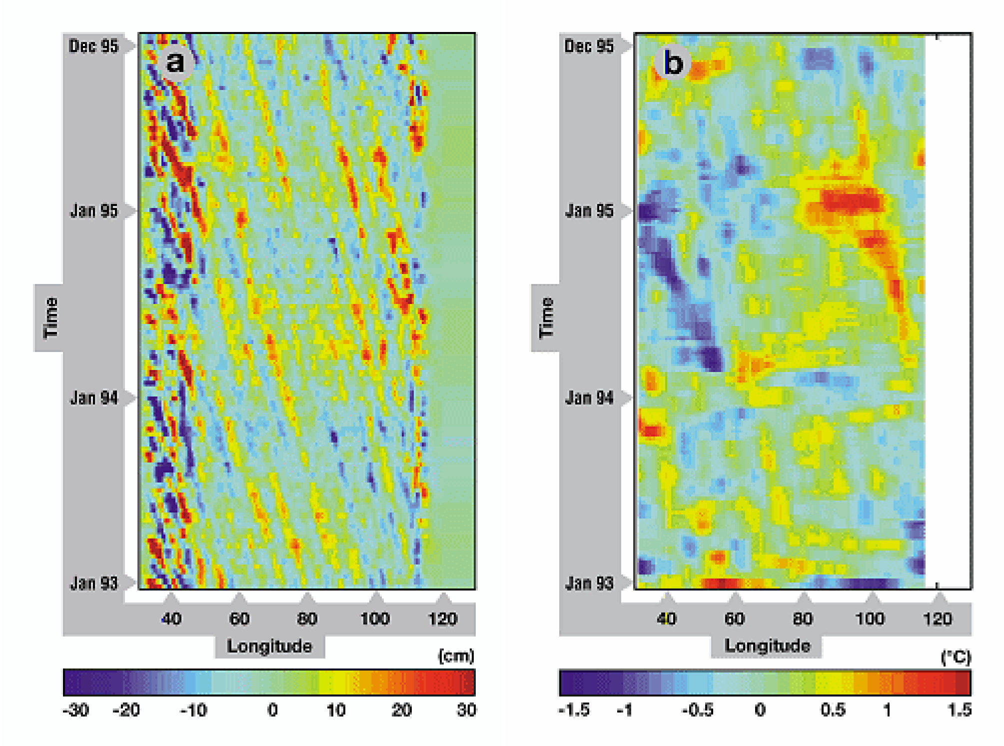

Figure 1
Longitude-Time plots of a) T/P sea level anomalies (in cm) and b) Reynolds SSTs (in °C) at 29°S in the southern Indian Ocean for the period 1993-1995.

The ocean-atmosphere interactions that generated this anomaly are not well understood, although large negative anomalies in the wind stress curl occurred simultaneously. These processes are currently being investigated with T/P altimetry and ERS-1 scatterometry, but clearly the mesoscale propagating signals in the sub-tropics can influence the large-scale SST distribution on interannual time-scales, and monitoring the variability on the eastern boundaries of subtropical oceans may be important for large-scale climate studies.

Inferring oceanic heat fluxes from TOPEX/POSEIDON

Seasonal variation of heat storage in the upper part of the ocean is responsible for steric height variations which account locally for more than 60% of the total variance of the sea level anomaly (SLA) [Stammer et. al., 1996]. At large spatial scales (typically 1000 km), these changes in heat content are mainly due to the surface heat fluxes, the advection being negligible, so that it is possible to deduce oceanic heat fluxes from SLA variations measured by TOPEX/POSEIDON (T/P).

A high resolution OGCM of the North Atlantic ocean has been forced daily with surface fields taken from recent ECMWF-reanalysis over five years (1989-1993). The simulation provides an estimate of the advection which is considered as the main error in the inversion method of calculating heat fluxes from SLA. The eastern part of the basin (east of 25°W and north of 20°N) is characterized by weak advection and poor entrainment/detrainment at the base of the mixed layer, so that the uncertainty of the annual harmonic of heat fluxes is less than 20 W/m^2. SLA from T/P has been inverted for the year 1993 and compared with heat fluxes derived from ECMWF; Figure 2 shows the difference in the first harmonic amplitudes.

In some places discrepancies exceed the level of uncertainty of the method, suggesting that heat fluxes inverted from T/P data could be used to improve the meteorological model heat fluxes.

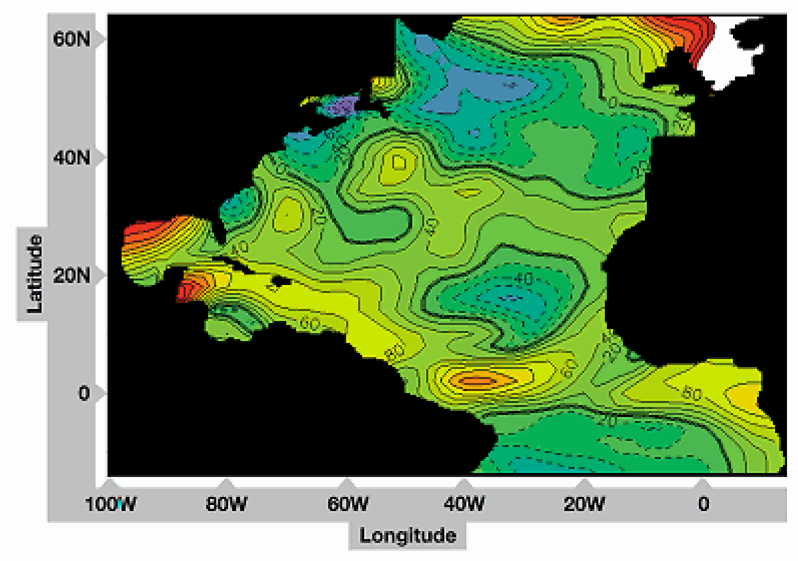

Figure 2
Difference between the annual amplitude of oceanic heat fluxes deduced from T/P data and from ECMWF for the year 1993 (W/m^2)

Estimation Of TOPEX sea level baroclinic contribution

We are investigating how much information on subsurface variability in the equatorial Pacific can be estimated from TOPEX/POSEIDON sea level data. For this, we first investigate the vertical structure of the variability in the equatorial Pacific from a 1985-1994 simulation of an Ocean General Circulation Model [Dewitte et al, 1997]. Using E-EOF decomposition techniques, information on the OGCM derived baroclinic contributions are used to estimate the first 3 baroclinic contributions to TOPEX sea level [Dewitte and Reverdin, 1997].The results suggest that the normal method of assuming a single steady baroclinic mode structure when calculating TOPEX-derived Kelvin and Rossby components may not be sufficient (Figure 3). The method also gives some insight into how much of the subsurface variability can be inferred from altimetric sea level measurements. In the future, it will be interesting to compare these direct estimates with the vertical mode decomposition of an OGCM simulation into which T/P data are assimilated.

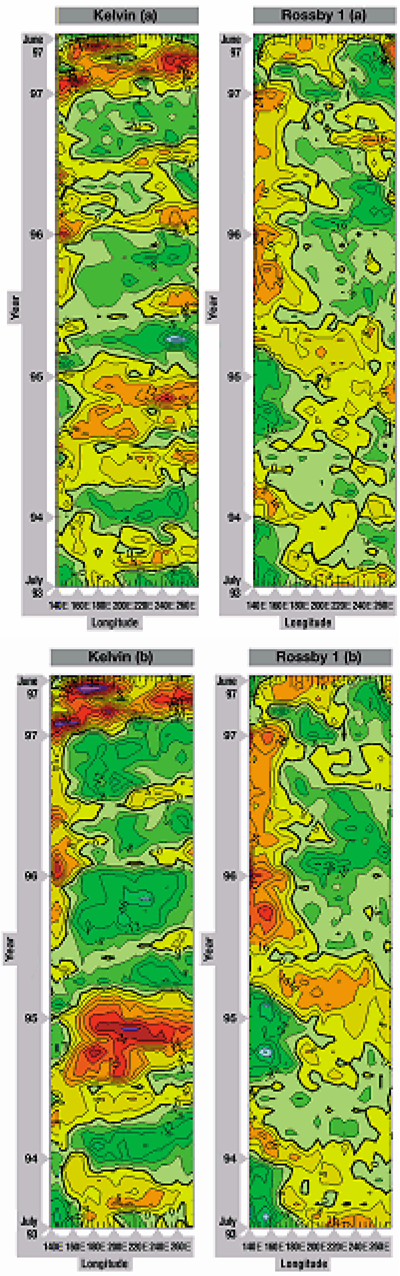

Figure 3
Longitude-time distribution of TOPEX anomalies derived Kelvin and first-meridional Rossby coefficients from July 1993 until June 1997 for the first baroclinic mode (a) using the method based on the OGCM simulation study and (b) assuming a one-baroclinic-mode steady structure for the ocean. Anomalies were computed relative to the seasonal cycle over the period January 1993-December 1996. Units are nondimensionalized.

(131 Kb)

References :

- Dewitte, B., G. Reverdin and C. Maes, 1997: Vertical structure of an OGCM simulation of the equatorial Pacific Ocean in 1985-1994, *JPO (*submitted).
- Dewitte, B. and G. Reverdin, 1997: Estimation of TOPEX sea level baroclinic contribution using the results of an OGCM simulation vertical mode decomposition. *Biarritz meeting proceedings*, oct 97
- Morrow, R. A. and F. Birol, 1997: Variability in the south-east Indian Ocean from altimetry - forcing mechanisms for the Leeuwin Current. *J. Geophys. Res.* (accepted).
- Stammer, D., R. Tokmakian, A. Semtner, and C. Wunsch, 1996: How well does a 1/4dg global circulation model simulate large-scale oceanic observation ?. *J. Geophys. Res.*, *101*, C10, 25779-25794.