SEASONAL-TO-INTERANNUAL VARIABILITY FROM ALTIMETRY AND MODELING

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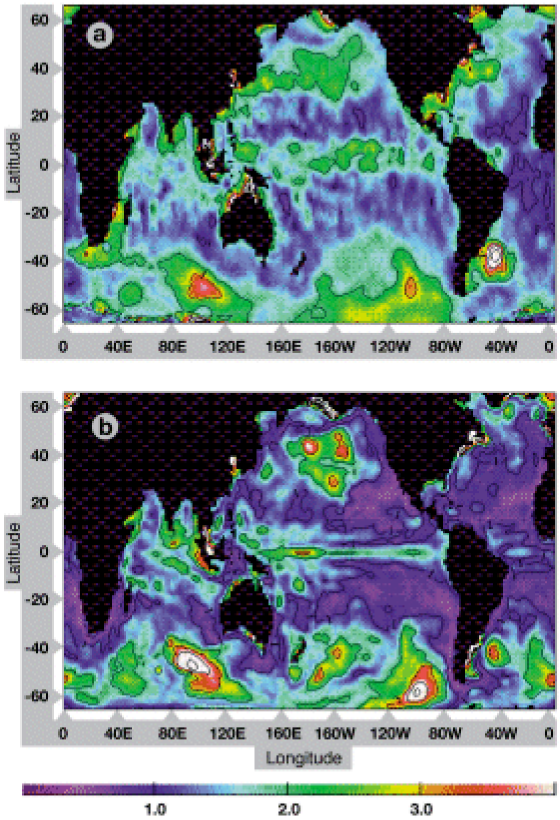
The main objective of the investigation is to understand and determine the time-evolving state of the ocean circulation through the use of the T/P data with numerical models as well as ancillary data during the entire span of the T/P Mission. This determination will be accomplished by using data analysis, numerical modeling, data assimilation and state estimation techniques. Results will be used to address the physical processes of the ocean that are responsible for the variability of the ocean on seasonal-to-interannual time scales. The investigation will be carried out in three interrelated projects.

Global Ocean Variabilities

A major contribution of T/P is its ability to sample the large-scale variability of the ocean with sufficient accuracy for delivering quantitatively useful information. For the first time global ocean general circulation models can be tested against a database with sufficient sampling and accuracy [Fu and Smith, 1996]. Agreement between model and data has been found in a wide range of space and time scales. The model then becomes a powerful tool for understanding the physical processes underlying the sea level observations. For instance, the observed intraseasonal (20-100 day time scale) large-scale sea level fluctuations at high latitudes are found to be due to the barotropic response of the ocean to wind forcing [Chao and Fu, 1995; Figure 1]. Using the model, one can decompose the sea level into its baroclinic and barotropic components and diagnose the mechanisms of sea level variability.



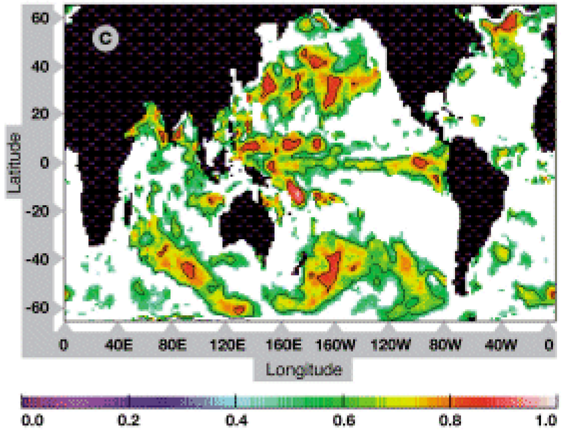


Figure 1
Amplitude of intraseasonal fluctuations (with period from 20 to 100 days) from T/P (a) and OGCM simulation (b), and the coherence between the two (c).

The discrepancies between model simulation and data can be assimilated by the model for improving the simulation of the entire state of the ocean, including current velocity, temperature, and bottom pressure [Figure 2; also see Fukumori, 1995]. The resulting state of the ocean will allow us to calculate the heat content and heat transport of the ocean. The heat budget of the ocean can then be analyzed over the entire global ocean. The current estimates of air-sea heat exchange (e.g., ECMWF or NMC products) are among the poorly known quantities that are key to climate problems. Since sea level is highly correlated to both the heat content of the ocean and the mass transport of ocean currents, the heat budget calculation based on the assimilation analysis should provide unique new information on the global heat budget of the ocean. The results would allow us to address the following questions: What is the heat balance on seasonal-to-interannual time scales? What is the seasonal cycle of the meridional heat transport in the ocean? To what extent are the seasonal cycles of the subtropical and subpolar gyres affected by the heat transport of the ocean in addition to local atmospheric forcing?

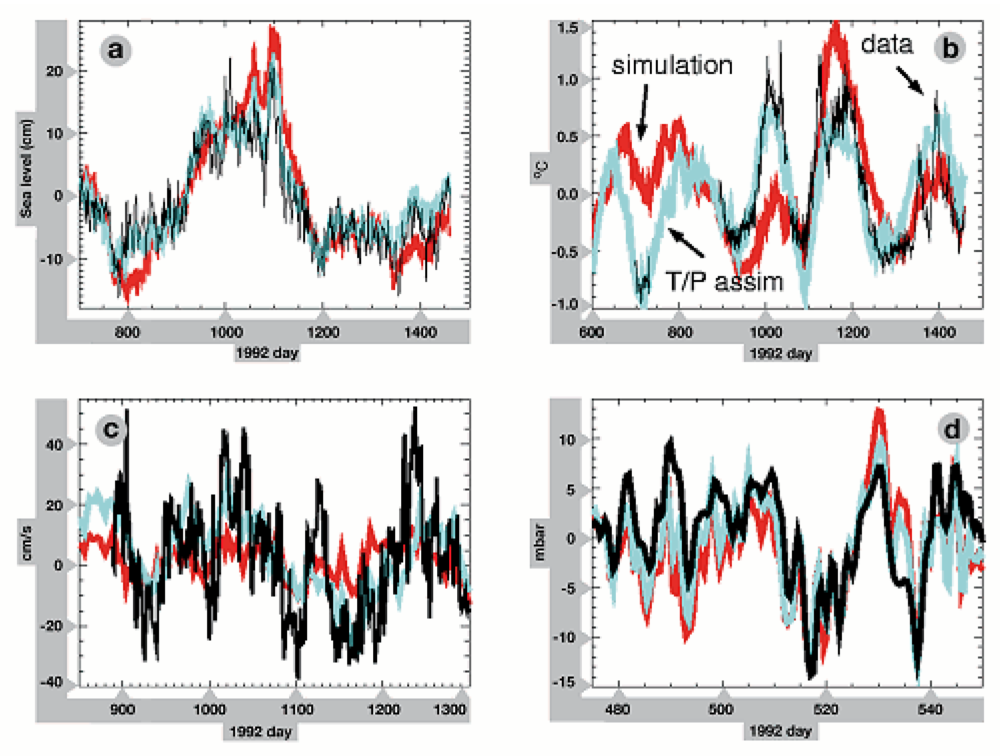


Figure 2

Validating T/P assimilation by comparison with in-situ measurements ; (a) Sea level at Christmas Islands (2°N, 157°W), (b) TAO temperature at 8°N 180°E (200 m), (c)TAO zonal velocity at 0°N 110°W (120 m), (d) bottom pressure near Crozet Island (3600 m, 47°S 52°E). Different curves are data (black), simulation (red), and T/P assimilation (blue).

Pacific Ocean Processes

ENSO is the most pronounced and documented mode of seasonal-to-interannual climate variability. Observations have shown a strong relation between ENSO events and heat content variability of the tropical Pacific. Potentially related to the long spell of warm conditions during the 1990s, the heat content of the tropical Pacific has shown a rising trend since the early 1980s. What is the role of the basin-wide circulation of the Pacific in this rising heat content during 1992-95 and its subsequent switch to a cold condition in 1996 and a fast return to a full-blown El Niño in 1997? Data collected by the T/P mission will provide crucial information to address this question.

Impact of Data Assimilation on ENSO Prediction

For a complex problem like ENSO in which many of the coupled physical processes are still poorly known, a coupled GCM is too unwieldy for understanding the impact of data assimilation. Simpler models that are efficient to run yet still contain the key physics are our choice for understanding the utility of observations in initialization of models. We have modified the Cane and Zebiak model [CZ model hereafter; Zebiak and Cane, 1987] to produce improved simulation of both the oceanic and atmospheric processes in the tropical Pacific [Perigaud and Dewitte, 1996; Dewitte and Perigaud, 1996]. This improved model has been used to illustrate the effect of sea level data in improving ENSO forecasts. It has been shown that the standard CZ model is actually insensitive to the assimilation of sea level data. The assimilation of sea level data has a positive impact on forecasting only after the model improvement has been made. Although the forecast error is significantly reduced, it remains comparable to the observed variance. There are several potential reasons in the present approach responsible for the errors: (1) the crudeness of the assimilation scheme (sea level data have been directly projected onto equatorial waves and inserted in the model); (2) the deficiencies of the model physics such as the role of the decadal trend, the role of the off-equatorial processes and meridional wind, as well as the role of the Indo-Pacific connection. We propose to conduct investigations addressing these issues.

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