ANALYSIS OF TOPEX/POSEIDON DATA AND ESTIMATING THE GLOBAL OCEAN CIRCULATION

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The T/P data have been analyzed on a global scale to produce estimates of the average frequency, wavenumber, and frequency/wavenumber spectra as well as their regional forms. Major contributions to the observed energy have been determined to include steric, tidal, atmospheric load and other effects. With the insights obtained, we combined the absolute and time-varying altimetric data with an oceanic general circulation model and in situ observations to produce full, three dimensional estimates of the flow field and its properties.

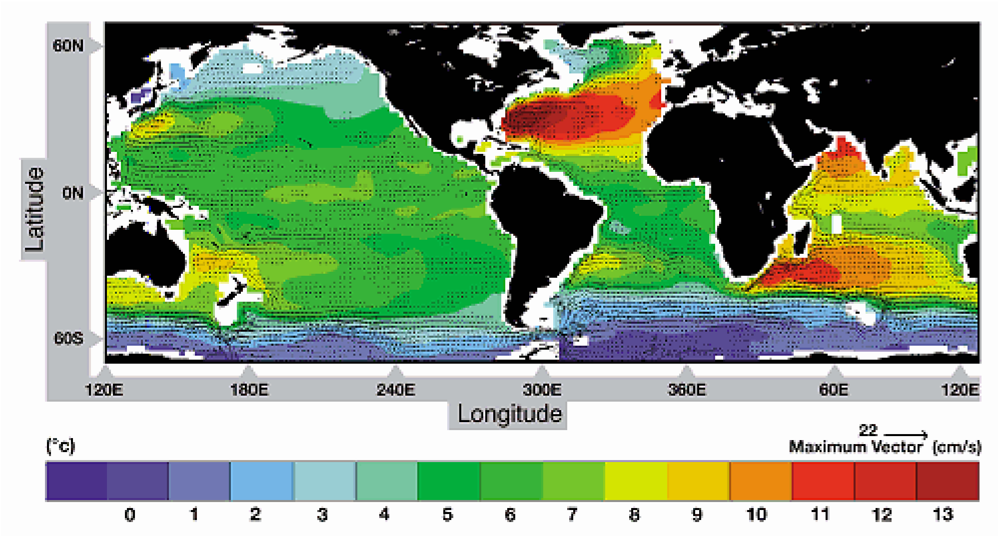
Spectral Descriptions

The very high accuracy and precision of the T/P data have made it the first true global ocean observing system. We have exploited the remarkable richness of the data to determine the nature of the oceanic general circulation with a specific emphasis on the global scales. Wunsch and Stammer [1995] were able to estimate the global average frequency/wavenumber characteristics of oceanic variability, and Stammer [1997] was able to produce a first estimate of a "universal" spectral shape independent of geography. Using a quasi-global data set Wunsch [1997] showed that to a good first approximation, altimeters depict the movement of the oceanic main thermocline, that is strongly reflect the deep interior flows. As the extended mission data become available, and with further analysis of models and in situ data, we anticipate producing a full three dimensional frequency/wavenumber description of oceanic variability extending from about 1 month to the order of a decade.

Global Data Assimilation

With understanding of the altimetry and its complex error structure, it is now possible to produce full three-dimensional, time-varying estimates of the oceanic circulation in a mode of operation somewhat like that in numerical weather prediction. Using the general circulation model of Marshall et al. [1997], the adjoint of that model found from the special compiler of Giering and Kaminski [1997], estimates we have made of the errors in the altimetry (including the EGM96 geoid error covariance), in the wind, and buoyancy fluxes from NCEP daily analyses, and in the Levitus temperature and salinity climatologies, we have succeeded in demonstrating the feasibility of a complete three dimensional, self-consistent oceanic estimate of the absolute varying circulation over a full year.

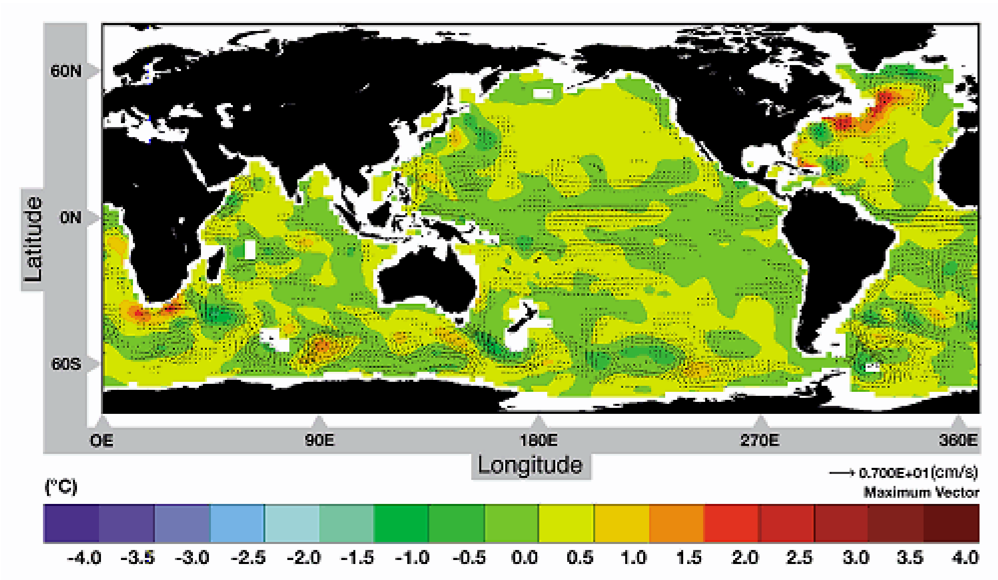
Figure 1 depicts the temperature and velocity fields at 610 m depth in the global ocean model before any data are used other than the surface wind and buoyancy driving. After the assimilation (technically it is a smoothing estimate using a full year of T/P data), modifications are forced on the model at this depth as shown in Figure 2. Adjustments are demanded of the gravity field (Figure 3) as well as all the forcing fields (stress, etc.) and initial conditions.



(130 kb)

Figure 1

Time mean (one year) velocity estimate (in cm/s) and potential temperature (degrees C) at 610 m in the model constrained to altimetric data.



(120 kb)

Figure 2

The changes in monthly mean (October 1993) temperature (in °C) and velocity (in cm/s) estimates due to the assimilation of altimetric data.

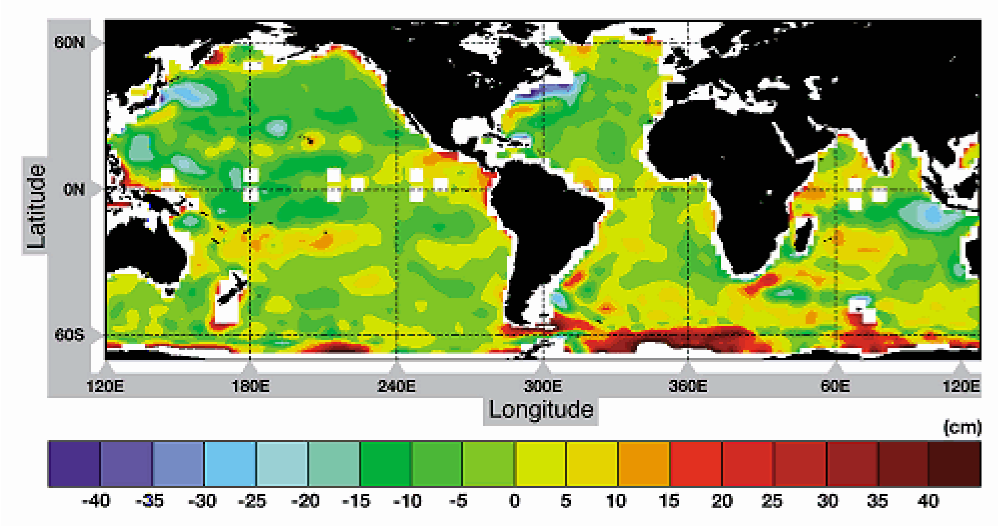


Figure 3

Estimated EGM96 error (mean removed). Adjustment required to EG96 geoid (in cm) to bring the model and all observations in to mutually consistency. These values, if subtracted from EGM96, correspond to a new, presumably improved, geoid.

The next major step is to use the full five years of T/P data, to increase the resolution of the model to at least 1 degree horizontally, to employ the full error covariance (non-diagonal) of EGM96, plus a host of improvements in the model including a full mixed layer, and ice cycle, and new mixing schemes. As the extended mission runs, we expect to move toward a quasi-continuous updating of our estimates so that within a few weeks of observation, estimates of the actual state of the ocean will be available. A major goal is to produce useful error estimates of the oceanic state as well as for the corrected geoid estimate. Oceanic state estimates would in turn be used to understand the physics of the ocean circulation and to greatly improve estimates of oceanic heat, fresh water, and carbon divergences to the atmosphere.

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