Global Ocean Dynamic and Transports

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The primary focus of this project is to use Jason, TOPEX/POSEIDON and other altimetric data (including those from the GEOSAT series, and the ERS-n series) to determine the general circulation of the ocean, on a global continuous basis. The central vehicle for this exploitation is a global general circulation model and its adjoint which we have developed into a system for global data assimilation and analysis [Marotzke et al., 1999]. Results from these efforts are being used to understand the oceanic heat and fresh water fluxes, their divergences, their dynamical causes and effects, as well as a variety of related issues connecting the oceanic circulation to climate variability.

Basically, our work falls into two sub-categories:

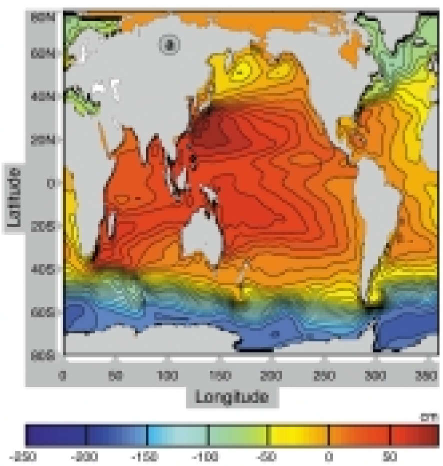
Statistical Descriptions

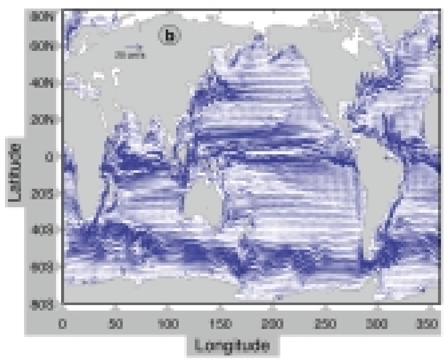
As part of that work, the T/P data have been analyzed on a global scale to produce estimates of the averaged frequency, wavenumber, and frequency/wavenumber spectra as well as their regional forms [Wunsch and Stammer, 1995; Stammer, 1997; Wunsch, 1997; Stammer, 1998]. Those studies include especially the estimation of eddy fluxes and eddy parameterization, spectral representations, response to atmospheric loading. We extended that work by including all available in situ information about ocean variability to estimate the first global spectral description of the oceans eddy variability on space scale from about 100 km to basin scale and from several weeks to a few years [Zang and Wunsch, 2001]. As part of this activity we also exploit the recently demonstrated, qualitatively important covariance of inter-annual altimetric signals with sea surface temperature anomalies and its implication for studying ocean currents.

As Jason data become available, we will continue the monitoring activity by applying the new data to ocean dynamics studies. Any inconsistency in the data will show up as spurious signals in the analyses that will be inconsistent with our knowledge about the ocean.

Global Data Assimilation

Based of T/P data we have demonstrated that it is now possible to produce full three-dimension, time-varying estimates of the oceanic circulation in a mode of operation some what like that of numerical weather prediction. Using the general circulation model of Marshall et al [1997] and its adjoint, estimates we have made of the errors in the altimetry, 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 if a complete three-dimensional self-consistent oceanic estimate of the absolute time-varying circulation over a 6-year period from 1992 through 1997. Results are being used to study ocean transports of heat, freshwater and volume and to understand their divergences and interactions with the atmosphere. A detailed discussion of the analysis is provided in Stammer et al. [2001].





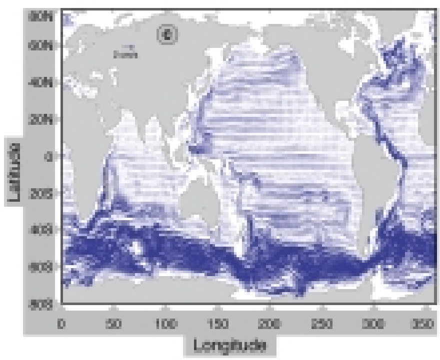


Figure 1: The estimated mean sea surface height field (a) and mean velocity fields at 27 m (b) and 1542 m (c) depth shows all major current systems. But with the low model resolution, they are necessarily overly smooth.

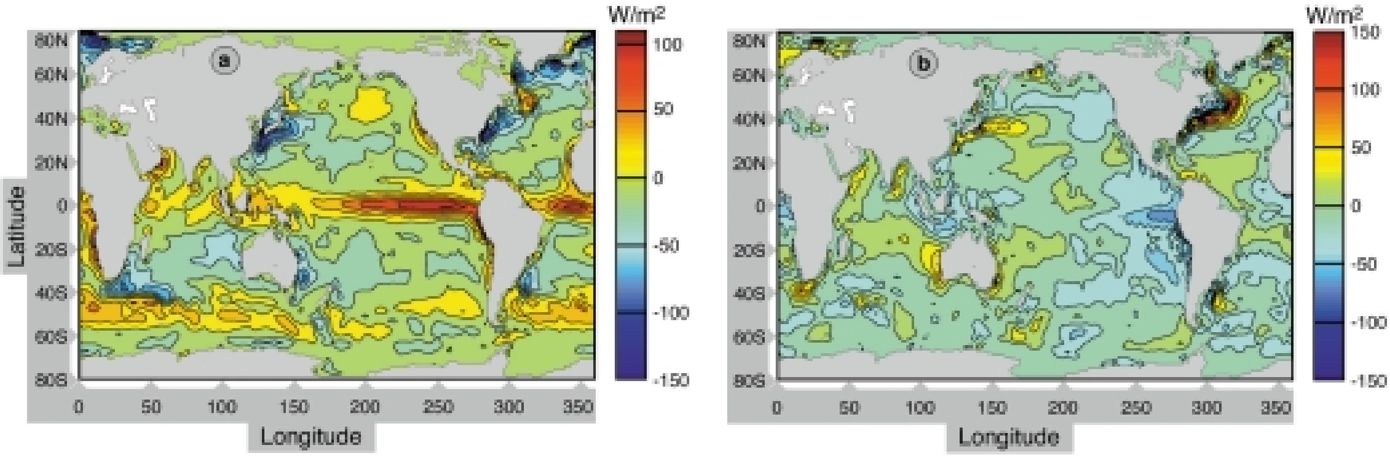


Figure 2: Mean net surface heat field as it results from the optimization (a), and mean change relative to the prior NCEP fields (b). All resulting modifications of the net NCEP heat fluxes, which are of the order of ± 20 W/m² over large parts of the interior oceans and reach ± 80 W/m² along the boundary currents, are consistent with our prior understanding of NCEP heat flux errors.

A few representative results are summarized in figures 1 and 2. The estimated mean sea surface height field and mean velocity fields at 27 and 1542 m depth (figure 1) shows all major current systems. But with the low model resolution, they are necessarily overly smooth. The mean net surface heat and freshwater flux fields as they result from the optimization are displayed in the upper row of figure 2. Their mean change relative to the prior NCEP fields are provided in the lower part of the figure. Ocean transports of all quantities are very energetic and variable. The estimated time-varying model state, model transports and consistent surface flux fields will be the basis for a wide variety of climate and societal applications. Many interdisciplinary applications are already under way or have begun recently, including studies of the ocean's impact on the earth angular momentum budget [Ponte et al., 2000]. Results are likewise being exploited to estimated the ocean uptake and distribution of CFS and ultimately carbon.

It is anticipated that, in two to three years, the project will be able to address the US CLIVAR and GODAE related objective of depicting the time-evolving ocean state with spatial resolution up to 1/4 degree globally and with substantially higher resolution in nested regional approaches which are required for quantitative studies of the ocean circulation. Complementary to this, a 50 year long re-analysis experiment is anticipated but with only a 1 degree spatial resolution that coincides with the NCEP/NCAR reanalysis period.

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