STUDIES OF THE NORTH ATLANTIC OCEAN CIRCULATION AND ITS VARIABILITY USING TOPEX/POSEIDON DATA AND EDDY-RESOLVING MODELS

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The overall scientific objective of this project is to improve the description of the general circulation of the North Atlantic Ocean and our understanding of its dynamics using a combination of TOPEX/POSEIDON (T/P) altimetric observations, available in situ data sets, and a state-of-the-art, eddy-resolving ocean general circulation model (OGCM).

The specific scientific objectives to be addressed are: 1) to describe the sea level variability over the North Atlantic Ocean on the subannual, seasonal, and interannual timescales; 2) to provide a quantitative evaluation of the accuracy of a state-of-the-art, eddy-resolving North Atlantic OGCM; and 3) to investigate the dynamics of specific aspects of the variability of the North Atlantic circulation, particularly those involving interactions of the meso-scale and large-scale flow.

The OGCM used in this study is a free-surface OGCM, which is based on the primitive equations ocean model [Bryan, 1969] developed at Geophysical Fluid Dynamics Laboratory (GFDL), and later known as the Parallel Ocean Program (POP) developed at Los Alamos National Laboratory [Dukowicz et al., 1993]. This OGCM predicts the sea surface height (SSH) which can be directly compared with satellite altimetric observations. The model domain covers the Atlantic Ocean from 35°S to 80°N and from 100°W to 20°E. The OGCM is formulated on a spherical grid with horizontal resolution of approximately 1/6 degree and 37 vertical levels. The OGCM was initialized with the Levitus climatology and integrated for thirty years forced with climatological monthly air-sea fluxes. Results from the last five years integration were saved every three days and used in the present analysis [Chao et al., 1996].

The SSH variability over the North Atlantic Ocean has been studied using the T/P observations and an eddy-resolving Atlantic OGCM. Horizontal maps of the standard deviation of the observed and simulated SSH are first compared. Maximum SSH variability is found to be associated with the major western boundary currents. Near these western boundary currents, the simulated amplitude of the SSH variability agrees well with the T/P observations. The alongtrack wavenumber spectra are then compared over various 10 degree by 10 degree subdomains in the Atlantic Ocean [Cheng et al., 1997]. Good agreement is found in the Gulf Stream area. Both the amplitude and the spectra slope are comparable between the model and data with the spatial scale up to 500 km. Moving away from the Gulf

Stream area, however, the model SSH variability is significantly weaker than the T/P observations. In the subtropical Atlantic Ocean, the model energy is comparable to the T/P observations in the low wavenumbers, but much weaker in the high wavenumbers. This weaker energy in the high wavenumbers is mostly due to the coarse resolution of the wind stress which can be further improved using the scatterometer wind observations.

A regional analysis over the Caribbean Sea has been conducted. Large anticyclonic eddies were found in both the TOPEX/POSEIDON observations and OGCM simulations [Carton and Chao, 1997]. These Caribbean Sea eddies appear once every 100 days near the Southern Lesser Antilles, and propagate westward at a speed of 12 cm/sec. It was hypothesized that these Caribbean Sea eddies are linked to eddies formed outside the Caribbean Sea over the North Brazil Retroflection region.

A comprehensive analysis of the Gulf Stream's sea-level variability is currently under way by applying singular spectrum analysis (SSA) to the T/P data and the 1/6 degree OGCM simulation. SSA [Vautard and Ghil, 1989] is a form of principal-component analysis, designed to extract as much information as reliably possible from short and noisy time series and to provide insight into the dynamics of the underlying system that generates the time series, and multi-channel SSA has the capability of describing the spatio-temporal structure of the variability. Our initial focus will be on the subannual and seasonal-to-interannual variability of the Gulf Stream. Several other aspects of the North Atlantic circulation and variability will also be investigated in the future.

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