Abstract View

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The Oceanic Response to Large-Scale Atmospheric Disturbances

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ABSTRACT

This paper is an analytical and numerical study of the response of the ocean to the fluctuating component of the wind stress as computed from twice-daily weather maps for the period 1973 to 1976. The results are described in terms of (time) mean and rms fields, frequency spectra and horizontal cross spectra, and local cross spectra between oceanic and atmospheric variables.

A forcing function with scales strictly larger than O(100 km) induces oceanic motion that is depth independent at periods between the inertial period and $\sim$300 days. The dynamics is essentially linear so that rectified currents are small, the associated rectified transport amounts to at most 1–2 Sv in the western boundary layer. Root-mean-square currents are typically a few centimeters per second and are most intense in the western part of the basin, and near major topographic features. Fluctuations in the transport of the western boundary layer can be as large as 20–30 Sv. Three distinct frequency bands characterize the wind-induced barotropic fluctuations: 1) At periods between the inertial period and about one week the energy density increases steeply with decreasing frequency. Current spectra have a slope between −2 and −4. These forced waves can show an (imperfect) coherence between wind stress and the corresponding current components, and between atmospheric pressure and subsurface pressure. But spatial inhomogeneities in the wind field or bottom topography can destroy this coherence. 2) At periods between a week and a month planetary (or topographic) Rossby waves are dominant so that westward phase propagation is prominent. 3) At longer periods westward phase propagation is less evident and there is a time-dependent Sverdrup balance between meridional (cross-isobath) currents and wind stress curl. The spectra at these long periods are frequency independent (white) and the zonal (along-isobath) velocity component is more energetic than the meridional (cross-isobath) component.

Despite the high degree of idealization in the models, local coherence between oceanic and atmospheric variables is virtually nonexistent (except possibly at periods between 1 and 10 days) because of the wavelike structure of the oceanic response, the broadband stochastic character of the atmospheric variability, and inhomogeneities in the wind field and bottom topography.

It is proposed that fluctuations observed at site D north of the Gulf Stream are primarily atmospherically forced. At the MODE central mooring, however, there must be an additional energy source.

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