Abstract View

Volume 27, Issue 8 (August 1997)

Journal of Physical Oceanography
Article: pp. 1533–1546 | Full Text | PDF (266K)

A Simple Model of the Decadal Response of the Ocean to Stochastic Wind Forcing *

Claude Frankignoul

Laboratoire d'Océanographie Dynamique et de Climatologie, Unité Mixte de Recherche CNRS–ORSTOM–UPMC, Université Pierre et Marie Curie, Paris, France

Peter Müller

Department of Oceanography, University of Hawaii, Honolulu, Hawaii

Eduardo Zorita

Laboratoire d'Océanographie Dynamique et de Climatologie, Université Pierre et Marie Curie, Paris, France

(Manuscript received May 15, 1996, in final form October 15, 1996)

DOI: 10.1175/1520-0485(1997)027<1533:ASMOTD>2.0.CO;2

ABSTRACT

A simple linear model is used to estimate the decadal response of the extratropical ocean to wind stress forcing, assuming a flat bottom, a mean state at rest, and no dissipation. The barotropic fields are governed by a time-dependent Sverdrup balance, the baroclinic ones by the long Rossby wave equation. The ocean is bounded by a coast in the east and a radiation condition is used in the west. At each frequency, the baroclinic response consists of a forced response plus a Rossby wave generated at the eastern boundary. For zonally independent forcing, the response propagates westward at twice the Rossby phase speed. The wind stress is assumed to be stochastic with a white frequency spectrum, so the model represents the continuous excitation of the ocean interior by the weather fluctuations. The model predicts the shape and level of the frequency spectra of the oceanic pressure field and their variation with longitude and latitude. The baroclinic response is spread over a continuum of frequencies, with a dominant timescale determined by the time it takes a long baroclinic Rossby wave to propagate across the basin and thus increases with the basin width.

The predictions for zonally independent forcing are compared with the North Atlantic pressure variability in an extended integration of the ECHAM1/LSG coupled GCM. The agreement is good in the interior of the subtropical gyre, but less satisfactory in the subpolar gyre. The theory correctly predicts that the baroclinic spectra are red with

a high-frequency ω^{-2} decay that levels off at low frequency, and how this spectral shape changes with longitude as a result of varying fetch and with latitude as a result of parameter changes. The theory predicts that the barotropic frequency spectra are white, whereas the GCM spectra are slightly red. Nevertheless, it captures how the barotropic pressure spectra vary with longitude, latitude, and wind stress intensity. The baroclinic predictions for a white wind stress curl spectrum are also broadly consistent with the frequency spectrum of sea level changes and temperature fluctuations in the thermocline observed near Bermuda. Stochastic wind stress forcing may thus explain a substantial part of the decadal variability of the oceanic gyre.

top