1. Title Observations and Modeling of the Transient General Circulation of the North Pacific Basin.

2. PI name and institution James C. McWilliams, University of California, Los Angeles.

3. Period of performance and funding 01 January 1996 to 30 June, 2000 [extended]. Budget: 1st yr = $115,710, 2nd yr = $110,342, 3rd yr = $115,182, total = $341,234.

4. Overview

Because of recent progress in satellite altimetry and numerical modeling and the accumulation and archiving of long records of hydrographic and meteorological variables, it is becoming feasible to describe and understand the transient general circulation of the ocean (i.e., variations with spatial scales larger than a few hundred kilometers and time scales of seasonal and longer—beyond the mesoscale). We have carried out various studies in investigation of the transient general circulation of the Pacific Ocean from a coordinated analysis of satellite altimeter data, historical hydrographic gauge data, scatterometer wind observations, reanalyzed operational wind fields, and a variety of ocean circulation models. Broadly stated, our goal was to achieve a phenomenological catalogue of different possible types of large-scale, low-frequency variability, as a context for understanding the observational record. The approach is to identify the simplest possible model from which particular observed phenomena can be isolated and understood dynamically and then to determine how well these dynamical processes are represented in more complex Oceanic General Circulation Models (OGCMs). Research results have been obtained on Rossby wave propagation and transformation, oceanic intrinsic low-frequency variability, effects of surface gravity waves, pacific data analyses, OGCM formulation and developments, and OGCM simulations of forced variability.

5. Results

Funds from this grant were used to partially support Drs. Pavel Berloff, Jeroen Molemaker, Alexander Shchepetkin, and Remi Tailleux; a graduate student; and myself. We have done research on the following subjects (related publications are cited in brackets here that refer to Sec. 6).

(A) Rossby Wave Propagation and Transformation

We developed a Planetary-Geostrophic theory for Rossby wave propagation over variable topographic and mean circulation. Our two major results are that the anomalous baroclinic Rossby-wave propagation speeds observed with altimetry (Chelton & Schlax, 1996) are quantitatively consistent with our predictions based on deep-pressure compensation, and that there is significant energy conversion to and from the barotropic currents due to topographic coupling [19-21].

(B) Oceanic Intrinsic Low-Frequency Variability

We formulated and analyzed two types of idealized models that show how instabilities of the general circulation lead to large-scale, low-frequency variability that exists in competition with the variability forced by climate fluctuations: wind-driven, mid-latitude, quasi-geostrophic gyres and Primitive-Equation, thermohaline, meridional overturning circulation coupled to an idealized atmospheric model [1-2,18].

(C) Effects of Surface Gravity Waves

We derived a new theory of how time-averaged effects of surface gravity waves influence the general circulation. Of greatest relevance to satellite observations are substantial changes in the surface Ekman current due to Stokes drift and a correction of the calculation of surface dynamic pressure from sea level due to $< (\frac{\partial \eta'}{\partial t})^2 > (x, y, t)$. Climatological estimates of these effects have been made using empirical wind-wave regressions [14,16].

(D) Pacific Data Analyses

We have analyzed SST and hydrographic data to study the Pacific Decadal Oscillation, showing its recurrence over almost the past century and its broad, equatorially antisymmetric spatial extent [3-4].

(E) OGCM Formulation and Development

In a sustained collaboration with NCAR scientists, we have contributed to the development of an OGCM in a variety of ways that have made it more skillful in its simulations of large-scale time-mean, seasonal, and forced-transient circulation [5-6,8,10-13,15].

(6) OGCM Simulations of Forced Variability

Our guiding hypothesis is that most large-scale, inter-annual oceanic variability is forced by climate fluctuations (but also see (2) above), especially near the surface where the observational data sets (including from satellites) are most complete. We have calculated and analyzed OGCM solutions that test some aspects of this hypothesis, and we have shown that it has considerable validity [7,9-11,17].

6. Publications

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