Atmospheric/Oceanic Interaction Studies

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LONG-TERM GOAL

The ultimate goal of this project is to improve our understanding of the interactions of the earth's atmosphere and ocean on the time scales ranging from days to seasons. This increased understanding is a precursor to the development of a global coupled system that will provide increased global forecast skill and high resolution initial and boundary data for the Navy's operational mesoscale coupled weather system, the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) and Fleet Numerical Meteorology and Oceanography Center's (FNMOC) ocean and wave models.

OBJECTIVES

We wish to develop procedures and strategies for coupling the Navy Operational Global Atmospheric Prediction System (NOGAPS) to global ocean models and to determine the causes of the systematic errors of the coupled atmospheric/ocean model. Using the coupled NOGAPS system and a simpler coupled system, we wish to investigate the interaction and feedbacks between atmospheric heat and momentum forcing and global scale oceanic oscillations.

APPROACH

This research contains both theoretical and modeling components. In the theoretical studies we have built a conceptual analytical model that includes all essential physical processes in the air-sea coupled system. The dynamical framework of this conceptual coupled model is based on the previous theoretical studies on the seasonal cycle and ENSO mechanisms performed under this research grant. The second part of the research has focused on coupling NOGAPS to the Modular Ocean Model (MOM) and an ice prediction model, and developing procedures for lessening the systematic climate drift of the coupled system. Several multiyear coupled integrations have been performed and the systematic errors were analyzed. Several of the extended simulations were performed as part of the Department of Energy's international Coupled Model Intercomparison Project (CMIP).

WORK COMPLETED

NOGAPS has been coupled to MOM, which is a state-of-the-art dynamic and thermodynamic global ocean model. A flux adjustment scheme has been developed that can successfully simulate both the seasonal cycle and interannual variation. The impact of this correction on the seasonal and interannual variations of the tropical Pacific has been investigated. Multiple year integrations have been performed with the coupled system and the results compare favorably with the existing climate. In addition, using a

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simplified coupled modeling system, we have investigated the role of the different mechanisms (solar radiation reflection off cirrus clouds, evaporative cooling, and dynamical ocean heat transport) that determine the dynamical and thermodynamic regulation of ocean warming.

RESULTS

The results of the coupled model experiments clearly demonstrate the importance of correctly predicting the time-mean state for seasonal and interannual variability in the tropics. With the correct time-mean SST and surface wind, the coupled modeling system is capable of simulating the observed annual cycle. In addition, the system is capable of simulating the westward propagation of the SST and the wind along the equator, in both the Pacific and Atlantic. The structure of the simulated interannual oscillations resemble those observed during El Nino events. Also, the results using a simplified coupled modeling system clearly indicated that the radiative effects of clouds and latent heat release (in addition to the ocean dynamics) must be properly modeled in order to obtain the correct tropical ocean sea surface temperature.

IMPACT/APPLICATION

The Navy is pursuing the goal of coupling atmospheric numerical weather prediction models to ocean prediction models to simulate more accurately and at a higher resolution the evolution of atmospheric and oceanic circulations. Ultimately, the high resolution prediction must come from a globally re-locatable, mesoscale prediction system, such as COAMPS, with an ability to forecast motions down to several kilometers. However, the skill of any mesoscale system is a function of the boundary forcing that drives the forecast model. In addition, since the ocean has a much longer memory than the atmosphere, the initial ocean conditions will play a critical part in the mesoscale coupled model forecasts over a long period of time. This initial and boundary forcing must come from a global prediction system, which is capable of globally predicting accurately the complexities of currents and ocean temperatures.

TRANSITIONS

Several improvements to the atmospheric component of the NOGAPS coupled modeling system were transitioned to 6.2 for further study. These include improved cloud prediction and improvements to the surface flux parameterization.

RELATED PROJECTS

This atmospheric model development effort is part of our vertically integrated program for basic (6.1) and advanced (6.2) research as well as transition to operations (6.4). Related 6.1 projects within program element (PE 0601153N) include BE-033-02-4K, BE-033-02-45, 031-03, and 015-08, which represent basic research in aerosols, air-sea interactions, boundary layer processes, coastal mesoscale processes, air-ocean coupling, and tropical cyclones. Related advanced development (6.2) projects within PE 0602435N are BE-35-2-20, 035-32, 035-33, BE-35-2-19, 035-71, 035-23, and BE-35-2-32, which focus on the development of data assimilation systems, prediction of aerosols, development of coupled air-ocean-wave prediction systems, and the utilization of massively parallel computer architecture for solution of non-linear prediction systems. Related 6.4 projects under PE 0603207N include X0513-02, and X0523-01, which focus on the transition of the 6.2 development to operations at FNMOC.

PUBLICATIONS

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