Atmospheric Models/Global Atmospheric Modeling

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LONG-TERM GOAL

The ultimate goal of this project is to improve the numerical global weather prediction ability of the Navy. This objective is to be obtained by developing state-of-the-art numerical algoritms and physical parameterizations that demonstate superior statistical and synoptic skill over existing techniques when tested in a data assimilation cycle similar to that used in operations.

OBJECTIVES

The objective of this project is to develop a global numerical weather prediction model that has forecast skill out to 7-10 days. The output from this model will be used to provide weather information for military planning and exercises; to provide boundary conditions for mesoscale models; and to provide surface fluxes to ocean, wave, and ice prediction models. This model must be capable of providing consistent, accurate depictions of the atmosphere with a range of scales from global down to mesoscale, for weather phenomena such as tropical cyclones, fronts, and intense precipitation. The payoffs for having such a model includes improved forecast guidance and products for many Fleet activities such as weapons support, meoscale and local weather, ocean thermal structure and circulation forecasting, ice prediction, wave forecasting, ship routing, flight planning, and mission planning.

APPROACH

Our approach is to build a global atmospheric model based on the hydrostatic primitive equations. This model represents the forecast component of the Navy Operational Global Atmospheric Prediction System (NOGAPS). The use of the NOGAPS forecast model for operations implies that efficient solution techniques must be used. The solution of the dynamics is done on a spectral grid, which avoids the complication of the convergence of grid points near the poles, present when solutions are attempted using finite difference techniques. A semi-implicit time integration technique is used to allow for larger time steps, and therefore, a more efficient solution than that attainable with conventional explicit solution techniques. State-of-the-art parameterizations are used to include relevant physical processes. These include convective and large-scale precipitation processes, radiation parameterizations to account for long-wave and solar radiative processes (clear-sky and cloudy interactions), planetary boundary layer turbulent mixing, and a surface layer flux parameterization.

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WORK COMPLETED

In FY '98, the 6.2 NOGAPS work focused on identifying systematic errors, improving some of the existing parameterizations, testing the impact of the revised TOVS retrievals, and developing new numerical methods to replace the spectral dynamical formulation. An effort is underway to identify deficiencies in the various physical parameterizations and the systematic errors in tropical cyclone track predictions. Testing has begun on implementing a semi-Lagrangian advection and thin-grid schemes into NOGAPS. Major work is continuing in improving the surface flux, gravity wave drag, cumulus convection, and radiation schemes. Conference and journal articles have been written and submitted, which include the development of NOGAPS' adjoint, tropical cyclone forecasting, and numerical methods on geodesic grids. An improved diffusion formulation at the model top, an improved stratiform cloud parameterization, and a new normal mode initialization of the multivariate optimum interpolation's (MVOI) increments have been transitioned to 6.4.

RESULTS

The overall results of the work resulted in the transition of NOGAPS 4 to operations. NOGAPS 4 constitutes a major upgrade in the Navy's weather predictive skill. The results from data assimilation/forecast tests over a summer month, a winter month, and 2 tropical cyclone periods demonstrate an increase in skill in nearly every statistical measure examined, with significant improvements in the tropics and stratosphere. The new initialization procedure marks a major break-through in providing even more accurate 0-48 hour forecast products to the Navy's mesoscale weather prediction system COAMPS, which depends critically on global boundary conditions

IMPACT/APPLICATION

The global modeling project addresses a DOD Key Technology of Environmental Effects by employing DOD Critical Technologies of Simulation and Modeling and assessing Weapon System Environments. Mission Area Thrusts in Decision Support, Distributed C2, Information Management, and Scene Description and Simulation are addressed. Virtually all of the DOD Science and Technology Thrusts are affected by improved assessment and prediction of atmospheric conditions.

Safe and efficient operation of ships and aircraft at sea and ashore highly depends on accurate predictions of hazardous weather and sea conditions. Mission planning, rehearsal, and execution require knowledge of current and future atmospheric and ocean conditions. A staggering range of spatial and temporal scales must be addressed, from cloud droplets to global weather patterns and from instant support for low-flier detection to 10-day predictions for mission planning. NOGAPS is central to all requirements for environmental support. Not only does NOGAPS provide the weather information needed for global-wide support of DOD assets, it also provides the boundary conditions for tactical scale atmospheric prediction systems and provides the forcing for ocean, ice, and wave predictions. Thus improvements in the global model have far-reaching DOD implications.

In addition to benefiting all of the DOD and broader defense-related activities, technology developed at NRL is also being used by other civilian agencies. For example, NOGAPS has earned strong respect as a skillful hurricane forecast model, and the NOGAPS forecasts are frequently referred to in the official guidance issued by NOAA's Hurricane Center. Furthermore, graphical NOGAPS products made available by FNMOC over the Internet are used by National Weather Service and public media forecasters as additional guidance when preparing their local forecasts. Feedback during this past winter's El Nino-enhanced storm season was very favorable concerning NOGAPS prediction of these damaging west coast storms.

TRANSITIONS

The results of this work (new initialization of increments, improved cloud prediction, and improved surface fluxes) have been transition to 6.4 (Global Atmospheric Models, PE 0603207N, X-0513, SPAWAR PMW-185) and ultimately became part of the latest version of NOGAPS (NOGAPS 4), which was transitioned to operations at FNMOC in June 1998.

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 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.

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