National ESPC Committee Support

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LONG-TERM GOALS

The goal of this project is to accelerate the rate of improvement in the US National Earth System Prediction Capability (ESPC) and National Unified Operational Prediction Capability (NUOPC), focusing primarily on the current and future generation global modeling enterprise. Improvements in the Numerical Weather Prediction (NWP) and climate prediction capabilities are expected to result in better environmental situation awareness, severe weather warnings (hurricanes, tornadoes, snow storms), better cost avoidance for weather sensitive industries (agriculture, transportation, utilities, and defense), and better informed decision making for industry, defense and the general public.

OBJECTIVE

The objective of the interoperability and interagency work is to accelerate the improvement of our national prediction capability in the following ways: (1) Advancement of a physical interoperability layer that will allow sharing of physical parameterization suites with the ESPC enterprise; (2) Advancement of a global atmospheric multi-model ensemble system designed to enhance predictive capability and to provide probabilistic prediction for severe weather events; (3) Clearly articulating operational requirements and articulating a corresponding National research agenda; (4) Sharing the development efforts and promote collaborations of NWP and climate systems among the operational agencies; (5) Accelerating the transition of new technology into the operational centers; (6) Designing requirements and standards of future NWP ESPC systems; (7) Accelerating the development and transition of the Navy ESPC system and its participation in the national multi-model ESPC ensemble system; and (8) Implementing methods to enhance broad community participation in addressing the National research agenda. These goals will be achieved through model development under a common model architecture and other software-related standards.

APPROACH

The general approach of the ESPC and NUOPC efforts is that each US operational NWP Center (AFWA, FNMOC, NCEP) runs global deterministic and ensemble prediction systems based on a numerical weather prediction (NWP) system configured to best meet their individual mission requirements. Each NWP system is configured from interchangeable components implemented under the Earth System Modeling Framework (ESMF) following NUOPC standards. To support this goal we are focused on these efforts:

1) Continue to implement ESMF in NAVGEM for interoperability and diversity of ensemble prediction systems. ESMF is a coupling framework that reduces the recoding and occurrence of inadvertent errors when coupling numerical prediction models (atmosphere, ocean, wave, ice, land, aerosol, etc.) from various sources and on differing hardware systems. It can also be employed to couple model components such as combining the physics parameterizations from one system with the dynamics core from another system. Under NUOPC funding, ESMF development will be completed, maintained and evolved to address DoD and NOAA requirements. In addition, a standardized method of implementing ESMF will be developed for NUOPC team partners in order to achieve interoperability goals. This will include standard templates, user support and training.

2) Revision of codes to meet the NUOPC and ESPC standard input/output formats, and physical constants to achieve the interoperability goal. The testing and evaluation will move toward the NUOPC standard to facilitate interactions and collaborations within the research and development community.

3) The general approach of the NUOPC global ensemble weather prediction system is that each US operational NWP Center (AFWA, FNMOC, NCEP) runs a global ensemble suite based on a numerical weather prediction (NWP) system configured to best meet their individual mission requirements. Each NWP system is configured from interchangeable components implemented under the ESMF. Participating centers shall coordinate and agree to the following for their global ensemble suites:

    - Horizontal and vertical resolution and number of ensemble members (all of which may vary from Center to Center),
    - Forecast length and forecast output intervals, and
    - Global ensemble suites from each Center assembled into a Unified Global Ensemble under the auspices of NUOPC.

4) Staffing and Coordination: NUOPC is a collaboration among the three primary operational NWP centers; however, it also involves collaboration with other primary NWP development centers such as NASA, NCAR, and DOE and will require project management staff, travel and coordination meetings. NUOPC interoperability and coding standards will require frequent discussion and coordination in order to establish evolving standards as NWP science, software and hardware technology advances.

5) Focused NUOPC development projects: NUOPC will undertake development initiatives to enhance collaboration between NOAA and Navy and to accelerate development on common objectives. Currently, areas being addressed are hurricane track and intensity forecasts through global ensembles, improved ceiling and visibility forecasts and probabilistic wave and sea products.

6) The physical parameterization interoperability will require implementation of common architecture with regard to the physical parameterization driver software at Navy, NOAA, NASA, and AFWA. This interoperability capability will allow for more straightforward and efficient exchanges of physical parameterization suites between operational partners and the research community at large.

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WORK COMPLETED

In the past year, we continue to work on the implementation of the ESMF in NAVGEM, HYCOM, CICE, and Wavewatch III for interoperability, coupling, and diversity of ensemble prediction systems. A standardized method of implementing ESMF is being developed for NUOPC team partners in order to achieve interoperability goals. These include standards for ESMF, templates, user support and training. A joint journal paper describing the ESMF effort has been accepted for publication in the *Bulletin of the American Meteorological Society*.

There are several committees within NUOPC that this work is involved with, namely the Common Model Architecture (CMA) and Technology Transition Processes (TTP) Committees. There is also a subcommittee, Content Standards Committee (CSC), under CMA. An additional subcommittee under CMA is the Physics Interoperability (PI) Group. The performers of the project at NRL served in all the committees and have been actively participating in the telecom meetings held bi-weekly and the workshops. The Navy leads the monthly conference call for the physical parameterization interoperability group. Additionally, NRL-Monterey participates in the NOAA NGGPS conference calls related to the testing of the physics driver.

RESULTS

The physical parameterization interoperability will require implementation of common architecture with regard to the physical parameterization driver software at Navy, NOAA, NASA, and AFWA. This interoperability capability will allow for more straightforward and efficient exchanges of physical parameterization suites between operational partners and the research community at large. In the past year, we continued to collaborate with NCEP on the interoperable physics driver. We anticipate modifying this software physics driver and testing it in the Navy NEPTUNE and possibly NAVGEM systems in the coming months. A prototype of the driver was delivered in June 2015 for further testing and evaluation as part of the NOAA Next Generation Global Prediction System (NGGPS) project. We are working closely with the dynamical core groups from NGGPS to test the driver in a multitude of dynamical cores. The feedback from the groups has been valuable.

Implementing existing or new physical parameterizations in numerical weather prediction and climate models is often a major challenge because there is no standard set for the physical parameterization interfaces. In this project, we seek to establish such a standard interface.

The schematic in Figure 1 summarizes our generalized physics driver. The attributes of this driver are as follows

- A pre-physics interface is used to translate between the dynamics and the physics driver. This interface destaggers the necessary variables, and prepares the variables to pass into the driver as 1D or 2D fields.

- The atmospheric physics driver is a software wrapper around the physics suite that is designed to be a standard interface and generally independent of the details of the physics suite.
- From the physics driver, other models can be called, such as ocean, LSM, wave, chemistry, aerosol, ice etc. We assume these drivers are ESMF compatible and formulated within the NUOPC layer.
- After the physics time step, fields can be output directly for budget calculations, and the tendencies and updates are passed back through the standard driver interface to a post-physics interface.

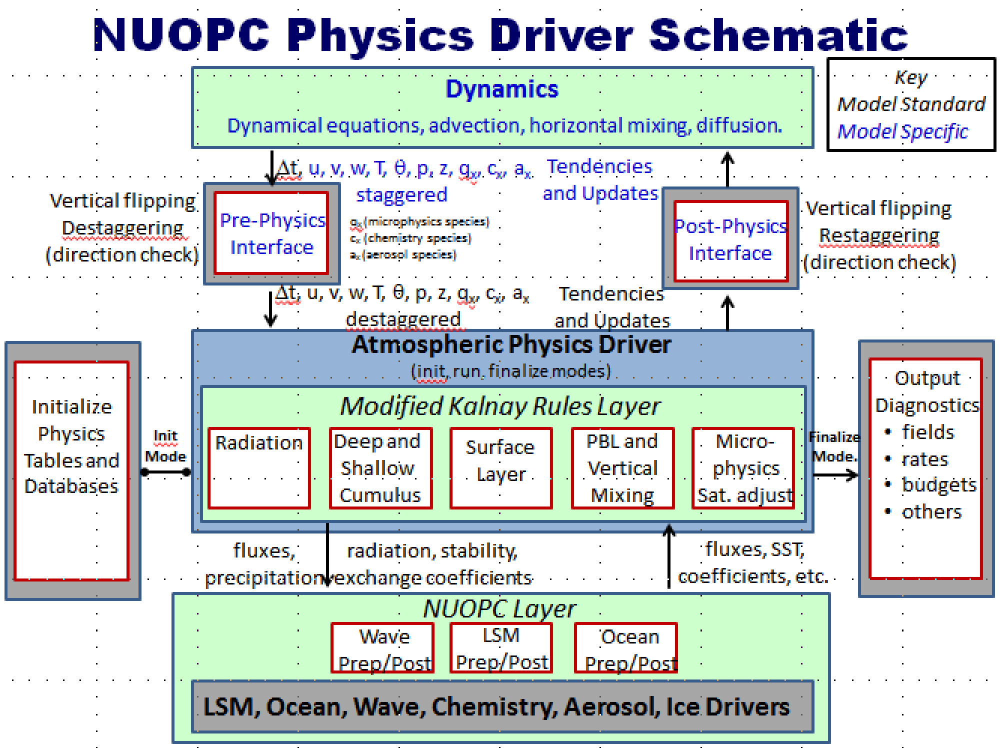

Figure 1. Schematic illustrating the conceptual design of the NUOPC Physics Driver.

IMPACT/APPLICATIONS

Interoperability among national operational and development agencies will lead to accelerated advancement of environmental numerical prediction, better sharing of computing resources and more reliable operational backup. The system will enable Navy production centers to produce the best guidance possible to support forecasts, ship routing guidance, and associated decisions.

Joint collaboration among ESPC and NUOPC partners will accelerate the rate of improvement in the skill of global weather prediction systems and will forge partnerships in the development of next generation ESPC systems.

This effort will reduce the risk to Naval operations, improve planning capabilities, and mitigate hazards to navigation by improving global, regional and tactical atmosphere and ocean data assimilation systems and numerical prediction systems through improvements in data assimilation, ocean and atmospheric dynamics, physical parameterization, model coupling and ensemble techniques. It will allow for the development of a numerical weather prediction competitive advantage that is consistent with the National Earth System Prediction Capability (N-ESPC) initiative to execute OPLAN and CONPLAN objectives inside adversaries' decision cycles through new physics and data assimilation schemes, increased numerical model resolution, and data sources.

TRANSITIONS

The research performed under this project will be transitioned as part of the Earth System Prediction Capability (ESPC) program. We anticipate the new physics driver will be transitioned into operations at Fleet Numerical Meteorology and Oceanography Center (FNMOC) and potentially other partners including NOAA in the next several years. Transitions of advanced physical parameterizations will be made to the NAVGEM and COAMPS 6.4 programs during the next several years. The ultimate goal is to develop a unified physics driver that can be used to exchange physics suites across operational global prediction systems.

RELATED PROJECTS

This project is closely coordinated with the other ESPC projects including the air-sea coupled components and the ESPC next generation model efforts. This work is closely coordinated with the ongoing 6.4 Small Scale and 6.4 Global modeling efforts. In particular, we are leveraging mature physical parameterization research and air-sea coupling research that is in the transition process in these projects.

PUBLICATIONS

Refereed Publications: Submitted or appeared.

Theurich, G., C. DeLuca, T. Campbell, F. Liu, K. Saint, M. Vertenstein, J. Chen, Robert Oehmke, J. Doyle, T. Whitcomb, A. Wallcraft, M. Iredell, T. Black, A. da Silva, T. L. Clune, R. Ferraro, P. Li, M. Kelley, I. Aleinov, V. Balaji, N. Zadeh, R. Jacob, B. Kirtman, F. Giraldo, D. McCarren, S. Sandgathe, S. Peckham, R. Dunlap, 2015: The Earth system prediction suite: Toward a coordinated U.S. modeling capability. (Accepted, *Bull. Amer. Meteor. Soc.*)