Semi-Lagrangian Global Models

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LONG-TERM GOALS

The long-term goal of this project is to develop numerical integration algorithms that will enable then the Navy Operational Global Atmospheric Prediction System (NOGAPS) to achieve higher horizontal and vertical resolution, higher vertical extent, increase meteorological skill, and additional predictive constituents, all with no appreciable increase in run time efficiency.

OBJECTIVES

The objective of this project is to develop and transition a semi-Lagrangian/semi-implicit integration algorithm into the NOGAPS. This numerical algorithm is the only numerical integration technique that removes the CFL constraint on the system's time step and thus is the only numerical technique that will allow for increased resolution, more dynamical variables, and higher accuracy, without a significant decrease in computational efficiency.

APPROACH

The approach is to explore various different semi-Lagrangian advection algorithms in the NOGAPS. One of the approaches is to convert the new u-v formulation of NOGAPS dynamics into a working semi-Lagrangian framework. A second approach is to develop a semi-Lagrangian based on the current vorticity/divergence formulation of the system. Accompanying all development of a semi-Lagrangian dynamical core will be development of new physical parameterizations algorithms, which will be needed for higher step steps. The semi-Lagrangian dynamical core must also be capable of performing data assimilation with the Navy's 3-d and 4-d data assimilation systems. At the end of this project, the semi-Lagrangian version of NOGAPS (NOGAPS-SL) is expected to transition to 6.4 for preparation for operational use.

WORK COMPLETED

A new version of the NOGAPS dynamic core, based on the u- and v-velocity components rather than vorticity and divergence, was developed. This new core was also coupled to the full suite of physical parameterizations currently used in the operational version of NOGAPS that uses a spectral formulation of the equations of motion that are based on vorticity and divergence.

Report Documentation Page

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14. ABSTRACT
The long-term goal of this project is to develop numerical integration algorithms that will enable then the Navy Operational Global Atmospheric Prediction System (NOGAPS) to achieve higher horizontal and vertical resolution, higher vertical extent, increase meteorological skill, and additional predictive constituents, all with no appreciable increase in run time efficiency.

15. SUBJECT TERMS

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RESULTS

A u-v dynamical core for NOGAPS, which supports semi-Lagrangian advection, has been coupled to the latest NOGAPS physics parameterization. Non-data assimilation tests that have been performed comparing the u-v formulation with the existing vorticity/divergence indicate that both formations give similar results. However, there is a significant loss in skill with the u-v semi-Lagrangian advection formulation. Figure 1 shows the 500 hPa geopotential anomaly correlation scores for the Northern and Southern Hemisphere for the month of January 2007. Both the semi-Lagrangian and non semi-Lagrangian (standard Eulerian advection) integrations were performed at the same (low) time step and at the same resolution of 239 triangular wave resolution (55 km) and 30 vertical levels. In terms of meteorological skill, the results indicate that the semi-Lagrangian integration has 8 hours less skill than the non semi-Lagrangian integration. Problems associated with the interpolations for the departure points in the upper model levels for semi-Lagrangian advection have been identified (Figure 2) and research are progressing to identify the cause of the large mean errors. A package of code, initial conditions, and diagnostics has been prepared for semi-Lagrangian testing.

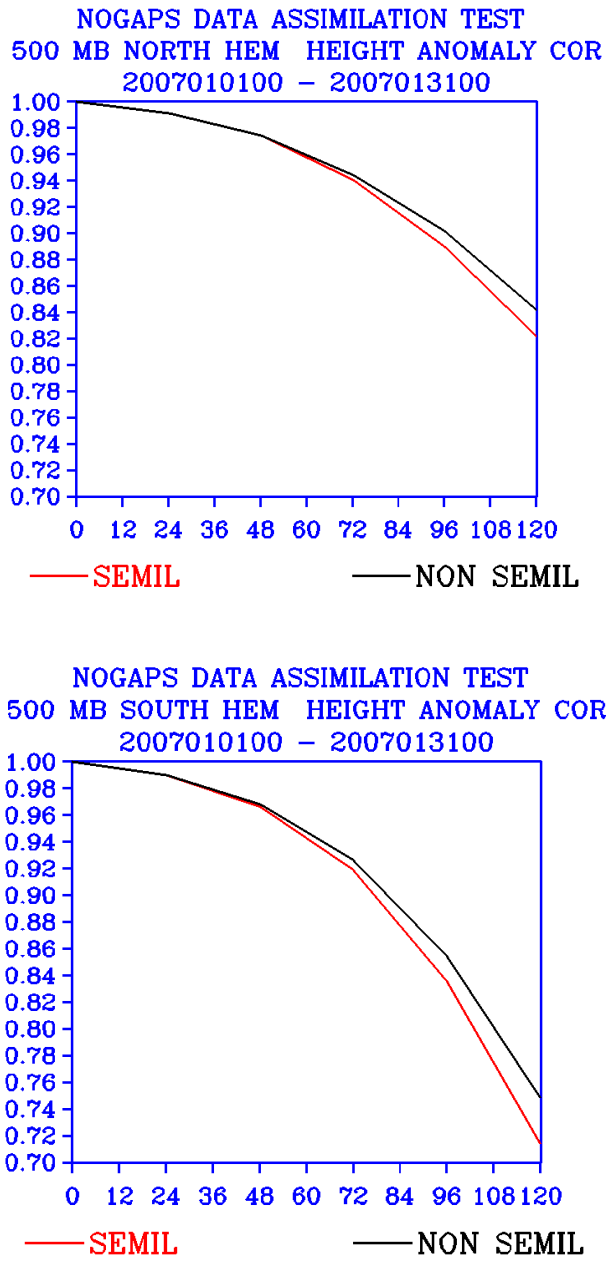

Figure 1. The Northern and Southern Hemisphere 500 hPa geo potential height anomaly correlation for the month of January 2007, using NOGAPS u-v formulation with a semi-Lagrangian algorithm (red) and without the semi-Lagrangian (black).

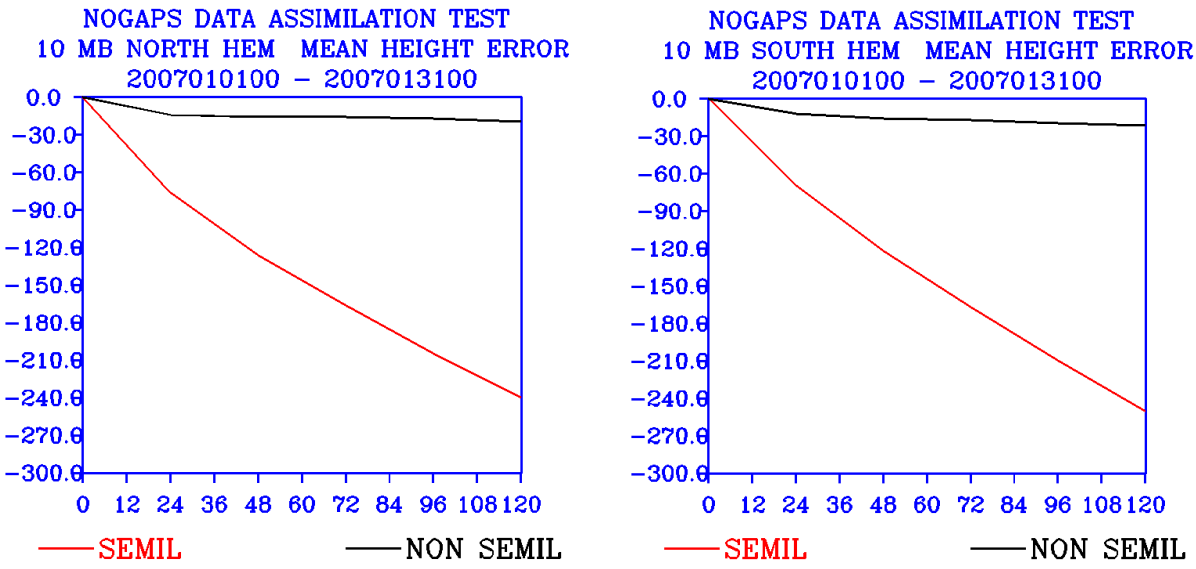

Figure 2. The Northern and Southern Hemisphere 10 hPa geo potential height error for the month of January 2007, using NOGAPS u-v formulation with a semi-Lagrangian algorithm (red) and without the semi-Lagrangian (black).

IMPACT/APPLICATIONS

The successful completion of this project will enable an significant increase in the NOGAPS horizontal and vertical resolution, an increase in the vertical extent of NOGAPS to above 0.1 hPa (65 km), an increase in meteorological skill as measured by both the standard statistical (NOGAPS scorecard) and synoptic measures, and the addition of more constituents (ozone, dust, and aerosols) without a substantial increase in run time.

TRANSITIONS

No transitions to the operational code at this point.

RELATED PROJECTS

This project is not directly related any other NRL 6.2 funded project. All research completed under this project will be transitioned under the 6.4 Large-Scale Atmospheric Models project, under the sponsorship of PMW-180, Dr. Edward Mosley.

PUBLICATIONS

None

PRESENTATIONS

None