P7.3 A MESOSCALE NATURE RUN FOR PREDICTABILITY, TURBULENCE, AND PARAMETERIZATION STUDIES

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1. Introduction

The growth of computational power is enabling NWP model forecasts within the scale region defined by an observed $k^{-5/3}$ scaling in the kinetic energy spectrum. We have much to learn about how waves and turbulence interact, affecting predictability and optimal sub-grid parameterization, within this region and across the observed transition to larger scales. This paper describes an effort to produce a suite of "nature runs" with the WRF model that can serve as a basis for current predictability, turbulence, and parameterization study in a multi-scale environment that spans scales above and below the spectral transition. The Advanced Research WRF (ARW) model (Skamarock et al. 2005) has shown the ability to produce the observed mesoscale spectral regime (Skamarock 2004), making it a candidate to produce these nature runs.

The suite of nature runs will begin with the the Held-Suarez benchmark (Held and Suarez 1994), and increase in complexity. The Held-Suarez case is useful because it can be directly compared to GCM results. Its implementation will also expose technical challenges with running the WRF on very large grids. Additional complexity will be introduced by including moisture and additional forcing such as might arise from orography or land-masses.

Here we report on initial experiments at coarse resolution. The next section describes how the WRF is adapted to the Held-Suarez simulation. Section 3 presents initial results, and section 4 summarizes progress to date.

2. The Held-Suarez Simulation for the WRF

The experimental domain is designed to cover a hemisphere, and the polar stereographic projection is adopted in a secant configuration true at the equator. This configuration helps to minimize the distortion of the flow fields at low latitudes. Initial experiments are run with a grid spacing of 150 km on 31 vertically stretched levels. When satisfactory results are achieved on this coarse grid, the fields will be interpolated to a $1500\times1500\times91$ grid with $\Delta x = 10$ km for the final experiments. This cascading approach makes the model spin-up period computationally tractable.

Initial conditions conform to the model base state, at rest and in hydrostatic balance with respect to the WRF equations. Open boundary conditions are employed. The following modifications were introduced, and are applied every time step, to relax the model toward the Held-Suarez equilibruim state:

1. Equilibrium temperature and linear momentum drag coefficients are computed as a function of latitude and the σ values of the time-dependent η levels.

2. Temperature is relaxed toward the equilibrium temperature on a 40-day time scale, and drag is applied to the winds, as specified in Held and Suarez (1994).

3. An extra $2\Delta x$ smoother is applied to the winds, temperature, and pressure south of the equator to control numerical instability where the map factors exceed 1.0 (south of the equator).

3. The Spin-up Process

Here we present initial results from imposing the Held-Suarez equilibruim on the WRF model at rest, at coarse resolution. Domain-integrated kinetic energy suggests that the momentum field takes about 40 days to spin up (Fig. 1). At this point, the flow is baroclinic and the kinetic energy appears to level off. The temperature does not reach the equilibrium temperature within the first 60 days.

Example kinetic energy fields are plotted in Figs. 2 and 3 at simulation days 30 and 60, respectively. Level 24 is shown, corresponding approximately to 250–300mb. At day 30, assymmetry is well developed and synoptic-scale waves are propagating around the hemisphere. By day 60, the jet streaks appear realistic as baroclinic processes are active.

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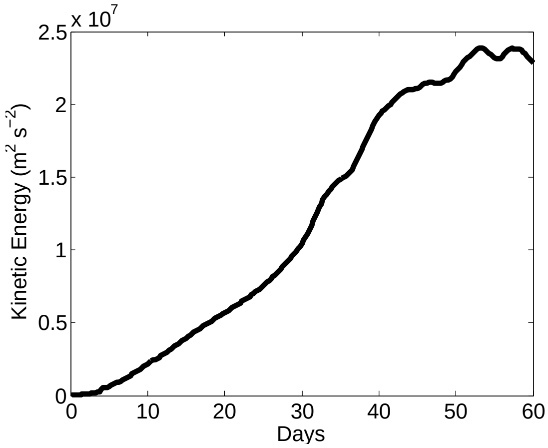

Figure 1: Domain-integrated kinetic energy as a function of simulation time.

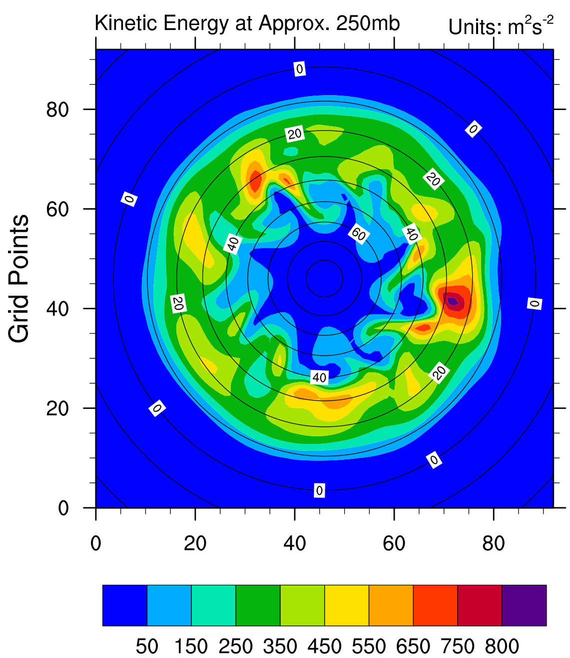

Figure 2: Kinetic energy on model level 24 (approx. 250–300mb) valid at simulation day 30. Black circles show latitude.

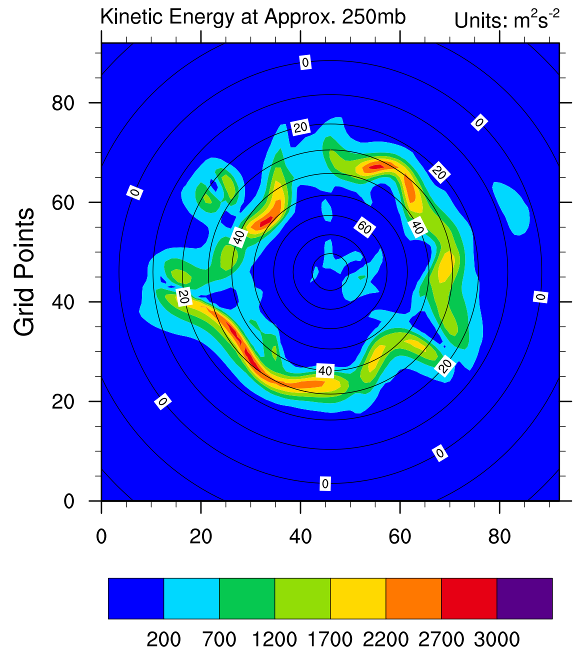

Figure 3: Same as 2, but for day 60.

4. Summary

A suite of mesoscale nature runs with the WRF (ARW) model are being developed to facilitate predictability, turbulence, and paramaterization studies. This paper presents preliminary results from spinning-up the WRF model on a hemispheric domain with the Held-Suarez forcing. The evolution of kinetic energy suggests that the dynamics are well-developed by day 40 in the simulation.

Future work includes downscaling the spun-up state to a grid with $\Delta x = 10$km, and adding moisture and more complex forcing if it is necessary to achieve fully-developed mesoscale turbulence.

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