Dynamical Downscaling of NASA/GISS ModelE: Continuous, Multi-year WRF Simulations

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Background and Motivation

The WRF model is being used at the U.S. EPA for dynamical downscaling of the NASA/GISS ModelE global climate model (GCM) fields to assess regional impacts of climate change in the United States. WRF will be used to downscale daily/decadal time slices of ModelE for recent past, current, and future climates for this simulation being conducted for the IPCC Fifth Assessment Report (AR5) basin-scale studies. The dynamically downscaled climate fields from WRF ultimately will be used by the EPA to predict the regional impacts of climate change on water quality and availability, agriculture, ecosystems, human health, air quality resulting from emissions control and climate energy demand. In addition to changes in local temperature and precipitation distributions, one goal of this research is understanding changes in frequency and severity of extreme events, such as heat waves, droughts, flooding, and migration episodes. This research focuses on the sensitivity to internal nudging in WRF. The use of internal nudging for dynamical regional climate models (RCMs) simulations has shown that differences obtained over the past several years have not been consistently attracting attention. Several recent studies have used reanalysis fields as a proxy for GCM input. In this study, the method of nudging and the choices made with respect to how much nudging is used in WRF are critical toward achieving a balanced RCM solution.

Preliminary Findings

Several WRF simulations have been run to demonstrate some sensitivities toward various methods of nudging. Simulations here are 108-km six-year simulations with one month of forcing. Some of these simulations benefit from the use of ModelE “obs” fields as a proxy for GCM input. The simulations were performed using WRF v3.2 and with spectral nudging. The model top is 50 hPa. The simulations are continuous (i.e., not reinitialized at any point in the run). The model physics options are as follows:

- WRF single-moment microphysics
- CAM large and small-scale turbulence
- NOAA land-surface model
- Geophysical Fluid Dynamics Laboratory (GFDL) 3D ensemble cumulus parameterization scheme

Simulations are performed with spectral nudging and with no nudging. In both techniques, nudging is restricted to fields above the PBL. The standard analysis nudging (“SN Reg”), the nudging coefficients are set to 4.5 x 10^{-5} s^{-1}. Other simulations are performed where the nudging coefficients are set to 4.5 x 10^{-5}s^{-1}. Additional analysis nudging simulations are performed where the nudging coefficients are set to 4.5 x 10^{-4}s^{-1}. It is shown that in these simulations the nudging is used. Even some month-to-month variations in ModelE, such as the winter of “2007”, are represented in the WRF simulations. It should be noted that the Plains region is represented in the simulations but not represented in the nudged cases. It should be noted that the Plains region is represented in the simulations but not represented in the nudged cases. It is shown that the Plains region is represented in the simulations but not represented in the nudged cases. It is shown that the Plains region is represented in the simulations but not represented in the nudged cases. In this study, the method of nudging and the choices made with respect to how much nudging is used in WRF are critical toward achieving a balanced RCM solution.

Monthly area-averaged mean 2-m temperature difference and accumulated precipitation are computed for each region for the six-year period. The 2-m temperature differences (left) show that the multi-year WRF runs using ModelE have persistent and systematic regional and seasonal differences, even when nudging is used. For example, the Midwest has a nearly zero annual bias in temperatures (both high and low) compared to ModelE and the nudged cases. It is shown that the Plains region is represented in the simulations but not represented in the nudged cases. It is shown that the Plains region is represented in the simulations but not represented in the nudged cases. In this study, the method of nudging and the choices made with respect to how much nudging is used in WRF are critical toward achieving a balanced RCM solution.

Modeling Configurations

Several WRF simulations have been run to demonstrate some sensitivities toward various methods of nudging. Simulations here are 108-km six-year simulations with one month of forcing. The simulations benefited from the use of ModelE “obs” fields as a proxy for GCM input. ModelE is one of the three U.S. GCMs that will be participating in IPCC AR5. It is a coupled atmosphere-ocean model with 2.0° x 2.5° resolution and 41 hybrid levels up to 1 hPa. It is shown that there are no observations. ModelE also serves as the source of verification and validation of the WRF simulations.

Monthly area-averaged mean 2-m temperature difference by region.

Monthly area-averaged accumulated precipitation by region.