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DOWSCALED REGIONAL CLIMATE SIMULATIONS FOR THE MID-ATLANTIC STATES USING RAMS

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1. INTRODUCTION

Climate modeling involves the use of general circulation models (GCMs) integrated for prolonged periods of time. Current computer resources available limit the resolution of such simulations, and in the model solution, a single point may represent an area the size of Colorado. Small scales are poorly represented, even though small-scale processes and their interactions with the large scales have been parameterized in the formulation of the model. For assessment of impacts of future climate change scenarios, as well as for better characterizing the present climate, representation of fine scales is needed.

In this study we are interested in the climate and climatic responses to different forcings, over the Mid-Atlantic states of the U.S. The approach that we take to obtain detailed simulations is to nest a limited area model in a global climate model. The regional model has finer resolution and a more sophisticated representation of topography and land-surface interactions, which are very desirable qualities for climate modeling. The technique is known as dynamical downscaling.

Here we examine the effects of different nudging techniques to communicate the large-scale circulation to the high-resolution nested model, comparing traditional Davies nudging to spectral nudging. We also examine the important issue of soil moisture initialization and nudging.

2. MODELS

The GCM employed is the NASA Goddard Institute for Space Studies (GISS) GCM (Hansen et al. 1983). It has a horizontal resolution of 4°x5° and 12 levels in the vertical. The regional model used is the Regional Atmospheric Modeling System (RAMS), which includes a complex land-surface model (Walko et al. 2000).

For modeling of the present climate we also use data from NCEP reanalysis (Kalnay et al. 1996) on a 2.5°X2.5° grid. The spectral model used in this reanalysis project had T62 horizontal resolution with 26 levels in the vertical.

3. EXPERIMENTS

Fig. 1 shows the domain for the experiments performed with RAMS. We utilize 2 nested grids with 2-way interaction between them, centered over New Jersey; the parent grid has 32x30 points and 160 km resolution and the nested grid covering the Mid-Atlantic states of the U.S., has 48x36 points and 40 km resolution. The vertical resolution is 30 levels, with the lowest one at around 50 m over the terrain.

A configuration with 2 nested grids was chosen to create an intermediate step between the coarse resolution of either the reanalysis or the GISS model, and the fine resolution of the internal grid, which is 40 km. In this manner the boundary conditions for the internal grid passes information of smaller scale than NCEP reanalysis or GISS. RAMS creates these finer scale details in the external (parent) grid.

The first experiments used NCEP reanalysis as boundary conditions. The purpose of these simulations was to better understand the behavior of RAMS with different configurations and nesting techniques. Real observational data are available for comparison.

3a. Davies nudging vs. spectral nudging

Fig 2 shows average surface temperatures in the internal grid for July of 1995, and Fig 3 depicts the corresponding average surface temperature differences between RAMS and NCEP reanalysis data, which in this experiment is used as boundary conditions with Davies nudging for the external grid of RAMS. Soil moisture from NCEP reanalysis is employed as initial condition for both grids in RAMS.

Spectral nudging consists of relaxing the large scales of the regional model solution to the same large scales of the outer global model or reanalysis data throughout the domain (Von Storch et al. 2000). We apply this relaxation above the boundary layer. This technique assures "real" downscaling, since the regional model can only develop features with scale above a certain wavenumber in the Fourier expansion. These small scales are added to the large scales largely determined by the global model data. Results from these experiments often show a better agreement with observed data, and we will compare these results in our poster.

3b. Nudging soil moisture

Sensitivity of the simulations to other parameters is also investigated. In particular we focus on soil moisture, to which surface air temperature is very sensitive. If the initial soil moisture conditions of the nested model are different from the large-scale model, serious spin-up problems will spoil in the interior solution. Even if it were possible to match the initial conditions, differences in the inner vs. outer model land surface parameterizations would cause spin-up problems. Therefore, we experiment with nudging the

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soil moisture content in RAMS to the NCEP reanalysis, and the results are improved.

Similar experiments were also carried out employing GISS model data instead of NCEP reanalysis, and will be presented.

4. REFERENCES

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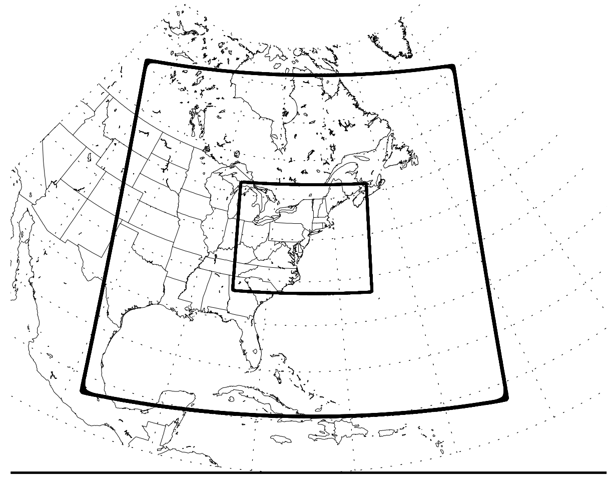

Figure 1. Domain and RAMS model configuration with 2 nested grids used in the experiments.

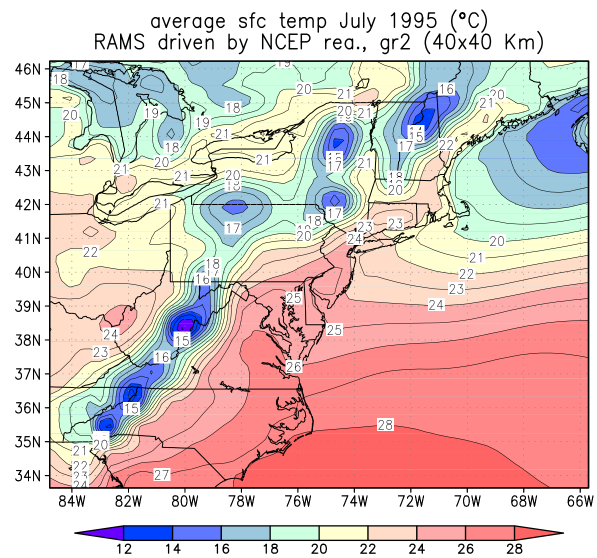

Figure 2. Average surface air temperature (°C) for July 1995 using RAMS with boundary conditions from NCEP reanalysis.

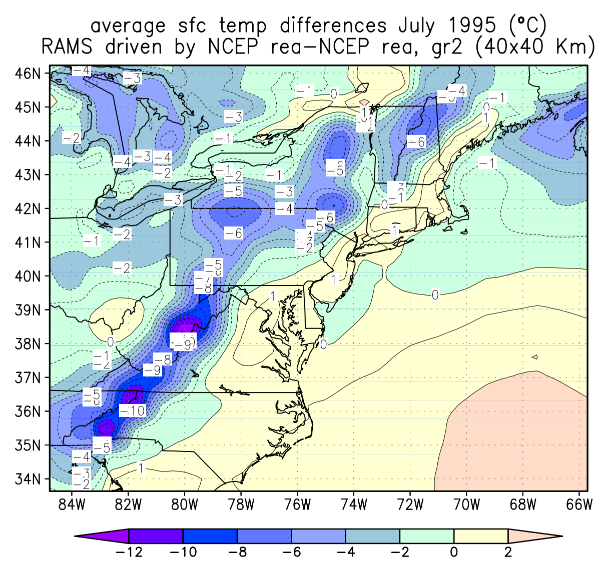

Figure 3. Differences of average surface air temperature (°C) for July 1995 between RAMS and NCEP reanalysis for the same experiment as in Fig. 2.