P1.7 PROJECT TO INTERCOMPARE REGIONAL CLIMATE SIMULATIONS (PIRCS): PRELIMINARY RESULTS FOR THE 1988 MIDWEST DROUGHT

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1. INTRODUCTION

Numerous publications have documented the capabilities of nested limited-area models to simulate climate in various regions. While the basic technique appears promising, the overall strengths and weaknesses of this approach to climate simulation have been difficult to assess because the disparate applications and models (such as those reviewed by Giorgi and Mearns, 1991 and McGregor, 1996) are not directly comparable.

The Project to Intercompare Regional Climate Simulations (PIRCS) was developed to provide a common simulation framework for evaluating mesoscale models run in climate mode, both versus each other and, more important, versus observations. Beyond the general PIRCS goal of evaluating the capabilities of this approach to climate simulation, PIRCS also provides a basis for improving mesoscale climate models, both individually and as a group. For this reason, PIRCS has developed with strong community involvement, through workshops (Takle, 1995; Gutowski et al., 1998) and additional informal exchanges among participants and advisors.

Here we describe the motivation and structure for the first PIRCS simulation experiment. We also present some preliminary results from the first experiment that give an initial indication of the collective capabilities of the participating models and of this approach to climate simulation. Additional details can be found at the PIRCS Web site, http://www.pircs.iastate.edu.

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2. DESCRIPTION OF EXPERIMENT 1(A)

(a) Domain and period

The simulation domain for Experiment 1 covers the continental United States with a specific focus on the central region. This region was chosen in part because its climate is known to be strongly influenced by mesoscale features such as the low-level jet (Rasmussen, 1967; Mitchell et al. 1995; Stensrud 1996). This region also includes a high density of routine and experimental observations useful for model evaluation. The extent of the simulation domain was chosen to reduce the presence of mountain ranges near the boundaries (Hong et al. 1998).

PIRCS Experiment 1 covers two periods of hydrologic extremes in the central U.S.: Experiment 1(a), 15 May - 15 July 1988, was a period of severe drought; and Experiment 1(b), June - 31 July 1993, includes the peak precipitation period of the record-breaking 1993 flood. These periods were chosen to give strong signals of climate variability that a model should be able to capture. Periods of only two months were initially chosen to balance limitations in computational and personnel resources for a largely volunteer effort against the need for simulations long enough to capture climatic behavior.

Here we discuss preliminary results for Experiment 1(a). Most of the modeling groups for which we show results also have completed or are performing Experiment 1(b). Comparative results for the two periods will be discussed in a future publication.

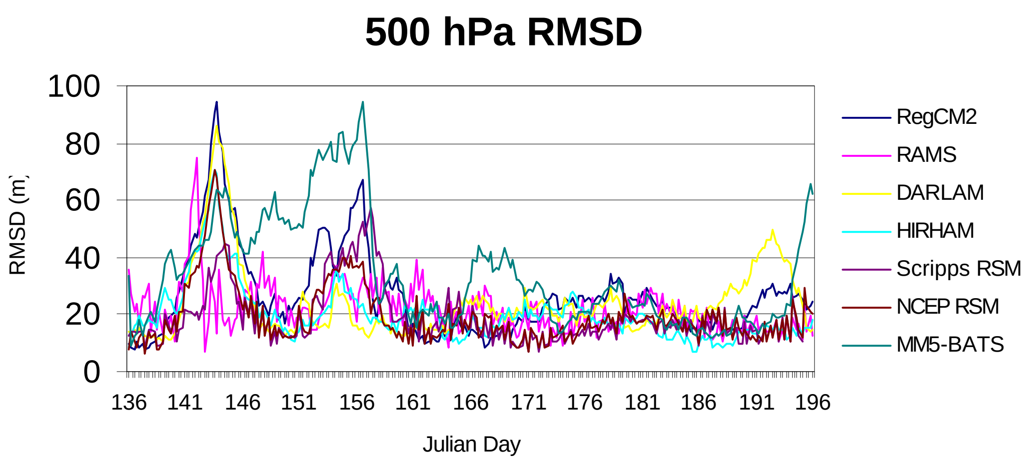

Figure 1. Spatially averaged root-mean-square deviation (RMSD) of model predicted 500 hPa heights relative to the NCEP/NCAR reanalysis.

(b) Initial and boundary conditions

Atmospheric initial and boundary conditions were extracted from the reanalysis produced by the National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) (Kalnay et al., 1996). The initial and boundary conditions used the finest output resolution available, sigma-layer fields on the T62 gaussian grid of the data assimilation cycle's forecast model. PIRCS scientists at Iowa State performed horizontal interpolation to produce driving files matching or nearly matching the standard PIRCS resolution of 60 km. A small degree of additional interpolation was needed to transfer the initial and boundary conditions files to forms actually ingested by individual models. The oceanic portions of the simulation domain used sea-surface temperatures (SSTs) derived from the reanalysis SST data set supplemented by direct observations of surface temperature in the Great Lakes and satellite observations of SST in the Gulf of California.

The most problematic initial condition was soil moisture. For consistency with the atmospheric driving conditions, PIRCS used the soil moisture produced by the surface parameterization of the reanalysis forecast model. The reanalysis soil moisture is subject to relaxation toward an estimated annual climatology (Roads et al., 1998) and thus must be viewed with caution as an initial condition.

(c) Output archive

Anticipated analyses of model output have guided the development of the structure of the output archive. A general goal of the archive is to permit analysis of key mesoscale features, such as the low-level jet, and energy and water cycles linked to mesoscale behavior. Therefore most fields are saved at least four times daily to allow analysis of diurnal variability. An additional goal has been to have a relatively simple archive to minimize the potential for confusion and mistakes in creating it and to promote archive accessibility. Archived output will be available to the general community, though interested users are required to maintain contact with PIRCS and participating modelers to promote understanding of the capabilities and limitations of the data.

(d) Participating models

Participation in PIRCS is currently open to all modeling groups willing to perform the simulations and furnish the output in a standard format. For this initial report, output is available from seven models. Results presented here are based on output selected from the models' contributions to the PIRCS archive for the 1988 PIRCS simulation.

3. INITIAL RESULTS

The ability of limited-area models to recover the mean and variability of atmospheric structure in the domain interior is a prerequisite for the validity of the nested modeling approach. We have used the NCEP reanalysis as a standard for evaluation of the 500 hPa height field predicted by the models. The density of rawinsonde observations over the U.S. is such that large-scale, upper air fields in the reanalysis are well observed. Discussion of large-scale features of the

1988 drought appears for example in Atlas et al. (1993) and Trenberth and Guillemot (1996).

We compared the 500 hPa height field for each model to that for the reanalysis using the root-mean-square deviation (RMSD) computed every 6 hours. The temporal trend of the spatially-averaged RMSD (Fig. 1) shows that most models exhibit a base level of RMSD around 10-20 m with occasional episodes of higher values. About 5 to 10 days after the start of the simulation (Julian days 140-145; May 20-25) the RMSD was relatively large for most models. During this time a strong 500 hPa closed low slowly migrated across the U.S. For Julian days 158-186 the RMSD was near minimum for all models. This was a period characterized by the gradual breakdown, partial re-development, and continued breakdown of an intense mid- and upper-tropospheric ridge over the central U.S. In a broad sense the models appear to handle development and breakdown of large-scale ridges well and the evolution of short-wavelength lows somewhat less well; however, there are substantial variations from model to model and from case to case.

4. SUMMARY

Limited-area models forced by large-scale information at the lateral boundaries are able to reproduce the bulk temporal and spatial characteristics of meteorological fields during the 1988 drought. The mean 500 hPa height field is generally well simulated, as is its temporal variability. There is some evidence that model skill varies with the synoptic regime in a common way. Specifically, situations dominated by a ridge or zonal flow are well simulated by most models as measured by the root-mean-square deviation from the reanalysis, while situations characterized by development and migration of short-wave lows or troughs tend to have larger RMSD.

In keeping with the goals of PIRCS, the side-by-side assessments here help define specific areas where modeling groups individually and collectively can focus efforts to improve model performance. Additionally, the models must be evaluated for their ability to provide useable information for assessing impacts of climate change in areas such as agriculture, human health and water resources. It is our intent that by providing a common framework for addressing these and other issues, PIRCS will help to advance the study of climate and climate change on regional scales.

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