Lessons from the Project to Intercompare Regional Climate Simulations (PIRCS)

W.J. Gutowski, Jr.[1], R.W. Arritt[1], E. S. Takle[1], Z. Pan[1], C.J. Anderson[1], D. Caya[2], S.-C. Chen[3], J.H. Christensen[4], S.-Y. Hong[5], H.-M. H. Juang[5], J.J. Katzfey[6], W.M. Lapenta[7], R. Laprise[2], G. Liston[8], P. Lopez[4], J. McGregor[6], F. Otieno[1], R. Pielke, Sr.[8], J.O. Roads[3], R. Silva[1]

[1]Iowa State University, Ames, Iowa, USA
[2]Université du Québec à Montréal, Montréal, Québec, Canada
[3]Scripps Institute of Oceanography, La Jolla, California, USA
[4]Danish Meteorological Institute, Copenhagen, Denmark
[5]National Centers for Environmental Prediction, Camp Springs, Maryland, USA
[6]Commonwealth Scientific and Industrial Research Organisation, Modialloc, Australia
[7]Marshall Space Flight Center, Huntsville, Alabama, USA
[8]Colorado State University, Fort Collins, Colorado, USA

1. INTRODUCTION

The Project to Intercompare Regional Climate Simulations is a community-based effort to evaluate regional climate simulation by mesoscale models using a common framework. PIRCS scientists have recently published initial results (Takle et al., 1999). These results provide lessons that can guide regional modeling programs such as Regional Climate of South America (RECOSA.)

The first PIRCS simulation experiment has focused on two 60-day summer periods of extreme climatic behavior in the central United States: drought (1988; Exp. 1a) and flood (1993; Exp 1b). The lengths of the simulations balances the need to simulate climatic behavior with computational constraints of a voluntary program. Experiment 1 presents a strong signal of climate variability for models to simulate. In addition, it occurs in a region with a substantial observational database for model evaluation, and it coincides with an important international program analyzing regional climate, the GEWEX Continental International Program (GCIP). All these features help optimize ability to evaluate the model simulations.

Boundary conditions for the simulations are given by the NCEP/NCAR reanalysis, supple-mented by observed surface temperatures in the North American Great Lakes and Gulf of California. Further details appear at www.pircs.iastate.edu.

2. SOME RESULTS

Initial results for 1998 drought simulations appear in Takle et al. (1999). Here we present a summary of 1988 simulations directed toward lessons for other modeling programs. All models simulate 500 hPa height fields quite close to those in the NCEP/NCAR reanalysis. For precipitation, a much more difficult simulation challenge, the models tend to reproduce the frequency of synoptic scale events, but have more difficulty reproducing precipitation magnitudes. All models display common biases, producing too much precipitation in the prime drought area, the U.S. Midwest, and too little in the south central States. All models also show a common tendency for daily minimum temperatures that are too warm in the upper Midwest and too cool in the southwestern U.S. In contrast, there is no common error behavior among the models in their daily maximum temperature simulations.

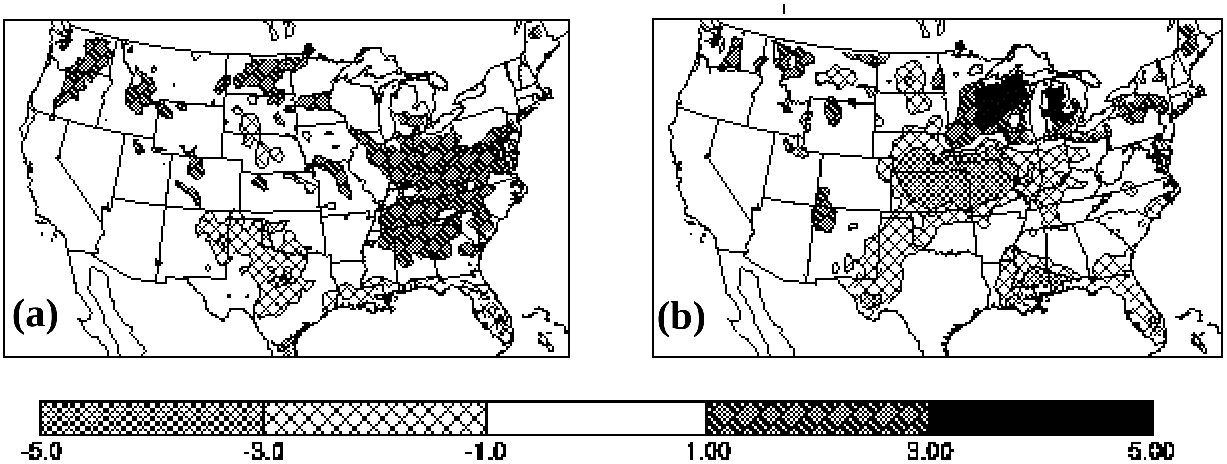

FIGURE 1 - Ensemble average precipitation bias [mm/d] for PIRCS models in (a) June 1988 and (b) July 1993.

Differences between 1993 and 1988 test the models' capability for simulating climate variability. All models simulate quite well the change in large-scale flow as measured by 500 hPa differences. However, their precipitation extremes generally show smaller change than observed. For example, the ensemble average precipitation during the June 1988 drought has generally positive bias versus observations in the U.S. Midwest (Fig. 1a), whereas the July 1993 ensemble has negative bias in the heart of the flood region (Fig. 1b), stretching across the states of Kansas and Iowa. Some of the deficit occurs because the models tend to place the precipitation too far to the northeast, but the displaced precipitation still tends to be weaker than what occurred. In both cases, ensemble average reproduce biases seen in each model. Thus, all models capture the large-scale circulation change between the two periods, but have difficulty translating it into precipitation change of observed magnitude.

3. CONCLUSIONS

There are several features of the results that are of interest to a South American regional climate program. First and foremost, an ensemble of models should be engaged in any multi-institutional program of regional climate simulation. No model emerges as the overall best model in PIRCS simulations. An ensemble allows the program to access a wide variety of modeling methods, giving a more complete evaluation of modeling capabilities.

The ensemble average also helps reveal two types of errors. Those common to all models indicate current generic limitations in using mesoscale models for regional climate simulation. Errors unique to a model indicate specific areas for model improvement, with the other models providing quantitative measure of how far the model lies outside contemporary state-of-the-art. PIRCS results show a common problem of converting interannual circulation variability into interannual precipitation variability, despite the variety of numerical methods employed. They also show distinctive problems to each model in simulating surface-atmosphere interaction.

An intercomparison project in South America has the potential to attract an ensemble of models comparable in size to the PIRCS North American group, for several reasons. The LBA experiment is generating a significant number of observation and assimilation data set that are vital for analyzing model performance. LBA is also prompting numerous studies of weather and climate in the Amazon region that would for a basis for understanding and evaluating model behavior.

The Amazon region is also subject to significant interannual variability through ENSO. These factors mimic those that motivated the PIRCS North American simulation. In addition, the Amazon basin is one of the most prominent energy source regions for the atmosphere, making it an intrinsically interesting simulation target. Finally, from a PIRCS perspective, the Amazon region gives modelers a tropical simulation testbed to complement the existing extratropical testbed of PIRCS Experiment 1.

4. ACKNOWLEDGEMENTS

Primary funding for PIRCS has come from the Electric Power Research Institute (EPRI). We thank Peter Gleckler, Eugenia Kalnay, Linda Mearns, Gerry Potter and Andrew Staniforth for their advice and support.

5. REFERENCES

Takle E. S., W. J. Gutowski, Jr, R. W. Arritt, Z. Pan, C. J. Anderson, R. Ramos da Silva, D. Caya, S.-C. Chen, F. Giorgi, J. H. Christensen, S.-Y. Hong, H.-M. H. Juang, J. Katzfey, W. M. Lapenta, R. Laprise, G. E. Liston, P. Lopez, J. McGregor, R. A. Pielke, Sr., and J. O. Roads, 1999: Project to Intercompare Regional Climate Simulations (PIRCS): Description and Initial Results. ***J. Gephys. Res.*** (in press).