REGIONAL CLIMATE SIMULATIONS FOR THE US MIDWEST USING MM5V3

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1. INTRODUCTION

In a recent IPCC report on *The Regional Impacts of Climate Change* it was concluded that:-

"The technological capacity to adapt to climate change is likely to be readily available in North America, but its application will be realized only if the necessary information is available (sufficiently far in advance in relation to the planning horizons and lifetimes of investments) and the institutional and financial capacity to manage change exists" (IPCC, 1998)

It was also acknowledged by IPCC that one of the key uncertainties that limit our ability to understand the vulnerability of sub-regions of North America to climate change, and to develop and implement adaptive strategies to reduce vulnerability, was the need to develop accurate regional projections of climate change, including extreme events (IPCC, 1998). In particular we need to account for the physical-geographic characteristics that play a significant role in the North American climate e.g. the Great Lakes, coastlines and mountain ranges, and also properly account for the feed-backs between the biosphere and atmosphere (IPCC, 1998).

The potential impacts of global climate change have long been investigated based on the results of climate simulations using global climate models with typical model resolutions of the order of hundreds of kilometers (IPCC, 1990, 1996). However, the assessment of the impacts of climate change at the regional and local scales requires predictions of climate change at the 1-10 kilometer scale. Model predictions from global climate models with such high resolutions are not likely to become widely available in the near future.

Accordingly, the primary mission in establishing a Regional Climate Center at Argonne is to link the predictive global climate modeling capability with the impact assessment and policymaking communities. The primary technical challenge is to downscale global climate model output to the regional scale. Our focus area is the Midwest region of the United States.

In order to carry out our mission we are focusing on:-

- Development of state-of-the-art software tools for assessing the local-scale effects of climate change and climate variability using the unique combination of scientific, technical and advanced computational resources available at Argonne

- Information dissemination via specialized quality assured data products delivered over the web
- Expert assistance to the assessment community and government and private-sector decision-makers
- Service to the assessment community by providing the tools, products and information they require to do their jobs

The activities of the Argonne RCCC are organized in three key areas – research, data products and service. Outreach will play a central role in the climate center activities as our research program develops.

2. CURRENT RESEARCH

We have commenced a range of research activities related to downscaling regional climate including:

- Testbed for Regional Climate Simulation Laboratory
- Parallel regional climate model development based on MM5v3 system
- Comparison of MM5 PBL with ABLE data
- Hydrology workbench (Nefedova, 2000)
- File and diagnostics tools for MM5
- High Resolution (10-30 km) MM5 experiments for the Midwest
- Performance testing on parallel computers using high resolution grids (10km) over Midwest with MM5
- Contributing to PIRCS-1B regional climate modeling intercomparison and have performed the PIRCS-1A experiment
- Delivering regional climate data using interactive web based tools
- Held a workshop on *Bridging the Climate Information Gap* at Argonne in order to develop a comprehensive science plan in consultation with the scientific community.

3. EXPERIMENTS

High resolution experiments have been performed over the US Midwest at 10 and 30 km resolution on the SGI Origin 2000 computer. Figure 1a and 1b show total convective precipitation for May, 1993 at 30 km and 10 km. A key conclusion is, at least for this experiment, that model resolution can be a significant factor in the prediction of convective rainfall. At high resolution more intense rainfall is produced in keeping with the increase in vertical velocities associated with increasing model resolution (Giorgi and Mearns, 1999). This experiment also demonstrated that it is possible to perform regional climate model simulations at 10 km resolution using existing computer hardware.

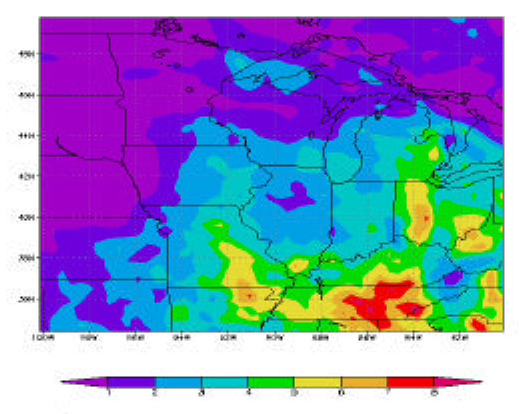

Figure 1a: Convective recipitation at 30 km resolution using MM5v3 for May 1993. NCEP I data provided the boundary conditions.

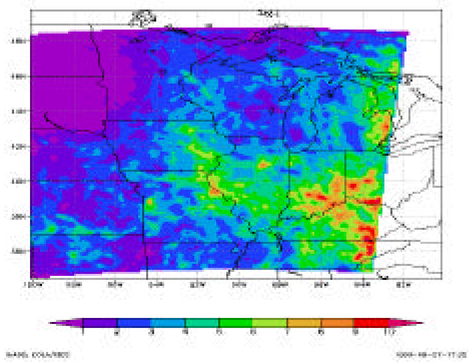

Figure 1b: Convective recipitation at 10 km resolution using MM5v3 for May 1993. The 30km run provided the boundary conditions.

4. PERFORMANCE TESTING

We have performed test simulations using MM5v3 using full scale test problems using the high performance parallel version of MM5v3 as released by NCAR. We have performed simulations for the US Midwest at 30 and 10km resolutions on the SGI O2000 and IBM SP2 computers at Argonne.

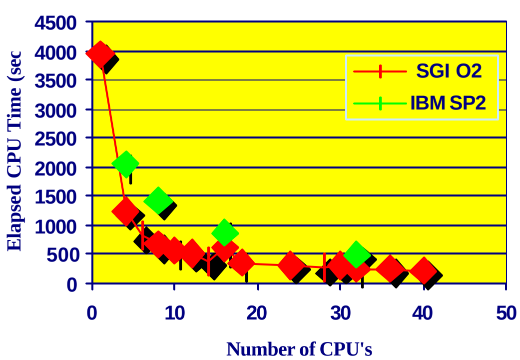

Figure 2: Execution time for MM5v3 with two domains with 30km and 10km resolution running on Argonne computers

5. DATA ANALYSIS

As part of our outreach activities and to facilitate research collaboration we have developed a test web based application tool that enables access via a web browser to the output of regional climate model runs using the MM5 system. Figure 3 below illustrates a typical session. The web browser uses the native MM5 data format, thus avoiding the need to store duplicate copies of model output, and works efficiently with gigabytes of data. The web tool was developed using IDL/ION.

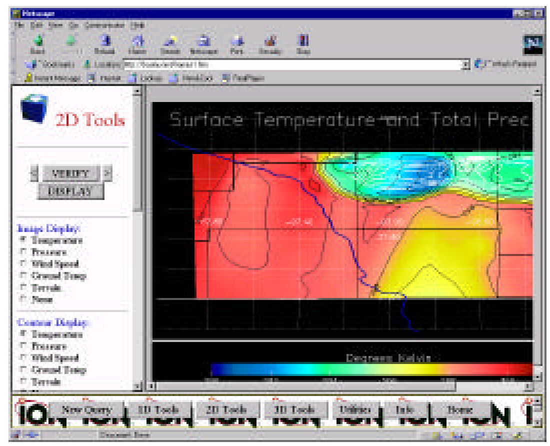

Figure 3: Interactive data analysis of MM5 output on the web.

6. CONTRIBUTION TO PIRCS 1B

We are currently participating in the Project to Intercompare Regional Climate Scenarios (PIRCS) (Takle *et al*., 1999). We are using Version 3 of the Penn State / NCAR MM5, with the OSU land surface model (Chen and Dudhia, 1999). We have performed PIRCS experiment 1b (1993 Midwest Flood), and our total precipitation results for the period June 1-July 31, 1993 are shown in Figure 4 below (center panel). Note the agreement with both the NCEP reanalysis forcing data (left panel) and the NCDC half-degree Cressman analysis of observations (right panel). We plan to use this experiment and the PIRCS 1a (1988 US drought) as primary testbeds for further enhancements of model physics.

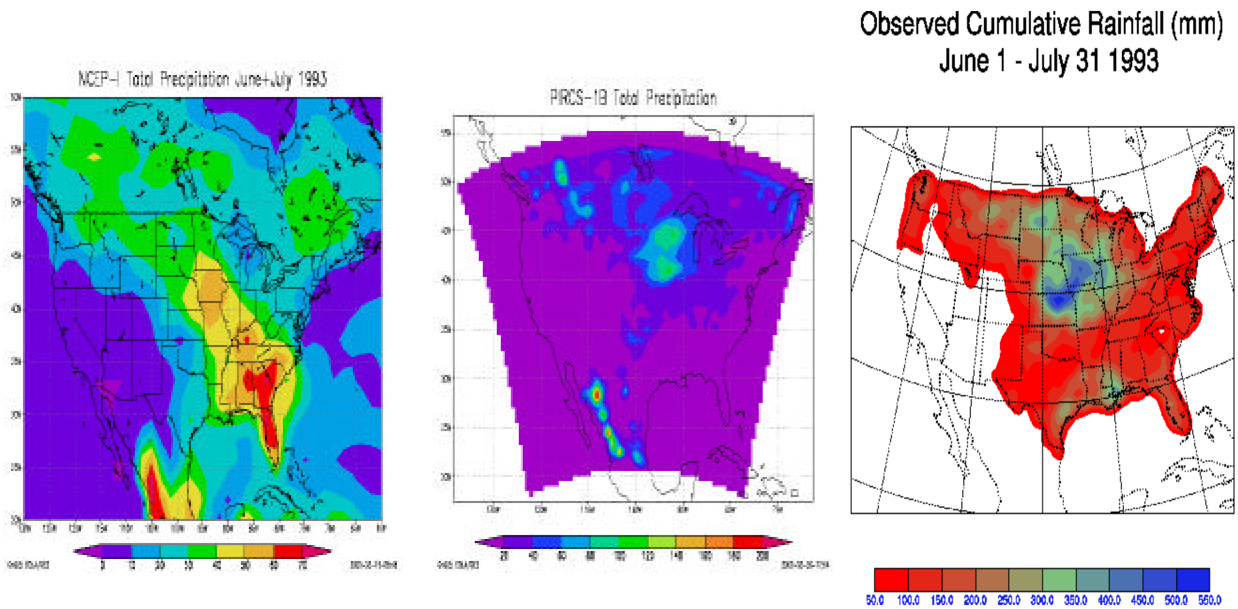

Figure 4: Total precipitation for the period June 1-July 31, 1993: NCEP I reanalysis data (left panel); MM5 simulation (center panel); NCDC half-degree Cressman analysis of observations (right panel).

7. CONCLUSIONS

We will continue to address the key scientific and computational issues in regional climate modeling (Giorgi and Mearns, 1999) and their importance to simulating the climate of the US Midwest including delivering 'quality' data products, improving our capability to do long term simulations, assessing the quality of GCM inputs and the role of spin up and climate drift. We plan to assess the importance of consistent physics, the sensitivity of climate to the lateral boundary conditions, and the effect of two way nesting.

8. ACKNOWLEDGEMENTS

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