Decadal Climate Studies with Enhanced Variable and Uniform Resolution GCMs Using Advanced Numerical Techniques

Michael S. Fox-Rabinovitz, ESSIC (Earth System Sciences Interdisciplinary Center), University of Maryland, Ferdinand Baer, Dale Allen, Ernesto Hugo Berbery, Kenneth Pickering, Department of Meteorology, University of Maryland, Joseph J. Tribbia, NCAR, Boulder, CO, and Georgiy Stenchikov, Rutgers University of NJ

Summary

The project is devoted to decadal climate studies using developed and evolving state-of-the-art GCMs (General Circulation Models) with enhanced variable and uniform resolution with advanced numerical techniques that are run on parallel-processing terra-scale SciDAC supercomputers. The variable-resolution stretched-grid (SG) GCMs produce accurate and cost-efficient regional climate simulations with mesoscale resolution. The advantage of the stretched grid approach is that it allows us to preserve the high quality of both global and regional circulations while providing consistent interactions between global and regional scales and phenomena. The major accomplishment for the year is the completion of the international SGMIP-1 (Stretched-Grid Model Intercomparison Project, phase-1) as a part of this research activities. Our SGMIP-1 simulations have been produced using SciDAC ORNL supercomputers. The results of the successful 12-year SGMIP multi-model ensemble simulations of the U.S. climate are available at the SGMIP web site (http://essic.umd.edu/~foxrab/sgmip.html). Our collaboration with J. Côté of (Meteorological Service of Canada/RPN and his group is a strong integral part of the joint effort. We are also collaborating with F. Baer and J. Tribbia (UMD-NCAR), and with the groups led by M. Déqué (Météo-France) and J. McGregor (CSIRO, Australia). The continuation of SGMIP-1 or SGMIP-2 (phase-2) has already began. It includes simulations for longer, 25-year period (1979 to present), with SG-GCMs as well as with high-resolution GCMs. It will provide unique high-resolution regional and global multi-model ensembles beneficial for modeling community. The WMO/WCRP/WGNE endorsed the SGMIP activities in Oct. 2004.

This research is devoted to: (a) conducting *decadal climate studies on anomalous climate events*, in a context of *climate variability and predictability*, and (b) developing the stretched-grid (SG) GCMs using *advanced numerical techniques and ensemble integrations*. The diversified impacts of enhanced horizontal regional resolution (at least 0.5º or finer) over the U.S. and other areas of interest are thoroughly investigated, in the context of *single- and multi-model ensembles*.

The following major issues are addressed in this study: (a) the impact of enhanced resolution on producing consistent global and regional anomalies at meso- and larger scales and their impact on floods, droughts, and monsoonal circulations, when resolving mesoscales; (b) the possibility of providing efficient downscaling capabilities when using the stretched-grid approach with consistent interactions of meso- and larger scales; (c) improved understanding and modeling of the processes that affect climate variability and predictability at broad-range temporal and spatial scales; (d) the possibility of reducing uncertainties of global and regional climate simulations using the single- and multi-model ensembles; (e) atmospheric chemistry impacts at mesoscales.

Collaboration with J. Côté of MSC/RPN and his group is a strong integral part of the joint effort. The companion study with the members of another SciDAC group, F. Baer and J. Tribbia, is devoted to developing a stretched-grid GCM using the advanced spectral-element technique with variable resolution, and the NCAR CAM physics.

The *major accomplishment* for the year is the *completion of the international SGMIP-1*

(Stretched-Grid Model Intercomparison Project, phase-1) conducted under this research activities. SGMIP-1 is aimed at in-depth studying the established SG-approach to regional climate modeling.

The key SGMIP-1 scientific and computational objectives are: studying multiyear U.S. climate events; efficient downscaling to realistic mesoscales; stretching strategies; approximation of model dynamics; treatment of model physics; using the multi-model ensemble mode; and an optimal performance on parallel supercomputers.

Regional climate simulations obtained with the state-of-the-art SG-GCMs developed in the U.S., Australia, Canada, and France, have been produced for SGMIP-1 with 0.5° resolution over the major part of North America including the U.S. The 12-year (1987-1998) SGMIP-1 simulated products have been processed and analyzed, with emphasis on the U.S. climate.

SGMIP-1 provides *multi-model ensemble mean* results of *higher quality* than any individual ensemble members. The SGMIP-1 ensemble mean regional *biases are about 25%-50% of typical observational errors.*

The strong *coordinated international* SGMIP-1 effort involving the U.S., Canadian, French and Australian collaborators led by M. Fox-Rabinovitz, J. Côté, M. Déqué, and J. McGregor, puts us in a favorable position for a comprehensive investigation of the diversified impacts on regional climate simulations due to enhanced regional resolution, including the *multi-model ensemble* results. Our participation in SGMIP-1 was possible only through *using the SciDAC terra-scale supercomputers at ORNL* where all our simulations had been produced. (Note that foreign SGMIP participants used their own supercomputers.)

The continuation of SGMIP-1 or SGMIP-2 (phase-2) has already began. It includes simulations for *longer, 25-year* period (1979 to present), with *SG-GCMs*, and with *uniform high-resolution* GCMs. It will provide *unique high-resolution regional and global multi-model ensembles.*

Maintaining the developed and evolving SGMIP web site allows us to: (a) disseminate the SGMIP data/products and analysis results to the climate modeling community; (b) make the SGMIP data/products and analysis results available on demand to national and international programs and groups such as WMO/WCRP/WGNE, CLIVAR, and IPCC.

The SGMIP effort reflects a trend in climate modeling and broader communities to move towards more detailed regional climate assessments important for the U.S. public, business and policy decision-makers, and for productive international collaborations on climate-related issues.

The SGMIP results were *reported to and endorsed by the WMO/WCRP/WGNE* at its Meeting in October 2004 in Exeter, UK.

References

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For further information on this subject contact: Dr. Michael S. Fox-Rabinovitz, ESSIC, University of Maryland, College Park, MD, Phone: 301-405-5395
E-mail: foxrab@essic.umd.edu