SGMIP-2 (Stretched-Grid Model Intercomparison Project): Decadal Regional Climate Simulations with Enhanced Variable and Uniform-Resolution GCMs

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Variable-resolution GCMs using a global stretched-grid (SG) with enhanced resolution over the region(s) of interest constitute an established approach to regional climate modeling providing an efficient means for regional down-scaling to mesoscales. This approach has been used since the early-mid 90s by the French, U.S., Canadian, Australian and other climate modeling groups along with, or as an alternative to, the current widely-used nested-grid approach. Stretched-grid GCMs are used for continuous climate simulations as usual GCMs, with the only difference that variable-resolution grids (Fig. 1) are used instead of more traditional uniform grids. The advantages of variable-resolution stretched-grid GCMs are that they do not require any lateral boundary conditions/forcing and are free of the associated undesirable computational problems. As a result, stretched-grid GCMs provide self-consistent interactions between global and regional scales while a high quality of global circulation is preserved, as in uniform-grid GCMs.

The international SGMIP-2 (Stretched-Grid Model Intercomparison Project, phase-2) includes 25-year (1979-2003) climate simulations using enhanced variable and uniform-resolution (UG)- GCMs developed at major centers/groups in Australia, Canada, France, and the U.S. The SGMIP-2 high resolution regional (North American) and global multi-model ensemble products are analyzed in recent papers (Fox-Rabinovitz et al. 2006, 2008) and are available as a link to the WMO/WCRP/WGNE web site: http://collaboration.cmc.ec.gc.ca/science/wgne.

The major SGMIP-2 conclusions are as follows.

1. High quality of global simulated products is obtained for SG-GCMs and UG-GCMs.
2. Regional climate variability for the SGMIP-2 ensembles, analyzed using both time mean spatial and temporal prognostic and diagnostic products, represents well the climate variability shown in observations or reanalysis.
3. Over the region of interest: (a) SG-GCMs with $0.5° \times 0.5°$ regional resolution have overall smaller errors, than those of the intermediate ($1° \times 1°$) uniform-grid (UG)-GCMs with the same number of global grid point as for the SG-GCMs; and (b) SG-GCMs and fine ($0.5° \times 0.5°$) resolution UG-GCMs have overall similar errors.
4. The positive impact from enhanced regional resolution on efficient downscaling to realistic mesoscales is obtained. Small regional biases are a fraction (~50% or less) of observational or reanalysis errors), and overall, regional biases are within the uncertainties of available observations and/or reanalysis.
5. The SGMIP-2 results showed that using a multi-model ensemble for the state-of-the-art SG-GCMs is beneficial for reducing the uncertainty of the multi-decadal regional climate simulation with enhanced regional resolution.
6. Orographically induced precipitation and other SGMIP-2 prognostic and diagnostic fields (such as temperature, winds, moisture, sea-level pressure, and hydrological cycle components) are well simulated at meso- and larger scales due to high-resolution regional forcing. The major positive regional impact from stretching is obtained from better resolved model dynamics and regionally-enhanced resolution of stationary lower-boundary forcing (orography). In that sense, the

improvements are obtained near small-scale terrain features and are reflected, for example, in the Appalachian area precipitation.
7. Regional spectra for SG-GCM and fine (0.5° × 0.5°) UG-GCM ensembles are close to each other and closer to reanalysis than the spectrum for the intermediate (1° × 1°) UG-GCM (Fig. 2).
8. SGMIP-2 shows better results than those of SGMIP-1 due to its increased integration period.
9. The SGMIP-2 products provide the practical possibility of creating joint, with the NARCCAP (North American Regional Climate Change Assessment Program) and other groups, regional multi-model ensembles for nested- and stretched-grid models which may be beneficial for the national and international regional climate modeling communities.
The SGMIP products and analysis results are available to national and international programs and groups such as WMO/WGNE, NARCCAP, CLIVAR, and IPCC.
SGMIP-2 was endorsed by the WMO/WCRP/WGNE at its annual meetings in 2004 – 2007.

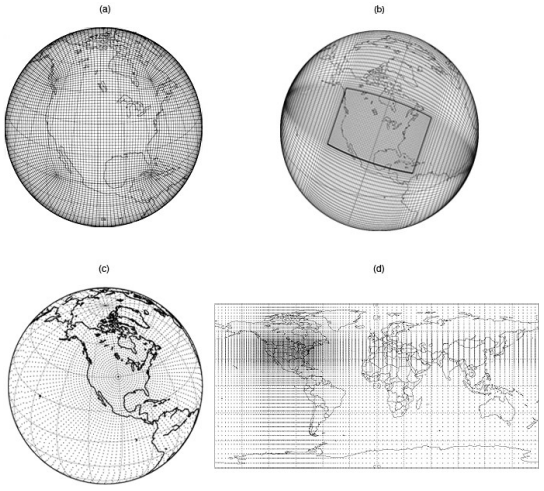

Fig. 1 SGMIP stretched grids with the area of interest over the major part of North America used in the following SG-GCMs: (a) CCAM, CSIRO, Australia; (b) GEM, Environment Canada; (c) ARPEGE, MeteoFrance; (d) GEOS, NASA/UMD,
U.S. Every other grid-line is shown.

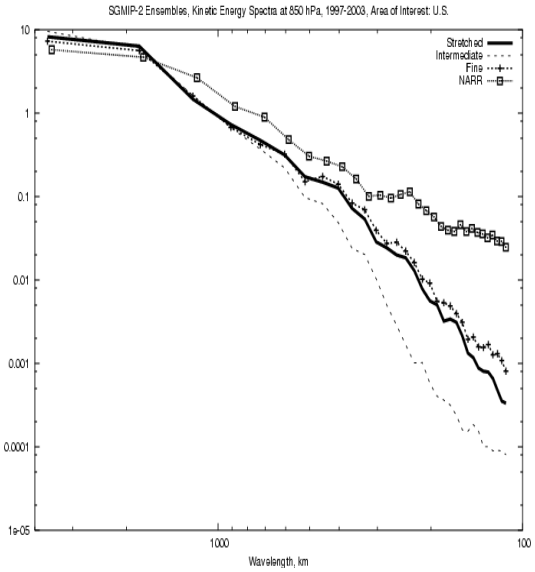

Fig. 2 Regional energy spectra at the 850 hPa level for: the SG-GCM ensemble (the solid line), the intermediate uniform-resolution UG-GCM ensemble (the dotted line), the fine uniform-resolution UG-GCM ensemble (the solid-cross line), and the NARR reanalysis (the square-solid line). The logarithmic scales are used for both the x,y axes.

References

1. Fox-Rabinovitz, M.S., J. Côté, B. Dugas, M. Déqué, and J.L. McGregor, 2006a: Variable resolution general circulation models: Stretched-grid model intercomparison project (SGMIP), *J. Geophys. Res.,* 111, D16104, doi:10.1029/2005JD006520.
2. Fox-Rabinovitz, M.S., J. Côté, B. Dugas, M. Déqué, J.L. McGregor, and A. Belochitski, 2008: Stretched-Grid Model Intercomparison Project: Decadal regional climate simulations with enhanced variable and uniform-resolution GCMs, *Meteor. Atm. Phys*., accepted.