Water Research Foundation & Sponsors

Authors: Rob Wilby & Kathy Miller

Date: 30 April 2009

Technical Briefing Paper (4): Rationale and Application of Regional Climate Downscaling

Synopsis Regional downscaling involves the development of climate information for a point or small area from coarse resolution climate model scenarios. Although this is an appealing prospect from the point of view of impacts and adaptation assessment, there have been relatively few examples of such scenario-led planning to date. This shortcoming may be addressed by increasing availability of user-friendly downscaling resources. However, care must be taken to ensure that downscaled scenarios are applied appropriately and only in regions where their value-added can be demonstrated.

Explanation Due to their immense computational burden global climate models cannot supply information at the scales typically required for impacts and adaptation assessment. Regional downscaling techniques can add value to the spatial (and temporal) resolution of climate model output under present and future climate conditions. This is accomplished by two groups of methods.

First, a finer resolution (10-50 km) Regional Climate Model (RCM) may be embedded within a relatively coarse (50-400 km) global climate model. The latter provides information about large-scale atmospheric conditions along the boundary of a domain that might cover a region the size of Europe or North America. The RCM takes this "driving" data and, using the same dynamics as the host model, generates weather phenomena and processes controlled by topography at the finer scale.

A second set of downscaling techniques involve deriving physically-sensible statistical relationships between local variable(s) of interest (such as daily precipitation) and large-scale atmospheric predictors (such as sea level pressure, humidity, etc). These relationships are assumed to hold true regardless of changing land surface or climate conditions. Both dynamical and statistical downscaling rely on information supplied by host climate model(s) to simulate changes in future climate.

Until relatively recently, downscaling was mainly performed within research institutions. However, there has been steady growth in the development of public domain downscaling tools (e.g., ClimGen, LARS-WG, PRECIS, SDSM) and online scenario portals (Figure 1). For example, the University of Cape Town portal provides free access to daily precipitation and temperature scenarios for hundreds of meteorological stations across Africa and Asia (see: http://data.csag.uct.ac.za/).

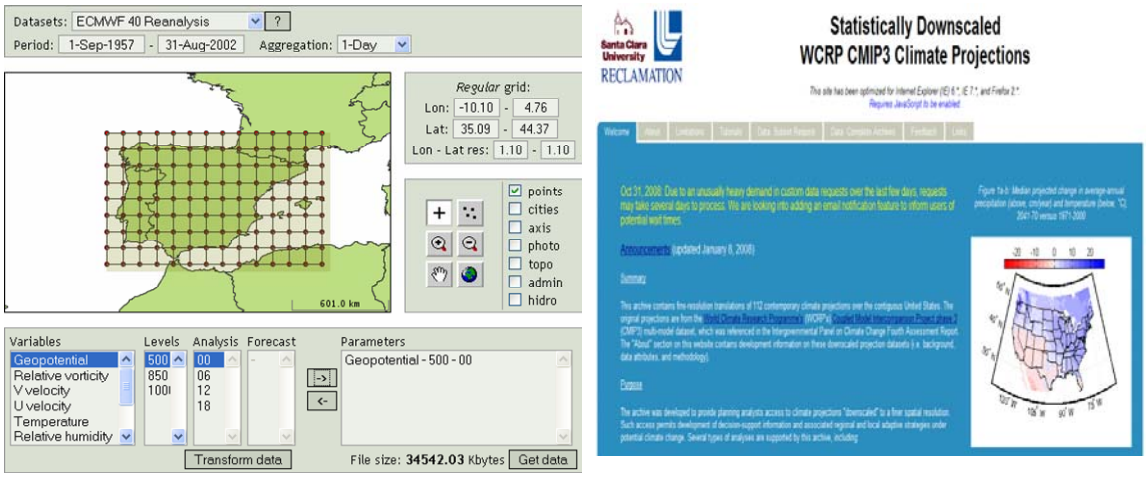

Figure 1 Public domain downscaling tools: EU ENSEMBLES web portal for climate data access and downscaling (left panel) [http://www.meteo.unican.es/ensembles/]; Statistically Downscaled WCRP CMIP3 Climate Projections for the contiguous US provided by Lawrence Livermore National Laboratory (right panel) [http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/].

Application Improving access to high-resolution climate model products does not eliminate uncertainty. Despite increased availability of climate risk information at the "decision-making scale" there are still relatively few examples of scenario-led adaptation measures or infrastructure developments. This is thought to reflect the large uncertainties arising from the choice of host climate model, emissions scenario, downscaling technique, downscaling predictor variables, and impacts model. Although downscaling may add apparent precision, in practice the step inflates still further the "bandwidth" of the regional climate change projection that might otherwise have been interpolated from the original climate model output. There is also some concern that the so-called "stationarity assumption" (i.e., stable large-to-local-scale climate relationships) may be invalidated.

Therefore, downscaling is most justified when: 1) there is strong consensus amongst host climate models about the pace and directions of regional climate change; 2) important processes are not resolved at the scale of the climate model (or RCM) (e.g., flash flooding, tidal surge, or urban heat island metrics); 3) projected changes are used to bound climate sensitivity studies and to test the robustness of alternative adaptation options.

Case Study The North American Regional Climate Change Assessment Program (NARCCAP)

NARCCAP is an international collaboration that is producing high resolution climate simulations for investigating uncertainties in regional scale projections of future climate. The program is also generating regional climate change scenarios for impacts studies (e.g., agriculture, water resources).

In Phase I a set of six RCMs was driven by present-day NCEP Reanalysis II data for the period 1979 to 2003 over a domain covering the conterminous United States and most of Canada (see Figure 2). In Phase II different combinations of climate model and nested RCM are being run for the 2050s under the SRES A2 emissions scenario. This experiment will compliment the EU PRUDENCE and ENSEMBLES projects by sampling a wider range of climate models, and provide further options for comparison with statistical downscaling models.

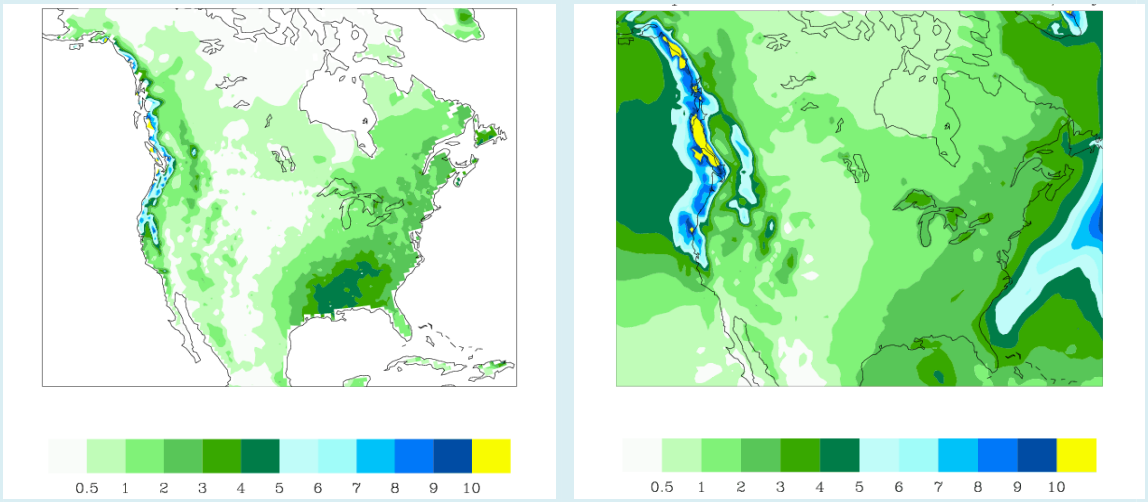

Figure 2 Comparison of observed (UDEL, left panel) and dynamically downscaled (MMFI, right panel) average winter precipitation (mm/day) for 1980-2004. Source: http://www.narccap.ucar.edu/results/ncep-results.html . *We thank the North American Regional Climate Change Assessment Program (NARCCAP) for providing these data. NARCCAP is funded by the National Science Foundation (NSF), the U.S. Department of Energy (DoE), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Environmental Protection Agency Office of Research and Development (EPA).*

Supporting materials and links

Christensen, J.H., Hewitson, B., Busuioc, A. et al. 2007. Regional Climate Projections. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Solomon, S., Quin, D., Manning, M., et al. (eds.), Cambridge University Press, UK.

Fowler, H., Blenkinsop, S. and Tebaldi, C. 2007. Linking climate change modelling to impacts studies: recent advances in downscaling techniques for hydrological modelling. *International Journal of Climatology,* **27**, 1547-1578.

Wilby, R.L., Charles, S., Mearns, L.O., et al. 2004. *Guidelines for Use of Climate Scenarios Developed from Statistical Downscaling Methods.* IPCC Task Group on Scenarios for Climate Impact Assessment (TGCIA). http://www.ipcc-data.org/guidelines/dgm_no2_v1_09_2004.pdf