Use of Climate Scenarios Developed from Regional Climate Model Experiments For Impacts and Adaptation Studies

Abstract for
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1. Regional Climate Models (RCMs) are useful tools for generating high resolution climate change scenarios for use in climate impacts and adaptation studies.

Coupled atmosphere-ocean global climate models (AOGCMs) are the modeling tools traditionally used for generating climate change projections and scenarios. However, the horizontal atmospheric resolution of present day AOGCMs is still relatively coarse, order of 300 km, and regional climate is often affected by forcings and circulations that occur at smaller scales. As a result, AOGCMs cannot explicitly capture the fine scale structure that characterizes climatic variables in many regions of the world and that is needed for many impact assessment studies.

What is commonly referred to as the nested regional climate modeling technique consists of using output from global model simulations to provide initial conditions and time-dependent lateral meteorological boundary conditions to drive high-resolution RCM simulations for selected time periods of the global model run. The basic strategy underlying the nesting approach is that the GCM is used to simulate the response of the global circulation to large scale forcings and the RCM is used 1) to account for sub-GCM grid scale forcings (e.g. complex topographical features and land cover inhomogeneity) in a physically-based way, and 2) to enhance the simulation of atmospheric circulations and climatic variables at fine spatial scales. Over the last decade, regional climate models have proven to be flexible tools, capable of reaching high resolution (down to 10-20 km or less) and multi-decadal simulation times and capable of describing climate feedback mechanisms acting at the regional scale. A number of

widely used limited area modeling systems have been adapted to, or developed for, climate application.

2. The issue of the spatial resolution in scenarios must be put in the context of other uncertainties of climate change.

Climate change impact and adaptation assessments recognize that there are a number of sources of uncertainty in such studies which contribute to uncertainty in the final assessment. These uncertainties form a series, or cascade, extending through each of the following areas: specifying alternative emissions futures; converting emissions to concentrations; converting concentrations to climate forcing; modeling the global climate response to a given forcing; converting the model response into inputs for impact studies; modeling impacts and adaptations.

At each step in the cascade, alternative approaches or estimates are available which then have the potential to yield a range of valid results as inputs for the next step. High resolution modeling may be viewed as potentially part of the process of both modeling the climate response to a given forcing and converting the model response into inputs for impact studies. Its objective is to take coarse resolution climate change results and produce climate change information at a spatial scale closer to that required for the impact application. Obtaining such high resolution results introduces its own uncertainty, as different regional models (or statistical downscaling methods) can yield different results even when conditioned by the same GCM.

If the relative importance of the various sources of uncertainty is measured in terms of the sources' effects on the final range of possible impacts, then their importance will likely vary from one impact study to another. The uncertainty that is addressed when high resolution modeling is introduced into a study needs to be weighed up against the effect of the other uncertainties. For example, it would be a mistake to put considerable resources into preparing high resolution information if other uncertainties, potentially more relevant to the results, are left unaddressed.

Research so far has identified uncertainty in the emissions scenarios and uncertainty in the climate model responses to external forcing as two central parts of the cascade.To date, there has not been sufficient research to evaluate the relative importance of spatial scale in the cascade. However, ongoing programs such as PRUDENCE (Prediction of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects) and NARCCAP (North

American Regional Climate Change Assessment Program) consider multiple uncertainties including spatial scale

3. The importance of high resolution climate scenarios for impacts and adaptation studies remains to be thoroughly explored.

High resolution scenarios developed from regional climate model results have been applied to impacts assessments only in the past five years. One of the most important aspects of the impacts work is determining whether the high resolution scenarios actually lead to significantly different estimates of impacts compared to the coarser resolution GCM from which the high resolution scenario was partially derived. In studies so far, mainly concerning agriculture and water resources, significant differences in the estimated impacts based on spatial resolution are found. The effect of the increased resolution of the scenarios on required adaptation remains under-investigated. One study so far explicitly demonstrated that the necessary adaptation measures varies with the spatial resolution. And of course this point could be deduced from the fact that the level of impacts varies. A point that remains to be fully explored, however, is whether the high resolution scenarios are in some critical ways more 'believable' than coarse resolution ones, and thus can provide better information on levels of adaptation that may be necessary for resource systems in the future.