Challenges and Perspectives in Regional Climate Modeling

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Regional climate model (RCM) has become an important tool to produce fine-scale climate change variability and projection because RCMs with detailed physical processes and higher resolution can generate added values that cannot be resolved by relatively low-resolution global climate models (GCMs). Since the late 1980s, a number of challenges and efforts have been devoted to RCM development, evaluation, and application.

Many RCMs tend to reproduce regional climates by reducing model systematic errors. In particular, in regional climate simulations over Asia, systematic errors can be generated by natural characteristics of complicated topography, land-surface conditions, local ocean conditions, convection, dust and aerosol, and seasonal monsoon circulation. To reduce the systematic errors, various techniques and methods have been applied to the development of RCMs. An approach is to employ the spectral nudging technique as lateral boundary condition for long-term integrations to prevent RCM from climate drift. To represent realistic interactions among earth system components, sophisticated land surface models and slab/full ocean models are implemented into RCMs. In addition, physical parameterization schemes incorporated in numerical weather prediction models are modified or optimized for long-term RCM simulations.

Nevertheless, RCMs still have uncertainties cascading from GCMs or imperfect numerical model. Recently, multi-model ensemble methods have been developed through international programs such as RMIP (Regional climate Model Intercomparison Project) and CORDEX (COordinated Regional climate Downscaling EXperiment) to evaluate and reduce uncertainties. Sources and ranges of uncertainty in climate change projections, and adaptation and mitigation strategies to reduce the risk induced by climate change on regional scale are connected in the programs. There are attempts to develop regional earth system models that include two-way interactions among atmosphere, land, and ocean as well as aerosol and dynamic vegetation changes. Convection-permitting RCMs with resolution of less than 5km can lead to advanced simulations of high-impact weather events such as heavy rainfall and tropical cyclone. The upscaling effect from RCM to GCM may improve uncertainties induced by lateral boundary condition.