abstract

This study performs numerical modeling for the climate of semi-arid regions by running a high-resolution atmospheric model constrained by large-scale climatic boundary conditions, a practice commonly called climate downscaling. These investigations focus especially on precipitation and temperature, quantities that are critical to life in semi-arid regions. Using the Weather Research and Forecast (WRF) model, a non-hydrostatic geophysical fluid dynamical model with a full suite of physical parameterization, a series of numerical sensitivity experiments are conducted to test how the intensity and spatial/temporal distribution of precipitation change with grid resolution, time step size, the resolution of lower boundary topography and surface characteristics.

Two regions, Arizona in U.S. and Aral Sea region in Central Asia, are chosen as the test-beds for the numerical experiments: The former for its complex terrain and the latter for the dramatic man-made changes in its lower boundary conditions (the shrinkage of Aral Sea). Sensitivity tests show that the parameterization schemes for rainfall are not resolution-independent, thus a refinement of resolution is no guarantee of a better result. But, simulations (at all resolutions) do capture the inter-annual variability of rainfall over Arizona. Nevertheless, temperature is simulated more accurately with refinement in resolution. Results show that both seasonal mean rainfall and frequency of extreme rainfall events increase with resolution. For Aral Sea, sensitivity tests indicate that while the shrinkage of Aral Sea has a dramatic impact on the precipitation over the confine of (former) Aral Sea itself, its effect on the precipitation over greater Central Asia is not necessarily greater than the inter-annual variability induced by the lateral boundary conditions in the model and large scale warming in the region. The numerical simulations in the study are cross validated with observations to address the realism of the regional climate model.

The findings of this sensitivity study are useful for water resource management in semi-arid regions. Such high spatio-temporal resolution gridded-data can be used as an input for hydrological models for regions such as Arizona with complex terrain and sparse observations. Results from simulations of Aral Sea region are expected to contribute to ecosystems management for Central Asia.