Geophysical Research Abstracts
Vol. 21, EGU2019-12043, 2019
EGU General Assembly 2019

Simulating Warm-Season Precipitation in China with a Convection-Permitting Regional Climate Model

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The warm-season (May-August) precipitation in China has many unique features associated with complex interactions between surface heating, orographic forcing, direct and indirect impacts of aerosol, multi-scale convection, and the advance and retreat of the East Asian summer monsoon, and its simulation has been a tremendous challenge for both global and regional climate models.

Convection-permitting regional climate models have been shown to improve precipitation simulation in many aspects, such as the diurnal cycle, frequency, intensity and extremes in previous studies over several geographical regions of the world, but their skill in reproducing the warm-season precipitation characteristics over the East Asia has not been robustly tested by multi-year simulations. Motivated by recent advances in computing power, model physics and newly available high-resolution reanalysis, in this study we use the convection-permitting Weather Research and Forecasting (WRF) model configured with 3 km grid spacing to simulate the warm-season precipitation in eastern China for 10 seasons (2008-2017). The simulations consist of (i) 3-km-resolution simulations without convective parameterization, (ii) 3-km-resolution simulations with different scale-aware convective parameterizations, and (iii) 3-km-resolution simulations with interactive aerosols. The hourly 31-km-resolution ERA5 reanalysis data are used to provide initial and boundary conditions for all simulations. The objectives are 1) to evaluate the skill of the convection-permitting WRF model at simulating warm-season precipitation climatology in the East Asian monsoon region, 2) to quantify the direct and indirect impact of aerosol on seasonal precipitation, and 3) to examine the value of scale-aware convective parameterization at convection-permitting grid spacing.

Preliminary results demonstrate that the 3-km-resolution WRF model reasonably reproduces the seasonal/sub-seasonal precipitation distributions, the seasonal meridional migration associated with the summer monsoon activity, the diurnal variation (especially the coherent pattern associated with propagating convection east of the Tibetan Plateau), and the climatological characteristics of rain storms including mesoscale convective systems. The overall performance is superior to the previously reported coarse-resolution modeling results. In addition, sensitivity experiments suggest that the inclusion of aerosol impacts helps to suppress the oft-reported high precipitation amount. These results provide a good basis for the future climate simulations using the pseudo-global warming approach.