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Effects of Large-Scale Urbanization on Precipitation over Eastern China and Uncertainty Analysis

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The rapid urbanization over Eastern China has an important impact on the surface evaporation and precipitation. Studies with regional climate models (RCMs) and general circulation models (GCMs) show inconsistent urbanization effects on precipitation during the East Asian Summer Monsoon. In the simulations with RCMs, reanalysis data were normally used as the lateral boundary conditions (LBCs) for both urban and nonurban experiments such that the urbanization effects might be limited due to the same LBCs. In this study, the NCEP Global Forecast System (GFS) nested with the WRF-ARW version 3.7.1, both of which were coupled with the Simplified Simple Biosphere Model (SSIB) and an urban canopy model, were used to explore the urbanization effects from 2005 to 2014. The simulation covered from May through August. The urban land use map included two urban areas: one is over the Pearl River Delta in the southern China, and the other is a large-scale urban area over the eastern China lowland plains, mainly covers Beijing-Tianjin-Hebei and Shanghai-Hangzhou-Jiangsu. The WRF's LBCs in the runs with/without urbanization were provided by the GFS's runs with/without urban, respectively. Result shows profoundly reduction of evaporation over the urban areas due to the large portion of impervious ground. The precipitation decreased significantly over most of the urban areas, mainly due to decrease in evaporation, and increased significantly over the upwind edge of the large-scale urban area. Probably the dramatic change of surface roughness at the edge of the city initiated or enhanced the convection. Moreover, to the south of the large-scale urban area, the precipitation increased substantially. An anomalous cyclone of the atmospheric circulation was formed due to the surface roughness increase and atmospheric heating in the large-scale urban area. For the simulations with the same LBC for both urban and no-urban runs, there was no significant change for precipitation to the south of the large-scale urban area.

There are large number of parameters required for the urban modeling. The urban fraction is an important parameter in the urban modeling but the accurate number is largely unknown. We tested the sensitivity of urban effects to the urban fractions. Two urban fraction maps were employed in the sensitivity experiments: one is with constant urban fraction of 0.4 for all the urban areas, and the other is an urban fraction map estimated based on a Global Artificial Land Surface Dataset. The results suggested that the urban fraction is an important factor affecting the effects of urbanization. The assignment of urban fraction might be a key factor that determines whether the positive or negative effects of urbanization on precipitation would dominate the change of precipitation within the urban areas.