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Impact of Urbanization on Heavy Convective Precipitation under Strong Large-Scale Forcing: A Case Study over the Milwaukee-Lake Michigan Region

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In this study, observational and numerical modeling studies based on the Weather Research and Forecasting (WRF) model are used to investigate the impact of urbanization on heavy rainfall over the Milwaukee-Lake Michigan region. We examine urban modification of rainfall for a storm system with continental-scale moisture transport, strong large-scale forcing, and extreme rainfall over a large area of the upper Midwest of the US. WRF simulations were carried out to examine the sensitivity of the rainfall distribution in and around the urban area to different urban land surface model representations and urban land-use scenarios. Simulation results suggest that the urbanization plays an important role in precipitation distribution, even in settings characterized by strong large-scale forcing. For the Milwaukee-Lake Michigan region, the thermodynamic perturbations produced by urbanization on temperature and surface pressure fields enhance the intrusion of the Lake Breeze and facilitate the formation of a convergence zone, which create favorable conditions for deep convection over the city. Analyses of model and observed vertical profiles of reflectivity using contoured frequency by altitude displays (CFADs), suggest that cloud dynamics over the city do not change significantly with urbanization. Simulation results also suggest that the large scale rainfall pattern is not sensitive to different urban representations in the model. Both urban representations (Noah land surface model with urban land categories and the Urban Canopy Model) adequately capture the dominant features of this storm over the urban region.