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Impacts of urban development and climate change on near-future extreme rainfall projections over the PRD megacity

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It is well-known that urbanization can have significant impacts on the local climate over city areas. At the same time, global warming will result in changes in the large-scale circulation, as well as the frequency and intensity of extreme temperature and precipitation events in many locations over the world. Thus, it is necessary to investigate and understand how urban development and also climate change might affect near-future projections of rainfall extremes. Due to heavy rainfall and poor urban drainage system, urban surface water flooding is one of water-related issues in most Chinese big cities. In this study, the Pearl River Delta (PRD) was selected as a case study to conduct a suite of numerical experiments under various background climate and land use/land cover (LULC) conditions. The Weather Research and Forecasting (WRF) model with a single-layer urban canopy module (UCM) was utilized to simulate the meso-scale atmospheric conditions over the PRD region. Based on historical and RCP8.5 future climate simulations from the Geophysical Fluid Dynamics Laboratory-Earth System Model version 2 (GFDL-ESM2M), extreme rainfall cases in the PRD from the historical (1946-2000) and near-future (2000-2050) eras were dynamically downscaled by WRF-UCM to a 2km$\times$2km resolution in the region. Furthermore, the historical 1999 LUCL data and the 2030 projection (based on Cellular-Automata-type land use change modeling) built on the World Urban Database and Access Portal Tools (WUDAPT) method were used, for representing the PRD megacity land use in the 1990's and 2030's, respectively. Three experiments were conducted in this research, the first one with 1999 land use under the historical climate (1999LS-HIS), 1999 land use under the near-future climate (1999LS-FUT), and the 2030 land use under the near-future climate conditions (2030LS-FUT). Results show that both urban development and global warming play a positive influence on the amount of extreme rainfall. In particular, both can lead to an enhancement of the occurrence rate of extreme rainfall over the urban area, with comparable magnitudes. Urban development may have a stronger effect on heavy rainfall in low intensity urban locations, while global warming intensifies extreme precipitation in the high-intensity urban area, such as those labelled as commercial and industrial. Also, there is evidence that global warming can lead to a delay in the peak diurnal rainfall to later hours in the afternoon during extreme precipitation events, possibly due to modifications on atmosphere stability and land-sea breeze characteristics. This finding can be served as scientific basis for local policy makers and planners to make a better understanding on urban flooding risk and develop a climate change adaptation plan accordingly.