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Towards realistic representation of hydrological processes in integrated WRF-urban modeling system

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To meet the demand of the ever-increasing urbanized global population, substantial conversion of natural landscapes to urban terrains is expected in the next few decades. The landscape modification will emerge as the source of many adverse effects that challenge the environmental sustainability of cities under changing climatic patterns. To address these adverse effects and to develop corresponding adaptation/mitigation strategies, physically-based single layer urban canopy model (SLUCM) has been developed and implemented into the Weather Research and Forecasting (WRF) platform. However, due to the lack of realistic representation of urban hydrological processes, simulation of urban climatology by current coupled WRF/SLUCM is inevitably inadequate. Aiming at improving the accuracy of simulations, in this study we implement physically-based parameterization of urban hydrological processes into the model, including (1) anthropogenic latent heat, (2) urban irrigation, (3) evaporation over water-holding engineered pavements, (4) urban oasis effect, and (5) green roof. In addition, we use an advanced Monte Carlo approach to quantify the sensitivity of urban hydrological modeling to parameter uncertainties. Evaluated against field observations at four major metropolitan areas, results show that the enhanced model is significantly improved in accurately predicting turbulent fluxes arising from built surfaces, especially the latent heat flux. Case studies show that green roof is capable of reducing urban surface temperature and sensible heat flux effectively, and modifying local and regional hydroclimate. Meanwhile, it is efficient in decreasing energy loading of buildings, not only cooling demand in summers but also heating demand in winters, through the combined evaporative cooling and insulation effect. Effectiveness of green roof is found to be limited by availability of water resources and highly sensitive to surface roughness heights. The enhanced WRF/SLUCM model deepens our insight into the dynamics of urban land surface processes and its impact on the regional hydroclimate through land-atmosphere interactions.