EGU22-7324, updated on 19 Aug 2022
https://doi.org/10.5194/egusphere-egu22-7324
EGU General Assembly 2022

Assessing co-benefits of urban greening coupled with rainwater harvesting management under current and future climates across USA cities

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Globally, urban areas will face multiple water-related challenges in the near future. The main challenges are intensified droughts leading to water scarcity, increased flood risk due to extreme rainfall intensification, increased total water demand due to an increasing urban population, amplified urban heat island intensities due to urban sprawl, and reduction in urban carbon sink due to plant water stress. Urban greening is an excellent option for mitigating flood risk and excess urban heat. Meanwhile, rainwater harvesting (RWH) systems can cope with water supply needs and urban water management. In this study, we investigated how urban greening and RWH can work together to mitigate the aforementioned risks. We evaluate the joined-up management approach under climate projections for 30 cities in the USA spanning a variety of climates, population densities and urban landscapes. By incorporating a new RWH module in the urban ecohydrological model UT&C and flexible operational rules of reusing harvested water for domestic use and urban green space irrigation, we tested 4 intervention approaches: control, RWH installation, urban greening supported by RWH, and urban greening supported by traditional irrigation (i.e., supplying via mains water). Each intervention approach was evaluated using our adapted version of UT&C and forced by the last generation convection-permitting model simulations of current (2001-2011) and end-of-century (RCP8.5) climate from Weather Research and Forecasting (WRF). The volume of RWH is assumed to be 2000L per household for all cities. Results showed that neither urban greening nor RWH could contribute significantly to reducing the expected increase in canyon temperature, because of the strong change in background climate (i.e., increases in average atmospheric temperature). However, RWH alone can sufficiently reduce the intensifying surface flood risk and effectively enhance water conservation, and urban greening can significantly increase the carbon sink of cities especially in dry regions, and if supported by traditional irrigation. Those results vary with the background climate: the benefits of urban greening, either supported by RWH or traditional irrigation, on canyon temperature reduction and carbon sink improvement increased with average air temperature and decreased with wetness index respectively; the benefits of RWH on runoff reduction and water conservation are both positively dependent on local annual precipitation.