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The potential for hail and intense rainfall enhancement over urban areas: improving urban extreme weather risk assessment

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Urban communities and their infrastructure are particularly vulnerable to the impacts of organized thunderstorm systems. Current models of urban extreme weather risk do not fully represent the complexity of the hydrometeorological processes involved, particularly in relation to intense convective precipitation and severe weather. Hail is a severe thunderstorm hazard that can be extremely damaging to property (especially automobiles, buildings and agriculture) over and in proximity to urban environments. This study identifies some of the mechanisms that future generations of catastrophe models should consider incorporating in their representation of hydrometeorlogical hazards in urban areas. In addition, such information could help to inform planning policy and improve urban resilience to extreme events.

Evidence is provided that urban environments, through the existence of high-rise buildings and densely build-up areas, but also through air-pollution (aerosols) can potentially lead to an enhancement of both flooding and hail. Conclusions are drawn from two separate studies over the heavily urbanized corridor of the northeastern United States but could be expanded to apply to other urban areas.

Observational and modelling (Weather Research and Forecasting - WRF) analyses of an extreme thunderstorm over the Baltimore, Maryland metropolitan area on 7 July 2004 provided evidence that the urban canopy redistributed heavy rainfall and convergence centres in the vicinity of the urban environment. Modelling analyses suggest that convective rainfall around the urban core was increased by about 30% due to the heterogeneities of land surface processes associated with the city of Baltimore. Chesapeake Bay also played an important role in rainfall distribution by acting as a divergence zone for northerly winds. Cloud-to-ground lightning analyses show that the city of Baltimore and the Chesapeake Bay combined played a role in the distribution of lightning in the periphery of the urban core.

Detailed modelling analyses (WRF-Chem) of a series of convective storms over the New York City metropolitan area, suggest that under certain meteorological conditions, increased concentrations of aerosols can lead to better organization of convection, higher vertical velocities and significantly increased convective rainfall accumulations. Higher vertical velocities were more widespread and reached deeper atmospheric levels when meteorological conditions were favourable, under increased aerosol concentrations. Areas that are downstream of sources of aerosols (i.e. New York City) are more prone to experience convective enhancement.