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Changing spatial patterns of convective rainfall across urban areas

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Observations using remote sensing data reveal that urban areas affect the intensities and spatial structure of rainfall fields on small scales (i.e., at sub-hourly and sub-kilometer resolutions). However, there is currently disagreement regarding the precise pattern of change and the driving dynamic and thermodynamic forces behind it. As the hydrological response in urban areas is fast and highly sensitive to space-time rainfall variability, it is crucial to understand how urban areas change the intensity and spatial structure of rainfall to improve our abilities to nowcast rainfall and urban floods. We used high-resolution weather radar data to analyze the intensity, spatial structure, and motion of convective rainfall events that crossed several urban areas with diverse characteristics (e.g., Milan, Italy; Phoenix, US). We present an automatic methodology (i.e., does not require an expert's interpretation of rainfall fields) that can be applied to different urban areas worldwide. We first tracked convective rainfall events using a storm-tracking algorithm (from a Lagrangian perspective) and investigated changes to the properties of the rainfall fields (e.g., mean intensity, area, and intensity distribution profile) at varying upwind and downwind distances relative to each urban center. We also investigated changes to storms' trajectories and to the frequency of storm initiations, terminations, splitting and merging events. We validated our results by repeating the analyses in control regions, that were adjacent to each study region and did not contain large urban areas within them. Our results show a general intensification of rainfall over cities, conserved spatial structures (instead of an expected weakening), as well as, increased storm initiations downwind of urban areas. Our findings also suggest that urban areas might be acting as barriers, by increasing storm terminations upwind of urban areas and deflecting incoming storms leftwards; possibly as a result of roughness-induced frictional turning.