RAL/MMM SEMINAR SERIES

A Numerical Investigation of Supercell Storm Interactions With the Urban Environment

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It is well known that cities can modify rainfall distributions, particularly by more frequently triggering deep moist convection over and downwind of urban areas. However, the effect of cities on organized convection, such as supercells, has been poorly studied. This topic needs further investigation since exposure and vulnerability to severe storm risks are greater in cities than in the surrounding rural areas.

To address this topic, idealized simulations were conducted using the WRF model. An idealized circular city is placed in a flat domain with cropland as the predominant land use. Urban-atmosphere exchange processes are resolved using the Building Effect Parametrization (BEP) and the Building Energy Model (BEM). A supercell is initiated in the domain at 4 pm using a thermal bubble and is then advected by the mean flow toward the city. To enhance the analysis, 10 ensemble members are generated for each experiment using SKEBS. Several experiments were conducted changing the city size, the urban fraction, the height and density of the buildings. The impact of different morphological parameter on the simulated supercell is assessed by examining how key diagnostic variables of the storm change upwind, over, and downwind of the city.

The results show a statistically significant weakening of the supercell with increasing city size. A similar trend is observed when varying the density of the buildings and the urban fraction, although these are not statistically significant for most of the variable considered. On the other hand, a statistically significant trend of intensification of the supercell storm is observed with taller buildings. An in-depth analysis of the pre-storm environment shows that the weakening of the storm is primarily driven by the urban dry island, that substantially reduces the convective available potential energy. While the initial storm can be strongly weakened by the city, a thermodynamically induced downwind pressure minimum triggers a new supercell in some ensemble members. This suggests that this study does not contradict previous research, but rather expands our understanding of the complex interactions between the urban environment and deep moist convections. Convective storms can be initiated by city-induced wind convergences but can also be suppressed by the urban dry environment. Event website