EGU24-17845, updated on 14 Jan 2025
https://doi.org/10.5194/egusphere-egu24-17845
EGU General Assembly 2024

Can a city modify a severe convective windstorm?

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It is well known that cities can modify the rainfall distributions, in particular deep moist convection is more frequently triggered over and downwind urban areas. However, the effect of cities on the most extreme convective events, such as hailstorms, downbursts or tornadoes, is poorly studied. This topic needs further investigation since exposure and vulnerability to severe storm risk is larger in cities than in the surrounding rural area. What happens if a severe convective windstorm impacts a big city? Is the storm modified by the urban land use?

Our analysis focuses on a case study that occurred on 25 July 2023, when a nocturnal downburst affected the city of Milan, in northern Italy, with measured wind gusts up to 30 m/s. The intense wind gusts downed many trees in the public parks and over the streets, blocking urban mobility. The event is investigated in depth using both observations and high-resolution numerical simulations performed with the WRF model.

Observations show that a UHI over Milan before the storm was negligible, while there was a drier air mass over the city than over the surrounding rural area. Consequently, a pool with low values of equivalent potential temperature (theta-e), a quantity that strongly influences deep moist convection, was present over the city.

Four nested WRF simulations are carried out with grid resolution from 9 km up to 333 m, and 64 vertical levels starting from 5m AGL. Two different boundary layer parametrizations are tested, namely MYJ and BouLac schemes, as well as two different microphysics schemes: Thompson and WRF Single-moment 6-class. Moreover, simulations with bulk urban parametrizations are compared with those coupled with the building effect parameterization and the building energy model (BEP-BEM), employing data of the World Urban Database and Access Portal Tools (WUDAPT). Simulations without the urban land use (no-urban) are carried out to test the effect of the Milan urban area on the convective storm. Results of all these simulations are compared with surface observations and radar data. The simulations have a similar skill, with slightly better results using the BouLac scheme coupled with BEP-BEM. Simulations using urban parametrizations are able to reproduce the pre-storm pool with low theta-e values over Milan, while no-urban simulations do not simulate the low theta-e pool.

All WRF simulations accurately reproduce the violent windstorm, both in terms of simulated wind gusts, rainfalls and radar reflectivity. Removing the city, stronger wind gusts are simulated at the

surface due to the significantly reduced drag. However, rainfalls are slightly intensified downwind of the city, as well as the drop of potential temperatures associated with the downdrafts.

In conclusion, the urban canopy may have prevented the development of even more violent wind gusts in the city, due to the increased surface roughness. On the other hand, despite the presence of a pool of low theta-e values, the storm likely intensified downwind the city. A possible motivation to that intensification will be proposed in the presentation.