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Validation of a downburst analytical model through the survey of hail damage on building facades

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ABSTRACT

Severe winds produced by thunderstorm outflows and in particular downbursts can reach high wind speeds and threaten human safety and structures. Due to their high frequency of occurrence and their small spatial extent, downbursts may be considered one of the most hazardous meteorological phenomena, particularly in mid-latitudes countries.

In the current work the authors use an analytical model to describe some kinematic parameters associated with a real downburst event which took place at Sânnicolau Mare, Romania on June 26, 2021. The analytical model employed in this paper was developed by the authors in 2020. The model simulates the mean horizontal wind speed and direction, evaluated at a fixed height above the ground level, originating from a travelling downburst whose outflow is embedded in a low-level, large-scale ABL wind. The analytical model consists of 11 field parameters which are necessary for simulating each thunderstorm event. The estimation of these parameters is performed using a global optimization algorithm which minimizes a single objective function evaluated starting from simulations and recorded data. The algorithm used for the minimization is the Teaching Learning Based Optimization (TLBO) technique.

(a) (b)

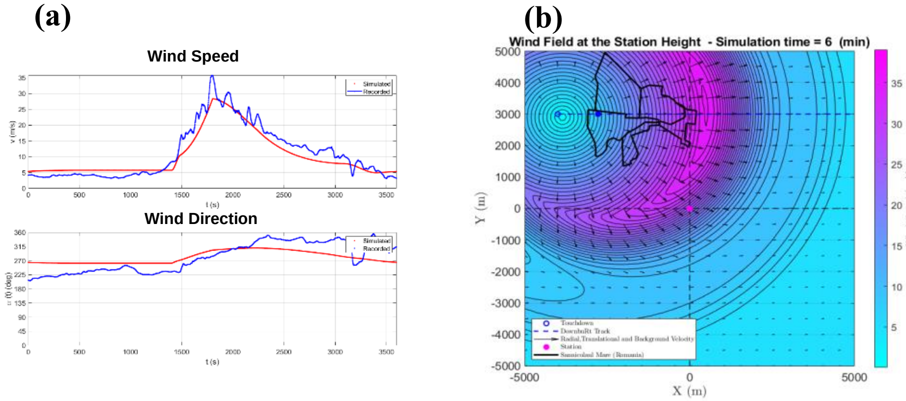

Figure 1. Simulation of the Sânnicolau Mare downburst, June 26, 2021. (**a**) Comparison between measured and simulated wind speed and direction. (**b**) Reconstruction of the outflow wind field at the simulation time equal to 6 minutes after touchdown.

Fig. 1 shows the downburst reconstruction obtained using the TLBO technique applied to the real event in Sânnicolau Mare. The event was measured by an anemometer located at 50 m above the ground level near the city. Fig. 1a reports the comparison between the slowly varying (30 s averaged) recorded and simulated wind speed and direction. Fig. 1b shows the reconstruction of the outflow velocity field 6 minutes after the touchdown and highlights how the downburst passed over the city travelling from west to east.

The Sânnicolau Mare downburst was a very strong event which caused hail damage to the facades of many buildings in the city. After this strong event, a damage survey was carried out in collaboration between the University of Genoa (Italy) and the University of Bucharest (Romania). The damage survey identifies the location of the building in Sânnicolau Mare that suffered hail damage during the event. Using the wind field simulated through the analytical model, the simulated damage "footprint" (i.e., the maximum wind speed that occurred at a given place at any time during the passage of the downburst) was calculated. Fig. 2a shows the footprint for the entire downburst, whereas Fig. 2b shows an enlarged view of the footprint over the city, overlapping the simulated maximum wind velocity vectors (blue arrows) onto hail damages, also represented as vectors pointing to the damaged facades (red arrows).

(a) (b

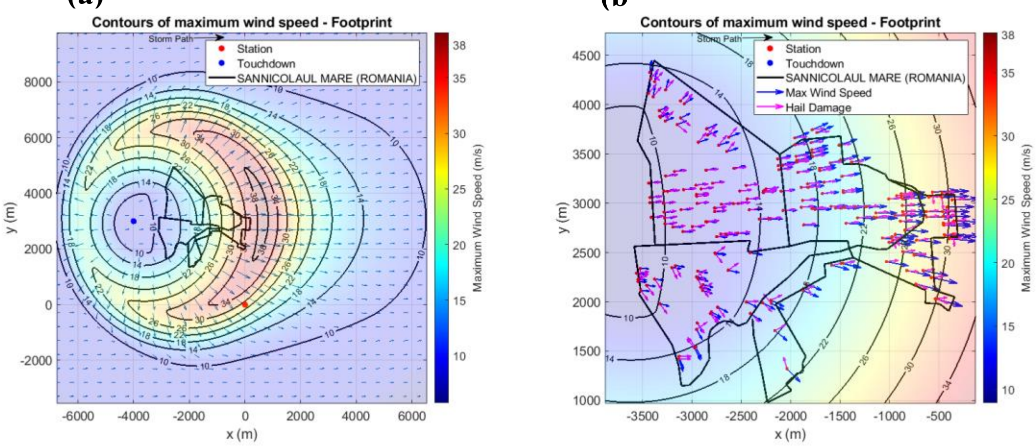

Figure 2. (**a**) Simulated damage footprint for the Sânnicolau Mare Downburst. (**b**) Comparison between the hail damage and the maximum simulated wind speed during the passage of the downburst.

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