Leveraging GNSS tropospheric delays to nowcast severe weather events by assimilation into WRF and by machine learning techniques: the hailstorm of 13 July 2021 on Milano Malpensa airport

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Abstract

In the H2020 projects SINOPTICA and ALARM, experiments were carried out on two different approaches to nowcast severe weather events capable of adversely affecting air traffic management operations. The SINOPTICA approach consists of the assimilation of GNSS ZTD in combination with other weather-related measurements into the WRF model using a 3D-Var technique in rapid update cycle mode, while the ALARM approach is based on machine learning techniques. The objective was to evaluate the impact of GNSS ZTD on the nowcasting of the weather parameters of interest, including rain, hail, and wind, for the hailstorm event that affected the Milano Malpensa airport on 13 July 2021. The WRF simulations with data assimilation improve the prediction of the convective cell in terms of intensity: the forecasted hail diameter is consistent with the damage reported for an aircraft. However, the WRF simulations show a small error in the location of the convection. The machine learning algorithm is based on a Long Short-Term Memory (LSTM) network with encoder/decoder structure, providing in output wind speed and rain rate at each station location and over the Malpensa airport. The probability of detection of extreme wind within 1h around Malpensa is about 93% with about 1% of false alarms and it can predict the intensity of the wind with an RMSE of 0,081 m/s. The detection of extreme rain is more difficult because the algorithm underestimates the intensity, however with a post-processing procedure we reach about 97% of probability of detection with 2% of false alarms.