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Spatio-temporal nowcasting of local severe weather events with deep neural networks

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In the last decades, the intensity and frequency of extreme weather events have increased in Europe. The climate change, through its impact on the atmospheric processes, is expected to lead to further increase of such severe phenomena which also affect the air traffic activities. Therefore, a continuous monitoring and understanding of convective and pre- convective environment is highly demanded and indeed several studies have been made towards this direction. However, there are still gaps and uncertainties, especially regarding extreme weather events that are locally developing in a short time range. The nowcasting of extreme weather is a difficult task due to the complex structures and non-linear relation between its features. The existing weather numerical models are computationally expensive and limited by the difficulty to transform the acquired knowledge into accurate mathematical equations. For these reasons, this topic has gradually gained attention in the artificial intelligence community which aims at establishing more accurate models than the existing well-known techniques.

Within the H2020 SESAR multi-hAzard monitoring and earLy wARning system (ALARM) project, we focus on nowcasting the rain and wind speed using different algorithm input configurations that account for convective and pre-convective environments using data from weather stations, lightning detectors, radar and GNSS receivers with 10-minute sampling rate. The selected areas are Milano Malpensa and Brussels Zaventem airports, where extreme weather events are highly active. With the good quality datasets available for 10 years, we built an end-to-end spatio-temporal nowcasting model that ensembles independent Long Short Term Memory based encoder decoder sub-models to predict rain and wind speed absolute values up to 1 hour ahead given 2 hours of past observations.

Following the regression analysis of the predicted features, we classify rain and wind speed extremes events and we present the assessment of the nowcasting model in terms of the probability of detection, false alarm ratio and the critical success index. For specific case studies we also showcase the potentials of the model as a useful tool for aviation management. The results show excellent wind speed nowcasting performances with probability of detection higher than 90% and false alarms ranging from 1% to 3%. The rain nowcasting model underestimates the observations but a post-processing adjustment allows to reach probability of detection higher than 80% and about 10% of false alarms.