EGU General Assembly 2023

EGU23-14545, updated on 22 Jan 2024
https://doi.org/10.5194/egusphere-egu23-14545
EGU General Assembly 2023

Machine Learning models for probabilistic rainfall nowcasting applied to a case study in Italy: the extreme rainfall event on 26 November 2022 over Casamicciola town, Ischia Island.

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On 26 November 2022, an extreme rainfall event occurred over Ischia Island (Italy). It triggered a mudflow that swept over Casamicciola Terme town and caused 12 victims. Based on available rainfall data from 4 rain-gauge stations over the island, the precipitation values registered during the event were higher than the annual maxima values of the previous 15 years. With regards to 1 and 24 hours, the rain-gauge stations measured values between 40.6 and 57.6 mm, and between 145.4 and 176.8 mm, respectively. Since one of the main challenges during these phenomena is predicting rainfall sufficiently in advance in order to allow water managers to take action (issue warnings or real-time control), this study investigates how much time before the peak - or threshold exceedance - a machine learning model is able to capture the peak - or threshold exceedance. A model that predicts rainfall intervals and the corresponding probability of occurrence for lead times from 10 minutes to 6 hours is proposed. The model employs cumulative rainfall depths from recording stations in an area of 50 km radius from the Ischia Island as inputs for a Feed Forward Neural Network to nowcast rainfall in the 4 rain-gauges over the study area. Based on almost 400 rain events observed during years 2009-2022, 24 machine learning models were independently trained for each rain-gauge and each of the 6 lead-times - 10, 30, 60, 120, 180 and 360 minutes. The performance of each model was evaluated and compared using different metrics, both continuous (RMSE and MAE) and categorical (POD and FAR). In addition, the Eulerian Persistence (EP) was considered as a benchmark model. The rainfall nowcasts showed encouraging results. Even though for convective rain events the potential lead-time is short, the models produced consistent nowcasts for lead-times up to 2 hours. With probabilities of almost 90%, the thresholds exceedance was forecasted up to 1 hour before. As expected, predictive accuracy and probabilities gradually decreased as the lead-time increased, according to physically based models. Moreover, the proposed models outperformed the benchmark EP for all the lead-times and performance criteria. Results confirmed that the use of cumulative rainfall depths for precipitation nowcasting made this approach a promising tool for nowcasting purposes, and his flexibility and conceptual simplicity resulted in a rapid, easily replicable and convenient nowcasting approach. To conclude, the proposed models enhanced a first identification of critical thresholds, which should be further analysed in order to achieve a better, complementary understanding of the occurring phenomenon.

Keywords: Precipitation nowcasting; Multi-step predictions; Rain-gauge measurements; Pattern recognition; Feed forward neural networks; Cumulative rainfall fields.