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A year-long total lightning forecast over Italy made with a dynamic lightning scheme using the WRF model

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Lightning is an important threat to life and properties and its forecast is important for practical applications. We show the performance of a dynamic lightning scheme for the next-day strokes forecast. The prediction is compared against the LINET network, and the forecast period spans one year. Specifically, a total of 162 case studies were selected between 1 March 2020 and 28 February 2021. The events span a wide range of lightning intensity; 69 cases occurred in summer, 46 in fall, 18 in winter, 29 in spring.

Three different settings of the lightning scheme are considered to test the sensitivity of the method to the key parameter of charge transferred in 1 second: $0.5*10^{-4}$ C (L50), $0.75*10^{-4}$ C (L75), and $1.0*10^{-4}$ C(L100).

The meteorological driver is WRF. Each simulation lasts 36h and the first twelve hours are the spin-up time and are discarded from the analysis. The focus is on the next-day forecast (12-36 h). The horizontal resolution of the simulations is 3 km and 50 unevenly spaced vertical levels extend from the surface to 50 hPa.

Lightning is closely related to convection in the atmosphere and model errors in the lightning forecast have two main sources: errors in forecasting the convection and errors in the representation of the electric processes inside the clouds. This makes the lightning forecast a difficult task.

Results are discussed for the whole year and for different seasons. Moreover, statistics are presented for the land and sea. LINET strokes are remapped into the WRF 3km grid and then further elaborated for comparison with the strokes forecast.

Among the three configurations of the lightning scheme, L75 forecasts accurately the total number of strokes recorded for all the cases, L50 underestimates the strokes and L100 overestimates the strokes. The time-series correlation of daily observed and forecasted strokes is around 0.75 and depends on the season.

Qualitative scores (FBIAS, ETS, POD, FAR) computed for the 3km grid and different strokes thresholds have low values and upscaling the model output, by summing the forecast and observed strokes over grids with larger grid spaces (from 6 to 48 km), improves the results. Among the

different configurations of the dynamic lightning scheme, L75 performs slightly better. However, L50, L75, and L100 show very similar spatial patterns of predicted strokes.

The analysis of the fraction skill score shows that the best lightning forecast is for summer, followed by fall, winter, and spring. This happens for all configurations L50, L75, L100.

The lightning forecast performance varies between sea and land; the analysis of the Taylor diagram shows better performance over the land than over the sea. This result shows that the convection is better simulated over the land than over the sea, where the effect of topography, partially represented by the model, may focus the convection on specific areas.

The result of this study shows that lightning forecast with the dynamic lightning scheme can be performed with success in Italy; nevertheless, a careful inspection of the forecast performance is necessary for tuning the scheme to the specific purpose.