SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year ……2024……..……

Project Title: Improvement on NWP prediction at the short-range for high impact meteorological events

Computer Project Account: ……SPITFEDE……..……

Principal Investigator(s): ……Stefano Federico (cm4)

……..……

Affiliation: …… CNR-ISAC (National Research Council – Institute of Atmospheric Sciences and Climate)...

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Name of ECMWF scientist(s) collaborating to the project (if applicable)

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Start date of the project: ……01/01/2024…….……

Expected end date: ……31/12/2026……..……

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	/	/	20000000	4000000
Data storage capacity	(Gbytes)			100000	84000

Summary of project objectives (10 lines max)

The main focus is to show the potential of data assimilation at improving the forecast of intense and severe meteorological events at the short-range (0-6h). Four main sources of data are considered: lightning, radar reflectivity, WInd VElocity Radar Nephoscope (WIVERN) pseudo-doppler, and GNSS (both ZTD and slant path). We investigate two different time ranges 0-3h and 3-6h after the last data assimilation time and we use 3DVAR or nudging for data assimilation. The model performance is evaluate against a dense network of raingauges homogeneously spread over Italy.

Summary of problems encountered (10 lines max)

No specific problems were encountered in the period.

Summary of plans for the continuation of the project (10 lines max)

The project will continue to investigate the problem of data assimilation of different data sources. While in the first part of the project we are focusing on the lightning and radar reflectivity data assimilation, in the second year we will consider the assimilation of WIVERN pseudo-observations of winds for the case study of the Medicane Ianos, occurred in mid-September 2020 in the Central Mediterranean. The assimilation of GNSS will be considered during the third year.

List of publications/reports from the project with complete references

For this special project there aren't yet publications. One paper will be submitted in the month of July 2024. In this publication, the role of the lightning and radar reflectivity data assimilation is shown for an intense storm occurred over southern Italy on 3-4 December 2022. WRF simulations with different configurations and physical parametrisations will be compared with a simulation considering lightning and radar reflectivity data assimilation. It is shown that data assimilation outperforms the precipitation forecast of other model configurations, nevertheless not all aspects of the forecast are improved.

Summary of results

Two main experiments are considered in this first year for radar reflectivity and lightning data assimilation: in the first experiment we focus on a case study occurred on 3-4 December 2022 over Calabria, southern Italy. This event produced heavy rains, wind gusts and at least one tornado over Calabria. The event was studied using the WRF model with different physical parameterizations and different initial conditions. About 40 numerical experiments were considered changing the initial and boundary conditions (IC/BC, GFS or ECMWF-IFS, respectively), the parameterization of the planetary boundary layer, the microphysics parameterization, and the cumulus convection parameterization.

Results show, in general, a good prediction of precipitation, as most of the configurations can simulate the heavy rainfall that characterized this event. However, when ECMWF-IFS IC/BC are used in place of GFS IC/BC, WRF predicts better the event at the local scale, enhancing both the spatial representation and the precipitation amount. Simulations were performed at 3 km horizontal resolution.

The above experiments are then compared with three sensitivity tests: the first using more accurate sea surface temperature map, the second using a higher horizontal resolution (1km) of the WRF model, the third performing lightning and radar reflectivity data assimilation. We divided the whole event (from 12 UTC on 3 December to 12 UTC on 4 December) in four 6h frames. The results of sensitivity tests show that: enhancing the horizontal resolution of the WRF model has some positive impact on the representation of the precipitation maxima (both for positioning and amount);

enhancing the sea surface temperature mask had a minor impact on the forecast of this event; using data assimilation improved substantially the rainfall prediction, improving both the correct forecast and the false alarms, in a way similar to that shown in Federico et al. (2024).
The second experiment focuses on the assimilation of lightning over northern Italy, in an area around the city of Milan (200km by 200km wide). This experiment is larger than the previous one as it involves about 70 case studies that developed deep convection in the urban area of Milan and surroundings. Simulations are being performed with and without lightning data assimilation to evaluate the impact of lightning data assimilation on the precipitation forecast. A preliminary result of the impact of lightning data assimilation in the prediction of the convective events, for a subset of 10 case studies, is shown in Figure 1.

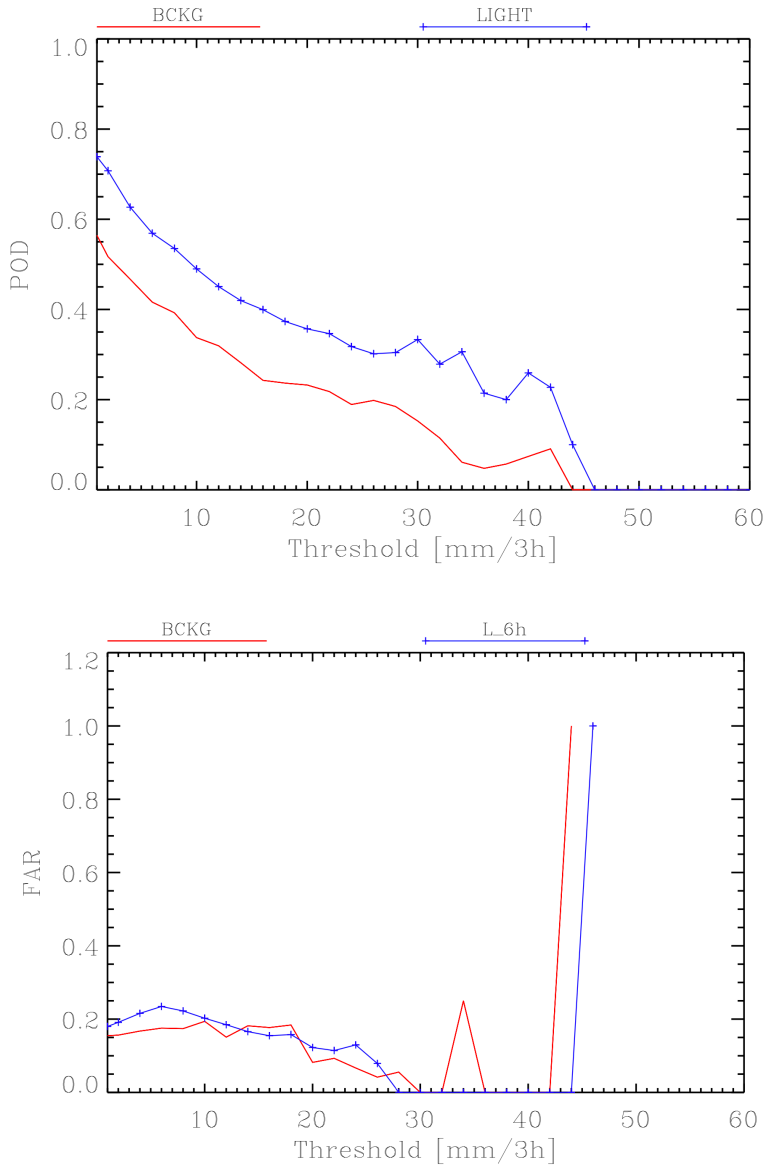

Figure 1: Probability of Detection (POD, upper panel) and False Alarm Rate (FAR, lower panel) for 10 convective case studies occurred in Milan and surrounding areas.

The POD is substantially improved by lightning data assimilation, and we note that the score is about 0.4 for the intense precipitation threshold of 30 mm/3h (it is about twice the corresponding score of the control simulation, without lightning data assimilation). It is also noted that the FAR remains comparable with that of the control simulation, or even reduced for some thresholds.

References

Stefano Federico, Rosa Claudia Torcasio, Jana Popova, Zbyněk Sokol, Lukáš Pop, Martina Lagasio, Barry H. Lynn, Silvia Puca, Stefano Dietrich, Improving the lightning forecast with the WRF model and lightning data assimilation: Results of a two-seasons numerical experiment over Italy, Atmospheric Research, Volume 304, 2024,107382, ISSN 0169-8095, https://doi.org/10.1016/j.atmosres.2024.107382.