SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

Project Title:	RAIN -Reflectivity Assimilation for an Innovative Nowcasting approach
Computer Project Account:	spitlaga
Start Year - End Year :	2021 - 2022
Principal Investigator(s)	Martina Lagasio
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Other Researchers (Name/Affiliation):	Vincenzo Mazzarella/CIMA Research Foundation Massimo Milelli/CIMA Research Foundation Antonio Parodi/CIMA Research Foundation

The following should cover the entire project duration.

Summary of project objectives

(10 lines max)

This project aims to build up a nowcasting system with a NWP model (WRF) using a 3-hour rapid update cycling 3DVAR of radar reflectivity observations with a new postprocessing algorithm able to take into account the timely and spatial uncertainty in the convective field simulation. The main aim is to take into account the spatial and temporal uncertainties of the meteorological model, also considering that the most recent simulation is not necessarily the best one due to, for example, the spin up process. Performing a 3-hour cycling 3DVAR with 12 hours of forecast each time it is possible to guess that, for each time instant (dt=3 h in this case) starting from a given time, the nowcasting scheme allows to have 3 simulations providing a 6 hour forecast covering the same time window. The final product will be a rainfall hazard scenario map for the following 6 hours based on all the simulation considered. Moreover, the meteorological forecast obtained with the rapid update cycle data assimilation every 3 hours, has been used also in a complete meteo-hydrological chain.

Summary of problems encountered

(If you encountered any problems of a more technical nature, please describe them here.)

No problems encountered during the project development, the project simulations ended in june 2022 as reported in the second report, as all the SBU have been consumed and all the necessaries simulations have been run.

Experience with the Special Project framework

(Please let us know about your experience with administrative aspects like the application procedure, progress reporting etc.)

The experience obtained thus far has been positive, and the administrative process is sufficiently clear.

Summary of results

(This section should comprise up to 10 pages, reflecting the complexity and duration of the project, and can be replaced by a short summary plus an existing scientific report on the project.)

Heavy rainfall events cause numerous casualties and millions of euros in damages annually. With climate change underway, the frequency of extreme rainfall events is expected to rise globally, leading to greater social and economic impacts. Therefore, a crucial objective is to enhance forecast accuracy and improve risk communication to minimize social and economic losses. In recent years, the adoption of high-resolution meteorological forecasting methods, potentially coupled with data assimilation, has become essential for providing timely and precise short-term forecasts. However, both Numerical Weather Prediction (NWP) and radar-based nowcasting still face challenges, particularly regarding the ability to predict the precise timing and spatial localization of precipitation systems and the rapid deterioration of forecast accuracy, respectively.

To address these challenges, this project aims to introduce a nowcasting system that combines the NWP model (WRF) with a 3-hour rapid update cycling 3DVAR of radar reflectivity and lightning data, using a blending technique with the radar-based nowcasting system PhaSt. Additionally, an innovative post-processing algorithm called SWING (Score-Weighted Improved NowcastinG) has been developed to account for the timely and spatial uncertainty in simulating convective fields.

The results obtained from applying the SWING algorithm to a 24-days case study suggest that it could enhance the predictive capabilities of a traditional deterministic nowcasting forecast system while maintaining a useful forecast timing and integrating existing forecast procedures. This would enable automatic warnings with overall good performance, even in the case of highly unpredictable extreme events. Furthermore, the SWING algorithm offers exceptional versatility as it can be employed with any meteorological model within a multi-model forecast approach.

Forecasting floods remains also a significant challenge, particularly in environments with small drainage areas (i.e., 103 km2 or smaller). This project also aimed to assess the performance of two short-term rainfall forecast methods (SWING application against a more traditional Blending application) in predicting streamflow. Both methods combine a nowcasting extrapolation algorithm with numerical weather predictions based on the rapid update cycle meteorological forecast mentioned earlier. A distributed hydrological model is employed to convert rainfall forecasts into streamflow predictions. The possibility of assimilating radar and lightning data or radar data alone has also been evaluated. The results were aggregated based on basin size to examine the impact of catchment integration. The findings obtained on the 24-days case study indicated that both rainfall forecast methods demonstrated relatively good performance, with no clear advantage of one method over the other. Additionally, the results revealed that assimilating both radar and lightning data on average improved performance.

List of publications/reports from the project with complete references

Lagasio, M., Campo, L., Milelli, M., Mazzarella, V., Poletti, M. L., Silvestro, F., ... & Parodi, A. (2022). SWING, The Score-Weighted Improved NowcastinG Algorithm: Description and Application. Water, 14(13), 2131.

Mazzarella, V., Milelli, M., Lagasio, M., Federico, S., Torcasio, R. C., Biondi, R., ... & Parodi, A. (2022). Is an NWP-Based Nowcasting System Suitable for Aviation Operations?. Remote Sensing, 14(18), 4440.

SWING algorithm presented at MetMed 2023 conference (https://www.metmed.eu/86600/section/38942/9th-international-conference-on-meteorology-and-climatology-of-the-mediterranean.html)

Nowcasting algorithm will be presented at RadMet 2023 (https://sites.google.com/arpae.it/radmet2023it)

Silvestro, F., Lagasio, M., Poletti, M. L., Parodi, A., Mazzarella, V., Campo, L., Falzacappa, M., Federico, S. and Milelli, M. Hydrological verification of two rainfall short-term forecasting methods with floods anticipation perspective. Is under review on Journal of Hydrology.

Future plans

(Please let us know of any imminent plans regarding a continuation of this research activity, in particular if they are linked to another/new Special Project.)

The project is finished.