LATE REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE: Italy

Principal Investigator[1]: Martina Lagasio

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Project Title:

RAIN - Reflectivity Assimilation for an Innovative Nowcasting approach

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ___________________	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2020	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☒

Computer resources required for the years: (To make changes to an existing project please submit an amended version of the original form.)		**2020**	**2021**	**2022**
High Performance Computing Facility	(SBU)		950000	950000
Accumulated data storage (total archive volume)[2]	(GB)		2160	2160

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

[2] If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year.

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Extended abstract

The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used.

Requests asking for 1,000,000 SBUs or more should be more detailed (3-5 pages).

Following submission by the relevant Member State the Special Project requests the evaluation will be based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, disciplinary relevance, and justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

All accepted project requests will be published on the ECMWF website.

Background and scientific plan

The Mediterranean region is frequently struck by severe rainfall events causing numerous casualties and several million euros of damage every year (Gaume et al., 2016). In particular, the unusually complex terrain of the western Mediterranean areas, characterized by high mountains close to the coastlines (Alps, Apennines, Massif Central, Pyrenees), can enhance or trigger the deep convective processes often originating over the warm sea in the fall season (Rebora et al., 2014, Ducrocq et al., 2014, Fiori et al., 2017). It is well known in literature that "convection-permitting" or "convection-allowing" Numerical Weather Prediction (NWP) simulations produced more skilful guidance than those from a coarser-resolution model employing convective parameterization (Done et al., 2004; Kain et al., 2006; Weisman et al., 2008; Clark et al., 2009). However, the use of NWP for nowcasting purposes is still a challenge for two main reasons. The first one is the model spin-up (3-6 h for convective-permitting model resolutions) appearing when the model is initialized by interpolating a coarser resolution analysis due to the initial condition's inability to represent the physical processes at the convective scale. Beyond this first issue, even if NWP models often show some ability to forecast the convection initialization and mode, their accuracy in timing and location of convective structures cannot satisfy the needs of nowcasting (Sun et al., 2014). To reduce the period required for model spin up, data assimilation with rapid update cycles are developed in some NWP to provide forecasts with a "warm start" (Benjamin et al., 2004). Several studies have shown the benefit of the rapid update cycling in improving convective precipitation forecast skills (Benjamin et al., 2004; Sun et al., 2012, Lagasio et al., 2019a). Although significant progress has been made in using NWP models for nowcasting applications, there are still many open issues such as the predictability of precipitation systems, the need for improved mesoscale observation networks, and the improvement of rapid update NWP and DA systems (Sun et al., 2014). 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. As aforementioned, the observational data to be assimilated via 3DVAR in WRF is the reflectivity from weather radars. These data are provided by Meteorological Radar national mosaic operated by the Italian Civil Protection (Vulpiani et al. (2008), CAPPI data on 3 levels: 2000,3000 and 5000 m a.s.l.) covering the whole Italian territory. To deal with the aforementioned main open issues about using NWP models for nowcasting applications, in this work a new post-processing algorithm is built up. 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, in an operational-like mode, for each time instant (dt=3 h in this case) starting from a given time (hereafter called "now"), the nowcasting scheme allows to have 3 simulations providing a 6 hour forecast (or 2 simulations providing a 9 hour forecast) covering the same time window. Furthermore, each forecast has at least 3 hours of simulation "in the past" with respect to the now instant. Thus, the new algorithm aims to consider not only the most recent simulation at each time, but all the simulations covering a given time instant. We will start using three simulations with a 6-hour overlapping forecast. It is important to notice that every three hours a new forecast is available, so the nowcasting forecast will be updated every three hours starting from the now until the end of the run period used for this experiment. Using 3 forecasts for each time window has the main advantage of having different warm start times and different assimilation cycles for each of them. Every simulation is weighted based on the 3 hours of forecast "in the past" with respect to the now. This weighting is performed through an object comparison between the simulated and observed rainfall fields (observations are from the radar and rain gauges merging maps to avoid losing information over the sea areas) with an object-based validation. When a weight for each of the 3 (or 2) forecasts is obtained, a rainfall hazard scenario map for the following 6 hours from now can be retrieved.

Technical characteristics

This project is mainly addressed to satisfy the computational needing to run some set of experiments trying to improve the current performance of NWP in nowcasting applications. The Weather Research and Forecasting (WRF) model v3.8.1 (Skamarock et al., 2008) was selected as numerical weather model to accomplish all the experiments. It is a compressible non-hydrostatic model with mass-based terrain-following coordinates that was developed at the National Center for Atmospheric Research (NCAR) in collaboration with several institutes and universities for operational weather forecasting and atmospheric science research. Concerning the data assimilation system, the package (WRFDA) 4.1 is chosen. Three two-way nested domains will be used. The domains have, respectively, a horizontal grid spacing of 22.5 (216×191 grid points), 7.5 (523×448) and 2.5 km (430×469), covering the whole Italian territory (Figure 1), with 50 vertical levels, all domains top reach 50 hPa. The physical setup chosen has been described in Lagasio et al., 2019b. Lagasio et al., 2019c and Lagasio et al., 2020 while a radar reflectivity assimilation with a 3dvar using the modified direct operator presented in Lagasio et al., 2019a will be adopted. The nowcasting scheme will be implemented with a 3-hour cycling 3DVAR and 12-hours forecast for a total of 8 runs in each considered day.

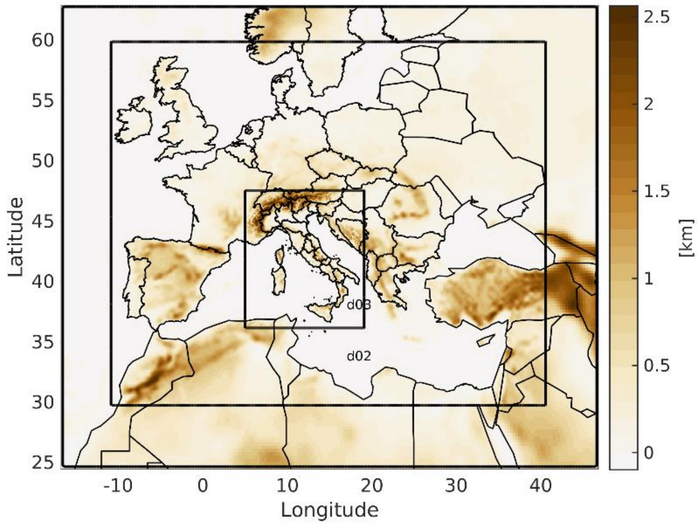

Figure 1 - WRF domains setup

Computational resources needed

*The nowcasting procedure here described will be applied to at least a 15 days period, possibly in two different seasons (summer and fall) and 8 runs with 12 hours of forecast per day are needed to implement the presented nowcasting scheme. Thus, for each day about 21351 SBU (elapsed time is about 16560s (seconds needed for 1 nowcasting day)*288cores) are required. To cover 15 days 320265 are needed and different choice for assimilation will be testes (such as different background errors covariance matrices, LSAC approach (refer to Lagasio et al., 2020)) for each set of experiments. Therefore, an overall cost of about 950000 SBU per year is required to address all the needed experiments. Depending on the results, the set-up of the nowcasting could be partly modified and it might be possible to have different simulations with respect to the ones described here. Moreover, we expect some debug work, at least in the first year.*

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