<u>LATE</u> REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE: Italy

Principal Investigator[1]: Dr. Agostino N. Meroni

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Project Title:

AWARE - Assimilating Water vapor during African heavy Rainfall Events

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.)	2021	
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)	-	850000	100000
Accumulated data storage (total archive volume)[2]	(GB)	-	5000	5000

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

High resolution numerical simulations of heavy rainfall are necessary to better understand the small-scale and complex dynamics of the atmosphere that leads to High Impact Weather Events (Roberts et al., 2018, HIWEs). These events strongly affect the society and are not easy to forecast, especially with global Numerical Weather Prediction (NWP) models (Vogel et al., 2018). The low skills in predicting HIWEs are generally ascribed to small-scale processes that low resolution models cannot capture explicitly and have to be approximated statistically or parameterized. These parameterization schemes are associated with most of the uncertainty in model simulations. In particular, the convection parameterization schemes have a significant influence on heavy rainfall phenomena, because they unavoidably represent some important factors for rainfall development (such as temperature and humidity vertical distribution, vertical motion, to cite some) in a crude way (Maranan et al., 2018, e.g.).

Regional NWP models perform better than global models in simulating such events, thanks to their finer spatial resolution, especially when convection is explicitly resolved with grid lengths of less than 4-5 km. Regional models run with high resolution over the area of interest and, thus, can produce more detailed simulations than what is possible with global models using the same amount of computational resources. The increased computer power that has been made available in the last years has opened up the possibility to explore the dynamical evolution of HIWEs in an unprecedented way. However, most of the research in the African continent has been performed on climatic and seasonal time scales, with very few studies of high resolution simulations of HIWEs.

Proposal

The Weather and Research Forecasting (WRF) model (Skamarock et al., 2019, V4.0.3) is a state-of-the-art fully compressible atmospheric model that is used both for research and operational applications, over a wide range of spatio-temporal scales. In the literature, many studies focused on the sensitivity of WRF simulated rainfall prediction to various physical schemes over relatively long timescales, including seasons, years and decades. On the one hand, to drive high resolution NWP models, high resolution input data and boundary conditions are needed. On the other hand, the present state-of-the-art high resolution NWP models coincide with the increasing availability of space-borne observational data sources characterized either by high spatial resolution (e.g., the Sentinel missions developed in the Copernicus program framework) or by a high temporal resolution (Global Navigation Satellite System, GNSS).

In this context, the Synthetic Aperture Radar (SAR) Interferometry (InSAR) technique (Bürgmann et al., 2000) applied to Sentinel-1 data enables the retrieval of information on a wide range of spatial scales of the potentially highly turbulent atmospheric water vapor field (Hanssen et al., 1999). Many studies demonstrate the positive impact of assimilating Integrated Water Vapor (IWV) (measured in kg m^{-2}) or, equivalently, Zenith Total Delay (ZTD) (measured in meters) observations in the forecast of heavy rain, both from InSAR and from GNSS (e.g., Lagasio et al., 2019).

The aim of this work is to evaluate the impacts of assimilating ZTD observations in NWP experiments of a heavy rainfall event that hit the city of Johannesburg in South Africa in March 2018 (Meroni et al., submitted), testing the sensitivity of the results to different spatio-temporal resolutions of the observations ingested. In particular, the following experiments will be carried out:

1. OL: Open Loop. Run with no data assimilation, to be used as reference for the evaluation of the added value of the data assimilation;
2. GNSS_3h: GNSS data are assimilated every 3 hours;
3. GNSS_6h: GNSS data are assimilated every 6 hours;
4. GNSS_NRT: Using the best results from the sensitivity experiments on the temporal resolution of the GNSS observations, a run using the near-real time orbits to process the GNSS data is performed. This is to evaluate the added value of the NRT GNSS data for NWP nowcasting applications;
5. SAR_4.5km: Experiment where the SAR ZTD maps are assimilated with a grid spacing of 4.5 km;
6. SAR_13.5km: The SAR ZTD maps are assimilated with a grid spacing of 13.5 km;
7. SAR_40.5km: The SAR ZTD maps are assimilated with a grid spacing of 40.5 km;

Computational Resources

The computation cost of each experiment is estimated to be 100000 SBU. Considering the 8 experiments listed above, this means that a total of 700000 SBU are needed for the runs. The extra 250000 are requested for debugging (which are often needed in this kind of application) and post-processing purposes.

References

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