LATE REQUEST FOR A SPECIAL PROJECT 2023–2025

MEMBER STATE: Italy

Principal Investigator[1]**:** Martina Lagasio

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Project Title:
MAGDA - Meteorological Assimilation from Galileo and Drones for Agriculture

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.)	2023	
Would you accept support for 1 year only, if necessary?	YES ☐X	NO ☐

Computer resources required for the years: (To make changes to an existing project please submit an amended version of the original form.)		**2023**	**2024**	**2025**
High Performance Computing Facility	(SBU)	2930000	2600000	
Accumulated data storage (total archive volume)[2]	(GB)	1000	1000	

Continue overleaf

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[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

Background and scientific plan

Farmers currently rely on weather forecasts and advisories that are either general for a wide region or customized by combining large-scale atmospheric variables. However, these forecasts often do not incorporate observations collected at or around the cultivated areas or utilize available measurements and observations from European space-based and ground-based assets. This project, in the framework of MAGDA H2020 project (https://www.euspa.europa.eu/meteorological-assimilation-galileo-and-drones-agriculture) aims to develop a modular system that can be deployed on large farms to continuously feed observations to tailored weather forecast, with results displayed through a dashboard or Farm Management System. This project goes beyond the state-of-the-art by creating a synergy between spaceborne, airborne, ground-based measurement technologies, including GNSS reflectometry, and meteorological models for the benefit of agriculture and water management operators. The weather objectives are to improve the accuracy and usefulness of weather forecasts feeding the hydrological models for agriculture and water management. The limited predictive capability of severe weather events, including heavy rain, hail, snow, windstorm, heat and cold waves etc., increasingly affects agriculture operations. Inaccurate predictions of the timing, location, and intensity of such events can result in extensive and/or severe crop damage, as well as over-irrigation or water shortages. The main challenges in Numerical Weather Models (NWM) predictive abilities with respect to extreme weather events are derived from the poor knowledge of the initial state of the atmosphere at small scales, leading to an inevitable model spin-up and inaccurate simulations of severe weather phenomena. The first source of uncertainties in weather modelling is the knowledge of the initial (and boundary) conditions. The amount of observational hydro-meteorological data has increased, benefiting from both conventional sources (e.g. weather stations, weather radar, radiosondes) and nonconventional ones (e.g. GNSS, meteodrones). Augmented datasets can help reconstruct the high spatio-temporal resolution evolution of variables such as temperature, wind speed and direction, relative humidity, water vapor, rainfall, and other microphysics-related variables (e.g. reflectivity). In-situ authoritative and personal weather stations, such as the Wunderground network, provide high-temporal resolution local observations of rainfall, temperature, wind, relative humidity, and pressure. Ground-based weather radar data offer high spatio-temporal resolution observations of the three-dimensional state of the atmosphere, using reflectivity fields and retrieved microphysical species. Satellite-derived measurements of integrated water vapor provided by GNSS are also becoming more widespread, with existing networks of GNSS stations being exploited at national and regional scales, as well as the deployment of cost-effective new-generation GNSS stations for local scale measurements.

As already mentioned, the uncertainty of initial atmospheric conditions at small spatio-temporal scales is a significant challenge in Numerical Weather Models (NWM). This becomes even more pronounced when the model grid spacing approaches the kilometric scale for short-range/nowcasting, due to the lack of high-resolution observations. Recent advancements have been made in forecasting heavy rainfall events by combining high-resolution meteorological models with data assimilation of in situ and radar observations (Davolio et al. (2017), Maiello et al. (2017), Mazzarella et al. (2017)). Several studies have investigated the effects of reflectivity data assimilation and in situ observations for severe convection events in different regions, including southwest England, Korea, Bangladesh (Lee et al. (2010); Liu et al. (2013), Ha et al. (2011); Das et al. (2015)]) but also central Italy, and northern Italy (Maiello et al. (2014), Maiello et al. (2017), Mazzarella et al. (2017), Lagasio et al. 2019a). Ingestion of different Sentinel-derived and GNSS-derived products into the WRF model has also shown positive effects for predicting deep moist convective processes (Lagasio et al. (2019b)). Finally, assimilation experiments of nationwide GNSS-derived ZTD and Copernicus Sentinel-derived EO products into high-resolution NWM were conducted in Italy as part of the ESA project STEAM (Lagasio et al., 2019c).

The project aims to tackle the significant uncertainties associated with weather prediction by utilizing a cloud resolving modelling approach using the WRF model (Skamarock et al., 2008) with a grid spacing of 2-3 km, coupled with assimilation of various variables through a rapid update cycle occurring every 1-3 hours. The assimilation process will include GNSS data to gain a more profound insight into the integrated water vapor content status at a high temporal frequency, weather radar reflectivity CAPPI to enhance the reconstruction of the 3D cloud field, and in situ authoritative and personal weather stations to better capture the near-surface atmospheric structure.

Technical characteristics and computational resources needed.

Three domains will be set to cover 3 different areas:

- *Demonstrator in Italy: will be made on North-Western Italy (Piedmont region, Saluzzo city surrounding).*
- *Demonstrator in France: will be made on two different crops: corn and grapes in the Gironde department (Southwest of France).*

- *Demonstrator in Romania: will be made in the South-East of the country, in the Brăila County that includes fields owned by Agriculture Research and Development Station Brăila (https://www.scdabraila.ro) , with long expertise in irrigation and drainage activities.*

Using 2 different domains of about 450x450 grid points at 2.5km resolution and using around 288 cores (similar to what has been already done in the RAIN project (https://www.ecmwf.int/sites/default/files/special_projects/2021/spitlaga-2021-request.pdf).

For assimilation purposes a 3DVAR approach will be used, thus it is necessary to build the background error covariance matrix by running 1 month of forecasts with 2 run for each day covering 24 hours of forecast (Lagasio et al., 2019a, Lagasio et al., 2019b, Lagasio et al., 2019c). Then, the SBU are calculated both for the matrix calculation and for case studies (used to find the best assimilation setting) and demonstrators separately.

For background covariance matrix:

SBU= Pxelapsed_time

P=0,005252613403200836

*elapsed_time=7200s(seconds for 2 run per day of 24h)*288cores=1036800 for 1 day of covariance matrix.*

SBU=Pxelapsed_time=5445,90957 for 1 day of covariance matrix

SBU=326754,574586 for 30 days of simulation with 2 run each day and di 24h of forecast over 2 different domains

For case studies and demonstrators:

*elapsed_time=28800s(seconds for 4 run per day da 48h)*288cores=8294400 for 1 day of experiment with 4 run of 48h per day.*

SBU=Pxelapsed_time=43567,276611 for 1 day of experiment with 4 run per day and 48h of forecast

SBU=5228073,19338 for 60 days of simulation with 4 run each day and 48h of forecast over 2 different domains

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