LATE REQUEST FOR A SPECIAL PROJECT 2024–2026

MEMBER STATE: Italy

Principal Investigator[1]: Simone Sperati

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Project Title: WRF-based high resolution numerical weather simulations to complete the extension of the new Italian Wind Atlas

To make changes to an existing project please submit an amended version of the original form.)

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ITSPER	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2025	
Would you accept support for 1 year only, if necessary?	YES x	NO ☐

Computer resources required for project year:		**2024**	**2025**	**2026**
High Performance Computing Facility	[SBU]		45,000,000	
Accumulated data storage (total archive volume)[2]	[GB]		35,000	

EWC resources required for project year:		**2024**	**2025**	**2026**
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			
Number of vGPUs[3]	[#]			

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 annual progress reports of the project's activities, etc.
[2] These figures refer to data archived in ECFS and MARS. 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 etc.
[3]The number of vGPU is referred to the equivalent number of virtualized vGPUs with 8GB memory.

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Extended abstract

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

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF and its Scientific Advisory Committee. The requests are evaluated based on their scientific and technical quality, and the 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.

Requests exceeding 10,000,000 SBU should be more detailed (3-5 pages).

Introduction

The new Italian Wind Atlas - Atlante EOLico ItaliANo (AEOLIAN) [1] is a tool aimed at determining the best locations for wind energy turbines. It has been developed to support institutional authorities in planning the use of local resources, to assist regulatory authorities in the proper development of the electricity grid, to support producers in wind energy turbine siting and to evaluate cases of lost wind power production due to curtailments. AEOLIAN has been carried out as a collaboration effort between RSE and the National Center of Atmospheric Research (NCAR), which provided additional scientific support and computational resources.

AEOLIAN provides 30 years (1990-2019) of wind speed data across Italy, including marine areas. It features a horizontal grid spacing of 1.33 km and provides hourly data outputs. The Atlas integrates a 2-grid dynamical downscaling of the ERA5 global reanalysis fields using the WRF model [2] with a statistical approach based on the Analog Ensemble (AnEn) [3] technique. These two methods have been used together to temporally extend high-resolution weather model data only available for the most recent 5 years (2015-2019) to an additional 25 years further in the past (1990-2014) using coarser mesoscale model runs [1]. Observational nudging on both domains has been activated using surface synoptic observations (SYNOP) of 2-m temperature, which are available for the entire 30-year period of this study. Also, observations of 10-m wind collected by the Regional environmental agencies (ARPAs) that include about 300 stations across Italy and a set of selected surrounding marine locations have been used for observational nudging on the fine-resolution grid because of their limited availability with time, becoming more abundantly available only after 2010.

As of present day, AEOLIAN has been extended of 2 additional years (2020-2021) with a WRF-based numerical downscaling of ERA5 data, in the same fashion as for the period 2015-2019, thanks to the resources used within a previous special project (SPITSPER, 2024). A new full special project has been submitted within our research group for 2025-2027 with the title "*WRF-based high resolution simulations to improve the resilience of the Italian Energy System*", with a more general aim of performing in-depth analyses to detect the ideal configuration of WRF for the Italian territory, investigating the response to atmospheric forcings in urban environments and extending the reanalysis datasets developed by RSE, which include AEOLIAN. While the extension of AEOLIAN in the context of that submitted project will be part of a more general scope of extending also other datasets and will be limited to about 1 year (i.e., 2022), this late request aims to focus on finalizing the extension covering additional 2 years (i.e., 2023-2024), so to close the activity at the end of 2025 with an up-to-date atlas with the most recent 10 years (2015-2024) covered by dynamical downscaling of ERA5. This will allow more robust considerations for planning and supporting decision-makers with an updated tool that takes into account the most recent wind conditions affecting the Italian territory. In fact, the increasing availability of measuring stations makes it preferrable to dynamically downscale the global fields to better capture the atmospheric dynamics, also in light of better reproducing the increasing frequency of weather extremes of recent years, which would be difficult to capture with a statistical approach.

Scientific plan

The work will be carried out with the WRF model V3.9, in order to remain consistent with the meteorological fields already generated for the period 2015-2021. WRF is nested on the ERA5 global reanalysis fields using two grids, as shown in Figure 1.

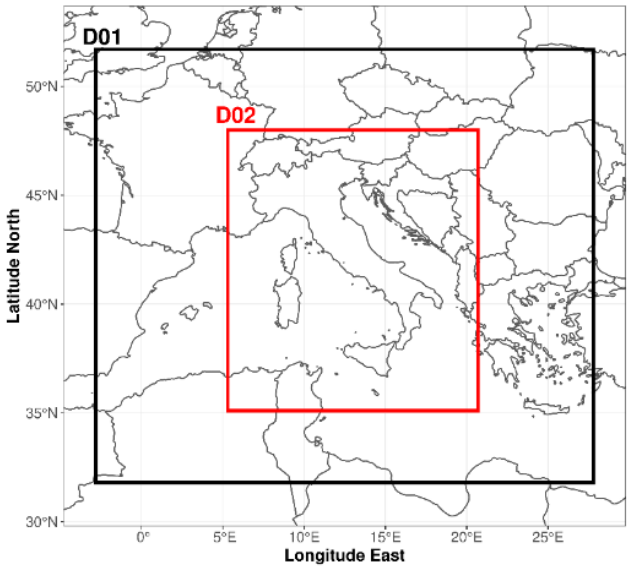

Figure 1 WRF computational domains. D02 is the finer, 1.33 km grid nested on the coarser, 4 km grid (D01).

The inner domain, identified as D02, constitutes the high-resolution meteorological fields of AEOLIAN. The setup of WRF follows the description reported in [1]. The observational nudging relies on 10-m wind data coming from measuring stations available from the Italian regional services. The weather network consists of about 300 stations homogeneously distributed across the Italian territory, as shown in Figure 2.

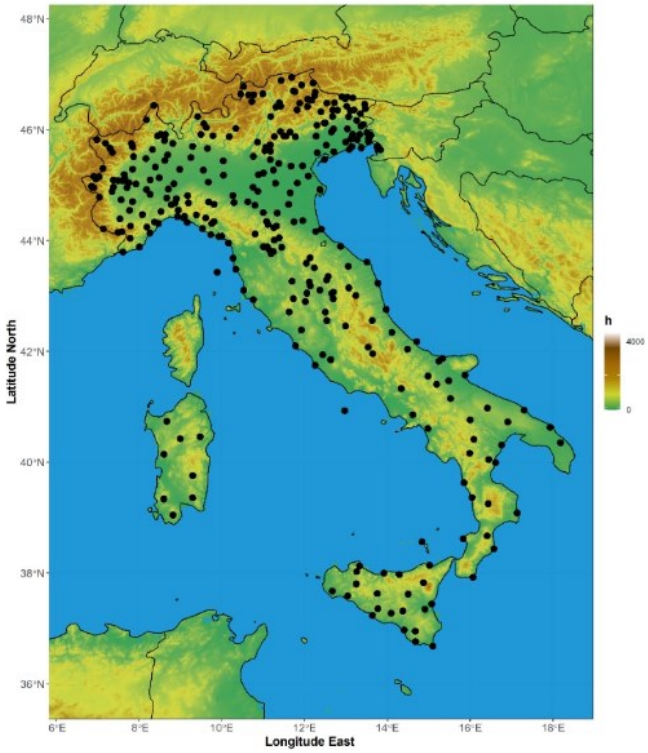

Figure 2 ARPA 10-m wind stations available for observational nudging in the WRF simulation.

The model runs are all initialized at 12 UTC every two days for the entire period to reconstruct with a temporal horizon of 60 hours, discarding the first 12 hours as a spin-up time. Each run is then concatenated with the next one at 00 UTC.

Justification of the computer resources requested

Tests carried out at the ECMWF's AC server allowed estimating the required resources for this project as follows:

• A single, 2-day WRF run submitted as a parallel job requires about 125,000 SBU

• 360 runs are required to reconstruct years 2023 and 2024

• Each run requires a disk storage of about 105 GB after cleaning of unnecessary files.

Technical characteristics of the code to be used

The required code for this project is the WRF model V3.9, which has been already installed on the ECMWF's AC server. The scripts to prepare the input files and launch the simulations are developed in R language.

1. Sperati S, Alessandrini S, D'Amico F, et al. A new Wind Atlas to support the expansion of the Italian wind power fleet. Wind Energy. 2024; 27(3): 298-316. doi:10.1002/we.2890.
2. Skamarock, W., Klemp, J., Dudhia, J. A description of the Advanced Research WRF Version 3. Tech. Note NCAR/;475;2008.
3. Delle Monache, L., Eckel, F.A., Rife, D.L., Nagarajan, B., Searight, K. Probabilistic weather prediction with an analog ensemble. Mon Weather Rev. 2013;141(10):3498-3516. doi:10.1175/mwr-d-12-00281.1.