REQUEST FOR A SPECIAL PROJECT 2026–2028

MEMBER STATE:	Italy
Principal Investigator[1]:	Antonio Giordani (antonio.giordani@agenziaitaliameteo.it)
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Project Title:	I-DREAM-IT: a new convection-permitting limited-area atmospheric reanalysis over Italy using ICON-DREAM reanalysis as boundary conditions and the ICON-2I meteorological model

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** …………..	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2026	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☒

Computer resources required for project year:		**2026**	**2027**	**2028**
High Performance Computing Facility	[SBU]	250 M	250 M	250 M
Accumulated data storage (total archive volume)[2]	[GB]	25000	50000	75000

EWC resources required for project year:		**2026**	**2027**	**2028**
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.

Principal Investigator: Antonio Giordani

Project Title: I-DREAM-IT

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

1. Motivation

The development of climate reanalysis datasets has been ever growing globally in the last decades. Atmospheric reanalyses consist in an optimal combination of Numerical Weather Prediction (NWP) simulations with observational data of the global observing system. This combination overcomes the inherent limitations of the singular components and exploits the benefits of both. Indeed, reanalysis datasets provide a homogeneous, temporally coherent and physically consistent description of the past atmospheric states. State-of-the art reanalyses include the global European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis v5 (ERA5 – Hersbach et al., 2020), the Japanese Reanalysis for Three Quarters of a Century (JRA-3Q – Kosaka et al., 2024), and the Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2 – Gelaro et al., 2017). These datasets are produced by assimilating observational data from several sources into the numerical models to correct the simulated estimates towards more realistic atmospheric descriptions. The development of reanalyses datasets have flourished in recent years owing to the realistic and valuable descriptions they provide which is of interest for a heterogenous plethora of stakeholders: from the atmospheric modelling communities, to downstream applications including the modeling of other Earth-system components (e.g. hydrology, oceanography, geology), to the agricultural and insurance sectors, as well as more recently for machine learning applications such as the development of data-driven models by training artificial neural networks.

In this context, the development of regional reanalysis datasets of higher spatio-temporal resolution for limited-area domains has progressively gained more and more interest. These, in fact, provide a more detailed representation of the atmospheric system, surpassing the capabilities of global datasets from which they are derived through downscaling. Regional reanalyses, especially those produced at the convection-permitting scale (i.e. with horizontal grid spacing of a few km ≤ 4), allow a more accurate representation of local-scale atmospheric processes, such as convective precipitation, and land-atmosphere dynamical interactions particularly in areas characterized by complex topography (e.g. mountainous terrains or coastal areas).

In Italy, numerous efforts have been devoted recently to the production of high-resolution regional reanalysis products. These are obtained by dynamically downscaling the global reanalysis ERA5 employing different numerical models, and include: the dataset based on the model MOdello LOCale in Hybrid coordinates (MOLOCH) ran at 2.5 km and developed by LAboratorio di Meteorologia e Modellistica Ambientale per lo sviluppo sostenibile (LAMMA - Capecchi et al., 2023), the Special Project High rEsolution ReAnalysis over Italy (SPHERA) based on the model COnsortium for Small-scale MOdelling (COSMO) ran at 2.2 km and developed by the hydro-meteo-climate service of the Emilia Romagna region, Italy (ARPAE-SIMC - Cerenzia et al., 2022; Giordani et al., 2023), the Very High Resolution REAnalysis for ITaly dataset (VHR-REA_IT) based on COSMO at 2.2 km and developed by the Centro euro-Mediterraneo sui Cambiamenti Climatici (CMCC – Raffa et al., 2021; Adinolfi et al., 2023), and the MEteorological Reanalysis Italian DAtaset High-resolution for Renewable Energy Sources (MERIDA_HRES) based on the Weather Research and Forecasting – Advanced Research (WRF-ARW) model ran at 4 km and produced by Ricerca sul Sistema Energetico (RSE - Viterbo et al., 2024).

All these individual datasets have demonstrated quantitative improvements over their common driver, ERA5, for the representation of essential climate variables such as precipitation, 2m-temperature and 10m-wind speed. These regional reanalyses have been recently inter-compared (Cavalleri et al., 2024a,b) and employed within a multi-model ensemble-based approach (Giordani et al., 2025), revealing substantial variability among them and improved precipitation estimates obtained by their ensemble aggregation. Additionally, other datasets with even higher spatial resolution are currently in production, such as the Moloch Reanalysis (MORE – Stocchi and Davolio, 2023), or covering larger spatial domains, such as the reanalysis Computational Hydrometeorology with Advanced Performance to Enhanced Realism (CHAPTER – Bernini et al., 2025) covering the Mediterranean area.

The numerical modeling community pertaining to the COSMO consortium has been transitioning in recent times to the novel model ICOsahedral Non-hydrostatic model (ICON – Zängl et al., 2015), jointly developed by Deutscher WetterDienst (DWD) and Max Planck Institut (MPI). ICON is a state-of-the-art numerical weather model using an icosahedral grid and designed as a unified modeling system suitable both for global and limited-area simulations. As of today, the lateral boundary conditions of ICON forecasts are employed by more than 30 national weather services worldwide (including the partners of the COSMO consortium) to force their limited-area weather simulations. The added value of the performance of the new ICON model over its predecessor has been prompting the development of numerous new applications. These include the development of a new global and regional reanalysis product: ICON Dual resolution Reanalysis for Emulators, Applications and Monitoring (ICON-DREAM) currently in production at DWD (Valmassoi et al., 2025a). ICON-DREAM will cover the global domain with a 13 km spatial grid, and will be nested over Europe with an increased resolution of 6.5 km. The new product will include a 20-member ensemble estimate at 40 km and 20 km resolution (for the global and European versions, respectively) for quantifying the uncertainty of the predictions, and a state-of-the-art Local Ensemble Transform Kalman Filter (LETKF) for assimilating a substantial amount of operationally employed observations. The assimilated observations include: conventional data (e.g. SYNOP, TEMP, DRIBU, PILOT, AIREP), atmospheric motion vectors, radio occultation, scatterometers and altimeters satellite data. Furthermore, DWD plans to produce also a convection-permitting reanalysis refinement centered over Germany and obtained by forcing the 2.2 km-resolution limited-area ICON model with ICON-DREAM, which will be called ICON Fine-scale Observation-based Reanalysis for Central Europe (ICON-FORCE – Valmassoi et al., 2025b).

In this framework, the national ItaliaMeteo Agency proposes the development of a new high-resolution atmospheric reanalysis dataset over Italy based on the model ICON at 2.2 km resolution, **ICON-DREAM over ITaly** (I-DREAM-IT). I-DREAM-IT will be produced by forcing ICON-2I with the boundary conditions from the European nest of ICON-DREAM, including the assimilation of observational data from multiple sources (i.e., in-situ and conventional networks, radars, and possibly also satellites) through the LETKF and Latent-Heat Nudging (LHN) assimilation procedures. Hence, multiple novelties will be introduced with this product: besides employing the new model ICON, also the use of a state-of-the-art data assimilation scheme such as the LETKF is an important innovation in the context of Italian regional reanalyses. Indeed, the products developed up to now have been based in purely downscaling the global reanalysis ERA5 without assimilating observations at the regional scale, or by employing nudging data assimilation schemes, which are nowadays obsolete.

The development of this new ICON-based regional reanalysis product is believed that will enhance the representation of the past atmospheric conditions at the local scale, which can have multiple implications. These include: the improvement of the representation of the recent climate over Italy, the enhancement of past extreme weather events and consequently the potential refinement of downstream modelling products using the dataset as meteorological input, or the training of novel data-driven models that can be of interest also to the wider machine-learning community pertaining to ECMWF’s Anemoi framework, which already prompted the development of the Artificial Intelligence Forecasting System (AIFS – Lang et al., 2024).

2. Scientific plan

The first step towards the production of the reanalysis is to define the optimal model configuration for the purpose. ItaliaMeteo is responsible for running daily the operational suites of the limited-area version centered over Italy of the ICON model (ICON-2I), which forecasts are disseminated over all regional meteorological bodies and the national civil protection department. ICON-2I is a non-hydrostatic limited-area convection-permitting model that integrates the fully compressible dynamical equations including the parameterization of boundary layer turbulence, radiation, soil physics, shallow convection and cloud microphysics. ItaliaMeteo in collaboration with ARPAE-SIMC has performed multiple sensitivity tests over time for the optimization of the model configuration. The latest of these pertains to testing a novel configuration of the microphysics parameterization scheme which evidenced a reduction in the precipitation biases observed for convective events characterized by weak synoptic forcings, and thus has been implemented operatively on the 26th of May 2025 (ItaliaMeteo-ARPAE, 2025). Hence, given the solid experience acquired over time with ICON-2I model configuration, the new reanalysis product will closely resemble the technical characteristics of the well-tested operational model setup. Particularly, the spatial domain covered by I-DREAM-IT will correspond to that of the operational model, as illustrated in Figure 1. The grid spacing within this domain will be set at 2.2 km.

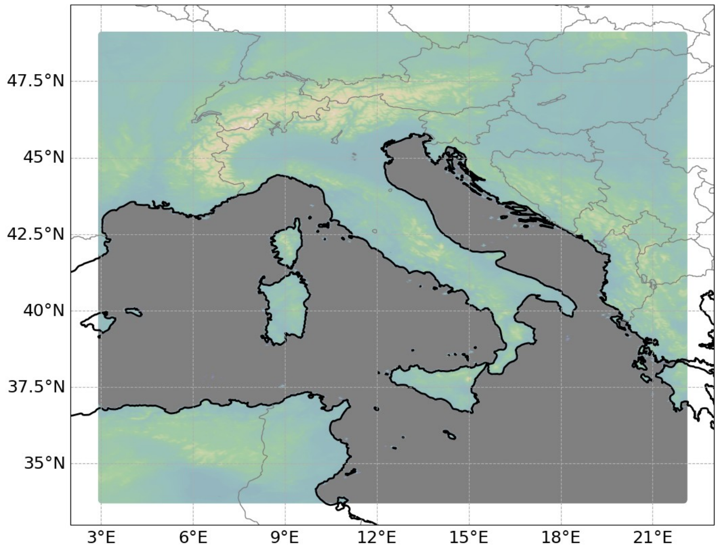

Figure 1: Integration domain of I-DREAM-IT reanalysis and model topography.

The I-DREAM-IT reanalysis will be produced considering the boundary conditions of ICON-DREAM European nest dataset through the ICON-2I model. Due to the temporal limitation of the currently available ICON-DREAM dataset, which spans from 2010 to 2025, I-DREAM-IT will initially be produced for this corresponding period. A potential backward extension is also planned, contingent upon the availability of the driver reanalysis dataset, as outlined by Valmassoi et al. (2025a).

3. Justification of computational resources

The computer-resource requirements have been estimated based on previous experiences with testing the model ICON-2I and ICON-LEPS (Limited-area Ensemble Prediction System) at ItaliaMeteo and ARPAE-SIMC performed over the High-Performance Computing (HPC) machine Galileo100 (G100) at the Consorzio Interuniversitario del Nord-Est per il Calcolo Automatico (CINECA - https://www.hpc.cineca.it/systems/hardware/galileo100/).

Based on the requirements for running the ICON-LEPS ensemble system, we have estimated the resources needed to produce 15 years of the I-DREAM-IT reanalysis—totaling 750 million SBUs (250 million SBUs per year of the special project)—taking into account the considerations outlined in the table below.

One ICON-LEPS run of 126 hours (20+1 ensemble members)	1.82 M SBUs
ICON-LEPS domain contains 2.2M grid points; ICON-2I domain contains 586k grid points	0.26 multiplying factor
ICON-LEPS model resolution is 2.5 km (R8B8) with a time step of 24”; ICON-2I model resolution is 2.2km (E9B8) with a time step of 20”	1.2 multiplying factor
One year of I-DREAM-IT reanalysis requires: 1.82 M SBUs * (365/5.25 days) * 0.26 * 1.2 = 40 M SBUs Considering also the inclusion of KENDA data assimilation:	50 M SBUs/year
15 years of I-DREAM-IT reanalysis requires	750 M SBUs

4. Technical characteristics of the code to be used

The development of I-DREAM-IT will rely on ICON-2I model codes which are based on ItaliaMeteo internal scripting routines written on Fortran and Python languages and developed at ARPAE-SIMC such as NWPRUN (https://github.com/ARPA-SIMC/nwprun) and NWPCONF (https://github.com/ARPA-SIMC/nwpconf), combined with ECMWF’s ecFlow workflow manager.

5. References

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