REQUEST FOR A SPECIAL PROJECT 2026–2028

MEMBER STATE:	Italy
Principal Investigator[1]:	Massimo Milelli (MCY)
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Project Title:	Hectometric scale experiments with ICON 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 X	NO ☐

Computer resources required for project year:		**2026**	**2027**	**2028**
High Performance Computing Facility	[SBU]	500000	500000	
Accumulated data storage (total archive volume)[2]	[GB]	100	50	

EWC resources required for project year:		**2026**	**2027**	**2028**
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			

[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.

Number of vGPUs[3]	[#]			

Continue overleaf.

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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).

The sub-kilometre scale study using the ICON model, with a focus on urban areas, represents an advanced approach to understanding meteorological and climatic phenomena within complex urban environments. In this work, the ICON model (ICOsa, a high-resolution atmospheric model developed by the German Meteorological Service, DWD, and other research institutions) is used to investigate in detail the sensitivity of results to different spatial resolutions, with particular emphasis on convective weather events, such as thunderstorms.

The analysis concentrates over Italy, a country characterised by a diverse range of geographical and climatic conditions, making it an ideal testbed for evaluating the model's performance under different spatial configurations. The use of sub-kilometre resolutions allows for a more detailed representation of critical phenomena, such as the formation and development of convective cells, the spatial distribution of intense precipitation, and the interaction between atmospheric flows and urban structures.

Focus on Urban Areas

Urban areas, with their high density of buildings and infrastructure, present unique challenges for meteorological modelling. The behaviour of the urban microclimate, including phenomena such as the urban heat island effect and the impact of built surfaces on atmospheric flow, is crucial for accurate forecasting of local weather conditions. The ICON model, due to its high resolution, can represent the interaction between the atmosphere and urban morphology with greater precision, thereby improving the prediction of extreme events such as severe thunderstorms, which are common in urban areas during summer.

Implications for Thunderstorm Prediction

The accuracy of thunderstorm predictions, including heavy rainfall and summer storms, is of paramount importance, particularly in densely populated urban areas. Adapting the ICON model to different spatial resolutions offers valuable insights into improving the forecasting of such events, thereby reducing the risk of sudden flooding, infrastructure damage, and threats to public safety. By analysing the model's sensitivities, optimal resolutions can be identified for different types of phenomena, enhancing the responsiveness of meteorological alert systems.

In conclusion, this study highlights how adopting the ICON model at sub-kilometre resolution, with a particular focus on urban areas, could represent a significant step forward in providing increasingly detailed and accurate weather forecasts. This is particularly vital in addressing the challenges posed by rapid urbanisation and extreme weather events.

Technical characteristics of the numerical codes

In the framework of this special project, the F90 ICON code (open source) will be used. ICON Model, which combines the non-hydrostatic dynamical core, with the parametrisation package originating from the ECHAM6 atmosphere model. The physics is adapted for the vertical coordinate system and time stepping scheme of the ICON dynamical core. ICON has an icosahedral grid which provides a nearly homogeneous coverage of the globe. This avoids the so-called pole problem related to the convergence of meridians in lat-lon grids, which poses severe challenges to a computationally efficient implementation. In the current operational version, the global ICON grid has 2,949,120 triangles, corresponding to an average area of 173 km² and thus to an effective mesh size of about 13 km. All scalar prognostic model variables (e.g. temperature, density, moisture quantities) are in the circumcentre of the triangles, whereas the edge-normal wind components are in the edge midpoints.

Computer resources

This work will consider deterministic runs only (no use of the EPS is foreseen). The simulations will be performed at very high horizontal resolution (around 1000-500 m). Therefore, an overall cost of about 500000 SBU per year is envisaged. Depending on the results, the set-up of the system could be partly modified, and it might be possible to have other simulations. The memory resources (hourly output) should also be limited.

References

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