REQUEST FOR A SPECIAL PROJECT 2022–2024

MEMBER STATE: The Netherlands

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Project Title: Impact of increase of horizontal resolution on NWP model performance

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.)	2022	
Would you accept support for 1 year only, if necessary?	YES **X**	NO ☐

Computer resources required for 2022-2024: (To make changes to an existing project please submit an amended version of the original form.)		**2022**	**2023**	**2024**
High Performance Computing Facility	(SBU)	30,000,000		
Accumulated data storage (total archive volume)[2]	(GB)	0		

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.

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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.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF as well as the Scientific Advisory Committee. The evaluation of the requests is based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, 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.

Requests asking for 3,000,000 SBUs or more should be more detailed (3-5 pages). Large requests asking for 10,000,000 SBUs or more might receive a detailed review by members of the Scientific Advisory Committee.

Impact of increase of horizontal resolution on NWP model performance

Background

The HARMONIE-AROME configuration of the shared ALADIN-HIRLAM NWP system, hereafter referred to as the HARMONIE-AROME model, is used operationally by European NMS for short-range high-resolution NWP. This is a limited-area, non-hydrostatic, convection-permitting model developed within the frameworks of ARPEGE and IFS software (further details may be found in Bengtsson et al., 2017). Heretofore, at the member services of the HIRLAM consortium (i.e., NMS in the Nordic, Baltic countries and those in the Netherland, Ireland and Spain), HARMONIE-AROME has been configured to run for main operational domains on a 2.5 km horizontal grid, supplemented with sub-km grid configurations for smaller domains using finer grids. Meanwhile, Météo France, the collaboration partner behind the ALADIN-HIRLAM system in the ACCORD collaboration, has been running the AROME model at a 1.3km with 90 vertical levels since 2016.

From January 2023 United Weather Centres West (UWC-W), a collaboration between DMI, IMO, Met Éireann and KNMI, will develop and deploy common operational HARMONIE-AROME based NWP systems. The UWC-W development team is tasked with conducting a series of configuration studies to consolidate on an optimal setup suitable for the first operational implementation.

The primary motivations for this study are as follow:

- Confirm the validity of running HARMONIE-AROME at higher resolutions, as described below
- Compare the quality of higher resolution HARMONIE-AROME forecasts to a reference
- Quantify the benefits of higher resolution HARMONIE-AROME configurations

The results of this study will be of interest to operational users of HARMONIE-AROME – DMI, ESTEA, FMI, IMO, Met Éireann, KNMI, MET Norway, AEMET, SMHI and LHMS.

Scientific Plan

The common UWC-W operational domain covers an extensive area with varying surface landscape and climate conditions, see Fig. 1. Common operational NWP will be developed to provide the UWC-W services with routine short-range weather predictions. In this regard, it is crucially important, through numerical experiments, to verify that the selected model configuration will meet the operational requirements at the member services, both in terms of meteorological and technical qualities. It is further considered ideal that the new shared setup would provide added value to the present operational products at member services, and that such an evolution in the operational setup is achieved in a cost-efficient manner.

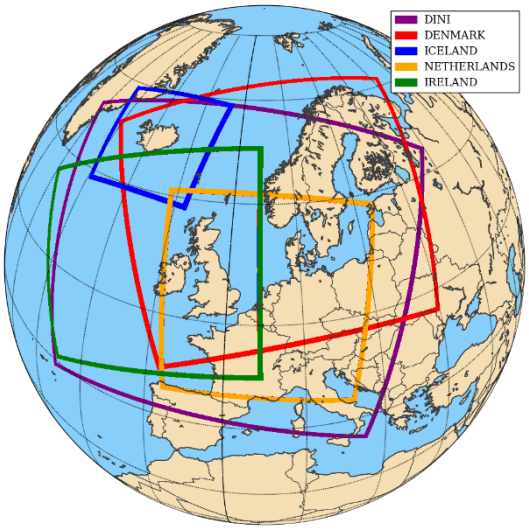

Figure 1Proposed DINI model domain coverage which is to be run by the joint UWC-W operation starting Jan 2023. The domain covers most of the geographic area to be serviced by the national weather services in Denmark, Iceland, Ireland and the Netherlands.

The common UWC-W forecast system will be based on the latest reference release of the HARMONIE-AROME forecast system. In view of the anticipated computation resource that will be available at the initial phase of the UWC-W collaboration, a baseline configuration for the main forecast model (on DINI domain, as shown in Fig. 1) has been proposed by the NWP experts in the UWC-W working group, with a grid definition of 1960x1620 points sin the horizontal and 90 levels in the vertical.

In this Special Project, we propose to carry out a set of numerical experiments to examine the baseline UWC-W NWP setup and to explore the relative merits between the baseline proposal to a number of alternative configurations, some with similar domain coverage but with finer grid-spacing, some with close similarity to the present main operational domains at member services. The setup of the baseline version and the main alternative configurations targeted for evaluation and inter-comparisons, are listed in the following table

Table 1 Proposed main domain setup in evaluation of optimal configuration for the common UWC-W NWP production. In this table the computational costs are estimated by a scaling to the DINI-2.0km forecast. A DINI-2.0 forecast hour is estimated to cost 375

Model Setup	grid-spacing	gridmesh	nr of gridpoints in million	time-stepping in s
DINI-2.0 (baseline)	2 km	1920x1620x90	286	60
DINI-2.5	2.5 km	1600x1300x90	187	75
DINI-1.8	1.8 km	2160x1800x90	350	60
DINI-1.5	1.5 km	2560x2160x90	498	45

For each domain configuration, the latest reference HARMONIE-AROME model will be implemented to run for a total of two months, one in summer and another in winter, each with a ca. two week spin-up. For each of the experiments, full data assimilation cycling is to be conducted using the reference settings, followed by two 2-day forecasts at 0000 and 1200 UTC each day. The model results will be validated using observations and compared to alternative model setups as listed in Table 1. In addition to the model setup lists above, it is also aimed to conduct inter-comparison runs on the four currently used operational domains at the UWC-W partner services,

- DMI (Denmark), NEA domain [1200x1080x65, 2.5 km grid]
- IMO (Iceland), ICELAND domain [500x400x65, 2.5 km grid]
- Met Éireann (Ireland), IRELAN25_090 [1000x900x65, 2.5 km grid]
- KNMI (the Netherlands), NETHERLANDS [800x800x65, 2.5km grid]

It is anticipated that, through these carefully designed and extensive numerical experimentation, it will help the UWC-W community to optimise the configuration for its coming joint operational activities. It is expected that the results about optimal model resolution configuration will also be of general value to the NWP community as a whole, especially so for the operational community using the HARMONIE-AROME system.

Justification of Computational Resources Requested

Based on the information collected in Table 1 and adding in addition the cost to conduct parallel experiments on smaller national domains (as detailed above) and preparation cost, it is estimated that this scientific investigation will require ca. 30 MSBU.

This proposal is closed connected to the preparation of the NWP setup towards operational use by the UWC-West operational collaboration. Normally, most of the operational-related numerical experiments are conducted either at the national HPC facilities or at the ECMWF HPC using the allocated computation resources. Presently, UWC-W is still at the preparation stage in which the joint HPC platform (UWC-W HPC) is yet to be installed in about one year time). The size of the proposed common model setup with DINI domain makes it rather challenging to arrange extensive numerical experiments to be done at the home HPC platform. It is therefore necessary for the UWC-W development team to look for additional support at the ECMWF HPC via the special HPC project.

Test description	Costs [DINI forecasts]	Costs [MSBU]
2.0 km L90 **BASELINE**	12,000 h	4.500
1.8 km L90	15,000 h	5.625
1.5 km L90	30,000 h	11.250
2.5 km L90	6,500h	2.400
other preparations, + runs with national domains	15,000h	5.000
TOTAL	**82,000 h**	**~30.000**

Technical characteristics of the code to be used

The proposed numerical experiments will be carried out using the latest reference HARMONIE-AROME system release, Harmonie-43h2.2. Harmonie-43h2.2 is derived from the ACCORD research collaboration and assembled by the HIRLAM-C programme, with ECMWF HPC defined as reference platform. It is anticipated that most of the numerical work will be conducted using the single-precision option (Vignes, 2019) for the forecast component.

References

Bengtsson, L., Andrae, U., Aspelien, T., Batrak, Y., Calvo, J., de Rooy, W., Gleeson, E., Hansen-Sass, B., Homleid, M., Hortal, M., Ivarsson, K., Lenderink, G., Niemelä, S., Nielsen, K. P., Onvlee, J., Rontu, L., Samuelsson, P., Muñoz, D. S., Subias, A., Tijm, S., Toll, V., Yang, X., & Køltzow,

M. Ø. (**2017**). The HARMONIE–AROME Model Configuration in the ALADIN–HIRLAM NWP System, Monthly Weather Review, 145(5), 1919-1935.

Vignes, O. (2019). Single precision in cycle 43 (**2019**), Joint 29th ALADIN Workshop & HIRLAM All Staff Meeting 2019, Madrid, 1-5 April 2019. http://www.umr-cnrm.fr/aladin/IMG/pdf/sp_cy43_olev_asm2019.pdf