REQUEST FOR A SPECIAL PROJECT 2022–2024

MEMBER STATE: The Netherlands

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Project Title: Impact of increase of vertical levels 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)	8,000,000		
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 vertical levels 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 can 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 using 65 vertical levels, 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. Figure 1 and Fig. 2 illustrates the difference between the 65 and 90 level definitions.

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. It is hoped the HPC resources will permit the use of 90 vertical levels for operational NWP. 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.

There are two primary motivations for this study are as follows:

1. Identify issues running HARMONIE-AROME on 90 vertical levels rather than the default 65. In particular, does the first model level at 5 m pose challenges for wind speed and wind gust diagnostics.
2. Show the benefits, or otherwise, of increased vertical resolution for LAM NWP with a special focus on the prediction of fog and low cloud.

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.

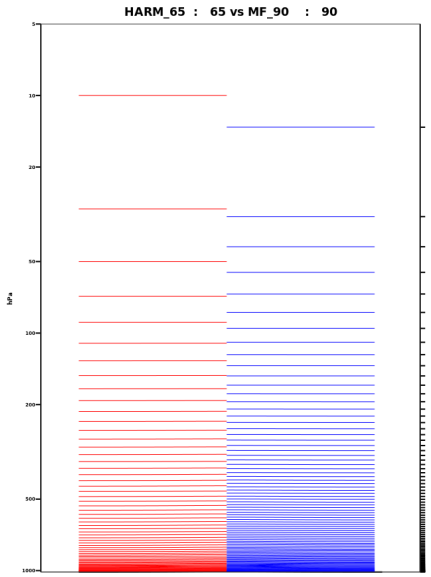

Figure 1 65 vertical levels (default, red) compared to proposed 90 vertical levels (blue).

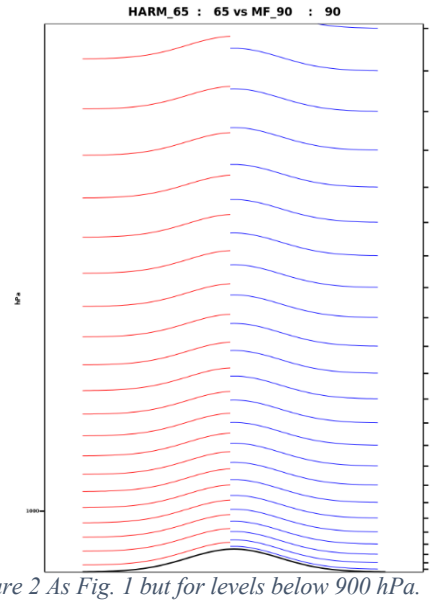

Figure 2 As Fig. 1 but for levels below 900 hPa.

Scientific Plan

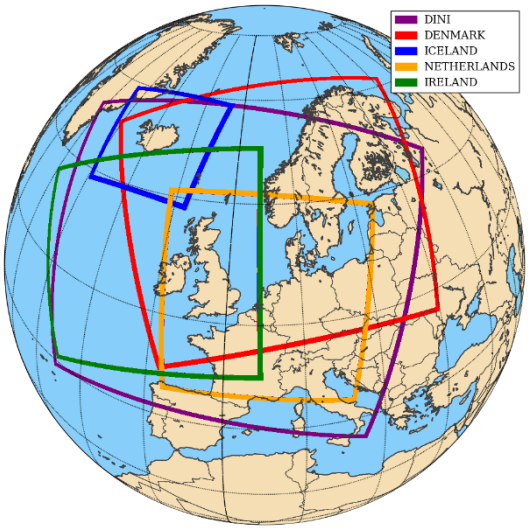

Figure 3 UWC-W DINI domain with current operational domains of Denmark, Iceland, the Netherlands and Ireland

Common operational NWP will be developed to provide UWC-W services with routine short-range weather predictions and the forecast system will be based on the latest release of the HARMONIE-AROME. An initial configuration for the main forecast model (on the so-called DINI domain, Fig. 3) has been proposed with a grid definition of 1960x1620 points in the horizontal and 90 levels in the vertical. In order to evaluate the use of 90 vertical levels, we propose to to run a series of experiments on the DINI domain. Multiple targeted HARMONIE-AROME experiments will be executed using 65 vertical levels (C_L65) and 90 vertical levels (E_L90).

An evaluation of the benefits of increased vertical resolution will be carried out in the following way:

- Use objective verification scores to compare the quality of C_L65 and E_L90 forecasts
- Use a (spring) fog case study to evaluate the benefits of increased vertical resolution for forecasting of fog and low cloud
- Use a (winter) wind storm case study to evaluate the benefits of increased vertical resolution for forecasting of wind and gusts.

Justification of Computational Resources Requested

It is estimated that this scientific investigation will require 7.875 MSBU to carry out the series of experiments described. This would allow for 90 simulation days of HARMONIE-AROME forecasts for C_L65 and E_L90.

Test description	Costs [DINI forecasts]	Costs [MSBU]
2 km L65: (2x48h + 6x6h) day x 90 day (C_L65)	9,000 h	3.375
2 km L90: (2x48h + 6x6h) day x 90 day (E_L90)	12,000 h	4.500
Technical tests in preparation for experiments		0.125
TOTAL	**60,000 h**	**8.000**

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