REQUEST FOR A SPECIAL PROJECT 2024–2026
(adjustments are shown in red)

MEMBER STATE: Ireland

Principal Investigator[1]: Emily Gleeson

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Colm Clancy

Project Title: An evaluation of the advanced model physics in cycle 46/49 of HARMONIE-AROME with particular emphasis on the new microphysics, radiation and surface schemes as well as aerosol options, the ICE-T scheme and other recent physics additions.

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.	**SPIEGLEE**	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2024	
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]	35 M		
Accumulated data storage (total archive volume)[2]	[GB]	(national allocation)		

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

1. Background

The shared ALADIN-HIRLAM numerical weather prediction system is used for operational weather forecasting by 26 national meteorological services in Europe and North Africa which form the ACCORD (A Consortium for COnvection-scale modelling Research and Development) consortium. The Irish Meteorological Service, Met Éireann, is one of the 26 members and has been using the HARMONIE-AROME canonical configuration of this system since 2011. We currently use cycle 43 of the system operationally with a set-up using a 1000 x 900 horizontal grid on a Lambert Conformal projection with 2.5 km spacing at the centre and 65 vertical levels. Further details about Met Éireann's implementation of cycle 43 are available in Bessardon et al., 2021 and Clancy et al., 2021.

Cycle 43 of HARMONIE-AROME has undergone testing by Met Éireann since 2019 and a version was made operational in March of 2021. Further development work has taken place since then including extensive testing regarding the prediction of fog, which is still one of the biggest issues in the model – this work was greatly aided by ECMWF special project SPIEMCAU.

A version of HARMONIE-AROME cycle 46 is currently being tagged. The advantage of this version is its more advanced physics (the 2-moment LIMA microphysics scheme and the ECRAD radiation scheme – however, they are incomplete in this version and hence not useable). In addition, the more advanced surface physics options (soil diffusion scheme, 3-layer snow scheme [Boone, 2000; Boone and Etchevers, 2001] and the MEB multi-energy balance scheme Explicit Vegetation Scheme [Boone et al., 2017; Napoly et al., 2017]) are not yet used operationally in HARMONIE-AROME. Moving to higher resolutions (horizontally and vertically) and the use of stochastic physics are also high priorities within the HIRLAM and ACCORD NWP consortia and need thorough investigation and analysis. Significant work on the use of near real time Copernicus Atmospheric Monitoring Service (CAMS) aerosols in the ICE3 microphysics scheme and the HLRADIA broadband radiation scheme in cycle 43 of HARMONIE-AROME has already been carried out (Rontu et al., 2020). This work has being extended to cycle 46 and including configuring the use of near real-time aerosols in the ALARO ACRANEB2 radiation scheme (Mašek et al., 2016, Geleyn et al., 2017) as well as in the LIMA microphysics scheme. The versions of ecRad and LIMA in cycle 46 do not work in the HARMONIE-AROME configuration of the system. A version called cycle 49h will be available later this year, which will have these physics options. Aerosol testing and surface physics testing will continue using CY46 but for the radiation and microphysics testing, we need CY49.

Some of the current issues in HARMONIE-AROME include continued over prediction of fog, too much evaporation leading to positive biases in dew point temperatures and humidities, inability to capture open-cell convection, too little cloud water in stratocumulus clouds, and issues with night time winds and temperatures in stable conditions. The purpose of this special project is to

thoroughly test the physics options available by carrying out experiments for all seasons and a list of appropriate case studies relevant to the above listed model deficiencies. Ireland is a member of United Weather Centres West for operational weather forecasting. Therefore, the testing will also be extended to other geographical areas in our domain.

So far I have started testing CAMS near real-time and CAMS climatological aerosols in HARMONIE CY46, as well as ICE-T, which is similar to ICE3 but contains elements of the Thompson scheme relevant for supercooled liquid water. The impact of the aerosols used, and the ICE-T scheme, is significant on cloud and radiation, so much so that it will be necessary to run many tests using HARMONIE in climate mode to get a good handle on the impact of several of the settings.

Therefore, for the continuation of the project, I plan to run the model in climate mode, continue testing various settings associated with CAMS NRT aerosols, such as the minimum cloud droplet number concentration, the inclusion of sea salt and desert dust emissions, the addition of extra aerosol types in the radiation calculations, and several other tuneable parameters. ICE-T requires further extensive testing and within the next year, a later cycle of HARMONIE will be available, which will include the full ecRad and LIMA schemes to enable testing of these for operational purposes.

2. SBU Justification for Various Experiments

The operational domain for Ireland covers an area of 1000 x 900 points (figure 1, orange domain) with a horizontal grid spacing of 2.5 km and 65 vertical levels. Running this domain for one 24-hour forecast cycle costs approximately 13000 SBUs. Our previous operational domain (Figure 1, red domain) covered an area of 500 x 540 grid points. To optimise the use of SBUs we use the smaller domain for testing. This has enabled us to run a comprehensive suite of tests with previous special projects which has proven greatly beneficial for operations and enhancing our knowledge of the model capabilities

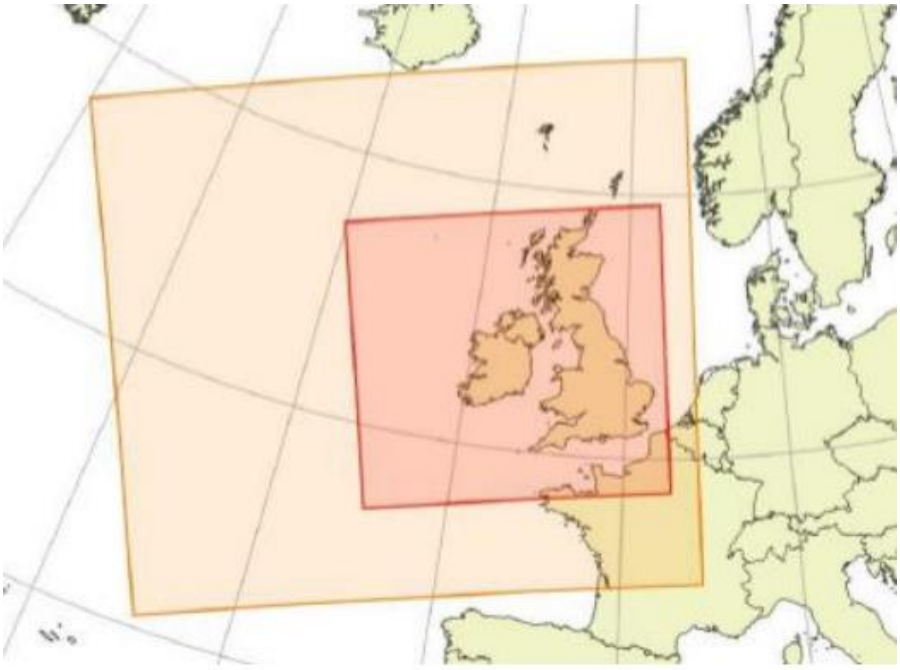

Fig 1. Irish operational domain in orange, old operational domain in red.

The requested resource of 35 M SBUs will be spent as follows:

- Systematic testing of LIMA versus ICE3 microphysics scheme. The ICE-T configuration will also be further tested.

- A comparison of all radiation schemes in HARMONIE-AROME (IFS cy25r1 and ECRAD) for clear-sky, thick frontal cloud, high cloud and fog cases.

- Further comparison of Tegen, CAMS climatology and near real-time CAMS aerosols in HARMONIE-AROME, including the various tuning parameters. Also carry out runs using HCLIM.

- An evaluation of LTOTREC and other options in relation to open cell convection.

- Systematic testing of all new physics options (one by one) in order to make concrete proposals for options suitable for UWC-West operations.

- Testing of roughness sub-layer options to improve night time near surface wind and temperature biases.

- Evaluation of physics options in conjunction with higher resolution physiography datasets for Ireland.

- Testing the wind farm parametrization, RFRMIN variables related to cloud microphysics and scale aware convection.

3. Benefits of the Project

Cycle 46/49 of HARMONIE-AROME contains many new physics options that have not been tested thoroughly for Ireland. Much work and thorough analysis has already gone into cycle 43 which uncovered several issues. These include: too much cloud water in the thickest clouds (alleviated using reduced cloud droplet number concentrations), over-representation of Ireland by grassland (alleviated by including 10% of trees in the grassland covers to account for hedgerows and isolated trees which increase roughness), over-prediction of fog. These issues were discovered due to experiments by Met Éireann and have led to improvements in cycle 43 of the model.

Such thorough testing is also required for cycle 46/49. The tests carried out by Met Éireann will be a follow-on from cycle 43, covering the same time periods and test cases for direct comparison but will also include additional tests over other parts of the UWC-West domain. Such systematic testing by us has already benefited the HIRLAM consortium and something similar with the more advanced options in cycle 46 will be the focus of this special project. A huge focus will be placed on validation of the physics options, using non-conventional data sources as issues with clouds and fluxes have recently been uncovered and were not detected using traditional verification methods.

The work has commenced in CY46 on the testing of aerosol options, ICE-T and cloud microphysics settings. This work has uncovered the huge sensitivity of the model to such datasets and settings. The volume of work and testing is much larger than originally anticipated and the use of HCLIM, HARMONIE-Climate, which make up a crucial part of this work. On top of this, we must worry about

ecRad, LIMA and moving to higher resolutions. Therefore, an extension to the special project would be very welcome and crucial to the success of the project.

4. References

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