REQUEST FOR A SPECIAL PROJECT 2026–2028

MEMBER STATE: IRELAND

Principal Investigator[1]: Dr Emily Gleeson

Affiliation: Met Éireann

Address: 65/67 Glasnevin Hill Dublin 9 D09 Y921 Ireland

Other researchers:

Project Title: Experiments on Cloud-Aerosol-Radiation Interactions in HARMONIE-AROME Cycle 49T2h

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]	35M		
Accumulated data storage (total archive volume)[2]	[GB]	National Allocation		

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.

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Extended abstract

The shared ALADIN-HIRLAM numerical weather prediction (NWP) 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. Met Éireann is part of United Weather Centres-West along with Iceland, Denmark and the Netherlands, which currently runs cycle 43h2.2 of HARMONIE-AROME operationally on a Lambert Conformal projection using a 1920x1620 horizontal grid with 2 km grid spacing at the centre and 90 vertical levels. UWC-West will upgrade to cycle 46 **[1]** within the next 12 months, and experiments have started with cycle 49T2h.

Considerable developments have taken place over the past few years in the area of cloud-aerosol-radiation interactions, with much of the time so far being dedicated to the complex technical work. In cycle 49T2h of HARMONIE-AROME, the old Tegen **[2]** aerosol climatology is the default, as is an old IFS radiation scheme from IFS cycle 25r1. The ICE3 microphysics scheme is used, with modifications safeguarded under the switch LOCND2, to improve conditions in colder climates mainly. Regarding aerosols, we also have the options of the CAMS climatological aerosols (11 aerosol species) and CAMS near real-time aerosols (14 aerosol species) **[3]**. With the CAMS climatology we have the option to use it instead of the Tegen climatology, keeping everything else as is (i.e. to use prescribed profiles of cloud droplet number concentration), or to use the CAMS mass mixing ratios (MMRs) to compute the cloud droplet number concentration (CDNC) for use in the calculation of the cloud droplet effective radius used in the radiation scheme using the same cloud droplet size distribution assumptions as in the microphysics scheme, and to also use the MMRs in the microphysics scheme. For CAMS NRT aerosols the MMRs are used in the calculation of the cloud droplet effective radius and in the microphysics calculations by default **[4]**. As well as the old IFS radiation scheme, the ecRad **[5]** scheme is available in cycle 49T2h for testing with the various aerosol datasets. Regarding microphysics, we can use ICE3 with and without the HIRLAM-flavoured changes under LOCND2. In addition, the are two call options to the microphysics scheme: rain_ice and rain_ice_old. The former has refactored code with some minor bug fixes, whereas the latter is not refactored and will eventually be phased out.

The focus of the experiments under this special project will be on testing the various cloud, radiation and aerosol options and permutations of these, to evaluate which are viable for operations. The SBUs will also be used for tuning some of the options. Experiments will start with a focus on clear sky radiation, with comparisons to station observations and CMSAF satellite products. The aim of this stage will also be to tune the background stratospheric aerosols which are not included in the CAMS datasets. The second phase will focus on cloudy situations where only liquid clouds are present, ice-only clouds and finally mixed phase clouds. For this work, shortwave radiation observations can be used as a proxy for clouds **[6]**, but I will also use data from CMSAF **[7]**, the EarthCARE satellite **[8]**, the Cloudnet network **[9]**, specialised measurement campaigns and RADAR retrievals from European RADARs. In terms of clouds the following will be analysed: cloud cover, cloud liquid, cloud ice, supercooled liquid, profiles of hydrometeors. As well as 3D experiments with HARMONIE-AROME, a suite of tests with also be run with the 1D model, called MUSC, but identical to HARMONIE-AROME in terms of source code. Shortwave radiation will also be analysed for all types of cloudy situations. Regarding aerosols, testing and tuning of the formulations is required. There are many formulations for computing the cloud droplet effective radius used by the radiation scheme, which need further testing. Similarly, the formulations used in the microphysics scheme, where the CDNC is used, also need to be tested thoroughly.

Sample domains that will be used for the experiments are shown below – A small Irish domain (an old Met Éireann operational domain and the latest domain used operationally by UWC-West (known as the DINI domain).

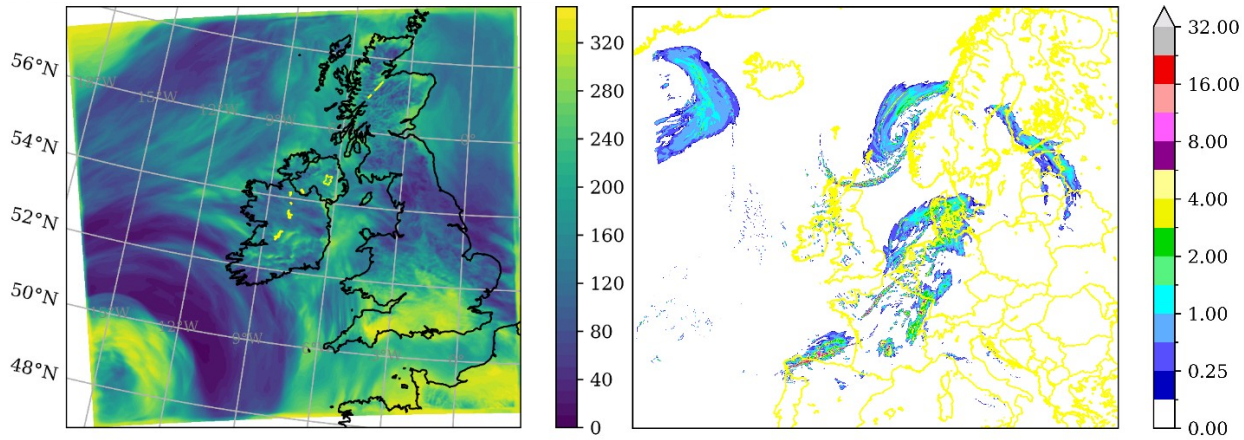

Figure 1: Sample domains that will be used for the experiments.

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

- Testing clear sky cases and tuning background aerosols.
- Testing aerosol options for clear sky and various cloud cases.

- Experiments for different cloud regimes (liquid, ice, mixed phase, supercooled liquid).
- Testing the formulations of cloud droplet size distribution for radiation.
- Testing the cloud droplet size distribution shape parameters.
- Testing the calls to the microphysics scheme and the LOCND2 switch.
- Testing the Old IFS and ecRad radiation schemes with the various aerosol options.

References

[1] Gleeson, E.; Kurzeneva, E.; de Rooy, W.; Rontu, L.; Martín Pérez, D.; Clancy, C.; Ivarsson, K.-I.; Engdahl, B.J.; Tijm, S.; Nielsen, K.P.; et al. The Cycle 46 Configuration of the HARMONIE-AROME Forecast Model. Meteorology 2024, 3, 354-390. https://doi.org/10.3390/meteorology3040018.

[2] Tegen, I.; Hoorig, P., Chin, M.; Fung, I.; Jacob, D.; Penner, J. Contribution of different aerosol species to the global aerosol extinction optical thickness: Estimates from model results. J. Geophys. Res. 1997, 102, 23895–23915.

[3] Bozzo, A.; Benedetti, A.; Flemming, J.; Kipling, Z.; Rémy, S. An aerosol climatology for global models based on the tropospheric aerosol scheme in the Integrated Forecasting System of ECMWF. Geosci. Model Dev. 2020, 13, 1007–1034.

[4] Martín Pérez, D., Gleeson, E., Maalampi, P., & Rontu, L. (2024). Use of CAMS near Real-Time Aerosols in the HARMONIE-AROME NWP Model. Meteorology.

[5] Hogan, R.J.; Bozzo, A. A Flexible and Efficient Radiation Scheme for the ECMWF Model. J. Adv. Model. Earth Syst. 2018, 10, 1990–2008.

[6] Nielsen, K.P.; Gleeson, E. Using Shortwave Radiation to Evaluate the HARMONIE-AROME Weather Model. Atmosphere 2018, 9, 163. https://doi.org/10.3390/atmos9050163

[7] CMSAF: https://www.cmsaf.eu/EN/Home/home_node.html

[8] EarthCARE: https://earth.esa.int/eogateway/missions/earthcare

[9] CloudNet. Available online: https://cloudnet.fmi.fi/