

REQUEST FOR A SPECIAL PROJECT 2021–2023

MEMBER STATE: Ireland

Principal Investigator¹: Eoghan Harney

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James Fannon,
Alan Hally

Project Title: Optimisation of Cycling Strategies for a Nowcasting configuration of HARMONIE-AROME for Ireland

If this is a continuation of an existing project, please state the computer project account assigned previously.	SP IEHARN	
Starting year: <small>(A project can have a duration of up to 3 years, agreed at the beginning of the project.)</small>	2021	
Would you accept support for 1 year only, if necessary?	YES <input checked="" type="checkbox"/>	NO <input type="checkbox"/>

Computer resources required for 2021-2023: <small>(To make changes to an existing project please submit an amended version of the original form.)</small>		2021	2022	2023
High Performance Computing Facility	(SBU)	9.5M	25M	
Accumulated data storage (total archive volume) ²	(GB)	5TB	0*	

* National allocation (ienwp) is being used.

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.

Principal Investigator: Eoghan Harney

Project Title: Optimisation of Cycling Strategies for a Nowcasting configuration of HARMONIE-AROME for Ireland

Continuation of an existing project

1. Background

This project application is a continuation of my special project from 2021 which has so far focused on cycling strategies and observation cut-off, details of which can be found in progress report. Initial results have been somewhat inconclusive and so experimentation over longer period with a larger number of configurations than initial thought will be required for significant differentiation in results of competing configurations. Testing has been done using the same resolution of 2.5km with 65 vertical layers as Met Éireann's Irish Regional Ensemble Prediction System, albeit on a reduced domain as shown below in Figure 1 of the original abstract. (IREPS domain in orange, test domain in red).

One aspect of the previous application which will not be addressed is testing at higher resolutions coupled with the use of more vertical levels. Increasing resolution is a key focus at operational centres of global models and limited area models alike. High resolution nowcasting is a particular focus of the ACCORD consortia (merger of HIRLAM and ALADIN) with a 2nd High Resolution and Nowcasting Workshop planned for late 2021, following on from one in 2019.

The aim of continuing this project will be to test an hourly nowcasting configuration of HARMONIE-AROME for Ireland at a high resolution, ideally at sub kilometre resolution, such as on the 750m test domains shown in Figure A below. This will build upon the work my colleague Colm Clancy performed under his 2021 special project "Investigating the optimal configuration of the HARMONIE-AROME NWP model for hectometric-scale forecasting over Ireland".



Figure A: Possible 750m resolution domains over Ireland, using 800x800 (red) and 600x600 (orange) grid-points.

Figure B, from my colleague Colm Clancy, below shows a clear example of the detail available when increasing the resolution from 2.5km to 750m.

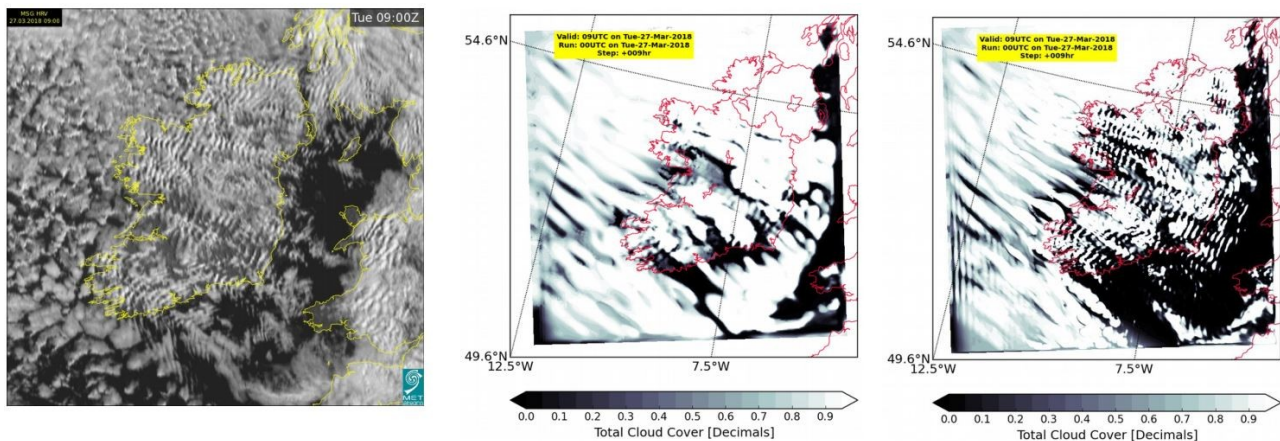


Figure B: Satellite image (left) of gravity waves over Ireland, along with simulations using HARMONIE-AROME at 2.5km (middle) and 750m (right) resolution.

2. Justification of additional SBU resources requested:

It is estimated that a day of hourly 12 hour forecasts on an appropriately sized 750m domain will cost approximately 200,000 SBUs, with the cost of a one week long experiment period being 1.4M SBUs. As stated above, numerous long test periods are required to differentiate appropriately between configurations.

It is provisionally planned that the requested 25M SBUs will be used as follows:

- 1) Initial technical testing comprising of a number of high resolutions on suitably sized domains testing stability and time step size, along with other technical options, estimated at a cost of 2M SBUs.
- 2) Week long testing for error verification of configurations for suitable test periods, estimated at a cost of 10M SBUs.
- 3) Two week testing for different weather regimes across the seasons, with a focus on heavy precipitation events, estimated at a cost of 12M SBUs.

Changes may occur to above plan based on future results in my own special project (for example it may be seen that running nowcasts beyond 6 or 9 hours to 12 hours brings little or no value). Also it is hoped that use of single precision, which is an active area of research in Met Éireann, will allow for reduced computing costs without significant degradation of forecast scores.

3. Benefits of continuing the project

It is hoped that a successful nowcasting configuration at high resolution will provide improved short term guidance to forecasters in high-impact weather events, and that the high resolution hourly analysis would give quicker verification of these events. Research on this topic will be of interest to our colleagues across the ACCORD consortia as many national services push to provide more frequent and higher resolution guidance to forecasters.

Original 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 HIRLAM (High Resolution Limited Area Model) and ALADIN (Aire Limitee Adaptation Dynamique Developpement International) consortia. 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 40 of the system operationally (Bengtsson et al, 2017, Met Éireann 2018) and since 2018 use HARMONIE-AROME as the basis for the Irish Regional Ensemble Prediction System (IREPS), an 11 member ensemble (10 perturbed + 1 control).

While NWP modelling has traditionally been focused at the short and medium range, it's use in the area of Nowcasting (0-6/9 hours) has become a growing area of research across many NMHS (Ballard S. et al, 2015; Auger L. et al, 2015; Olsen B.T. et al, 2015). The primary objective is to provide improved short term prediction of high-impact weather events (Yong Wang 2017).

The focus of this special project will be on developing an optimal configuration of HARMONIE-AROME suitable for Nowcasting purposes. This work will investigate cycling strategies (Rapid Refresh and Rapid Update Cycling), data assimilation algorithms (3D-Var and 4D-Var), techniques that can reduce model spin-up (Incremental Analysis Updates (Bloom et al, 1996)) and the assimilation of observations with higher spatial and temporal resolutions (radar reflectivity, Doppler winds, Mode-S, GNSS). Testing of these different aspects will provide the basis for a NWP Nowcasting configuration for Ireland which will be run on a smaller domain and higher model resolution than the current operational IREPS.

2. Justification of the SBU resources requested:

The current IREPS 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. The proposed experiment domain (Figure 1, red domain)

covers an area of 540 x 500 grid points. Running the proposed test domain for a Nowcasting type configuration consisting of twenty-four 12-hour forecast cycles per day would cost approximately 48000 SBUs.

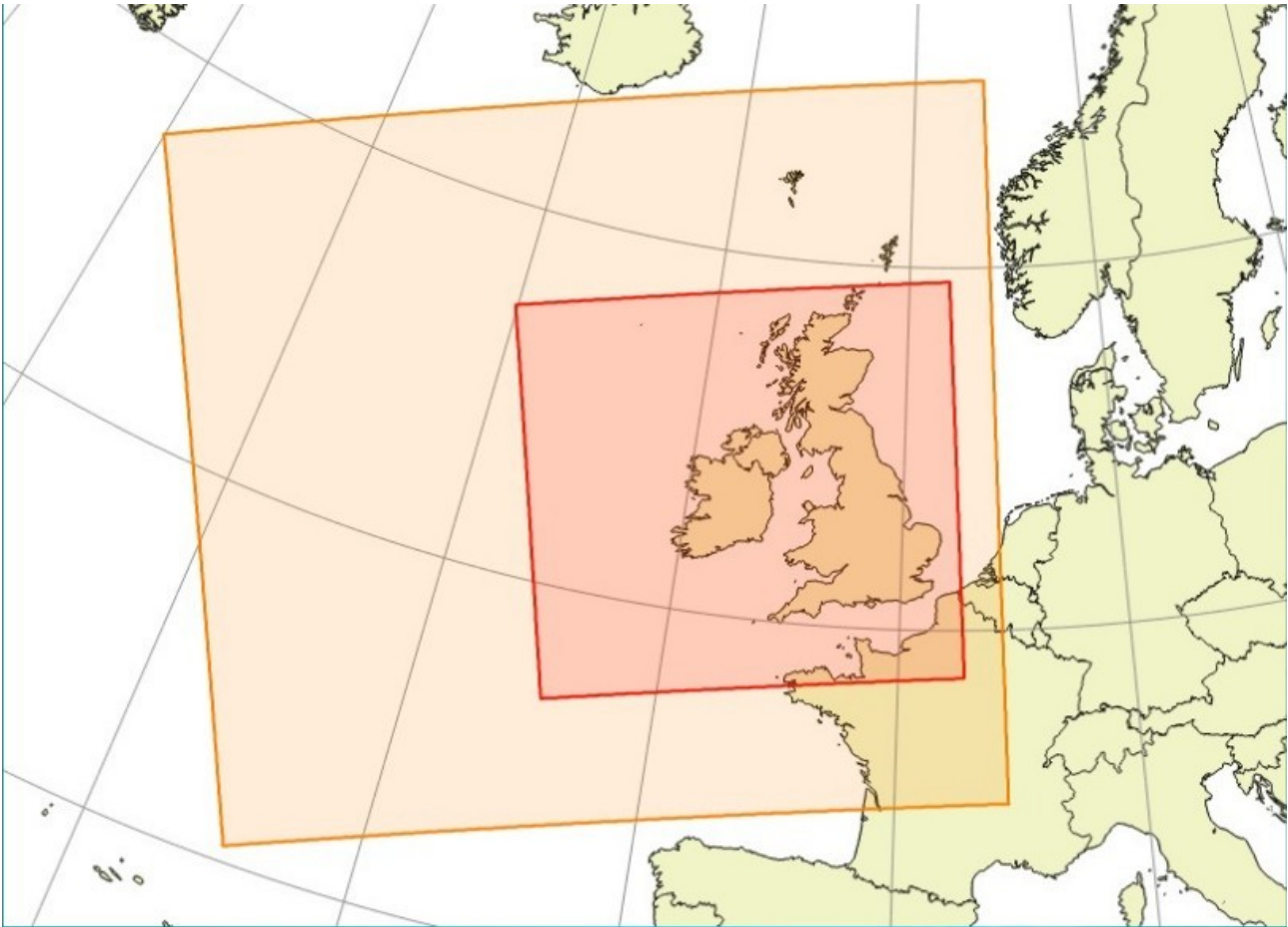


Figure 1: Current operational domain in orange, proposed test domain for experiments in red.

The requested resource of 5 MSBUs will be spent as follows:

1) Initial technical testing will be done with the cycling strategies and spin-up reducing techniques, this will consist of a number of one-day tests to ensure that the configurations work from a technical standpoint. It is proposed that there would be 2 tests with each option, giving a total of: 2 (tests per option) * 3 (3D-Var/4D-Var data assimilation, with 4D-Var costing approximately twice as much) * 3 (RR or RUC cycling strategy or IAU) * 48000 SBUs = 18 * 48000 SBUs ~ 1M SBUs.

2) Based on the results of the above two 5 day long tests will be performed on two periods (one in DJF and one in JJA). These will consist of one of the data assimilation algorithms (3D-Var/4D-Var) with one of the cycling strategies (RR/RUC) in combination IAU giving a total of: 2 (periods) * 5 days * 3

(3D-Var/4D-Var data assimilation, with 4D-Var costing approximately twice as much) * 2 (RR or RUC cycling strategy) * 2 (IAU) * 48000 SBUs = 120 * 48000 SBUs ~ 5.5M SBUs.

3) Based on the results of 2) the best performing configuration will be tested in an operational setting for 2 ten day long periods (one in DJF and one in JJA) to compare against our operational forecasts. This will use a total of: 2 * 10 days * 48000 SBUs = 20 * 48000 SBUs ~ 1M SBUs.

4) The tests run in 3) will also be performed on a 1.25km resolution grid. This will use a total of: 2 * 10 days * 96000 SBUs = 20 * 96000 SBUs ~ 2M SBUs.

The above tests will initially be run using a forecast length of 12 hours, but this can be reduced to 9 or 6 hours if it is seen that longer lead times are not providing increased skill compared to the latest available operational forecasts.

3. Benefits of the Project

It is hoped that a successful configuration from the proposed testing will provide improved short term guidance to forecasters in high-impact weather events, and that the improved hourly analysis would give quicker verification of these events. Furthermore, the envisaged work could be combined with extrapolation of observation type Nowcasting systems to provide the basis of a Blended Nowcasting system as recommended by the WMO (Yong Wang 2017).

4. References:

Auger L. et al. (2015). AROME–NWC: a new Nowcasting tool based on an operational mesoscale forecasting system. *Quarterly Journal of the Royal Meteorological Society*, 141: 1603-1611.

Ballard S., Li Z., Simonin D, Caron J-F. (2015). Performance of 4D-Var NWP-based Nowcasting of precipitation at the Met Office for summer 2012, *Quarterly Journal of the Royal Meteorological Society*, 142: 472-487.

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Bloom, S. C., L. L. Takacs, A. M. D. Silva, and D. Ledvina, 1996: Data assimilation using incremental analysis updates. *Mon. Wea. Rev.*, 124, 1256-1271.

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Olsen B.T., et al. (2015). On the performance of the new NWP Nowcasting system at the Danish Meteorological Institute during a heavy rain period. *Meteorology and Atmospheric Physics*, 127: 519-535.

Yong Wang et al. (2017). *Guidelines for Nowcasting Techniques*, World Meteorological Organisation 2017.