

SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year 2022

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

Computer Project Account: SPIEHARN

Principal Investigator(s): Eoghan Harney

Affiliation: Met Éireann

Name of ECMWF scientist(s) collaborating to the project (if applicable)

Start date of the project: 2021

Expected end date: End 2022

Computer resources allocated/used for the current year and the previous one (if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	9.5M	6.5M	25M	5.5M
Data storage capacity	(Gbytes)	5TB	0*	0	0

* National allocation (ienwp) is being used.

Summary of project objectives (10 lines max)

The objective of the special project is test Nowcasting type configurations of the HARMONIE-AROME model. This will include investigating 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) 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 Met Éireann's current operational limited area EPS system IREPS.

Summary of problems encountered (10 lines max)

In the early part of 2022 I tested the use of radar reflectivity data, but in a similar problem as last year with local BUFR files, if no radar files were available for a particular hour then a model crash would be encountered. To counter this I had to rerun experiments which used "fake files" which were merely copies of the last available file with the file name adjusted. Given the issue I only used 3 hourly cycling, not hourly, as missing files tended to be from hours not divisible by 3.

In the middle of 2022 to begin running 3D-Var at high resolution I ran the process to construct structure functions for a 800x800x90level 750m resolution domain over Ireland (see Figure 1 below). During this process I encountered numerous "out of memory" crashes on CCA for the Festat task. Thankfully this could be resolved by resubmitting the submit file requesting additional memory for Festat.

Summary of plans for the continuation of the project (10 lines max)

It is intended that the project will conclude this year.

During the remainder of the year I intend to focus on testing on a 90 level 750m domain, structure functions for this domain are being developed at the moment. I further intend to test the Incremental Analysis Updates method which should reduce model spin-up with the ECHKEVO diagnostic used to calculate model spin-up. Also intend to test the assimilation of Mode-S and Ascat observations.

List of publications/reports from the project with complete references

N/A

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

Introduction and Initial Domain/Model Version Choice:

Most of the experiments discussed below were done using HARMONIE-AROME Cycle 43h2.1.1 with the aim of developing an hourly operational nowcasting setup for Ireland. Experiments were performed on the 540x500 65level 2.5km resolution IRELAND25 domain as seen below, with a 10 day experiment with 4 days of warming up (to reduce spin-up from cold start) costing approximately 400,000 SBUs.

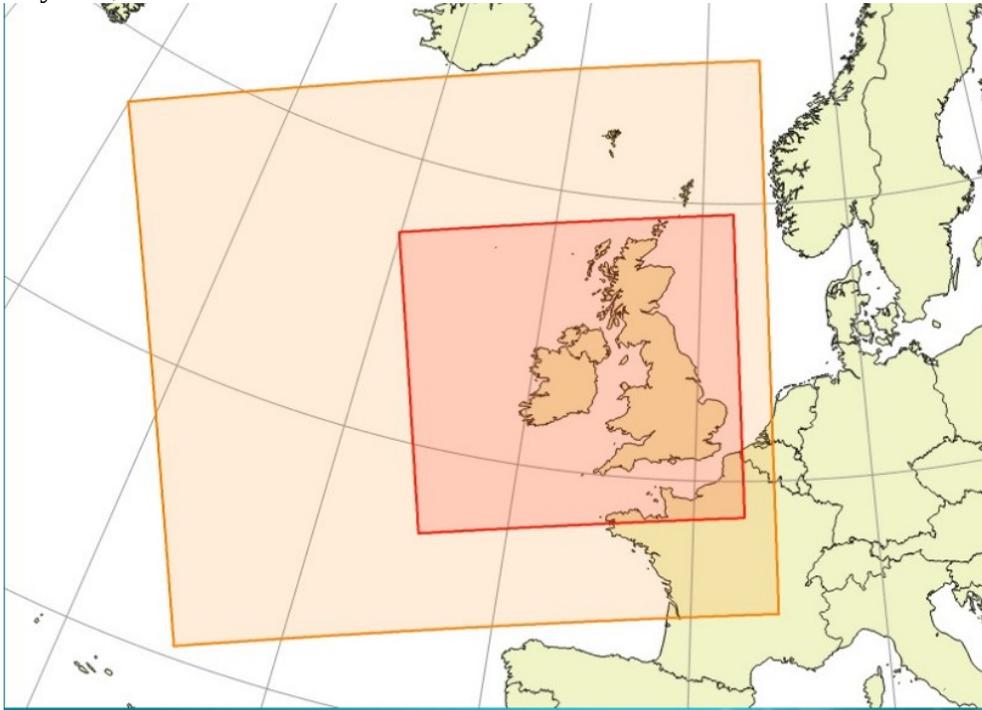


Figure 1: IRELAND25 domain (red) and Met Éireann's operational IREPS domain (orange).

Observation Cut-Off and Window:

To allow for the timely production of forecasts, ideally within an hour, requires the use of a reduced observation cut-off compared to standard operation forecasts. Initial one day testing was performed to test the impact of a reduced observation cut off on the number of conventional observation available for assimilation. These tests showed that a cut-off of 20 minutes resulted in a total loss of TEMP (radiosonde) observations, but are retained by using a 25 minute cut-off.

Based on these initial tests longer experiments were run on two 10 day periods (20201025-20201103 covering Storm Aiden, and 20210517-20210626 a period of heavy convective showers in Ireland) with standard 3 hour cycling using and symmetric observation windows of +/- 20/25/30 minutes. Some results for the second of these periods can be seen in the image below.

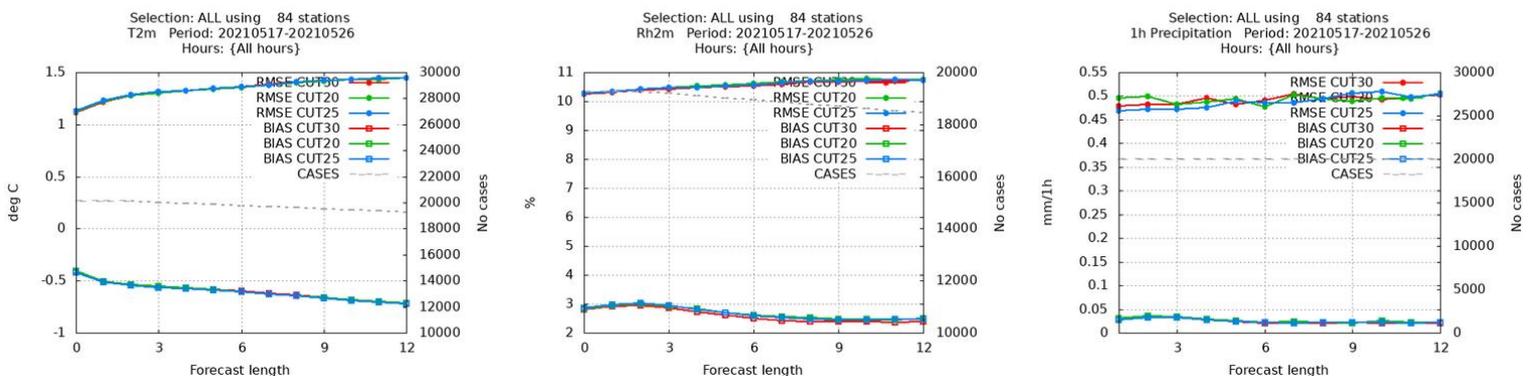


Figure 2: Verification results for 20210517-20210526 period using different symmetric observation windows of +/- 30 (red), +/- 25 (blue) and +/- 20 minutes (green), for 2m Temperature (left), 2m Relative Humidity (centre) and 1hr Precipitation (right).

As seen in Figure 2 there is very little difference seen between 2m Temperature and 2m Relative Humidity scores, and no clear superior experiment for 1hr precipitation.

Given little to no difference between a cut-off of 25 and 30 minutes, 25 minute cut-off has been taken as the cut-off in future experiments. Similar experiments were run using asymmetric observation windows of +25/-35 and +25/-90 minutes to test the impact of any additional earlier observations being assimilated. Results of these experiments, which are not shown, show no considerable differences.

Rapid Update Cycling:

Our operational setup IREPS, Irish Ensemble Prediction System, runs with 3 hour cycling, that is the forecast at HH uses as a background the 3 hour forecast from the HH-3 cycle. Running hourly provides the opportunity to use different cycling lengths. Hourly cycling can be performed using a single experiment, but running two or three hourly cycling requires the use of independent parallel experiments, with two independent cycles running at odd and even hours for two hour cycling and three independent cycles for three hour cycling.

Experiments were run for the same two 10 day periods (20201025-20201103 covering Storm Aiden, and 20210517-20210626 a period of heavy convective showers in Ireland) with one, two and three hour cycling. Some results for the second of these periods can be seen in the figure below.

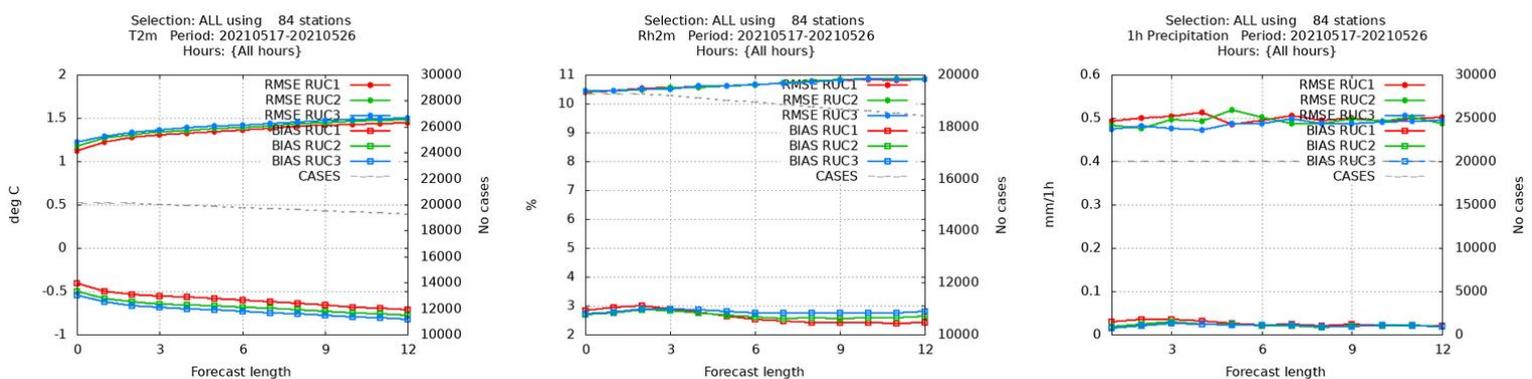


Figure 3: Verification results for 20210517-20210526 period using 1 (red), 2 (green) and 3 (blue) hourly Rapid Update Cycling, for 2m Temperature (left), 2m Relative Humidity (centre) and 1hr Precipitation (right).

As seen in Figure 3 there are some differences between using different cycling lengths. For 2m Temperature it can be seen that 1hr cycling has better scores than longer cycling lengths, whereas the results are more mixed for 2m Humidity and 1hr Precipitation. These sort of results have been seen by other experimenting with cycling lengths, with “dry parameters” benefiting from shorter cycling and “wet parameters” better with longer cycling. Based on these results, future experiments used 2hr cycling as a balance between the benefits in shorter and longer cycling for “dry parameters” versus “wet parameters”.

Coupling of Hydrometeors:

In operational IREPS lateral boundary coupling does not include coupling of hydrometeor species, of which there are five (cloud water, cloud ice, rain, graupel and snow). Coupling of these has been seen by Hirlam and ACCORD colleagues to reduce model spin-up, which is particularly important in a nowcasting setup.

Two experiments were performed for the second 10 day experiment period using a 2 hour Rapid Update Cycling setup, one coupling the cloud water and ice, the second coupling all five hydrometer species.

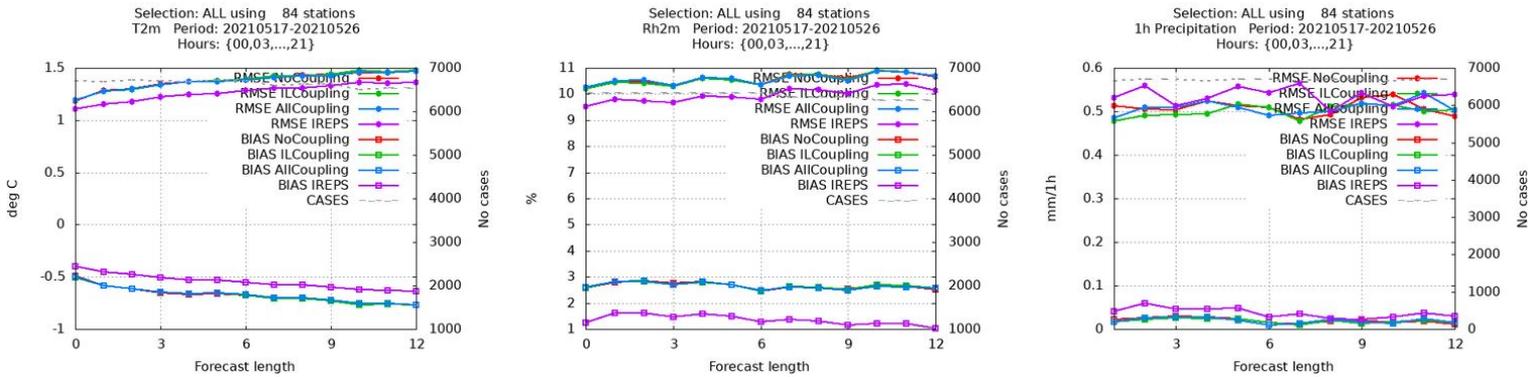


Figure 4: Verification results for 20210517-20210526 period using lateral boundary coupling of hydrometer species, no coupling (red), cloud ice and water coupling (green), coupling all hydrometer species (blue), operational IREPS control member (purple), for 2m Temperature (left), 2m Relative Humidity (centre) and 1hr Precipitation (right).

Results seen in Figure 4 above show no impact on 2m Temperature or Humidity, with some positive impact seen for 1hr Precipitation.

Radar Reflectivity assimilation:

The impact of the assimilation of radar reflectivity observations was tested using the second experiment period which encompassed a period of heavy convective showers across the island of Ireland.

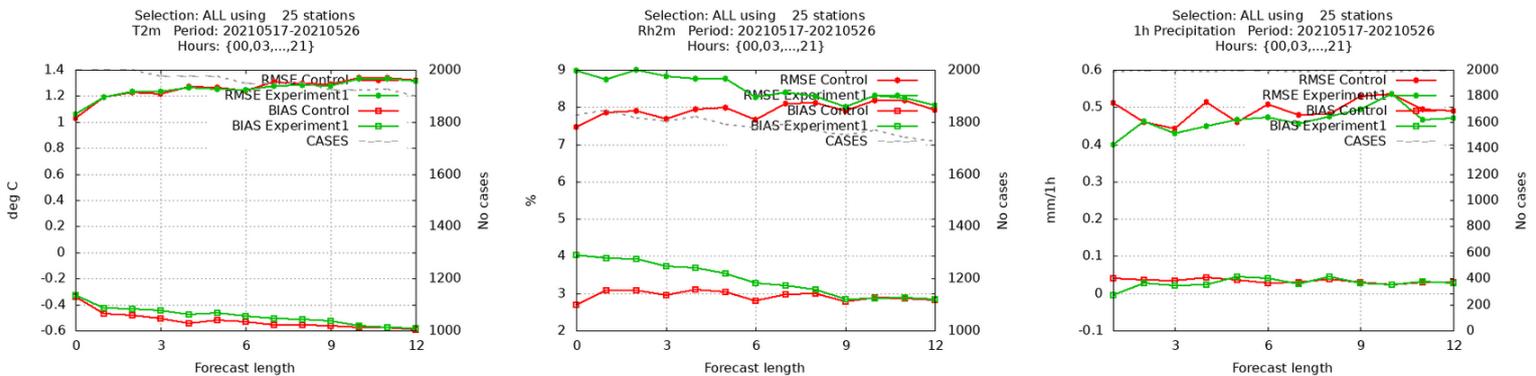


Figure 5: Verification results for 20210517-20210526 period testing assimilation of radar reflectivity observations; no assimilation of radar observations (red), assimilation of radar observations (green), for 2m Temperature (left), 2m Relative Humidity (centre) and 1hr Precipitation (right).

The results shown above in Figure 5 are from standard 3 hour cycling experiments run at the hours 00/03/06/... , this was done due to missing radar files outside these times. The results show that there is no impact on 2m Temperature, with a negative impact on 2m Humidity scores and a positive impact seen for 1hr Precipitation scores.

High Resolution Structure Functions:

Met Éireann has joined the United Weather Centres (UWC) consortium, as part of this is the development of joint operational forecasts as part of the UWC-West sub-consortia consisting of the National Met Services of Denmark, Ireland, Netherlands and Iceland. These joint forecasts will be run on the 2km DINI domain as in orange in the figure below. Given that Met Éireann’s main future August 2022

operational forecasts will be run at 2km, any hourly nowcasting configuration will have to run at the same or higher resolution.

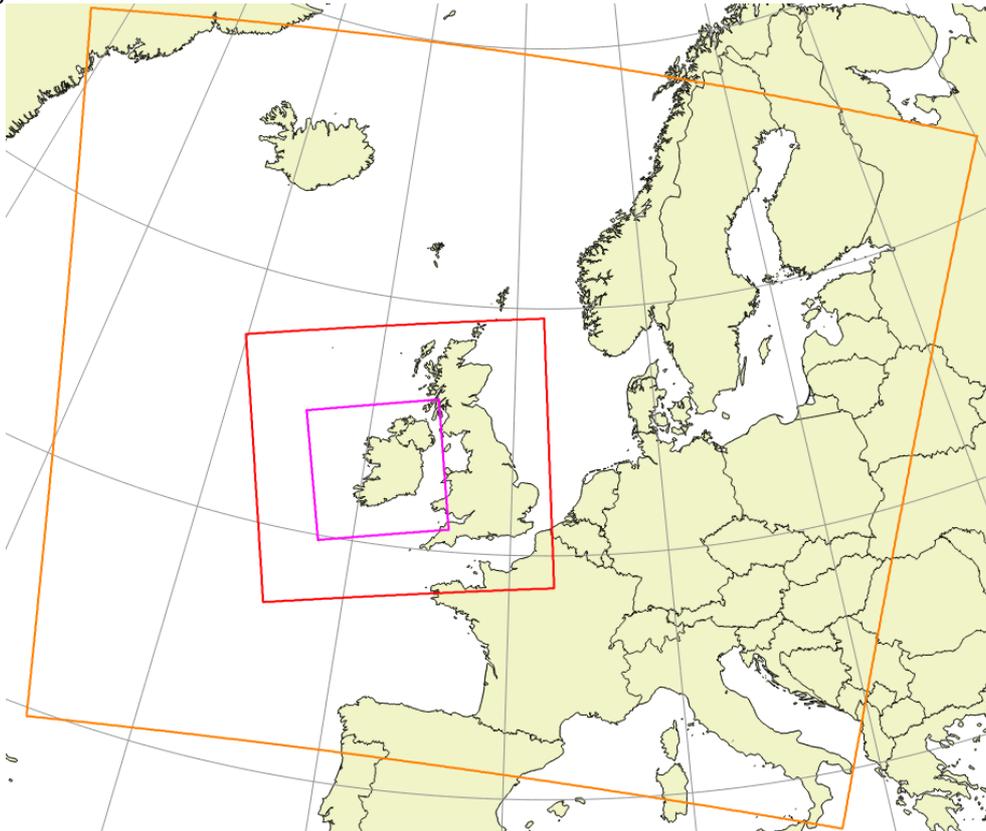


Figure 6: Proposed UWC-W DINI domain (orange), test IRELAND24 domain (red), proposed high resolution domain (purple).

I am currently running experiments that will produce structure functions for the proposed higher resolution domain that is shown in Figure 6, this domain is 800x800 points at a horizontal resolution of 750m and 90 vertical levels. Once these structure functions have been defined then further experiments will be run on the proposed high resolution domain.