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

2021

Project Title:

Investigating the optimal configuration of the HARMONIE-AROME NWP model for hectometric-scale forecasting over Ireland

Computer Project Account:

spieclan

Principal Investigator(s):

Colm Clancy

Affiliation:

Met Éireann

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

N/A

Start date of the project:

4 January 2021

Expected end date:

2 January 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 M	3.03 M
Data storage capacity	(Gbytes)			10000	(National allocation used so far)

Summary of project objectives (10 lines max)

The objective of this project is to explore the behaviour and the performance of the HARMONIE-AROME NWP model at hectometric-scale resolutions over Ireland; ideally to ultimately arrive at an optimal configuration for operational use.

Summary of problems encountered (10 lines max)

No technical problems relating to the Special Project or HPC facility.

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

More single-forecast experiments will continue in order to explore different model configurations and, in particular, diffusion strengths. So far the cases used have mainly involved storms and extreme winds. This will be expanded to consider other meteorological phenomena where we might hope to see a benefit in higher resolutions, such as fog or convective activity.
The bulk of the remaining HPC resources will then be used for tests of suitable configurations over extended periods to assess long-term performance and compile verification statistics.

List of publications/reports from the project with complete references

None

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.

The HARMONIE-AROME NWP is currently run by HIRLAM consortium members at an operational resolution of 2.5km in the horizontal, with 65 vertical levels. For this Special Project, we have run Cycle 43h2.1.1 of HARMONIE-AROME at a resolution of 500m with 90 vertical levels.

Initial tests focussed on a storm case on the 22/23 February 2021. The first experiments showed deficiencies in terms of the precipitation close to the domain boundaries. Lateral boundary conditions are taken from IFS-HRES forecasts, and it was found necessary to couple cloud liquid and water, as well as hydrometeors (Fig. 1, below); this is not done by default in the 2.5km operational context. Additionally, it was found that a domain size larger than the initial 500x500 horizontal grid-points was desirable (Fig. 2). The option of running the model using single precision has been implemented recently by the HIRLAM community, with initial testing showing a similar forecast quality (although more rigorous investigation is still required). Experiments with this option in the forecast model showed that the computational cost of using a 720x600 domain with single precision is comparable with a 500x500 domain at full double precision. It was decided that this was a preferable route: exploiting the savings from the the reduced precision to increase the domain size.

A large number of experiments have been carried out to investigate the appropriate level of diffusion at the higher resolutions, balancing the need for a stable integration while avoiding an overly-damped solution. This work is ongoing and represents one of the main aims of the project in the search for an optimal configuration. Sample forecasts from these tests are shown in Fig. 3 below. As well as these tests over Irish domains, experiments have been carried out over domains covering the Canary Islands and southern Greenland, representing areas of more complex orography. These have proved to be more challenging for the stability of the model and are providing insights into the limitations of the numerics.

From the single-forecast experiments, potential candidate configurations will be identified for testing over longer periods, so that statistical verification metrics can be analysed. Some week-long experiments have already been carried out for a period in February 2020 when a number of named storms impacted Ireland. The most notable preliminary result is the large difference in 10m wind-speed biases (see Fig. 4), where we see much lower values from the experiments using 90 vertical levels. It is not yet clear whether this is a “real” effect, or due to the diagnostic nature of the 10m wind in the HARMONIE-AROME model; further analysis will be carried out in the coming weeks.

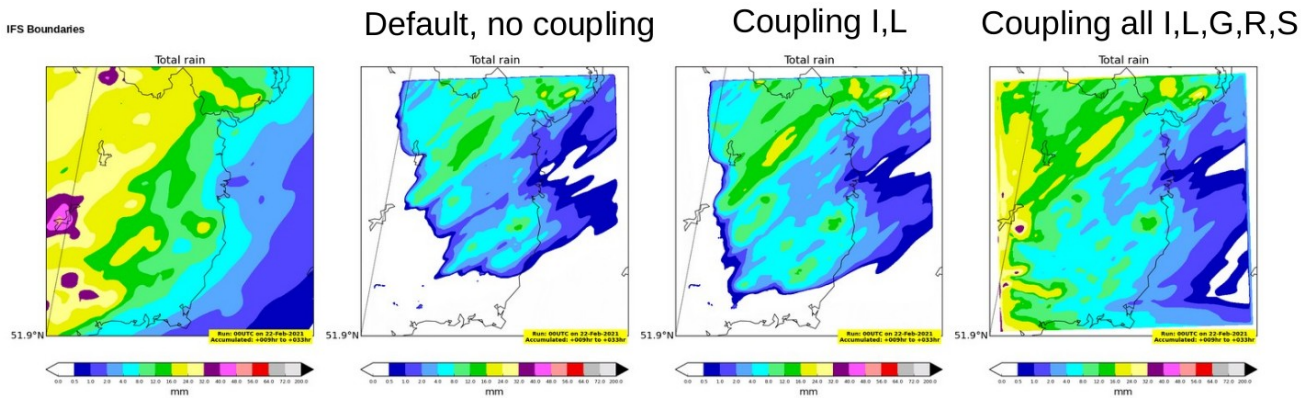

Figure 1: Forecasted 24-hour rainfall accumulations from HARMONIE-AROME experiments with IFS-HRES lateral boundary conditions (LBC). From left to right: 2.5km reference; 500m domain default; 500m where the cloud ice (I) and (L) are coupled from the LBC; 500m with I, L, and hydrometeors graupel (G), rain (R) and snow (S) coupled from the LBC

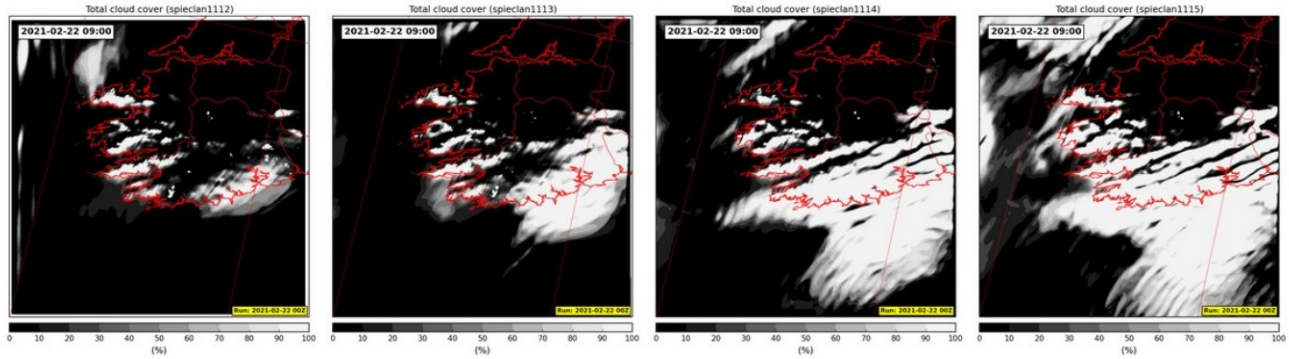

Figure 2: Forecasted total cloud cover from HARMONIE-AROME forecasts with 500m horizontal resolution, and increasing domain size. From left to right: 500x500; 600x540; 720x600; 810x640

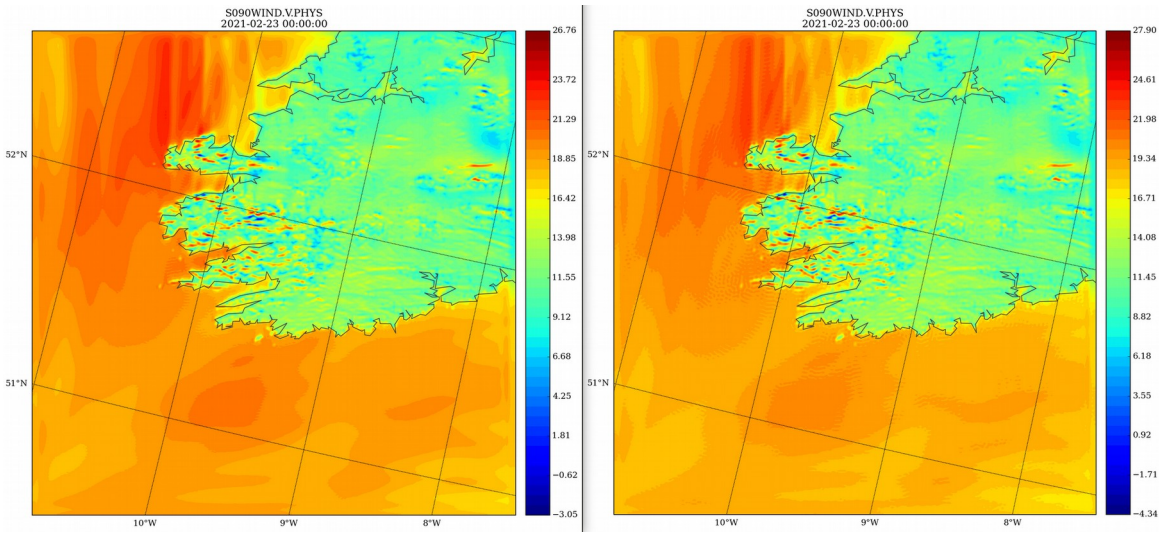

Figure 3: Sample forecast of meridional wind at the lowest level in high-resolution experiments. The experiment on the left uses a quadratic spectral grid, while on the right a cubic grid is used with lower levels of spectral diffusion.

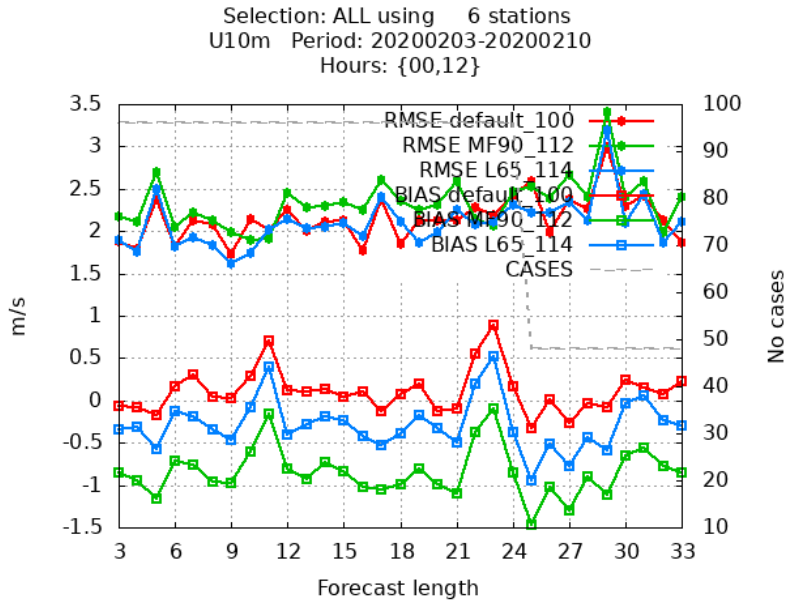

Figure 4: Point verification metrics (RMSE above, bias below) for week-long forecast cycling. The three experiments shown are: default 2.5km horizontal resolution with 65 vertical levels (red); 500m horizontal resolution with 90 vertical levels (green); 500m horizontal resolution with 65 vertical levels (blue)