REQUEST FOR A SPECIAL PROJECT 2022–2024

MEMBER STATE: Ireland

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Project Title: Evaluating the impact of single precision forecasts in HarmonEPS for various perturbation strategies

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.)	2022	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2022-2024: (To make changes to an existing project please submit an amended version of the original form.)		**2022**	**2023**	**2024**
High Performance Computing Facility	(SBU)	34.5M		
Accumulated data storage (total archive volume)[2]	(GB)	20TB		

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.

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Extended abstract

Background

Met Éireann, as part of the HIRLAM consortium, runs an operational Numerical Weather Prediction (NWP) suite using the HARMONIE-AROME canonical configuration of the shared ALADIN-HIRLAM NWP system (henceforth referred to as the HARMONIE-AROME model, Bengtsson et al., 2017). HarmonEPS, which is a limited-area, short-range, convection-permitting ensemble prediction system based on the HARMONIE-AROME model (Frogner et al., 2019), forms the basis for Met Éireann's operational EPS known as the Irish Regional Ensemble Prediction System (IREPS). IREPS currently uses Cycle 43 of the HARMONIE-AROME model and consists of a 1+15 member lagged ensemble with 2.5km horizontal resolution and 65 levels.

Building on work carried out at ECMWF and Meteo-France, significant efforts have been made within the HIRLAM community to enable HARMONIE-AROME to be run in Single Precision (SP). This option is now available in Cycle 43 of the model, with the convention that the forecast model alone is run in SP (Vignes, 2019). This work has been largely motivated by the substantial gain in computational efficiency reported when utilising SP within the IFS (Váňa et al., 2017) and the recent operationalisation of SP forecasts as part of the Cycle 47r2 upgrade at ECMWF. As such, there is an increased emphasis in HIRLAM on the perspective operational use of SP in order to capitalise on the approximately 30% forecast runtime saving offered by SP (Feddersen, 2021).

The focus of this special project will be on evaluating the impact of SP forecasts in HarmonEPS for a variety of perturbation strategies. Although experimentation with SP HARMONIE-AROME deterministic forecasts has already been carried out in a number of national meteorological services (Suárez-Molina and Calvo, 2021), questions remain regarding the performance and stability of the SP model for different perturbation techniques within HarmonEPS. For example, preliminary studies at Met Éireann suggest that switching to SP forecasts can lead to differences in the SP versus Double Precision (DP) ensemble verification scores for MSLP and upper-air humidity (Figures 1 and 2). This work will systematically investigate the differences induced by SP in the context of various HarmonEPS perturbation techniques, in particular the Stochastic Perturbed Parameterizations (SPP) scheme. This testing will therefore provide guidance for the operational use of SP in IREPS in the near future.

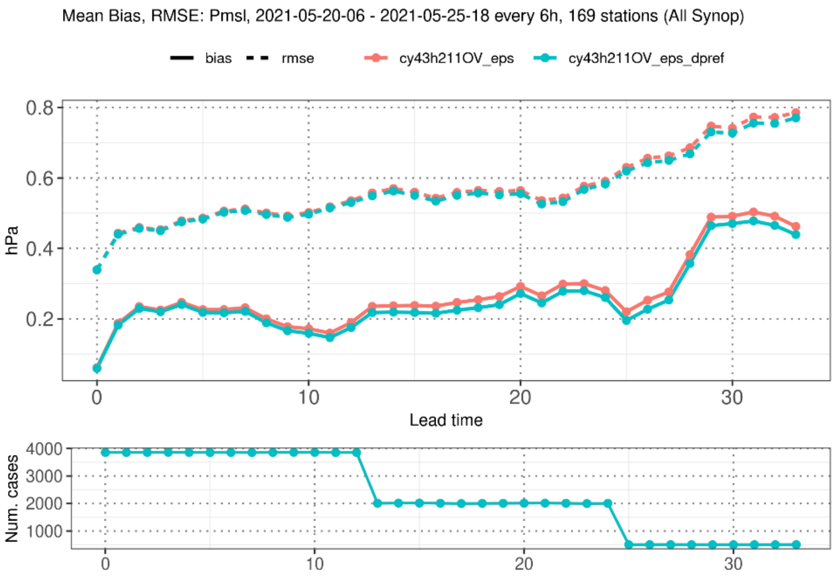

***Figure 1**: Comparison of ensemble bias (solid line) and RMSE (dashed line) for MSLP for two HarmonEPS experiments over the 540 x 500 (red) domain in Figure 2. The red line represents a 1+3 member ensemble where the control is maintained in DP and the perturbed members in SP. The blue line represents the same ensemble but with the perturbed members in DP.*

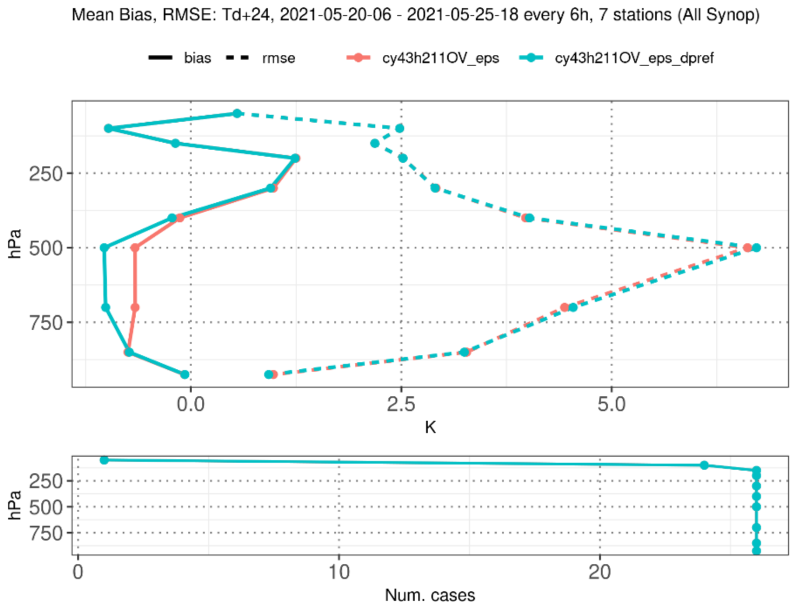

***Figure 2**: As in Figure 1 but for the dew point temperature profile at forecast hour 24.*

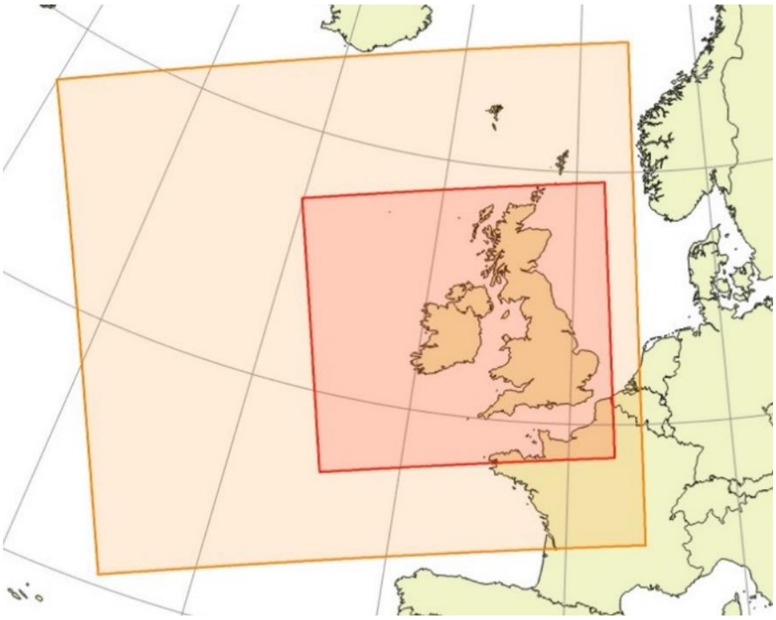

__Figure 3__: Current IREPS operational domain (orange) and experimental domain (red).

Scientific Plan

We propose running numerous sensitivity tests over a non-operational domain to investigate both the meteorological impact and stability of SP forecasts for a variety of perturbation methods. For boundary and initial condition perturbation techniques, such as SLAF, EDA, and surface perturbations, experiments will be carried out over a two-week period using 48-hour forecasts at 00Z. This will enable an assessment of drift between the SP and DP member forecasts both at longer lead times and due to cycling.

For model perturbations, a variety of sensitivity tests using SPP will also be carried out. Four different 2-week periods will be considered (one in each season) in order to assess SPP stability in different meteorological conditions.

Having tested these perturbation methods in isolation, we propose running an experiment with quasi-operational settings to test the performance of SP in this context. This would also be carried out over a period of interest in terms of extreme weather for Ireland, e.g. storms Ciara and Dennis during February 2020.

These experiments would allow us to investigate the following scientific questions:

- Do the perturbation schemes in HarmonEPS behave in SP as they do in DP?
- Are there any stability issues related to the SPP scheme in SP?
- Would SP IREPS maintain the same benefit from these suite of perturbations as it does in DP?

Justification of computational resources requested

Cycle 43h2.2 of HARMONIE-AROME will be used for this project.

The current IREPS operational domain for Ireland covers an area of 1000x900 points (Figure 3, orange domain) with a horizontal grid spacing of 2.5km and 65 levels. Running this domain for one 24-hour forecast cycle with one member in DP costs approximately 13000 SBUs (~1625 SBUs for a 3hr cycle). A smaller experimental domain (Figure 3, red domain) covering an area of 540x500 grid points is also illustrated. Running this domain for one 24-hour forecast cycle with one member in DP costs approximately 4000 SBUs (~500 SBUs for a 3hr cycle). Estimates for the 48hr SP forecasts below assume a saving of 30% relative to the respective DP SBU cost. The requested resource of 34.5M SBUs would be spent as follows:

1) Boundary and initial condition sensitivity tests: approximately 4 experimental configurations, 1+3 member ensemble, 540x500 domain, and 3hr-cycling over two weeks with 48hr forecasts at 00Z. SBU costs are estimated as follows:

a) DP experiments: 4 (perturbation configs) * 1 (cycles per day) * 14 (days) * 4 (members) = 224 (cycles) * 8000 (SBUs for +48 cycle in DP) + 7 * 224 * 500 (SBUs for +3 cycle) ~ 1.79M + 0.78M ~ 2.58M SBUs

b) SP experiments: ~ (0.7)*(1.79M) + 0.78M ~ 2.04M SBUs

2) SPP sensitivity tests: approximately 4 experimental configurations, 1+3 member ensemble, 540x500 domain, 3hr-cycling over two weeks with 48hr forecasts at 00Z, and 4 periods. SBU costs are estimated as follows:

a) DP experiments: 4 (perturbation configs) * 1 (cycles per day) * 14 (days) * 4 (members) * 4 (periods) = 896 (cycles) * 8000 (SBUs for +48 cycle in DP) + 7 * 896 * 500 (SBUs for +3 cycle) ~ 7.17M + 3.14M ~ 10.3M SBUs

b) SP experiments: ~ (0.7)*(7.17M) + 3.14M ~ 8.15M SBUs

3) Quasi-operational test: 1+10 member ensemble, 1000x900 domain, 3hr-cycling over two weeks with 48hr forecasts at 00Z, and 1 period. SBU costs are estimated as follows:

a) DP experiments: 1 (cycles per day) * 14 (days) * 11 (members) = 154 (cycles) * 26000 (SBUs for +48 cycle in DP) + 7 * 154 * 1625 (SBUs for a +3 cycle) ~ 4M + 1.75M ~ 5.76M SBUs

b) SP experiments: ~ (0.7)*(4M) + 1.75M ~ 4.55 SBUs

This gives an approximate total of ~33.5M SBUs, leaving ~1M SBUs available to account for slight underestimates in the above.

References

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