REQUEST FOR A SPECIAL PROJECT 2022–2024

MEMBER STATE: Ireland

Principal Investigator[1]: Alan Hally

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Project Title:
Investigating the impact of ensemble size and increased resolution in a convection-permitting EPS: focus on high-impact events

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 million		
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.

Principal Investigator: Alan Hally

Project Title: Investigating the impact of ensemble size and increased resolution in a convection-permitting EPS: focus on high-impact events

Extended abstract

HarmonEPS is an ensemble prediction system for the short-range (+ 48-54 hours) based on the non-hydrostatic HARMONIE-AROME model configuration in the ALADIN-HIRLAM NWP system (Bengtsson et al. 2017). The Irish Regional Ensemble Prediction System (IREPS) is a configuration of HarmonEPS in operational use at Met Éireann, currently based on cycle 43h2.1 of the HARMONIE-AROME code. IREPS utilises a scaled lagged averaging approach (SLAF, Ebisuzaki and Kalnay 1991) combined with an Ensemble of Data Assimilations (EDA) to represent boundary condition and initial condition uncertainty, along with stochastic surface perturbations (following Bouttier et al. 2015) and a number of multi-physics options in order to represent model/physics parameterisation uncertainties. A complete description of the options available in HarmonEPS can be found in Frogner et al. 2019.

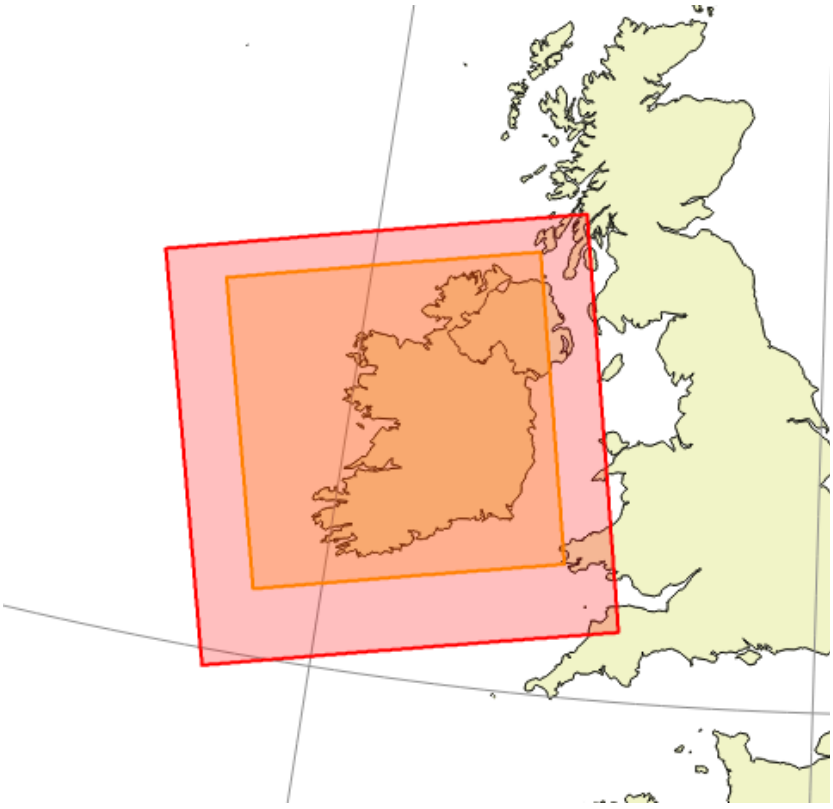

Figure1:Possible domains over Ireland to be used in this study, using 800x800 (red) or 600x600 (orange) grid-points for 750m resolution, or 240x240(red)/180x180(orange) grid-points for 2.5km resolution

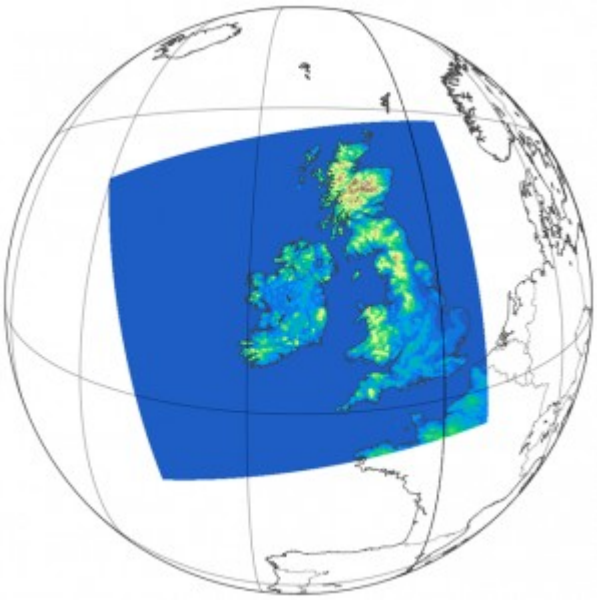

Figure 2: IRELAND25 domain @ 2.5km resolution (540x500 grid points)

Met Éireann recently upgraded IREPS from a 10+1 EPS cycling 4 times daily to a semi-continuous 15+1 EPS cycling 8 times per day (00-21Z at 3-hourly intervals). As a member of the ACCORD numerical weather prediction (NWP) community, Met Éireann has also begun investigating the advantages of higher resolution versions of HARMONIE-AROME. In operational convective-scale EPSs, naturally the question arises as to whether resources should be focused on increasing the number of members in an EPS or whether or not higher resolution simulations should be used.

This special project concerns itself with answering this question for the IREPS system, and in particular will focus on high-impact warning level events and the added value forecasters may obtain from increased ensemble size and/or increased horizontal resolution. A number of other institutes have looked into this question (Raynaud and Bouttier (2017), Hagelin et al. (2017) and Leutbecher (2019)). Both Raynaud and Bouttier (2017) and Hagelin (2017) suggest that increased ensemble size offers the most improvement, in particular for precipitation. However, Raynaud and Bouttier (2017) in particular underline the need for further analysis of the performance of the higher resolution EPS for high-impact events.

This is the main motivation behind this special project application, along with the fact that to the authors knowledge, the issue of more members or increased resolution is one that has yet to be investigated within the HarmonEPS community.

Method/Scientific Plan:

We propose running a number of experiments focusing on 2 high-impact weather events over Ireland from the 2019/2020 or 2020/2021 storm seasons. Numerous high-impact events took place during these two periods, for example Storm Ellen from August 2020 was a particularly unusual event in that it led to a red wind warning being issued during the month of August.

In order to save on computational resources, all experiments will be done using the single precision configuration of cycle 43 of the HARMONIE-AROME code.

We plan to investigate the following scientific questions specifically:

- Using objective verification scores, is it more worthwhile investing computational resources into increased ensemble size or increased horizontal resolution for a high-impact weather event?
- Are there any computational or stability issues related to running a high-resolution (on the order of 500-750m) EPS over an Ireland centred geographic domain? This will build on the experience of the SPIECLAN Special Project in 2021, which investigated high-resolution deterministic forecasting.
- What is the relative benefit to the forecaster of increased ensemble size or increased horizontal resolution for a high-impact event?

Justification of computer resources requested:

The requested resource of 34MSBUs would be spent as follows. 4 cycles over the 3 days leading up to each high-impact event will be run for each of the experiments detailed below. All high-resolution simulations will be carried out over either of the domains in red/orange in Figure 1, will emulate the operational IREPS configuration as closely as possible (an Ensemble of Data Assimilations, surface perturbations, cycling of all members on 3-hourly intervals, each member beginning from its own FirstGuess). All simulations @ 2.5km resolution will be carried out over the IRELAND25 domain, shown in Figure 2 and will also emulate an operational IREPS configuration.

One 24-hour forecast over the island of Ireland domain (red in Figure 1) @ 750m resolution has been estimated to cost ~20kSBUs. One 54-hour cycle of an 11 member EPS over the IRELAND25 domain (Figure 2) has been estimated to cost ~100kSBUs. 3-hourly cycling costs an additional ~10kSBUs per cycle for an 11 member EPS. Running the experiments in single precision is estimated to lead to ~30% computational savings. Full experiment costings are estimated below for:

1)A reference run of IREPS. This would be a 10+1 EPS @ 2.5km for: 4 cycles * 3 days * 2 events = 24*54-hour cycles + 24*3-hourly cycles, totalling 2.4MSBUs + 240,000SBUS = ~2.6MSBUs – 30% = ~1.8MSBUs

2)An IREPS run using an increased ensemble size of 15+1 @2.5km for: 4 cycles * 3 days * 2 events = 24*54-hour cycles + 24*3-hourly cycles, totalling 3.4MSBUS + 700,000SBUs = ~4.2MSBUs – 30% = 3MSBUs

3) An IREPS run using an increased ensemble size of 18+1 @ 2.5km for: 4 cycles * 3 days * 2 events = 24*54-hour cycles + 24*3-hourly cycles, totalling 4.1MSBUs + 829,000 SBUs = 5MSBUs – 30% = 3.5MSBUs

4) An IREPS run using an increased resolution of 750m and a 10+1 EPS for: 4 cycles * 3 days * 2 events = 24*54-hour cycles + 24*3-hourly cycles, totalling 12MSBUs + 660,000SBUs = 12.6MSBUs – 30% = ~9MSBUs

5) An IREPS run using an increased resolution of 750m and a 15+1 EPS for: 4 cycles * 3 days * 2 events = 24*54-hour cycles + 24*3-hourly cycles, totalling 17.2MSBUs + 960,000SBUs = 18.2MSBUs – 30% =~13MSBUs

This gives an approximate total of 31MSBUs, leaving 3MSBUs to account for any under-estimation in the above totals.

Experiments 1-3 would demonstrate any additional benefit to be found from running with an increased ensemble size at the current operational resolution of IREPS, 2.5km, while experiments 4 and 5 could be compared to experiments 1-3 to establish any added value of running an EPS at an increased resolution.

Objective verification scores will form the majority of the comparisons. Owing to the difficulty in verifying higher-resolution forecasts using traditional point verification metrics, it is envisaged that spatially-based metrics will also be employed (Mittermaier, 2014).

Forecaster focused products (probability of exceedance maps, paintball plots, meteo-grams, EPS plumes) will also form part of the evaluation process owing to the high-impact weather element of the study.

References:

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