REQUEST FOR A SPECIAL PROJECT 2026–2028

MEMBER STATE: United Kingdom

Principal Investigator[1]: Tim Woollings

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Project Title: **Sensitivity of atmospheric circulation anomalies to local processes, feedbacks and resolution**

To make changes to an existing project please submit an amended version of the original form.)

If this is a continuation of an existing project, please state the computer project account assigned previously.	N/A	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2026	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for project year:		2026	2027	2028
High Performance Computing Facility	[SBU]	120M	120M	80M
Accumulated data storage (total archive volume)[2]	[GB]	90000	180000	266000

EWC resources required for project year:		2026	2027	2028
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			
Number of vGPUs[3]	[#]			

[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.
[3]The number of vGPU is referred to the equivalent number of virtualized vGPUs with 8GB memory.

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Extended abstract

A. Scientific plan

Introduction

The aim of this project is to investigate how physical processes and model resolution impact the signal-to-noise paradox observed in various initialised seasonal predictions. The focus is on the well-known signal-to-noise problem in seasonal predictions of the winter North Atlantic Oscillation, the understanding of which is a research priority for the climate science community (Weisheimer et al. 2024).

Using targeted idealised experiments, we will explore the effects of atmospheric resolution, model formulation, and air-sea coupling on both predictable signals and atmospheric variability. A central question is whether local feedbacks affect jet perturbations in the same way, regardless of whether they are part of predictable signals or noise.

This work is part of an upcoming NERC-funded AUSPICE project (a 4-year project beginning Oct-2025) and parallel experiments to those outlined below are planned as part of the wider project, using atmospheric model underpinning the Met Office's seasonal forecasting system (i.e. "GloSea6") and the NCAR prediction system (i.e. "CAM6"). These companion experiments that will be run as part of the project provide a unique opportunity to examine the mechanisms underlying seasonal signals and the importance of physical process and resolution in a controlled manner across multiple models.

Atmospheric resolution and feedback sensitivity experiments.

We will examine the sensitivity of circulation signals to atmospheric model resolution, focusing on key predictive drivers identified in the wider AUSPICE project. Idealised experiments will prescribe global climatological SSTs and tropical perturbations (e.g., El Niños from years which dominate the signal-to-noise paradox; Weisheimer et al. 2018) across resolutions ranging from 100 to 10 km. While caution is needed when interpreting and comparing prescribed SST responses with coupled simulations, this approach allows us to isolate the impact of remotely-forced predictable signals on the North Atlantic atmosphere, including assessment of the pathway(s) of influence and the role of local atmospheric feedbacks.

We will apply detailed dynamical diagnostics, such as for physical characteristics of Rossby wave-breaking including morphology and spatial extent. Eddy-driven jet diagnostics will be used in addition to the NAO, as the latter can mix physically different signals on different timescales (Woollings et al. 2015). Diagnosis of eddy feedbacks–interactions between synoptic eddies and large-scale climate anomalies–remains challenging; following Saffin et al. (2024), we will test several methods with a preference for those that are regional in nature, using filtering to isolate specific timescales and minimise noise exposure (e.g., barotropic energy generation metric). Based on the outcomes, we will select the most promising feedbacks for further experiments, such as:

1. Testing orographic feedbacks by perturbing drag parameters in the model or the orographic height directly, as in Berckmans et al. (2013); this will be prioritised if the form drag around Greenland proves sensitive to resolution.

2. Testing diabatic feedbacks using a latent-heat-locking method (following Ceppi & Hartmann, 2016) to decouple the heating from the dynamics, focusing on storm track precipitation changes and their impact on baroclinicity (Auestad et al. 2024).

This project will deliver insight into how atmospheric model resolution and feedback processes influence circulation signals.

B. Technical plan and justification of resources

We plan to run experiments using variations of the atmospheric component of the ECMWF seasonal forecasting system SEAS6 (i.e. the IFS). The numbers below use costs of running the model at different resolutions based on the ongoing testing for SEAS6 from colleagues at ECMWF.

Our plan is to perform experiments across resolutions that span lower resolutions (i.e. comparable with the lower resolution models contributing to the operational C3S multi-system ensemble) through to higher resolution models currently used for operational NWP. This will provide useful insight into the importance of resolution through comparison with the operational resolution.

Horiz. resolution (atmos)	System name	Atmosphere-only sensitivity expts (WP3) - seasons	Cost	Cost per season (SBU)	Total cost (SBU)
TCo199 (50km)	SEAS6-lowres	1000	1000 per month	5000	5.25E+06
TCo319 (36km)	SEAS6	1000 + 2000 (physics)	4000 per month	20000	6.30E+07
TCo639 (18km)	N/A	1000	16000 per month	80000	8.40E+07
TCo1279 (9km)	N/A	500	64000 per month	320000	1.60E+08
				Total (SBU)	**3.12E+08**

Table 1: Summary of estimated costs of the different resolution experiments.

The indicative computation costs provided in Table 1 above are estimated by calculating the cost to perform 10 different SST perturbation patterns for 5 months with 100 ensemble members. Due to the costs of performing the highest resolution simulations (TCo 1279), a subset of half of the experiments will be run at this resolution, based upon what seems most appropriate from the lower resolution simulations. All estimates are based on recent simulations on the ATOS supercomputer.

Multiplying the estimated costs by the number of planned seasons, and adding 5% for pre/postprocessing costs and potential margin of error on the “cost per month” estimates, gives the total units for the runs planned as ~320M SBU spread across three years, as follows:

Year 1: 120M SBU
Year 2: 120M SBU

Year 3: 80M SBU
Total: 320M SBU

The work plan will be to do the main bulk of lower resolution experiments in the first two years of the project in addition to the initial runs at the highest resolution. In the third year the remaining targeted highest resolution experiments will be performed, guided by our results from the first two years.

In agreement with the reduced archiving settings of standard seasonal forecast research experiments at ECMWF, a total of 1,354 spatial fields per months will be archived. This includes a selection of 6-hourly and daily data together with monthly mean fields at the surface and selected pressure levels. With one field being of size 3.2 MB, this corresponds to 4.3 GB per month of simulations for the standard SEAS6 resolution. We then scale this figure for the appropriate resolution, multiply by the number of forecast months, ensemble members and start years to get the total number of GB required.

The total accumulated storage over the three years is estimated as 266 Tb, achieved as follows:

Year 1 (accumulated): 90 Tb
Year 2 (accumulated): 180 Tb
Year 3 (accumulated): 266 Tb

References

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