REQUEST FOR A SPECIAL PROJECT 2016–2018

MEMBER STATE: United Kingdom

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Project Title: Assessing sources of seasonal forecast skill over Europe in summer using relaxation experiments.

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** _____N/A_____	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2016	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2016-2018: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2018.)		**2016**	**2017**	**2018**
High Performance Computing Facility	(units)	12,000,000	12,000,000	12,000,000
Data storage capacity (total archive volume)	(gigabytes)	20,000	20,000	20,000

*An electronic copy of this form **must be sent** via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date): ……

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

Continue overleaf

Principal Investigator: Christopher O'Reilly

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Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

Project Description

Seasonal forecasting systems have recently exhibited encouraging levels of skill in predicting interannual circulation anomalies over Europe and the Northern Hemisphere extratropics during the winter season (Scaife et al., 2014; Stockdale et al., 2015), however, the same systems exhibit comparatively poor levels of skill during the summer season. Observational studies highlight some potential drivers of circulation anomalies over Europe, such as low-frequency extratropical SST variability (Sutton and Dong, 2012), interannual tropical precipitation variability (Gaetani et al., 2011) and Arctic sea-ice concentration (Screen, 2013), which are potentially sources of skill in seasonal forecasts.

The nudging, or relaxation technique is an established methodology to study the origins of forecast errors by relaxing the atmospheric model state towards an observed state (e.g. reanalysis data) for an isolated part of the atmosphere (Jung et al., 2010). While it has successfully demonstrated its potential in numerous studies of anomalous winter circulation over Europe, the relaxation technique has not been widely used to study the summer circulation. This project will make use of the availability of new relaxation code for the coupled ECMWF model IFS/NEMO which can be applied for seasonal forecasting sensitivity experiments. The new code includes relaxation to humidity-related variables like specific humidity, specific ice water content, specific liquid water content and cloud cover.

We plan to perform relaxation experiments with the coupled ECMWF system CY41R1 with horizontal resolution T255 and 60 vertical levels (similar to a development version of the model towards the new System 5) on monthly and seasonal time scales. In one set of experiments the model will be nudged towards reanalysis in the tropical belt over the 35-year hindcast period 1981-2015 for May start dates to study the systematic impact the tropics have on the circulation over Europe during summer. The experiment will be run as an ensemble with a size of 51 members to reach high levels of statistical confidence. These initial experiments should give us a good indication of the potential for midlatitude seasonal forecast improvement that could result from improved forecast skill of (boreal) summertime tropical processes.

Preliminary analysis of the System-4 seasonal forecasts (see Figure 1) suggests that the circulation response over Europe is overly sensitive to tropical heating anomalies in some regions (compared to reanalysis), whilst responding too weakly in other regions. To investigate the source of forecast error and potential predictability we plan to run a series of localised tropical relaxation experiments over the Sahel region, the Indian Monsoon region, the Caribbean region and the tropical Pacific. These experiments will enable us to quantify the relative importance of these different tropical regions, as well as estimate the potential for forecast improvement by correctly representing each of these individual regions.

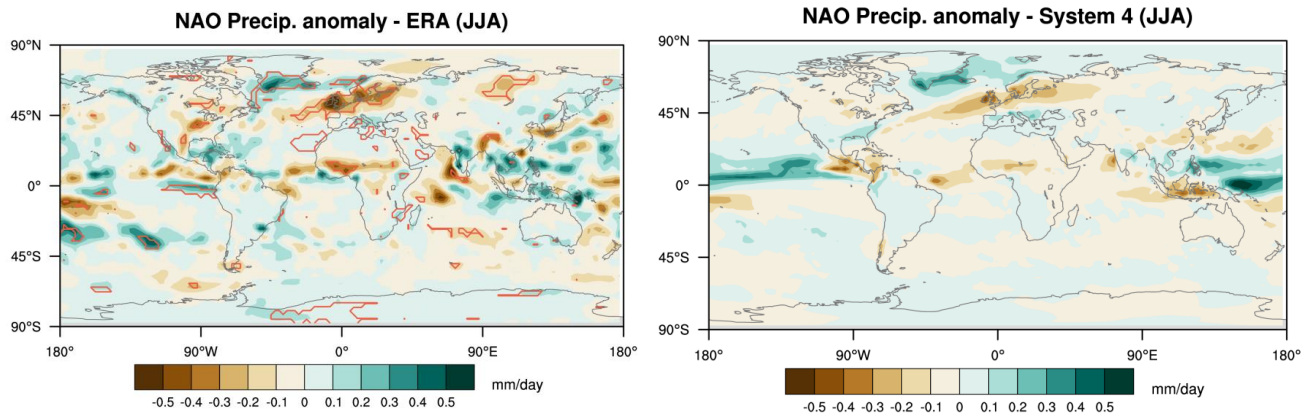

Figure 1: Left panel, precipitation anomalies regressed onto the normalised summer (JJA) North Atlantic Oscillation (NAO) defined using the ERA-Interim reanalysis (1981-2010), anomalies significant at the 95% threshold are outlined in red contours. Right panel, as in the left panel but for a synthetic NAO timeseries determined by projecting the ERA-Interim summer NAO pattern onto the JJA SLP anomalies of all 51 ensemble members in the System-4 hindcast period (1981-2010). Interesting regions include the Sahel region, the Indian monsoon region and the structure in the tropical Pacific. Precipitation anomalies along the tropical Pacific appear to project strongly onto the summer NAO in System-4, whereas no such structure is seen in ERA-Interim.

A second experiment will use a similar configuration of the model and experimental design but instead of the tropics the Arctic region will be used as a relaxation area with the view to investigate the role of sea ice and related atmospheric variables.

Using the relaxation technique we also plan to analyse individual seasonal case studies, to further test the influence of remote drivers, in a few of the more extreme seasons during the hindcast period. For example, Cassou et al. (2005) suggested a Rossby wave train originating in the tropical Atlantic contributed to the quasi-stationary wave pattern of the 2003 European heatwave. By relaxing the model towards the observed state of the atmosphere in the tropical Atlantic this hypothesis can be tested in a state-of-the-art seasonal forecasting model.

The team has extensive experience in running relaxation experiments of the coupled ECMWF system. We have previously performed a number of relaxation experiments for the anomalous NH winter 2013/14 as part of a different project (Watson et al., *in preparation*).

List of proposed experiments:

1. Relaxation of the entire tropical belt (20°S – 20°N)
2. Relaxation of the Sahel region
3. Relaxation of the Indian monsoon region
4. Relaxation of the Caribbean region
5. Relaxation of the tropical Pacific region
6. Relaxation of the Arctic

Timeline:

2016: Experiments 1 and 6

2017: Experiments 2 and 3

2018: Experiments 4 and 5

This project will be undertaken as part of the 4-year NERC-funded project SummerTIME (Summer: Testing Influences and Mechanisms for Europe), which the PI is working on. SummerTIME is a project focussed on an improved understanding of the summertime circulation and its predictability over the Euro-Atlantic sector. The project involves collaboration with scientists at the University of Reading and is supported by both ECMWF (Franco Molteni) and the Met Office.

Technical Requirements

It is planned to perform these monthly-to-seasonal relaxation hindcasts with the IFS atmospheric model in CY41R1 at a horizontal resolution T255 with 60 vertical levels (to match the nudging ERA-I vertical resolution). The proposed size of the ensemble is 51 members in accordance with both the operational forecast and System 4 hindcast ensemble size. This relative large size of the ensemble is especially important to detect signals in situations where the signal-to-noise ratio is potentially small, e.g. in Europe. Forecasts with a lead time of 4 months will be started every 1st of May over the period 1981-2015 so that they cover the main meteorological summer season for Europe (JJA).

The required resources for the proposed experimentation are estimated as follows:

Costs for one individual model run over one month with Cy41R1 without relaxation are:

- ~ 750 SBU

Total costs for 4 forecast months * 35 hindcast years * 51 ensemble members:

- ~ 5,355,000 SBU

The previous relaxation experiments mentioned above have were performed on the old IBM supercomputer. At the moment, we do not have any confirmed numbers of the additional SBU requirements due to the relaxation part of the code for CY41R1 yet but based on past experience we estimate this additional effect to be approx. 10%. Total costs for one set of relaxation experiment will thus be estimated to approx. 6,000,000 SBU.

Costs of proposed experiments:

1. Relaxation of the entire tropical belt: 6,000,000 SBU (in 2016)
2. Relaxation of the Sahel region: 6,000,000 SBU (in 2017)
3. Relaxation of the Indian monsoon region: 6,000,000 SBU (in 2017)
4. Relaxation of the Caribbean region: 6,000,000 SBU (in 2018)
5. Relaxation of the tropical Pacific region: 6,000,000 SBU (in 2018)
6. Relaxation of the Arctic: 6,000,000 SBU (in 2016)

The data storage requirements are estimated based on previous project data.

References

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