REQUEST FOR A SPECIAL PROJECT 2015–2017

MEMBER STATE: UK

Principal Investigator[1]**:** Warwick Norton

Affiliation: City Financial Investment Company Ltd (CFIC)

Address: 62 Queen Street

London EC4R 1EB

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E-mail: warwick.norton@cityfinancial.co.uk

Other researchers: Dan Rowlands (CFIC), Antje Weisheimer (University of Oxford), Tim Palmer (University of Oxford), Adam Scaife (Met Office), Alberto Arribas (Met Office)

Project Title: Attributing predictable signals at subseasonal timescales to tropical forcing and surface boundary conditions

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ________________	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2015	
Would you accept support for 1 year only, if necessary?	YES X	NO

Computer resources required for 2015-2017: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2017.)	**2015**	**2016**	**2017**
High Performance Computing Facility (units)	10 million	11 million	11 million
Data storage capacity (total archive volume) (gigabytes)	12000	12000	12000

*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): 13/6/2014

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 an annual progress report of the project's activities, etc.

Principal Investigator: Warwick Norton

Project Title: Attributing predictable signals at subseasonal timescales to tropical forcing and surface boundary conditions

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.

Introduction

There has been considerable recent interest in the strong monthly to seasonal weather anomalies that have occurred over the last few years (e.g. Met Office, 2014a). A key question is whether these events fit into natural variability or if there is connection to our changing climate.

Analysis of the performance of the ECMWF monthly forecasting system shows that many of these events have had extended range predictability (Figure 1). For example: the European cold spells in February 2010, December 2010 and January 2013; the European mild, wet & windy period (and the cold in the USA) in January-February 2014; the Russian heat wave of July/August 2010 (see Ghelli et al., 2010). Figure 1 shows there is significant variability in forecast skill on subseasonal to interannual timescales (e.g. 2010 & 2011 have overall better skill than 2012). Thorpe et al. (2013) discuss this drop in skill in 2012 in shorter-range HRES and ERA-interim forecasts (Vitart et al., 2013, also discuss the monthly forecasts) and they interpret this variability in forecast skill (as measured by anomaly correlation) as changes in the potential predictability of the atmosphere. Langland & Maue (2012) suggest the high skill in winter 2010 & 2011 is associated with the strong negative phase of the Arctic Oscillation (AO).

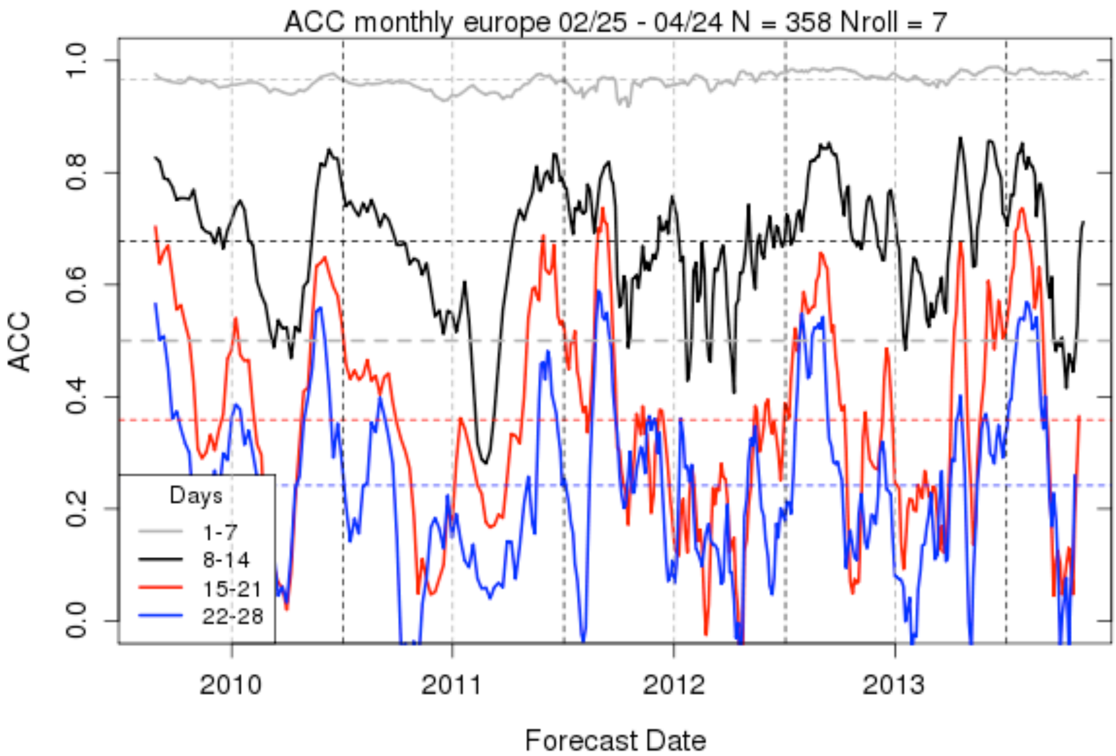

Figure 1 Anomaly correlation of 500 hPa geopotential height over the Atlantic-European sector (90W to 60E, 20 to 90N) from the ECMWF monthly forecast system (ensemble mean).

It is informative to examine the mean seasonal cycle in forecast skill (Figure 2) to understand which processes might be important in producing these enhanced periods of predictability. Figure 2 shows clear peaks in skill for weeks 3 & 4 in late winter but also a smaller secondary peak in mid-summer, these are both consistent with results from the monthly hindcasts which cover a much greater range of years. Possible processes that could be important include: in winter, more persistent circulation anomalies (e.g. the AO/NAO), teleconnections from the tropics (including but not only the MJO), the influence of the stratosphere; in summer, the Indian monsoon and the impact of land surface anomalies. However as yet there have been only limited studies of the underlying causes of these periods of enhanced predictability (modeling studies include: Jung et al., 2011, on the cold February 2010; Vitart et al., 2014a, on the cold March 2013) and some discussions have been mostly descriptive (e.g. Met Office, 2014b, on January-February 2014).

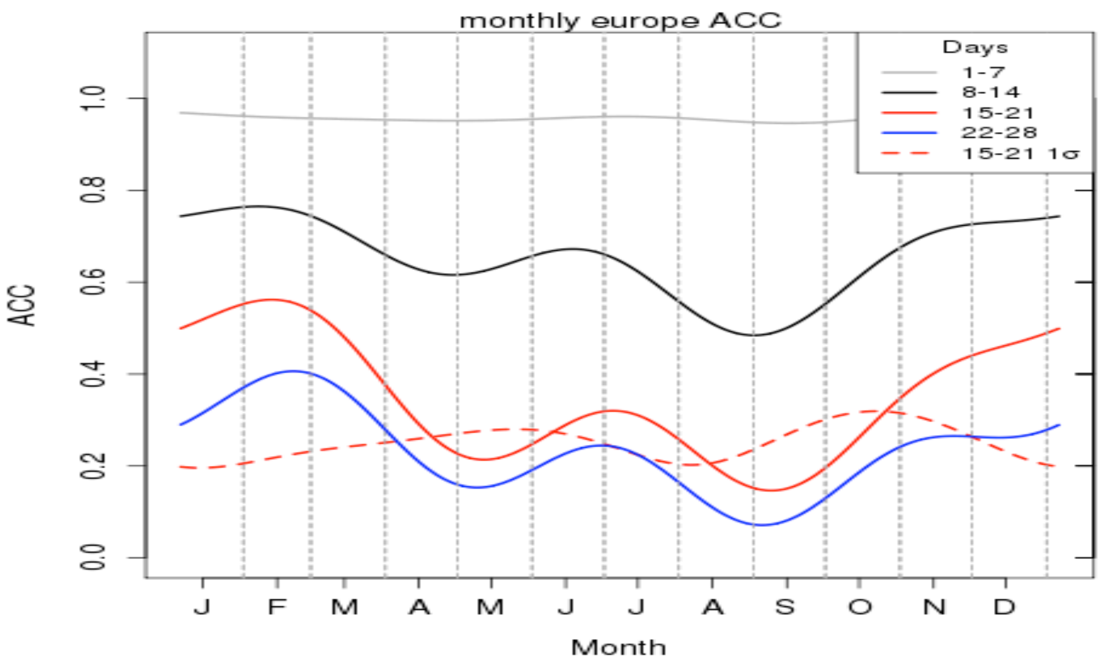

Figure 2 Smoothed seasonal cycle of the anomaly correlation in Figure 1 as a function of forecast start date. Dashed line is 1-std estimate of the interannual-variability of days 15-21.

This introduction indicates there is a strong need for a semi-operational system where the drivers and predictability of strong monthly to seasonal weather anomalies are assessed on a routine basis. This will increase the scientific and also public understanding of current weather. This increased understanding will enable better use of monthly to seasonal forecasts. It will also help to inform the debate around what role (and by what process) these strong anomalies play in climate change (e.g. the attribution system developed by the EUCLEIA project). For example Palmer (2014) makes a link between the warming of the tropical west Pacific SSTs and a teleconnection to North America which potentially drove the very cold winter in 2013/14.

Primary Project Objective

- Routine attribution of potentially predictable signals on subseasonal timescales (weeks 3-6).

Secondary Project Objectives

- Establishing case studies that could be used for testing model improvements.
- Suggesting areas where model improvements might increase predictive skill.

The aims of this project address the main goal of the joint WWRP/THORPEX-WCRP Sub-Seasonal to Seasonal Prediction Project (S2S) namely to improve forecast skill and understanding on the sub-seasonal to seasonal timescale.

Methodology

We propose to run a set of experiments using weekly start dates of the monthly forecast system where the tropics and surface (SSTs and sea ice) are either set to analysed values for the forecast period (for the tropics this will be through relaxation) or sampled from analysed values from the previous 20 years.

A matrix of experiments will be run:

1. The tropics and surface are sampled from the previous 20 years (the tropics and SSTs will be from the same year). This will test if any predictable signals emerge purely from the initial conditions in the extratropical atmosphere (this could include the stratosphere).
2. The tropics are set to the current year while the surface is sampled from the previous 20 years. This will test if any predictable signals emerge from tropical forcing.
3. The tropics are sampled from the previous 20 years while the surface is set to the current year. This will test if any predictable signals emerge from surface forcing.
4. The tropics and surface are set to the current year. This will test if any predictable signals emerge from a combination of tropical and surface forcing (it is possible that surface forcing, e.g. extratropical SSTs or SST gradients, only have a significant impact when reinforcing or modifying tropical teleconnections).
5. The tropics and surface are set to the current year while the initial conditions are sampled from the previous 20 years. This is a consistency check with experiment 1.
6. Experiment 4 is repeated with also soil moisture set to the current year.

Sampling a historical distribution of SSTs and tropical forcing is preferable to running experiments with mean climatological SSTs and tropical forcing given the likely non-linearity of the model response. For example with mean climatological tropical fields there would be no MJO.

In all experiments an ensemble size of 40 will be run using (apart from experiment 5) 40 of the initial conditions from relevant monthly forecast. In experiments 1-3, each of the 20 historical years will be used for 2 ensemble members of surface and/or tropics. In experiment 5, each of the 20 historical years will be used for the initial conditions for 2 ensemble members. In addition an 11 member hindcast will be run for the previous 20 years where the tropics and surface are set to analysed values to establish the climatology of this model for use in calculating anomalies.

Cases 1-5 will assess any non-linearity that may occur from the combination of the tropical forcing and surface boundary conditions. However not all experiments might always be run – this will be tested in the initial case studies.

There is conflicting evidence as to how sensitive the extratropical predictability is to the atmospheric initial conditions. Some studies e.g. Simpson et al. (2010) show the response to stratospheric anomalies is dependent on the tropospheric atmospheric state, while others e.g. Vitart (pers. comm.) show that the response to the MJO in March 2013 (in producing the cold for Europe) is insensitive to the atmospheric initial state. Hence in order to obtain a more comprehensive understanding of the response to driving factors, model experiments with a range of initial conditions will be performed. Therefore the experiments will be run once per week from monthly forecast start dates.

Note we consider atmospheric extratropical relaxation experiments too unrealistic as it relaxes the model towards the flow structure that we are trying to understand the predictability of.

Model Configuration

Model experiments will use the atmospheric component of the monthly forecast system at T255L91 (with no resolution changat day 10). We believe this lower resolution than the operational model is a realistic compromise since we have observed similar behaviors across a range of models (often at lower resolution), suggesting the predictability is more of an inherent property of the atmosphere rather than being resolution dependent. For example Figure 3 shows 14 day rolling average of the 13-15 day anomaly correlation from the ECMWF (red) and NCEP (blue) ensembles over the last 9 months. The ECMWF ensembles clearly have higher skill (average of nearly 0.5) compared to NCEP (around 0.4, note the greater ensemble size of the ECMWF ensemble will have some impact on this score) but the periods of high and low skill are remarkably similar between the two models (see also the analysis by Langland & Maue, 2012, who examined ECMWF, GFS and NOGAPS deterministic forecasts). One possible explanation of this result is from the Minerva experiment, which suggests increased horizontal resolution does not materially improve teleconnections from the MJO (Vitart, 2014b).

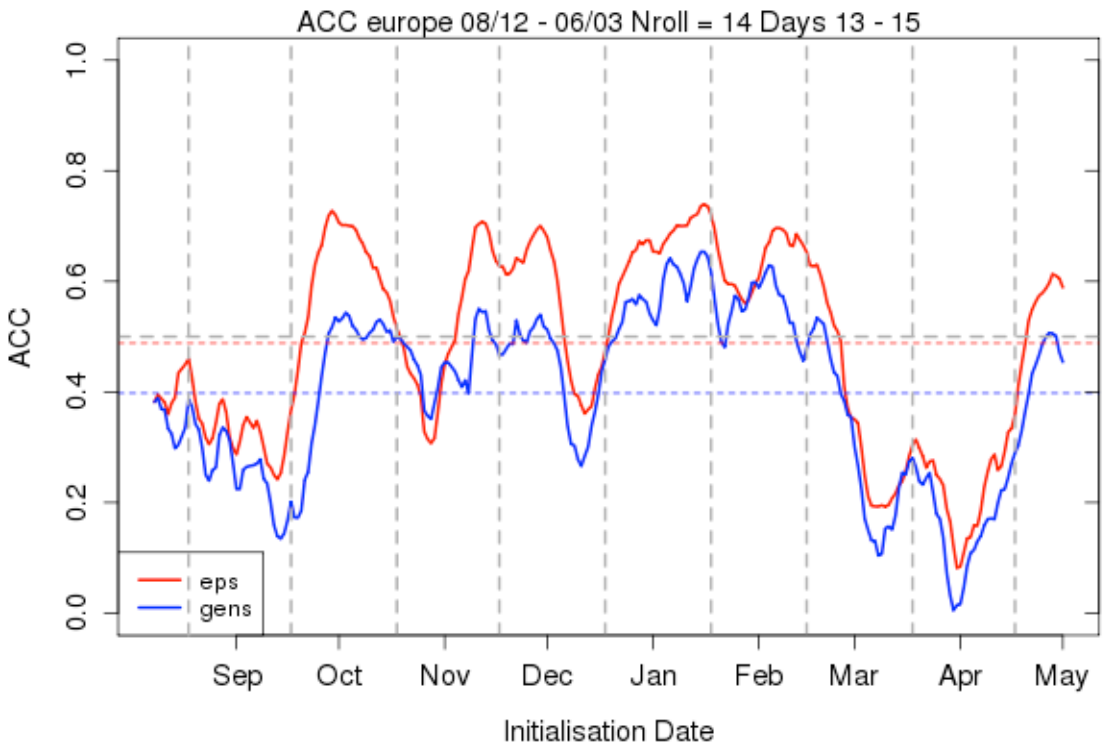

Figure 3 Anomaly correlation of 500 hPa geopotential height over the Atlantic-European sector (90W to 60E, 20 to 90N) from the ECMWF (red) and NCEP (blue) ensembles for days 13-15 for the period August 2013 to June 2014.

Initial case studies

To refine the methodology we will initially examine some recent cases where there is evidence of extended range predictability. Vitart et al. (2014a) used relaxation of the tropics to explain the cold wave over Europe in the March 2013. Further recent case studies could include:

1. The warm to cold transition from December 2012 to January 2013

   Both a stratospheric warming and the MJO were potentially important. This event was poorly simulated by the monthly forecasts in late December.

2. The cool to hot transition from June to July (2013)

   July 2013 was notable for being high pressure dominated. We will investigate if this can be reproduced in extended range forecasts as possibly implied by the summer peak in skill.

3. The persistent stormy period from December 2013 to February 2014

   This period was remarkable for the SW to NE track of low pressure systems through the UK. The period was also extremely cold in the US. The monthly forecast did a good job in capturing the overall +ve NAO anomaly (see Figure 4, top panels are composite week 1 forecasts for weeks between 25 November and 17 March, bottom panels are the same period from week 4 forecasts). However there are important errors in the week 4 forecast – the low pressure centre to the south of Iceland is missing, the ridging on the west coast of the US is too far west and the US is far too warm.

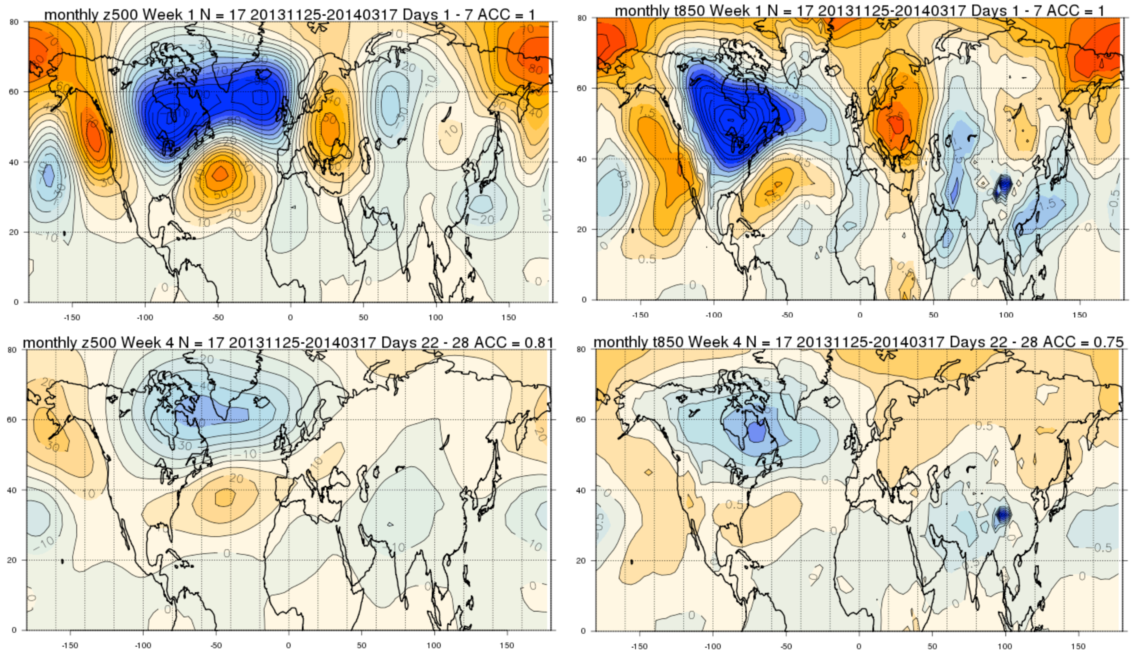

Figure 4 Week 1 forecasts for 25 November to 17 March (top), Week 4 forecasts (bottom), 500 hPa geopotential height anomalies (left), 850 hPa temperature anomalies (right).

This pattern of errors was even more pronounced in the System 4 seasonal forecast from 1 January. Potentially the tropical west Pacific convection, stratosphere (the westerlies were record strength in December), Atlantic and Pacific SSTs (e.g. SSTs in Gulf of Alaska were warm by 5 standard deviations) were all important in forcing this period.

Project timeline and computer resources

Year 1

The first 6 months will be used in setting up the model integrations and performing tests on the initial case studies. A single 32 day ensemble member at T255L91 requires 600 SBUs. In this period we envisage running from around 9 start dates.

At month 6 we will start the routine weekly runs of the experiments. This is a total of 240 ensemble members per week. In addition there are 220 hindcast ensemble members per week. The model version used in the project will be fixed so we require 1 year (52 weeks) of hindcasts to be run in total (26 of these will be run in year 1 and 26 in year 2). In years 2 & 3 we will use the hindcast with closest calendar date for calculating anomalies.

Total SBU year 1 (35 start dates x 460 ensemble members) = 10 million

Year 2

In the first 6 months all hindcast start dates will be completed. Forecast experiments continue throughout the year.

Total SBU year 2 (52 start dates x 240 ensemble members, 26 hindcast start dates x 220 ensemble members) = 11 million

Year 3

Forecast experiments continue throughout the year. Depending on the model results, some integrations and hindcasts will be extended to 45 days.

Total SBU year 3 (52 start dates x 240 ensemble members, 26 start dates x 460 ensemble members for days 32-45) = 11 million

Role of participants

CFIC will lead the project and run the model experiments. Oxford and the Met Office will help to analyse the experiments and will lead dissemination of the project results. We will also collaborate with the monthly forecasting team at ECMWF who we have discussed the proposal with.

References

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