REQUEST FOR A SPECIAL PROJECT 2018

MEMBER STATE: UK

Principal Investigator[1]: Warwick Norton

Affiliation: Citadel LLC

Address: 120 London Wall
London EC2Y 5ET

E-mail: warwick.norton@citadel.com

Other researchers: Dan Rowlands (Citadel)
Ann Shelly (Citadel)
Jason Beech-Brandt (Citadel)
Antje Weisheimer (University of Oxford)

Project Title: Attributing predictable signals at subseasonal timescales

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP**GBNORT	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2018	
Would you accept support for 1 year only, if necessary?	YES	

Computer resources required for 2018-2020: (To make changes to an existing project please submit an amended version of the original form.)		**2019**	**2020**	**2021**
High Performance Computing Facility	(SBU)	40 million		
Accumulated data storage (total archive volume)[2]	(GB)	10000		

***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): 28 June 2018

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.
[2] 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.

Principal Investigator: Warwick Norton

Project Title:

Attributing predictable signals at subseasonal timescales

Extended abstract

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used.

Requests asking for 1,000,000 SBUs or more should be more detailed (3-5 pages).

Following submission by the relevant Member State the Special Project requests will be evaluated by ECMWF as well as the Scientific and Technical Advisory Committees. The evaluation of the requests is based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, disciplinary relevance, and justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Large requests asking for 10,000,000 SBUs or more will receive a detailed review by members of the Scientific Advisory Committee.

All accepted project requests will be published on the ECMWF website.

Introduction

This proposal was submitted last year and was granted a 40 million SBU allocation over 1 year. However we have been unable to perform the work as ERA5 (back to 1979) has been delayed from intended release date of May 2018 to now end of 2018. In testing 43r3 initialised from ERA5 we only used 30 thousand of the SBU allocation.

We believe there is an even more compelling case for the proposal now as current Atlantic SSTs have switched to –ve AMO not seen since 1994. So to put current European predictability in context with previous years requires a hindcast period significantly longer than the 20 years used by the operational monthly forecasting system.

Background for 1 year extension of previous special project

We largely achieved the primary object of our previous special project "routine attribution of potentially predictable signals on subseasonal timescales (weeks 3-6)" by performing a matrix of experiments over the 2015/16 & 2016/17 winters (for a selection of results please see our final report).

These two winters provide a very interesting contrast in which to assess subseasonal predictability between the strong seasonal signal in the El Nino winter of 2015/16 and the weak seasonal signals of 2016/17. To put this in context, Figure 1 shows that the mean wintertime NAO for 2016/17 had its smallest amplitude since the early 2000s, with the period 2003-2015 having large excursions of both +ve and –ve NAO. Also apparent in Figure 1 is another predominantly high amplitude period of the NAO from 1988-1995 (this period was strongly +ve NAO except for 1995 which coincided with the AMO switching from –ve to +ve phase).

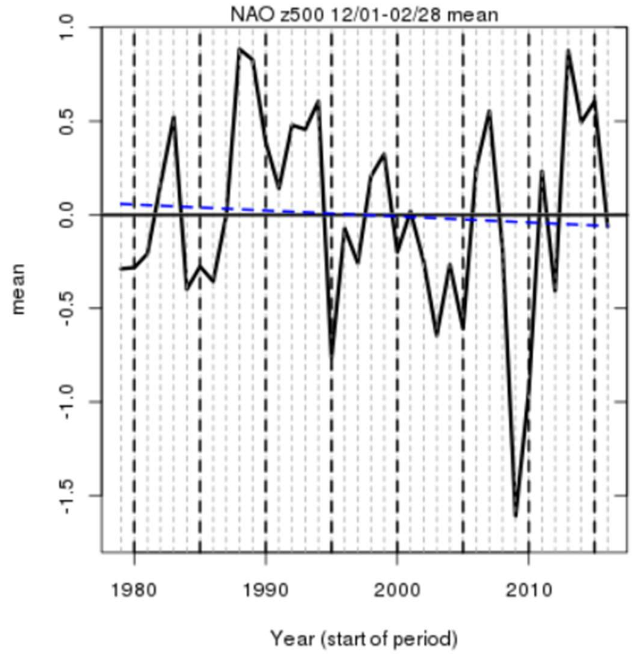

Figure 1. Mean winter (DJF) NAO (1979-2016) from Era-Interim based on z500 pattern index.

The winter of 2016/17 was also notable for the very poor predictability of the NAO in the subseasonal range. Indeed Figure 2 shows that the ECMWF monthly forecast had negative skill in predicting the NAO in week 4. What is apparent from comparing Figures 1&2 is that the recent period high amplitude period of the NAO since 2003 was also more predictable, both in terms of the seasonal and subseasonal signals (albeit the stronger seasonal signals appear to be the larger factor).

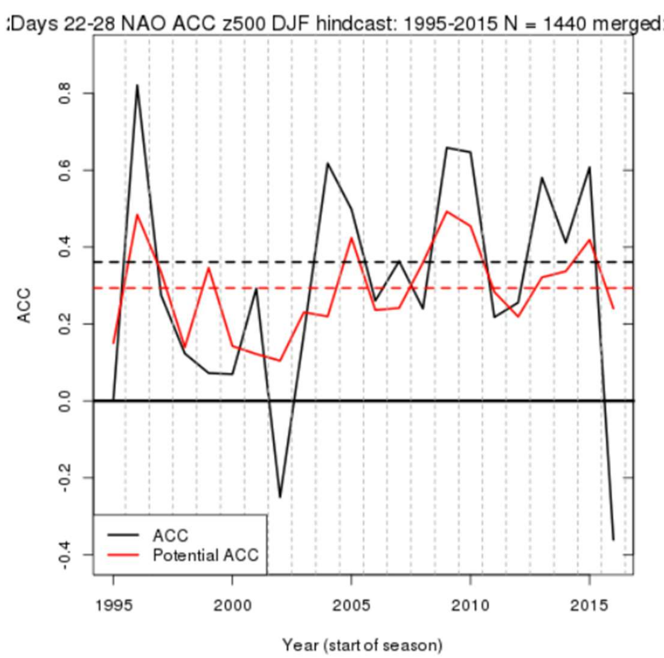

Figure 2. Week 4 NAO anomaly correlation (black) and potential anomaly correlation (red) from the ECMWF monthly forecasts/hindcasts for forecasts verifying in DJF (1995-2016).

Recent work by Weisheimer et al (2017) and O'Reilly et al (2017) found in very long seasonal integrations (1900-2009) that the period 1950 to the 1970s had relatively low seasonal skill of both the NAO and PNA compared to recent decades. They found that this was predominantly associated with –ve PNA winters when the atmosphere appeared to have weak coupling with tropical Pacific SSTs. This result is worth comparing to 2016/17 which was also predominantly –ve PNA. Our analysis in our previous Special Project shows this was partly due to the unpredictability of the tropics but there was also a contribution from a systematic underestimate of precipitation around the maritime continent in of the ECMWF model which meant the longer range signals (week 4+) tended to have the PNA having the opposite sign to the real world.

A further interesting feature in Figure 2 is that for many years the actual predictability of the NAO is higher than the potential predictability (where truth is taken from one of the ensemble members rather than the observed NAO). This implies the model forecast is under confident in years where there is a predictable signal. This result was first found in seasonal hindcasts of GLOSEA5 by Scaife et al (2014) where correlation skill is higher than would be expected from the model signal-to-noise ratio (see also Eade et al, 2014), but it appears to be a ubiquitous feature across a range of models and timescales (from week 2 to decadal). For example Figure 3 shows for the operational ENS (from 2010 to 2015) that the actual predictability of the wintertime NAO exceeds the potential predictability by around a factor of 1.2 at day 15 (we refer to this factor as beta, the factor by which the ensemble mean signals should be scaled).

The under prediction of the NAO has been called “The northern hemisphere winter predictability conundrum” (Tim Stockdale, ECMWF). It clearly is an important scientific question as to why it arises and has practical implications for users (like Citadel) of subseasonal to seasonal forecasts and the wider community as it suggests current operational systems are underestimating the amount of real world predictability in some quantities.

Conversely forecasts of the PNA appear not to suffer from this problem, although results from our previous Special Project suggest this may be from offsetting contributions of over-confident tropical convection forecasts versus under-confident teleconnections, which as of yet has not been addressed in the published literature.

In our previous Special Project we obtained detailed knowledge of the predictability for two winters. However given the interannual (and possibly longer timescale variability) of the predictability shown in Figure 2 and the seasonal predictability results of Weisheimer et al (2017) and O’Reilly et al (2017), there is a strong scientific case to assess the subseasonal predictability (including beta) over a much wider range of years. This is of particular current interest as Atlantic sea surface temperatures have significantly cooled during 2018 and it seems likely the AMO has switched by to a –ve phase (the AMO was negative previously prior to 1995).

Furthermore in our previous Special Project we have performed an 11 member hindcast over 20 years, but this is of limited use (except to provide a climatology) as the sampling noise on the NAO mean is ~50% by day 30 (see Figure 4) which makes the estimation of skill for low signal-to-noise ratio sub-seasonal forecasts problematic.

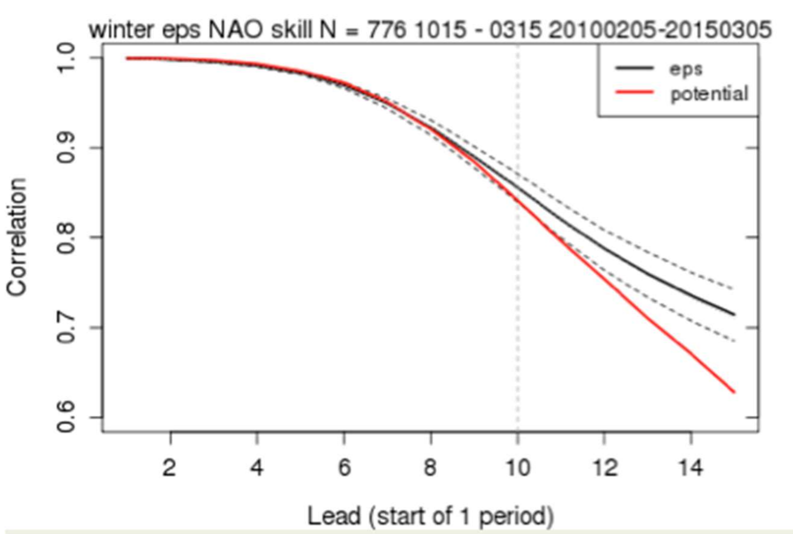

Figure 3. NAO anomaly correlation (black) and potential anomaly correlation (red) from the operational ENS as a function of lead time for winter months (November-March) over Feb 2010 to March 2015.

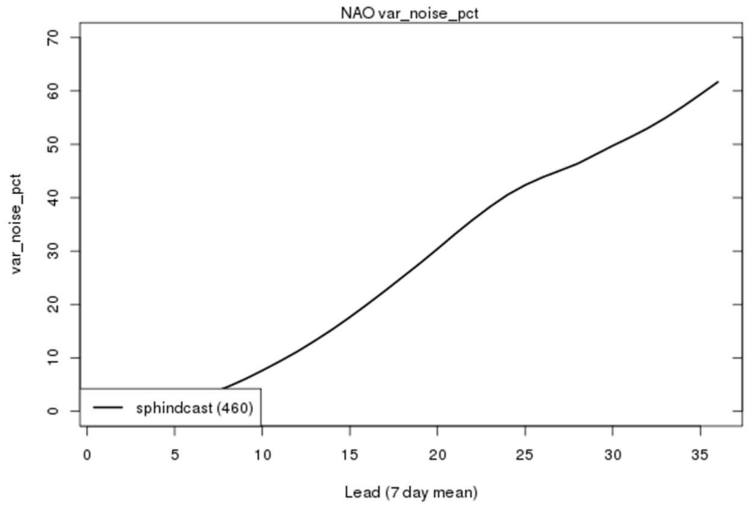

Figure 4. Percentage of signal variance in NAO ensemble mean forecasts attributable to sampling noise from 11-member hindcast ensembles as a function of lead time. By week 6 over half the signal variance arises from influence of the small ensemble size.

Extended monthly hindcasts

We propose an extension of our previous Special Project where we will perform extended hindcast experiments over 1979-2016 (38 years) with a 37 member ensemble. We propose using ERA5 instead of ERA-interim (as used in our previous Special Project) as this will give a more accurate analysis of the tropical atmosphere. The period 1979-2016 is due to be completed for ERA5 by late 2018. Furthermore it could enable us to keep the experiments up to date and extend the experiments back before 1979 (when those years become available in ERA5).

As in our current Special project we will perform 3 sets of experiments:

1. Control runs initialized from ERA5 with observed SSTs.

2. As in 1 with the addition that the 15N-15S band is relaxed to ERA5 tropical fields.

3. As in 2 except the initial conditions to form the ensemble are taken from the other 37 years of ERA5 while the tropical relaxation is taken from the correct year.

Hence experiment 2 includes the role of the initial conditions and perfect knowledge of the deep tropics, while experiment 3 has no knowledge of the initial conditions and skill only comes from the tropics. Note the results of experiment 3 can be reordered to determine the role of the initial conditions with no knowledge of the tropics (i.e. the tropics are taken from the other 37 years of ERA5).

For each year, the experiments will start once a week from 20 October to 15 February (so 9 start dates per year). The runs will be for a duration of 4 weeks (28 days) at TL255L137 and we intend to use a recent version of the ECMWF model (e.g. 43r3). Even though the horizontal resolution is significantly lower than the operational monthly forecast, we have not noticed a significant difference in skill at day 20+ between the control experiment in the previous Special Project (at TL255L60) and the operational monthly (and the key for this project is to understand the relative skill between different years). It is recommended (Linus Magnusson, ECMWF) that the model uses the same number of vertical levels as in the analysis used for relaxation (hence using L137 as in ERA5).

Objectives

We expect to address the following points with the extended set of monthly hindcasts:

- Examine interannual variability in predicting the NAO & PNA at week 3+ particularly to determine how unusual the poor skill of 2016/17 is?

- Was the strong +ve NAO period 1988-1994 forced from the tropics?

- Are years with poor NAO skill because seasonal NAO signals are weak or are there linkages to the predictability of the Pacific via the PNA? O'Reilly et al (2017) suggested it is internal mid-latitude variability in –ve PNA years which leads to poor skill but could it also be poor simulation or predictability of the tropical convection relative to the underling SSTs?

- How much predictability of the NAO comes from the tropics v the initial conditions (which includes the stratosphere)? This can be assessed from experiment 3. The relative skill of these experiments may suggest improvements in how operational sub-seasonal forecasts are run (for example if results from experiment 3 are more skilful than experiment 2, it suggests the extra-tropical initial conditions maybe distorting the predictable signals coming out of the tropics).

- What is the role of the tropics and the initial conditions in the NAO under prediction conundrum? Results from the special project suggest the NAO under prediction exists in relaxed runs (experiment 2 type runs), so the issue is not coming from tropical convection forecasts per-se, although we are unable to confidently confirm this given the issues discussed above on sampling noise.

- Identify the mechanism(s) generating errors in the model teleconnections from the tropics and develop subsequent diagnostics that can be used in the evaluation of new model versions.

- Results from this project could serve as input to scientific decisions on how future generations of the operational hindcasts are designed (e.g. ensemble size versus number of years for skill estimation).

Computer Resources

A single ensemble member of a control experiment (TL255L137) takes around 800 SBU while a tropical relaxed run takes around 1100 SBU. In both cases setting up/archiving an ensemble run take a further 2000 SBU. Hence experiments 1 will take around 11 million SBU and experiments 2 & 3 around 14 million SBU each.

References

Eade, R., *et al* (2014), Do seasonal-to-decadal climate predictions underestimate the predictability of the real world? *Geophys. Res. Letts*, 41, 5620-5628.

O'Reilly, C., *et al* (2017), Variability in seasonal forecast skill of Northern Hemisphere winters over the 20th century, *Geophys. Res. Letts,* 44, 5729-5738.

Scaife, A. A., *et al.* (2014), Skilful long range prediction of European and North American winters, *Geophys. Res. Letts.,* 41, 2514–1519.

Weisheimer, A., *et al* (2017), Atmospheric seasonal forecasts of the twentieth century: multi-decadal variability in predictive skill of the winter North Atlantic Oscillation (NAO) and their potential value for extreme event attribution, *Q. J. R. Meteorol. Soc.,* 143, 917-926.