C20C project on the summer North Atlantic Oscillation (SNAO)

Hans W. Linderholm[1] ,Chris Folland[1, 2] and Jee-Hoon Jeong[1]

[1]Regional Climate Group, Department of Earth Sciences, University of Gothenburg, Gothenburg, Sweden
[2]Met Office Hadley Centre for Climate Change, Exeter, UK

This document provides a brief description of the plan for the C20C SNAO project, as discussed at the 5th C20C Workshop. The primary purpose of the project is to make detailed analyses of the pattern, seasonal predictability and impacts of SNAO simulated from multi-models within the C20C community, links with tropical forcing, especially the West African monsoon, and compare these to reanalysis data. To assess the character and forcing of the SNAO in a decadal to century perspective, we will also view it from a paleoclimate perspective, utilizing annually resolved climate proxies of the SNAO and the Atlantic Multidecadal Oscillation (Chylek et al, 2011, 2012) over as long a period as possible.

1. Background

Summer climate in the North Atlantic-European sector possesses a principal pattern of year-to-year variability similar to the North Atlantic Oscillation in winter. This 'Summer North Atlantic Oscillation' (SNAO) is defined as the first EOF of July-August extratropical North Atlantic pressure at mean sea level. We will explore whether a definition over June-August is preferable and whether there is a significant intraseasonal variation in the SNAO pattern. The SNAO exerts a strong influence on European climate, e.g. rainfall, temperature and cloudiness, but is also associated to climate variability elsewhere, e.g. eastern North America, the Sahel region in Africa and eastern Asia (*Folland et al. 2009; Linderholm et al. 2011*). Moreover, modelling and observational results indicate that SNAO variations are partly related to the Atlantic Multidecadal Oscillation (AMO) on interdecadal time scales (Knight et al, 2006, Folland et al, 2009).

Observational evidence and modeling studies suggested that melting sea ice causes significant change in the large-scale circulation in the Northern Hemisphere of which pattern resembles the Atlantic/Arctic Oscillation (NAO/AO) in winter and quite like the AO/SNAO in summer (Balmaseda et al, 2010), though the SNAO was not explicitly named in that paper. By reducing the meridional temperature gradient, reduced sea ice in the Arctic is known to induce negative NAO/AO-like anomalies (*Alexander et al. 2004; Deser et al. 2007*). Compared to winter, however, the warm season response of large-scale atmospheric circulation is much less studied but no less potentially important.

2. Progress since the 5th Workshop in October 2010

Since the Beijing workshop, progress has been made in the following topics:

- A paper discussing SNAO links with the East Asian summer monsoon was published (*Linderholm et al. 2011*). An additional study, looking at the SNAO-East Asian climate over the last 400 years (using tree-ring data) has been submitted (*Linderholm et al. in review*).

Posters were presented WCRP Open Science Conference in October 2011 at the C20C cluster in session C34: Global Model Evaluation and Projections: CMIP5 and Other Model Intercomparisons: (a) "*The Summer North Atlantic Oscillation"* (b) "*C20C-Climate of the 20th Century: Interannual teleconnections between the summer North Atlantic Oscillation and the East Asian summer monsoon*"

3. Plans and expected results over the next 12 months

3.1. Identifying the SNAO pattern and its impact in C20C models

Commencing in spring 2012, we will start analyzing participating C20C AGCM models with focus on evaluating the SNAO pattern simulated by individual members. Our aim is to use at least 10 models and a total ensemble size exceeding 50 especially from 1950. Here we will examine composite maps for SAT, precipitation, and storm tracks from the different model, to evaluate the impacts of SNAO on different regions (including East Asia) varies between models. This will be compared with observations. We will also include coupled models where available. This will include a version of the new high vertical and horizontal resolution HadGEM3 model, designed to be used in future operational Met Office seasonal forecasts

3.2. SNAO and Arctic sea ice

We will investigate the general response of SNAO to melting sea ice. In addition to observational analysis, the physical association between the Arctic sea ice and SNAO will be examined by performing global climate model (GCM) experiments with/without feedbacks from melting sea ice and associated sea surface temperature (SST) changes. The general sensitivity of the SNAO polarity and amplitude with respect to the degree of melting sea ice, underlying physical mechanisms, whether these responses are linear or nonlinear, will be investigated. Detailed analysis will include:

i) the statistical coherence between the SNAO and melting sea ice, including spatiotemporal co-relationships
ii) quantification of the sensitivity of the SNAO to sea ice extent variability using

A. Reanalyses and observation data
B. C20C simulations
C. Additional AGCM experiments*: ensemble sensitivity simulations of CAM3 with reduced Arctic sea ice (0 to 200% gradually) and increasing SSTs over Arctic (0 to 200% gradually, north of 60N).
D. Later in the project, coupled models where available, particularly HadGEM3

The connections between sea ice and SNAO will be further assessed from long-term proxy records

3.3. SNAO and East Asian Climate

In addition to the results to be obtained in 3.1., in collaboration with the Lamont-Doherty Earth Observatory, University of Columbia, US, we will investigate the SNAO-East Asia connection, focusing on Mongolia (a “hot spot” in terms of associations with the SNAO in the region) in a long-term perspective using tree-ring data. One PhD student from the University of Gothenburg will go to the USA in May to work on that. The focus of this study will be to explore the influence of the SNAO on regional climate in Mongolia.

In May 2012 Professor Chris Folland, Professor Hans Linderholm, Dr Jianqi Sun and others will meet up for a week at the University of Gothenburg to work on the SNAO and related projects. During this time we will work on or plan publications related to the above topics to be submitted in 2012-13.

4. People/groups contributing, or firmly expected to contribute to, the sub-project

Presently scientists from the following research environments are involved in the project:
- *Regional Climate Group, University of Gothenburg, Sweden*
- *Met Office Hadley Centre for Climate Change, UK*
- *Institute of Atmospheric Physics, Beijing, China*
- *Korea Polar Research Institute, Republic of Korea*

We will make a call to the C20C community and envisage that more scientists from other C20C group will participate in the model comparison.

5. Additional comments

Funding for the project was unsuccessfully applied for from the Swedish Research Council. Another application will be submitted this year. However it is a confirmed project of the Hadley Centre Climate Research Program until May 2014.

6. References

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