This presentation covers the following areas

• Defining the SNAO
• SNAO and surface climate
• SNAO since 1706
• SNAO under enhanced GHG forcing
• Conclusions

Based on Folland et al, J. Clim., March 2009
Annual cycle of the 3 month NAO using EOF analyses

From Hurrell et al, 2003, pp1-34, AGU Geophysical Monograph 134
EOF1 of *daily* extratropical North Atlantic PMSL - definition of SNAO, 1881-2003

Units are hPa/standard deviation of the time series.
Full surface pattern of the July and August mean SNAO

28.3% of 2 month variance
First and Second EOFs of July-Aug PMSL, Daily EMSLP domain, 1881-2003

Summer NAO

Portis “Mobile NAO”
Daily K-means cluster analysis of summer NAO, July and August

Clusters based on daily data, 1850-2003.
Based on Fereday et al (J Clim, 2008)

Nearly equiprobable, 19% of all days explained by positive and negative clusters together based on 10 clusters. Other cluster analyses give similar patterns.
Correlation = -0.63, highly significant
June July and August SNAO time series

June, July August and high summer NAO, 1850-2007

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300hPa regression patterns for daily, ten day and 2 month mean SNAO

daily

10 day mean

2 month mean
Correlation of daily SNAO with surface temperature, July and Aug

HadCRUT3v/SNAO correlation (hi) 1900–2007

HadCRUT3v/SNAO correlation (lo) 1900–2007

Interannual

> 10 years

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SNAO correlation with rainfall and cloudiness, July and Aug

cloudiness

rainfall
Correlation of 0.47 highly significant, 1901-2007. Cross spectral analysis shows significant interannual and multidecadal relationships.
C20C Experiments

• This relationship is being investigated in the existing set of C20C experiments run with all forcings forced with HadISST for 1949-2001.

• Results suggest only a weak inverse relationship between PMSL near UK and model Sahel rainfall with rainfall leading by about 10 days.

• Consistent in sign with observations but much weaker. Does not suggest Sahel rainfall (and associated diabatic forcing) has a strong effect on SNAO
C20C results – HadAM3 model pressure over N W Europe and model Sahel rainfall

Initial C20C model Sahel rainfall and SNAO mean MSLP correlations from 12 50 year runs

<table>
<thead>
<tr>
<th>Lag of rainfall in days</th>
<th>Correlation</th>
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<tbody>
<tr>
<td>-20</td>
<td>-0.14</td>
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<tr>
<td>-15</td>
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<tr>
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<td>-0.08</td>
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<td>0</td>
<td>-0.06</td>
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<td>35</td>
<td>0.10</td>
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<tr>
<td>40</td>
<td>0.12</td>
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</tbody>
</table>
Zero lag correlation of Sahel rainfall and 300hPa height from NCEP

Correlation of GPCPv2 Sahel JJA rainfall with JJA day 300hPa height, 1979–2004, zero lag

Values > c. +/-0.45 in magnitude are significant
Similar but 10 day Sahel rain lead

Values >+-0.45 in magnitude are significant
Sahel rain and zero lead
PMSL

Correlation of GPCPv2 Sahel JA rainfall with JA MSLP, 1979–2004, zero rain lag

Values > ± c. 0.45 in magnitude are significant
El Nino and La Nina effects on SNAO

a. Regression of JA Niño 3.4 against JA PMSL 1876-2007, hPa/°C.

b. Composite MSLP (anomaly from 1901-2000) for coolest 20% Niño 3.4 years (Niño 3.4 < -0.59 °C). Units are hPa.

c. Composite as b but for warmest 20% seasons (El Niño case, Niño 3.4 > 0.44 °C).
SNAO and storm tracks in July-August

**Mean JA storm track**

- Standard deviation of 300 hPa Height on 2-8 day time scale
- Mean storm track

**SNAO correlation**

- Correlation of storm track with SNAO. Storm track moves north for positive SNAO
Europe and the Summer NAO

Data & a coupled model suggest some decadal predictability of summer pressure levels over UK might be possible

Surface pressure anomaly projects on negative SNAO in HadCM3 model

Detrended observed SNAO & Interhemispheric SSTs (AMO)

Knight et al, 2006, GRL, broadly similar in Sutton and Hodson, 2005, Science

Folland et al 2009, J Clim

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SNAO back to 1706

Reconstructed SNAO (red) and CET (blue)

Central England Temperature and reconstructed Summer North Atlantic Oscillation from tree rings, 1706-1976

- Standardised high summer Manley CET over 1706-1976
- Standardised Lindermholm Tree Ring SNAO over 1706-1976

R(1706-1800)=0.48; R(1706-1849)=0.47; R(1850-1976)=0.66; R(1706-1976)=0.55  All highly significant
Leading two patterns of July-Aug mean PMSL in two coupled models

HadCM3  
HadGEM1

Pattern 1  
SNAO

Pattern 2  
SNAO
SNAO and PMSL response to an increase to 4x pre-industrial CO2

PMSL change

PMSL change adjusted for mean domain change

SNAO 4xCO2 (red) compared to control (black)

Temporal change in CO2 and SNAO
Conclusions

- SNAO is the high summer equivalent of the winter NAO. More restricted north-south than winter NAO
- June pattern similar, but time series differs
- Strongly related to storm tracks, North West European summer droughts, wet periods and heat waves
- Strong interannual and recent multidecadal fluctuations
- Links to AMO, well correlated with West African Monsoon, but possibly not much forced by it? Both influenced by ENSO and AMO.
- Late 20th Century high SNAO level may be unprecedented since 1706. Recent downturn (UK wetter) may be influenced by positive AMO.
- SNAO may strengthen under strongly enhanced greenhouse gas forcing, exacerbating predicted drought and heat in North West Europe