Potential Predictability of the NAO: From Days to Decades

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- Predictability of NAO or AO?
- Short-range predictability
- Long-range predictability

Role of the Stratosphere in the Troposphere workshop, Whistler Resort, Canada, 29 April – 2 May 2003.

North Atlantic Oscillation or Arctic Oscillation?

Correlation of SLP with NAO

Correlation of SLP with AO

corr Dec-Feb averaged NAO-Azores index with Dec-Feb averaged NCEP/NCAR SLP corr Dec-Feb averaged AO SLP index with Dec-Feb averaged NCEP/NCAR SLP



Correlation maps of winter (DJF) NCAR/NCEP reanalyses 1958-98 Produced using the *Climate Explorer* at http://climexp.knmi.nl

And what about these two phenomena?



Brian Hoskins



Britney Spears

Correlation of r=0.56 (n=150x110=16500 pixels)Highly significant (p<0.001)</td>Which is more dynamical??Exampleby Matt S

Example kindly prepared by Matt Sapiano

Daily AO index from Sep 1999 - 2002



Persistence in the daily AO index



Heteroskedasticity



→ Almost 10 times the variance in winter than in summer

Autocorrelation of daily AO index



Autocorrelation of daily AO series



AR1 time series modelling of daily AO



 \rightarrow AR(1) provides a rough fit to the short-range features



Quantifying the size of a Stratosphere-Troposphere connection in the Arctic Oscillation

A.J.Charlton, A.O'Neill, D.B.Stephenson, W.A.Lahoz and M.P.Baldwin

 $AO(t+t) = \boldsymbol{b} AO(t) + \boldsymbol{b}_1 NAM(t) + \boldsymbol{e}(t)$

$$\Rightarrow r_t = r(AO(t + t), AO(t)) = \boldsymbol{b}_0 + \boldsymbol{b}_1 r(AO(t), NAM(t))$$



Example: NAM 150mb and AO to predict AO 20 days later



20-day AO autocorrelation=0.30=0.08+0.72*0.31

⁽c) D.B.Stephenson@reading.ac.uk 2002



→ Direct stratospheric effect important for AO 10-60day ahead

Direct and indirect effects for all NAM



Out of sample gain in MSE forecast skill



 \rightarrow 5% gain in MSE skill by using stratosphere as predictor of AO in 10-40 day ahead forecast range

Long-range correlation of daily AO



b) Autocorrelations for Dec-Mar AO daily values



→ long-range dependence in daily AO values

Potential predictability

Given knowledge of the daily AO index X(t) at time t, we would like to predict the following k-day mean:

$$\overline{X}_{k}(t) = \frac{1}{n} \sum_{k=1}^{n} X(t+k)$$

Consider AO to be the sum of a potentially predictable signal component and a "weather noise" component:

$$X(t) = T(t) + W(t)$$

$$\Rightarrow$$
 Var $(\overline{X}_k) =$ Var $(\overline{T}_k) +$ Var (\overline{W}_k)

Potential predictability is then defined as the ratio $F = Var(\overline{X}_k) / Var(\overline{W}_k)$

F>1 indicates more than short-range weather noise and hence some potentially predictable component.



Potential predictability



Accumulated daily AO from 1958-2002



→ Accumulated AO may be a good measure of climate state

Accumulated AO and NAM indices



→ Similar behaviour in troposphere and stratosphere??

Summary

- AO has both short and long-range dependence that can lead to predictability ("windows of opportunity")
- Short-range AO weather noise is not just AR1
- Stratosphere important for 10-60 day range
- Potential predictability on longer time-scales (more variability than just weather noise)
- Potential predictability increases with increasing time scale (long-range dependence)
- Strange co-varying long-term behaviour in troposphere and stratosphere.