The NAO and stratosphere-troposphere interaction

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Several factors trigger variability in Atlantic winter climate

(A number of which are stratosphere related)
Stratospheric changes give the same response across timescales

- All stratospheric – all show same response in troposphere
- A similar response occurs in the southern hemisphere

Kidston et al, accepted.
Characteristic pattern in surface climate

North Atlantic Oscillation or Arctic Oscillation

**Winter 1962/63**
- Weak P Gradient
- Cold advection into Europe
- Cold, calm and dry

**Winter 2009/10**
- Warm advection into Europe
- Mild, wet and stormy c.f. 2013/14

**Winter 2011/12**
- Strong P Gradient
Mechanisms

1) Reduction in wave driving => acceleration of jet
2,3) weaker Brewer-Dobson circulation, cooling of polar region
4,5) increased upper tropospheric wind and more/stronger tropospheric eddies
3,5) positive annular mode signal

Kidston et al, accepted.
Global Seasonal Forecast System 5

Model: HadGEM3H  N216L85O(0.25)

Initialisation: NWP state + NEMOVAR + Sea Ice

Winter Hindcasts: ensemble forecasts starting around 1st August
Predictability of the northern hemisphere
Skilful predictions of the winter NAO

Winter NAO skill: \textit{correlation}=0.62

Significant at the 98\% level

Similar result holds for AO

Surface weather skill

Skill for predicting impacts: storms, temperatures, winds…
Higher skill over Europe if inferred from forecast NAO only!

Scaife et al, GRL, 2014
Single predictions of stratospheric winds

Winter 1999/2000 +NAO
Winter 2009/2010 -NAO

Winter 1999/2000 has few SSW events
Winter 2009/10 has many
SSW events appear to have been more likely in 2009/10
Ensemble predictions of stratospheric winds (10hPa, 60N)

Ensembles of forecasts for each winter

Some winters show a large shift in probability of a SSW

=> Predictability
Predicted NAO is related to predicted probability of stratospheric events

The distribution of NAO values is related to the occurrence or absence of stratospheric events

Top with/without SSW
Bottom with/without SPV
Average difference is ~6hPa

NAO is correlated with probability of SSW

Scaife et al, submitted
Predictability of the NAO vanishes without stratospheric events

Stratosphere is intimately involved in winter seasonal skill

*Not necessarily driving or causing the predictability though*

*Scaife et al, submitted*
Unresolved question: effects of the QBO
(c.f. Ebdon 1975)

Well simulated in some models
Regular and predictable out to a few years ahead
but
Surface signal is not well modelled in all systems

Scaife et al, GRL, 2014.
Summary

Same response across timescales

The stratosphere rings the NAO ‘bell’

Predictability on seasonal timescales for NAO/AO/SAM

Stratosphere *intimately involved* in forecast skill

Skill in NAO vanishes without stratospheric events

Some aspects unresolved:

- teleconnections to QBO
- feedback from oceans
- relative importance of different coupling mechanisms