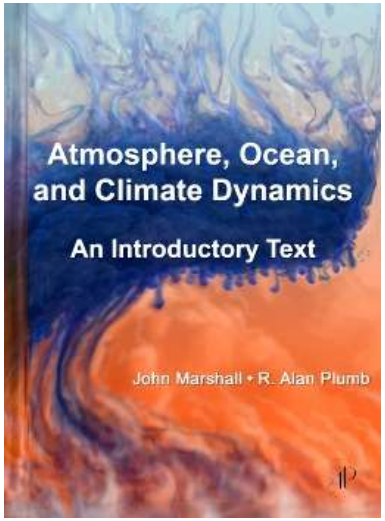
GEF 1100 – Klimasystemet

Chapter 12: Climate and climate variability - I



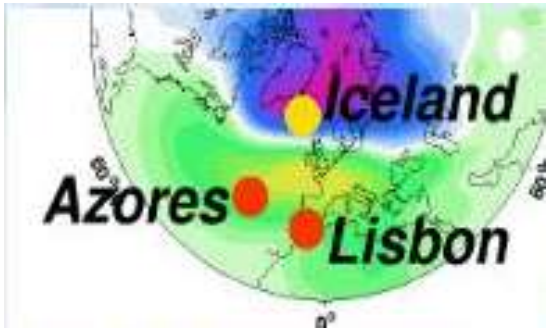
Prof. Dr. Kirstin Krüger (MetOs, UiO)

Lecture Outline – Ch. 12a

Ch. 12 – Climate and climate variability – Part I

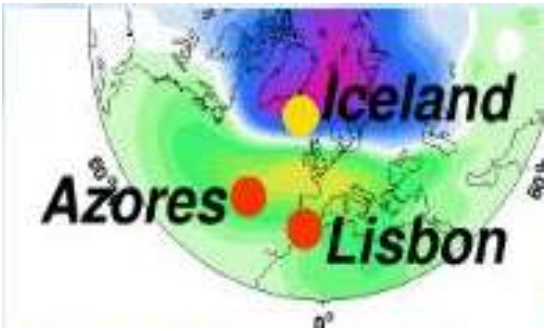
Ch. 12 - Part II: "Paleo-climate" by Wolfram Kürschner

1. Introduction
2. The ocean as a buffer of temperature change
3. El Niño and the Southern Oscillation (ENSO)*
   - 2.1 Internal variability
   - 2.2 Normal conditions
   - 2.3 ENSO
4. Other modes of variability
   - 3.1 North Atlantic Oscillation*
5. Summary
6. Take home message



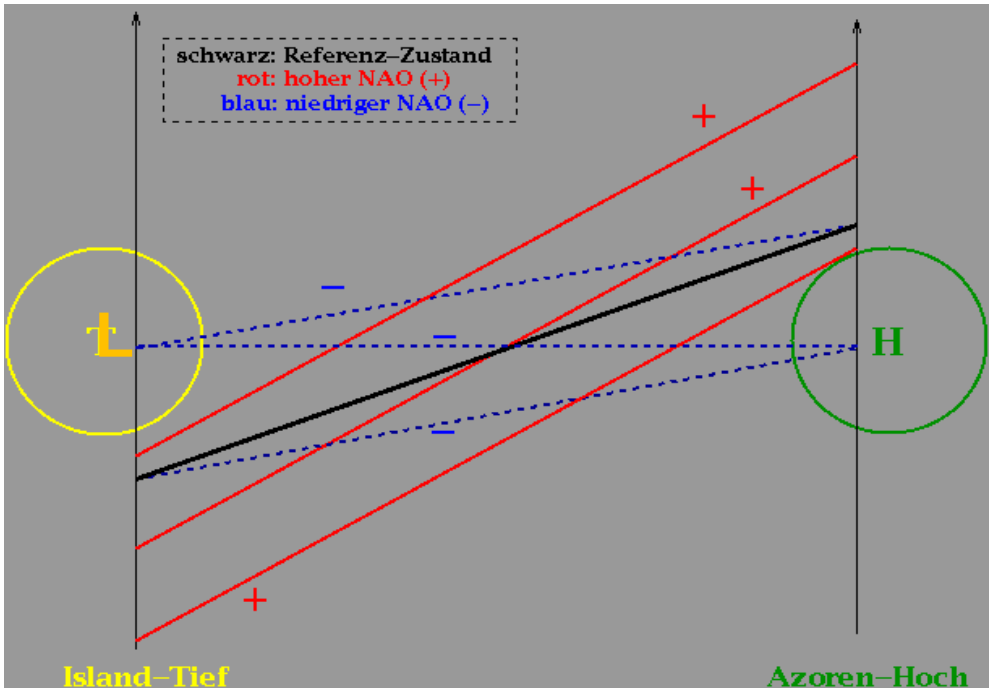
*Plus add-ons, not in the book.

Definition of the NAO



- The NAO is a large scale seesaw in atmospheric mass between the subtropical high and the polar low.
- Pressure difference between Iceland (65° N) and Azores (38° N)
- Most well-known and reoccurring pattern of atmospheric variability
- Most pronounced in winter (explains 31% of the total variance of temperature in winter)
- Difference between two phases => positive and negative phase
- Accompanied by changes in the mean wind velocity and wind direction
- Change of intensity and pathways of storms that cross the Atlantic
- Changes influence the seasonal mean heat and moisture flows between the Atlantic and its adjacent continents
- Influence of ocean and the stratosphere on the NAO!

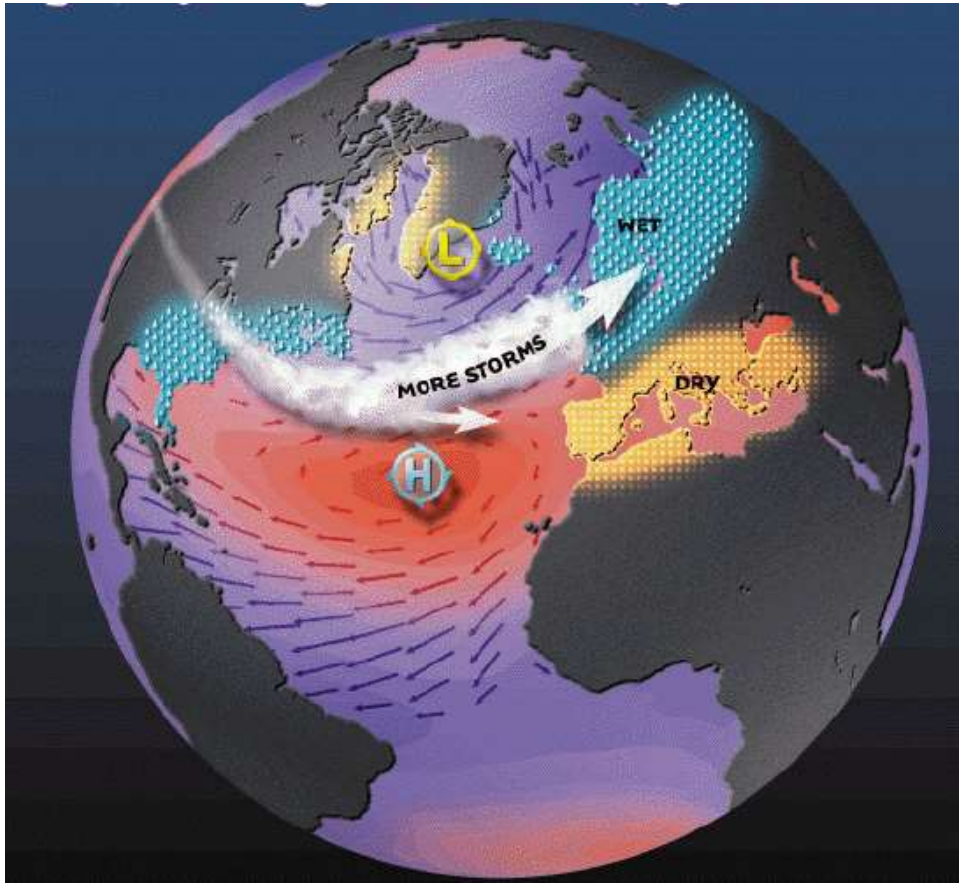
Definition of the two phases



Iceland Low **Azores High**

The NAO‘s positive phase

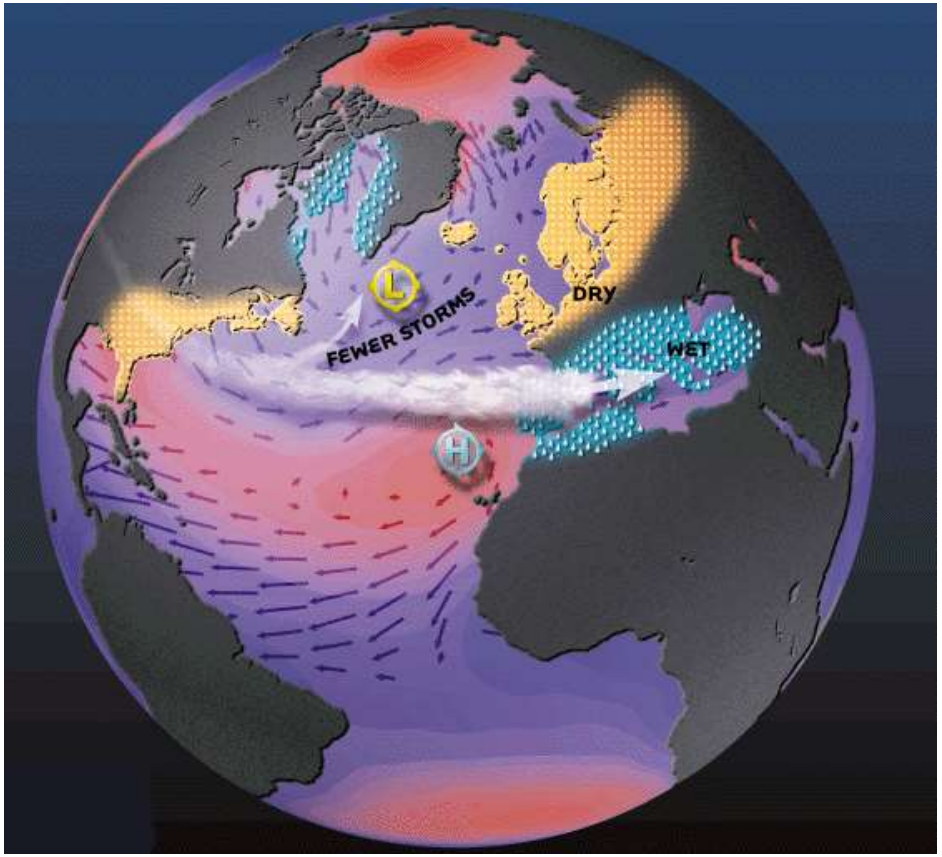
- **Significant enhanced pressure difference between Iceland and Azores**
- Intensified westerly winds over the North Atlantic
- Intensified heat and moisture transport to Northern Europe
- Stronger winter storms reach Northern Europe
- Dryer and colder winters in the Mediterranean region
- Greater ice export from the Arctic
- Colder Labrador Sea and warmer water in the Gulf Stream region
- Cooling down of equatorial Atlantic



www.ldeo.columbia.edu/res/pi/NAO/

The NAO‘s negative Phase

- **Smaller than average pressure difference between Iceland and Azores**
- Weaker westerly winds over the North Atlantic
- Colder and dryer winter in Northern Europe
- Warmer and more humid conditions in the Mediterranean region
- Ice masses in the Arctic retract
- Warmer continental air over Labrador Sea
- Cooler eastern coast of USA
- Weaker trade winds along the equator



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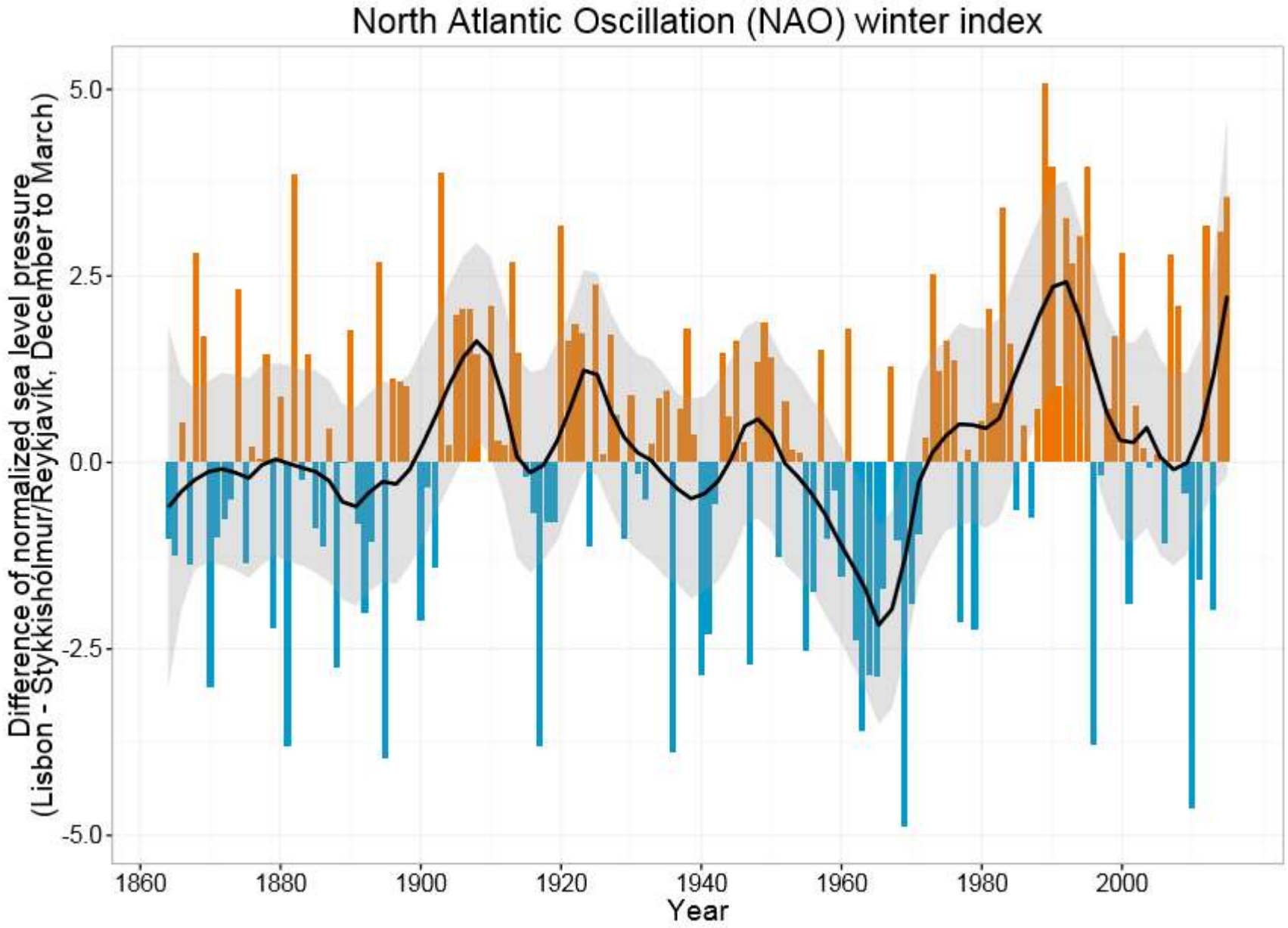
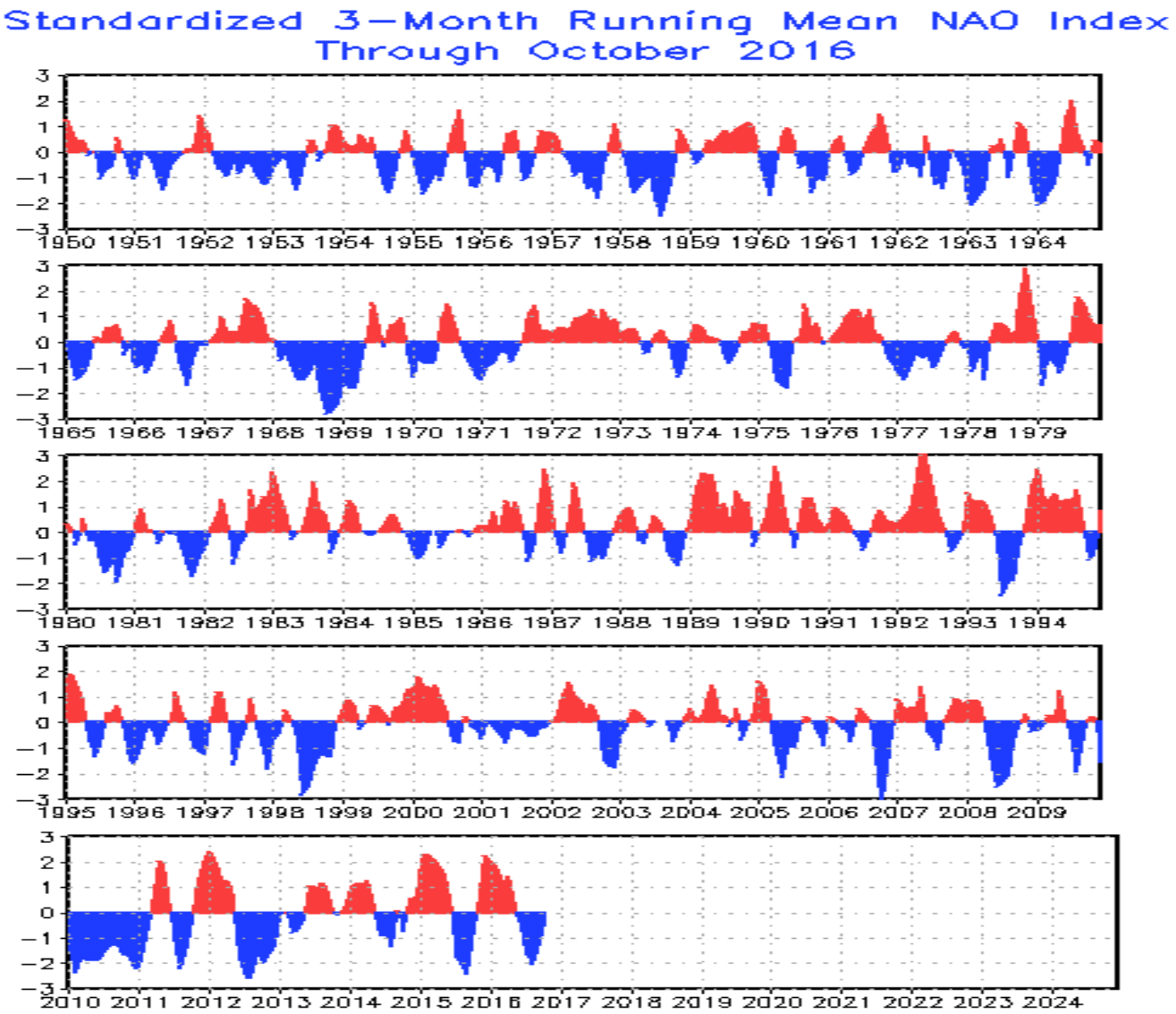


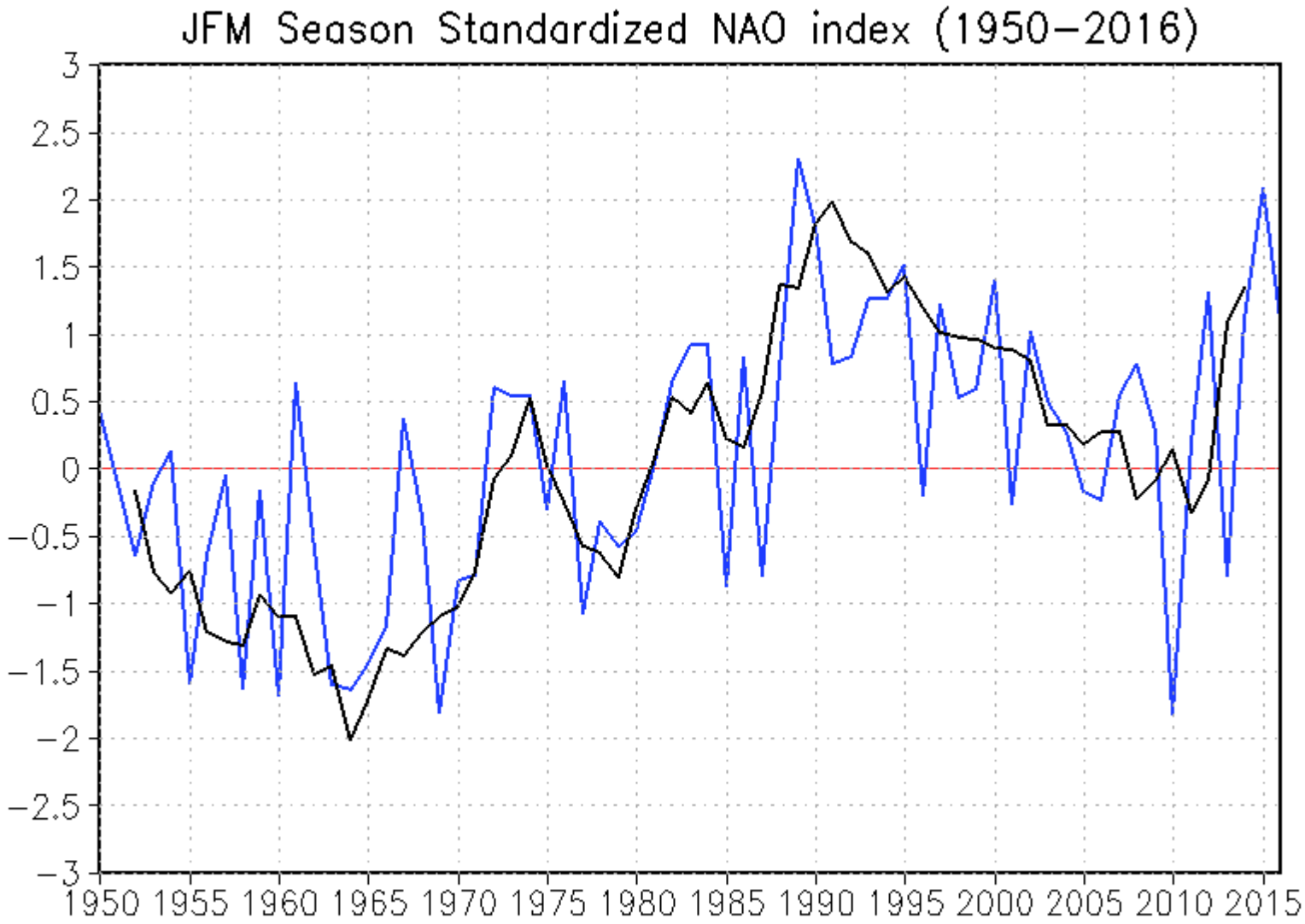
Winter index of the NAO based on the difference of normalized sea level pressure (SLP) between Lisbon, Portugal and Stykkisholmur/Reykjavík, Iceland since 1864, with a loess smoothing (black)

The NAO since 1950



www.cpc.ncep.noaa.gov

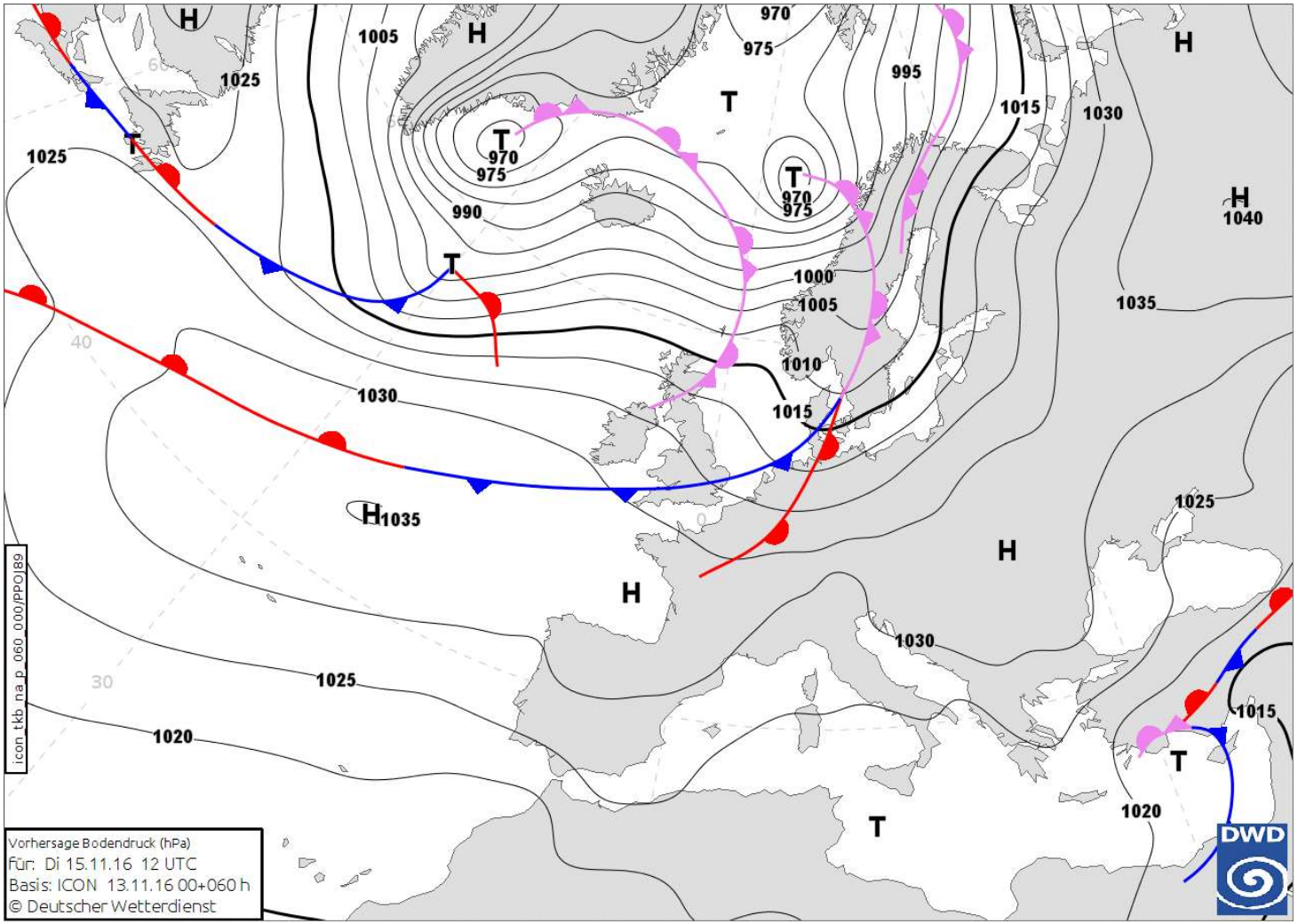
The NAO since 1950 - JFM



www.cpc.ncep.noaa.gov

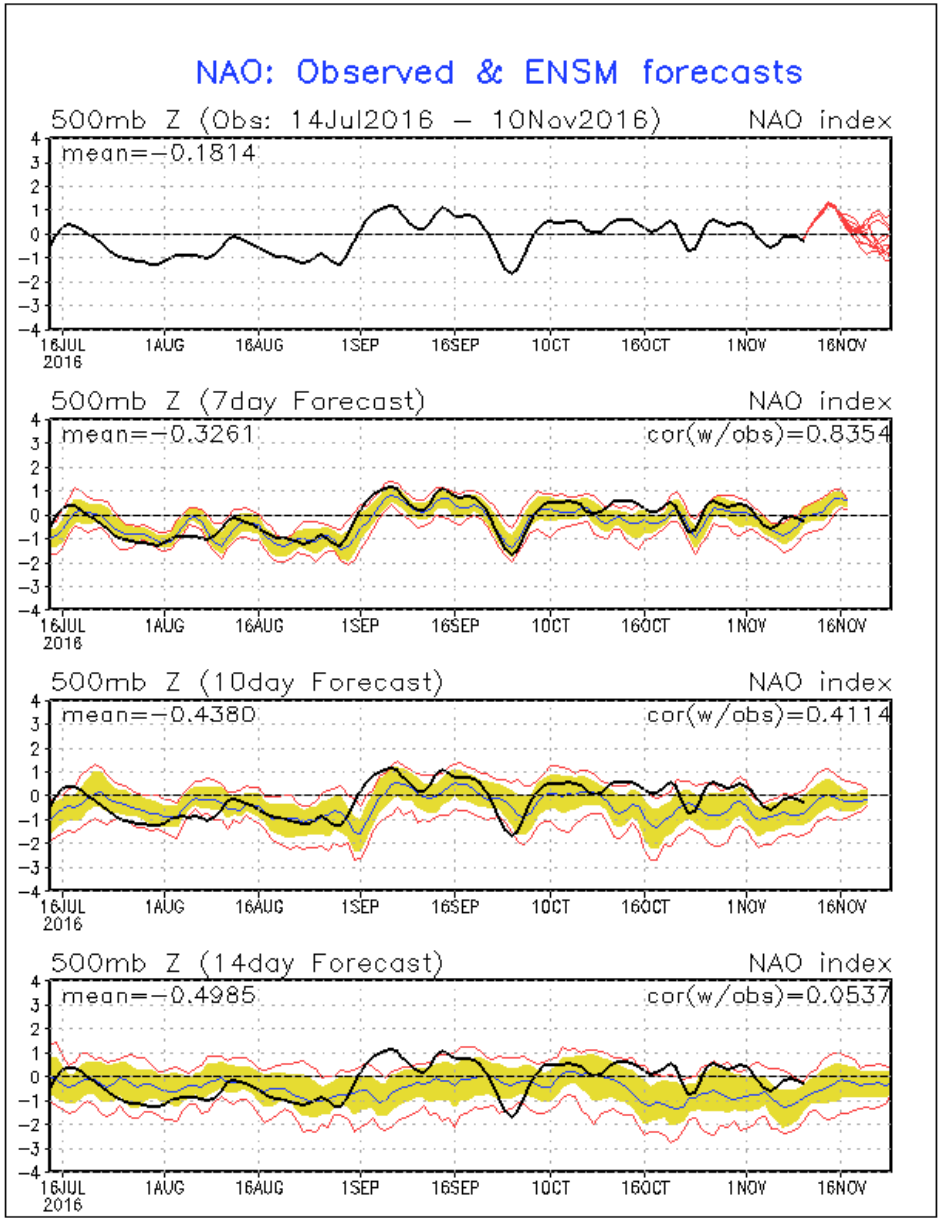
Weather today:

Quiz: Which NAO phase do we have?



T= Low pressure, H: High pressure

Short-range forecast of NAO



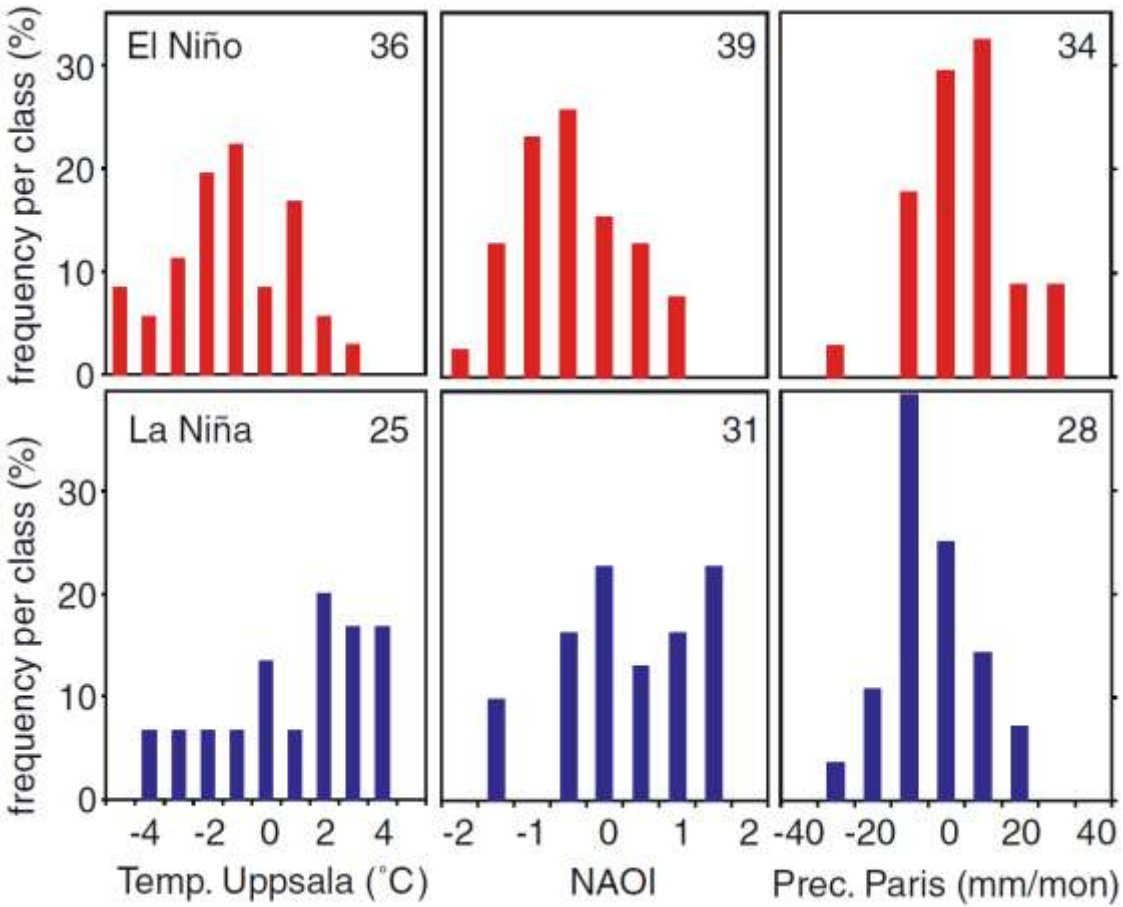
Positive NAO phase for the next week according to NCEP-model

(NAO phase for the entire winter?)

http://www.cpc.noaa.gov/products/precip/CWlink/pna/nao.sprd2.gif

ENSO-NAO relationship?

Jan-Mar averages since 18th century



Brönnimann et al 2007

La Nina composite anomalies

Temp Precip SLP 500hPa GPH

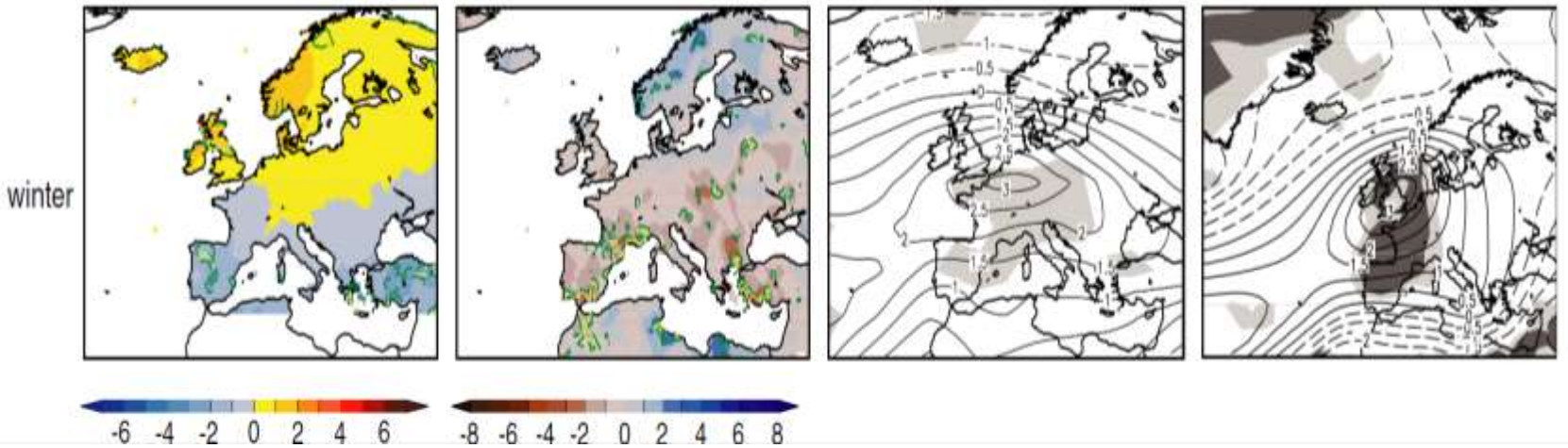
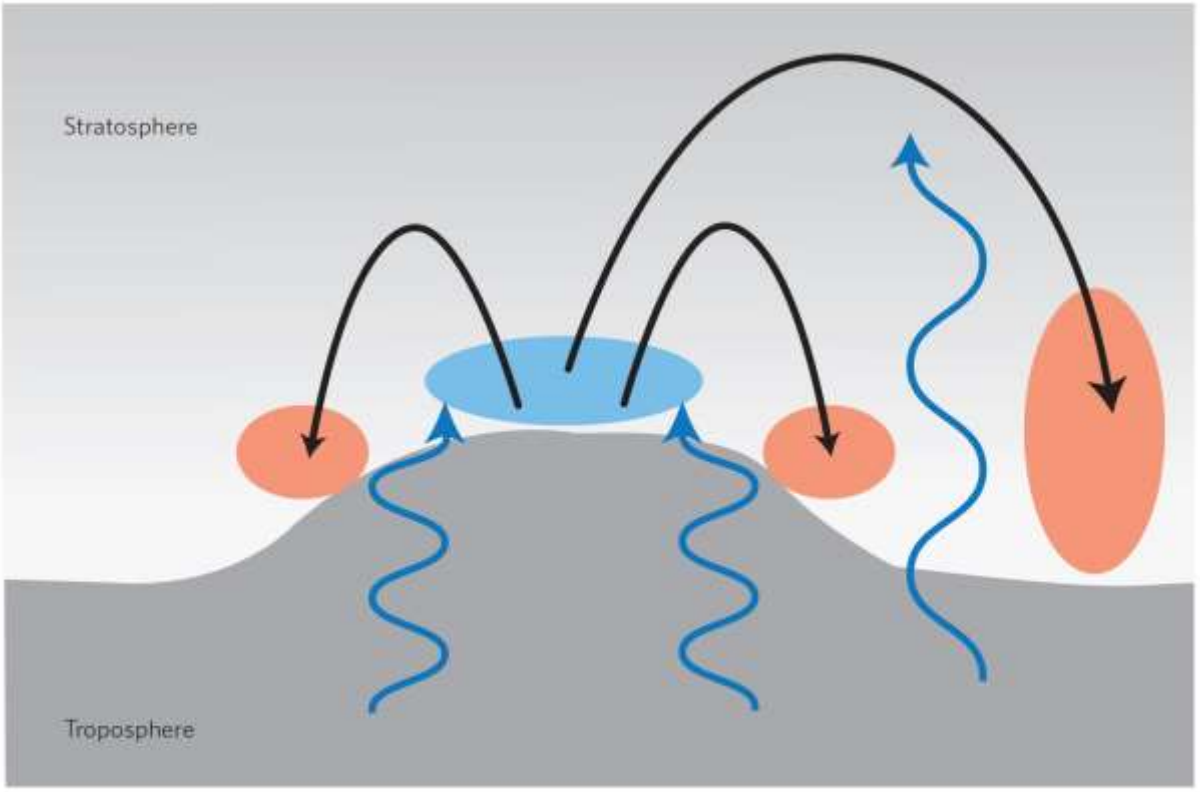


Fig. 3 Composite anomaly fields (scaled means, modified *t*-values; see text for details) of temperature, precipitation, sea-level pressure (*SLP*) and 500 hPa geopotential height (*GPH*) for different seasons during strong El Niño and La Niña events in the period INS (1880–2003, volcanically perturbed winters were excluded). Note that fall, winter and spring refer to OND, JFM and AMJ for temperature, SLP and 500 hPa GPH, but to SON, DJF and MAM for precipitation. Units are arbitrary. Shadings for SLP and 500 hPa GPH as well as the *dashed dark green* and *solid light green contours* (temperature and precipitation) indicate significance at the 95% and 99% confidence levels

Brönnimann et al 2007

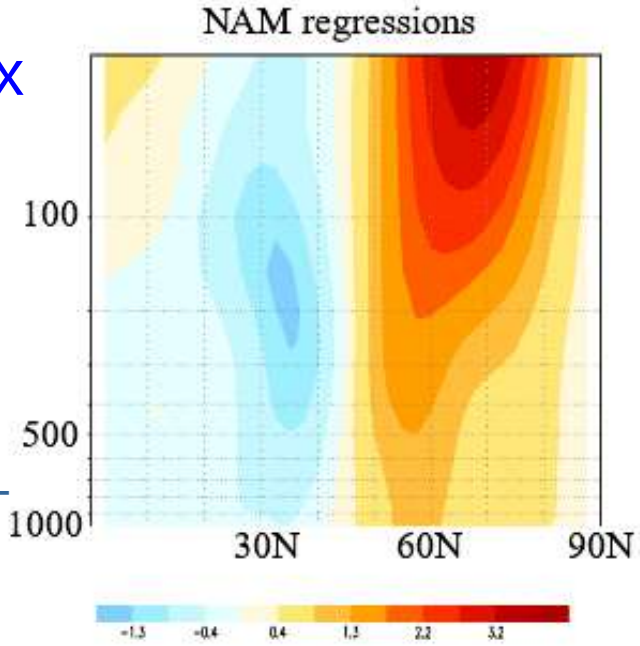
Proposed mechanism for ENSO



Manzini, 2009

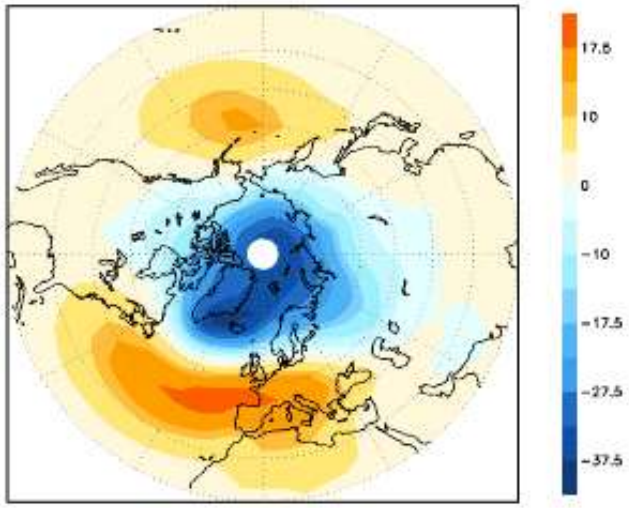
Figure 1 | Dynamical connection between ENSO and the stratosphere. A schematic of the zonal-averaged cross-section of the troposphere and stratosphere shows the remote influence of ENSO. Randel and colleagues[1] provide evidence for the coherent ozone and temperature variations (ovals: positive anomalies in red; negative anomalies in blue) that are associated with ENSO. These variations span the tropics and mid-latitudes, but extend to the Arctic region during winter. Waves propagate up from the troposphere (blue wiggly arrows) and break as they interact with the mean flow. This wave-breaking provides the force that drives the stratospheric circulation (black arrows). The complete chain of events links the conditions at the sea surface to those in the stratosphere.

Strong cold polar vortex



Zonal mean zonal wind

Stronger westerly winds over the polar region throughout the troposphere-stratosphere system



Sea Level Pressure

- lower pressure over the polar cap
- higher pressure over the subtropics

>Positive Northern Annular Mode (≈ NAO)

Thompson and Wallace, 2000

Zonal-mean zonal wind (top) and SLP (bottom) regressed on the NAM index. Regressions based on all months of the year.

Take home message

- NAO is a large scale seesaw in SLP (atmospheric mass) between the subtropical high and the polar low.
- NAO present the winter variability for Northern Atlantic/ Europe atmospheric circulation well.
- Variations of the NAO current research topic worldwide: role of ENSO, North Atlantic, stratosphere, volcanoes, solar activity.