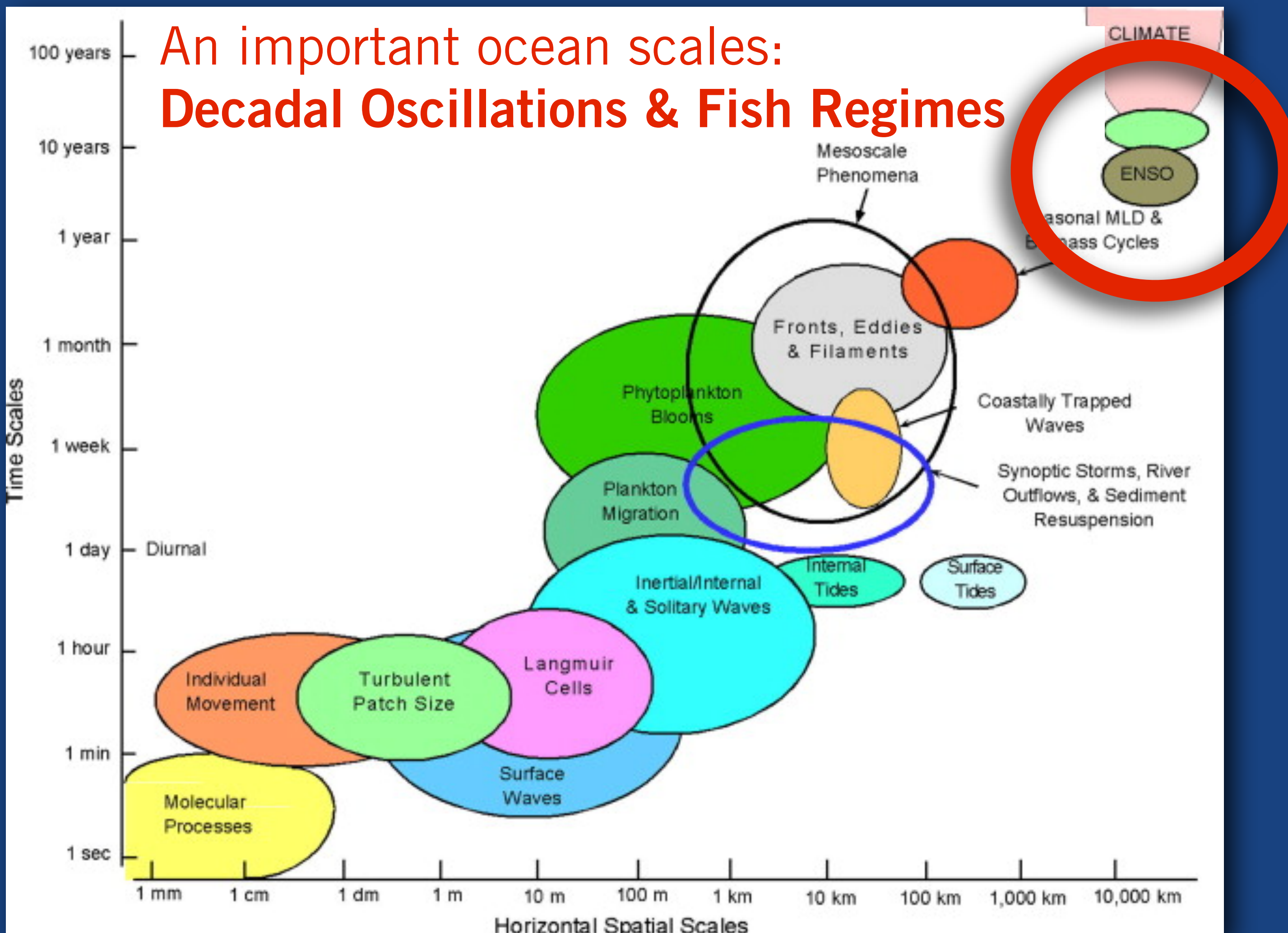
# Natural Climate Variability & Ocean Ecosystems

Time-scales




Spatial-scales

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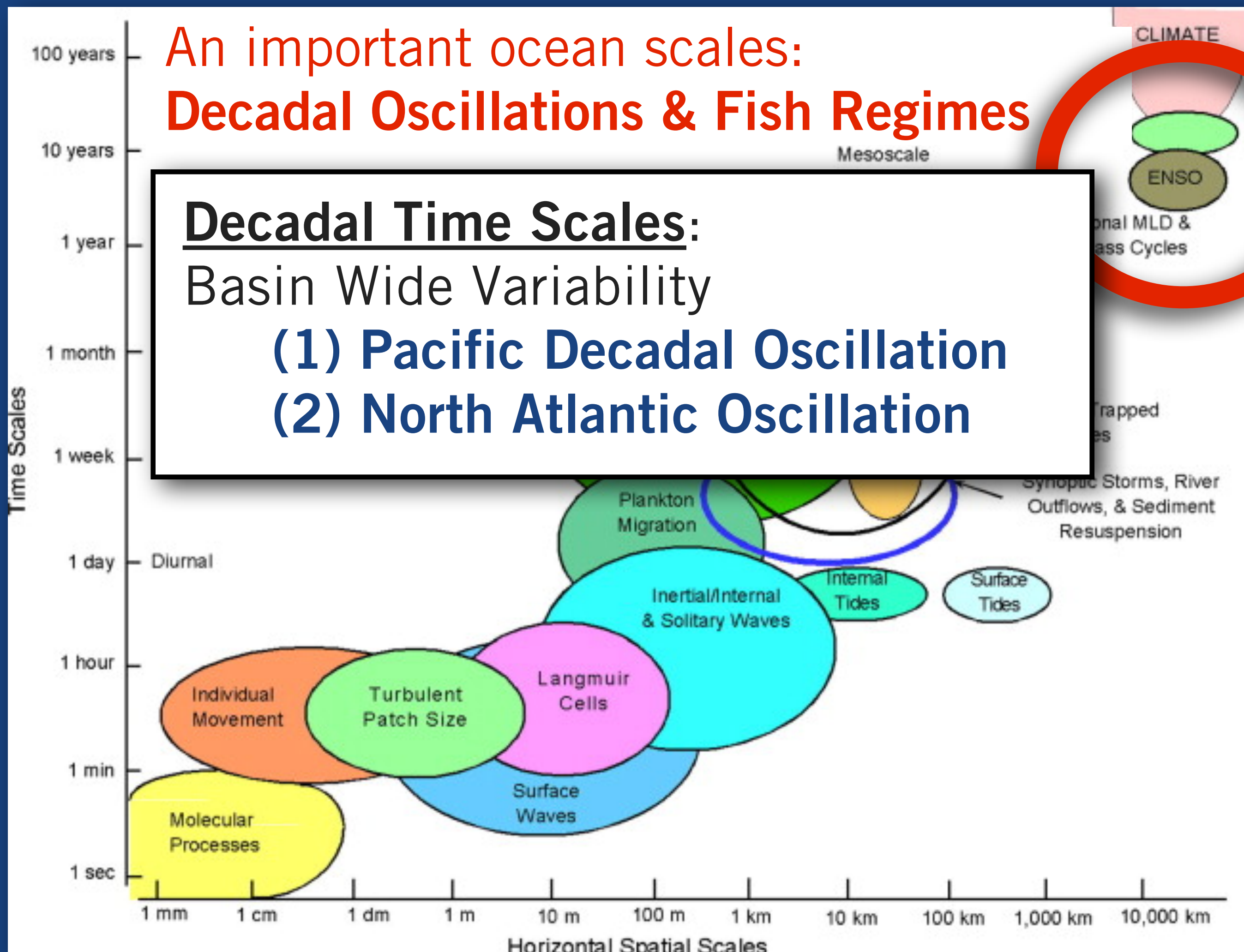
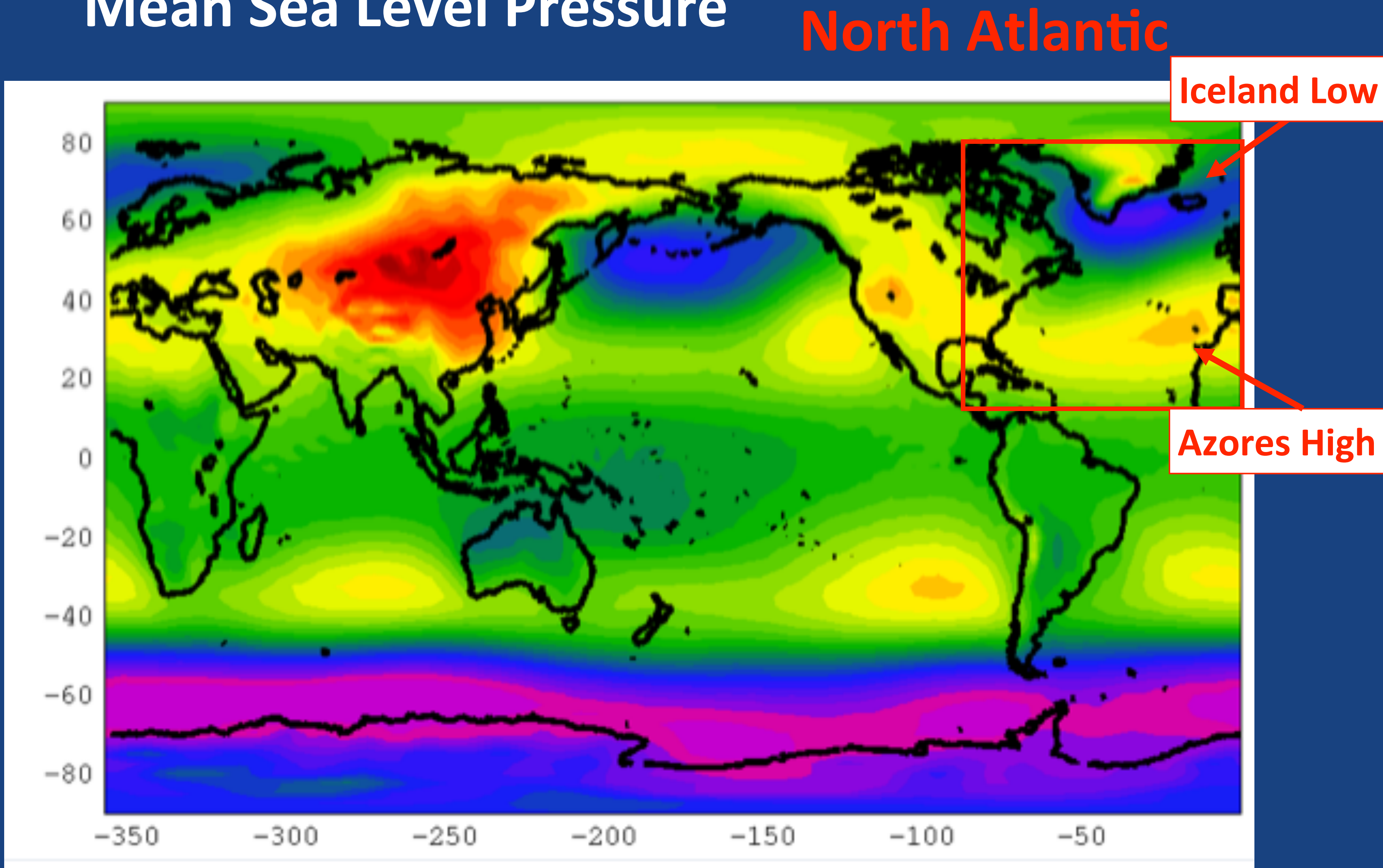
Time-scales

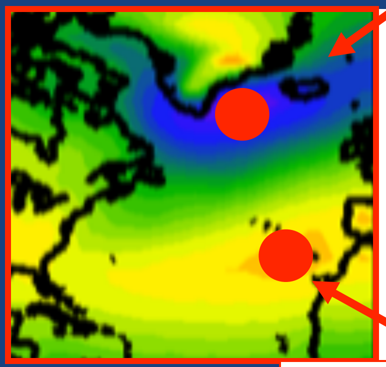



Spatial-scales

# Mean Sea Level Pressure

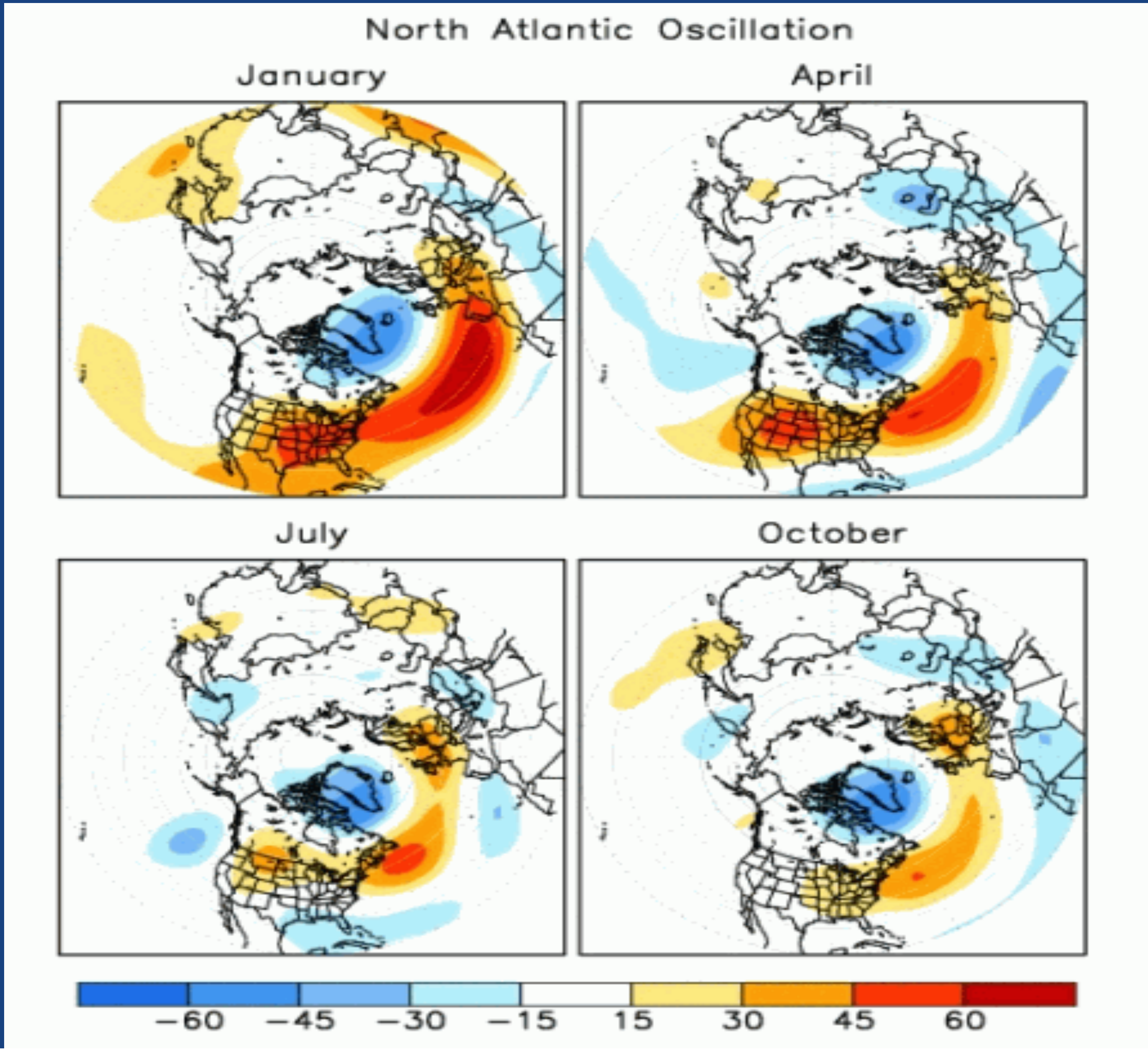


## North Atlantic Oscillation

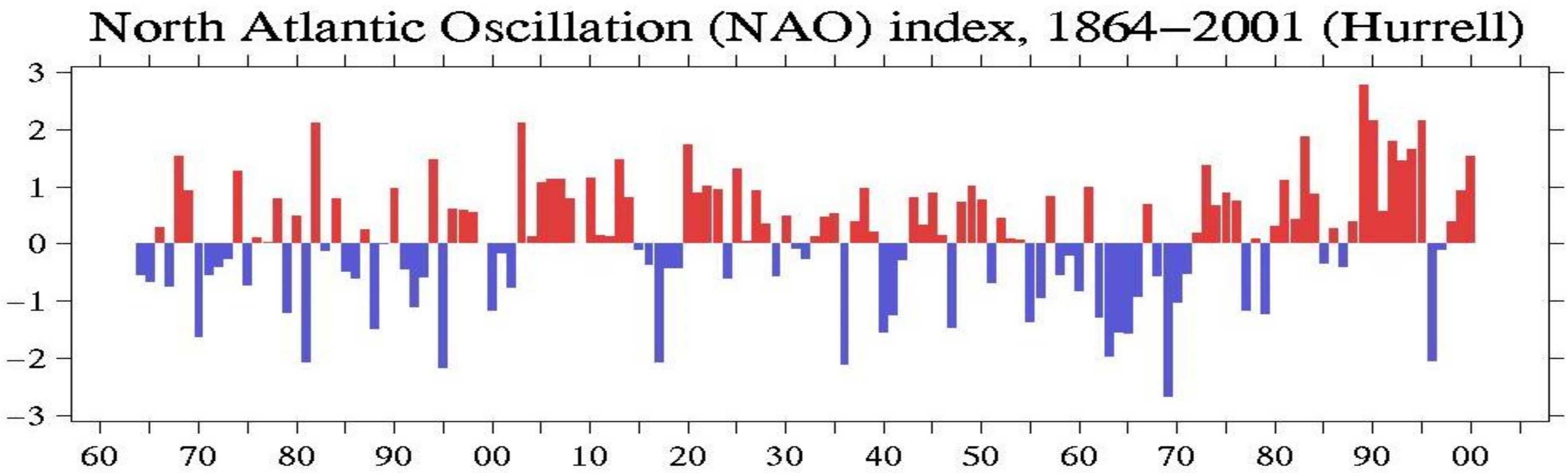



**NAO Index = $SLP_{(Azores\ High)} - SLP_{(Iceland\ Low)}$**

*measured November through March*


North Atlantic Oscillation
January
April
July
October
−60
−45
−30
−15
15
30
45
60

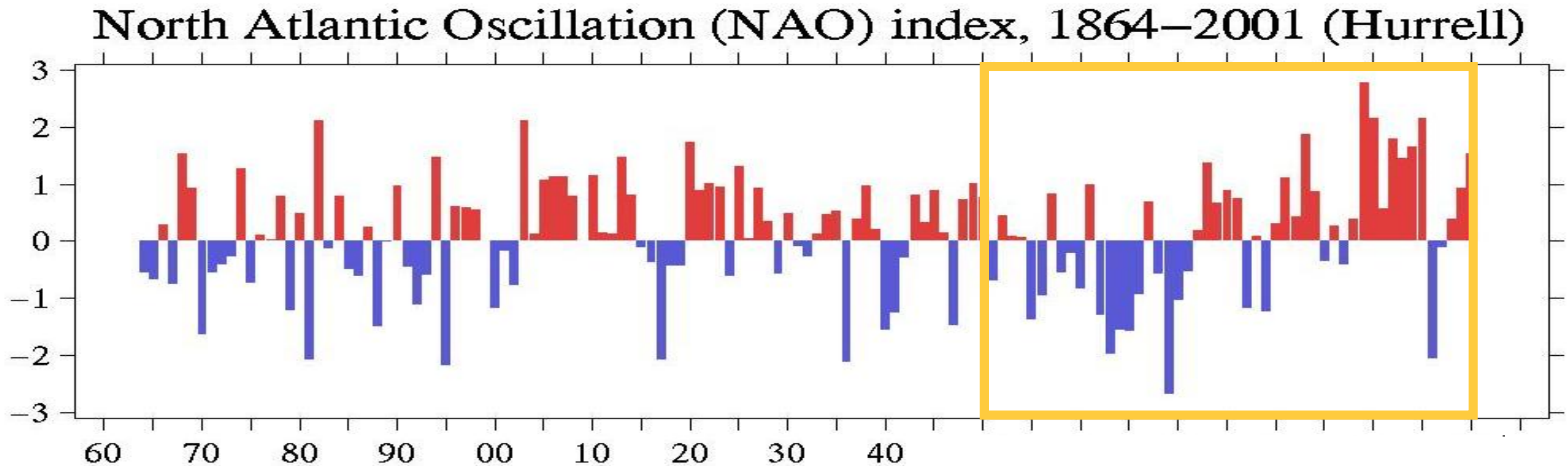
# The North Atlantic Oscillation Index




The NAO index shows large variations from year to year. This interannual signal was especially strong during the end of the 19th century.

*measured December through March*

# The North Atlantic Oscillation Index

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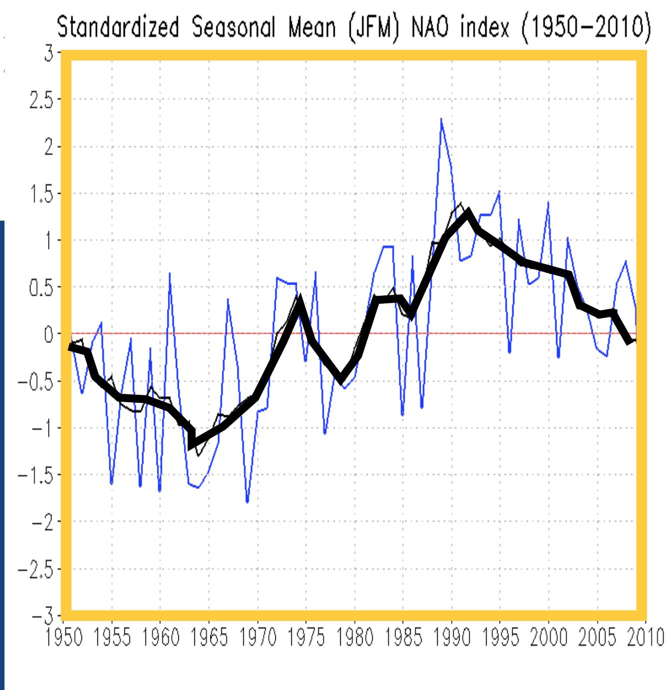
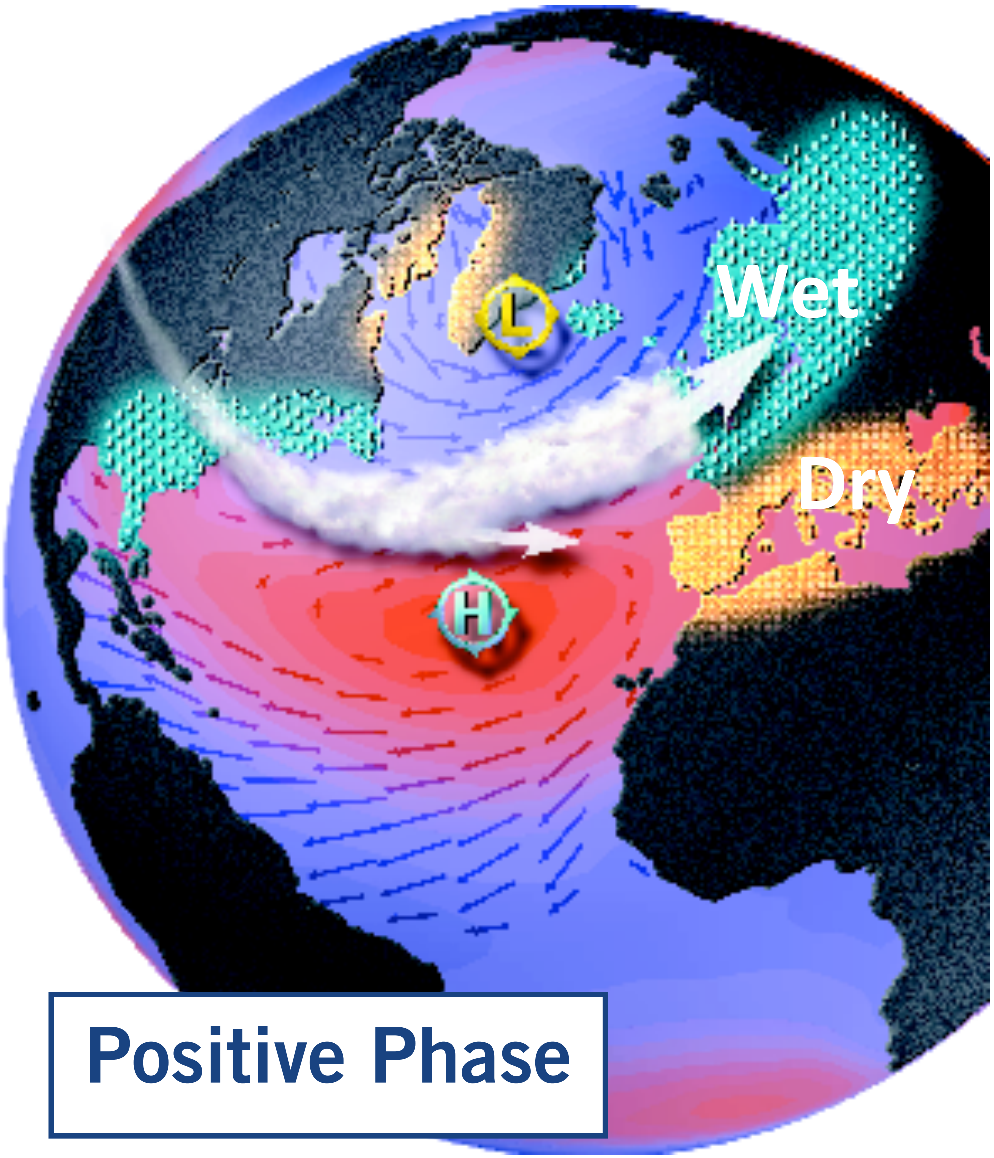


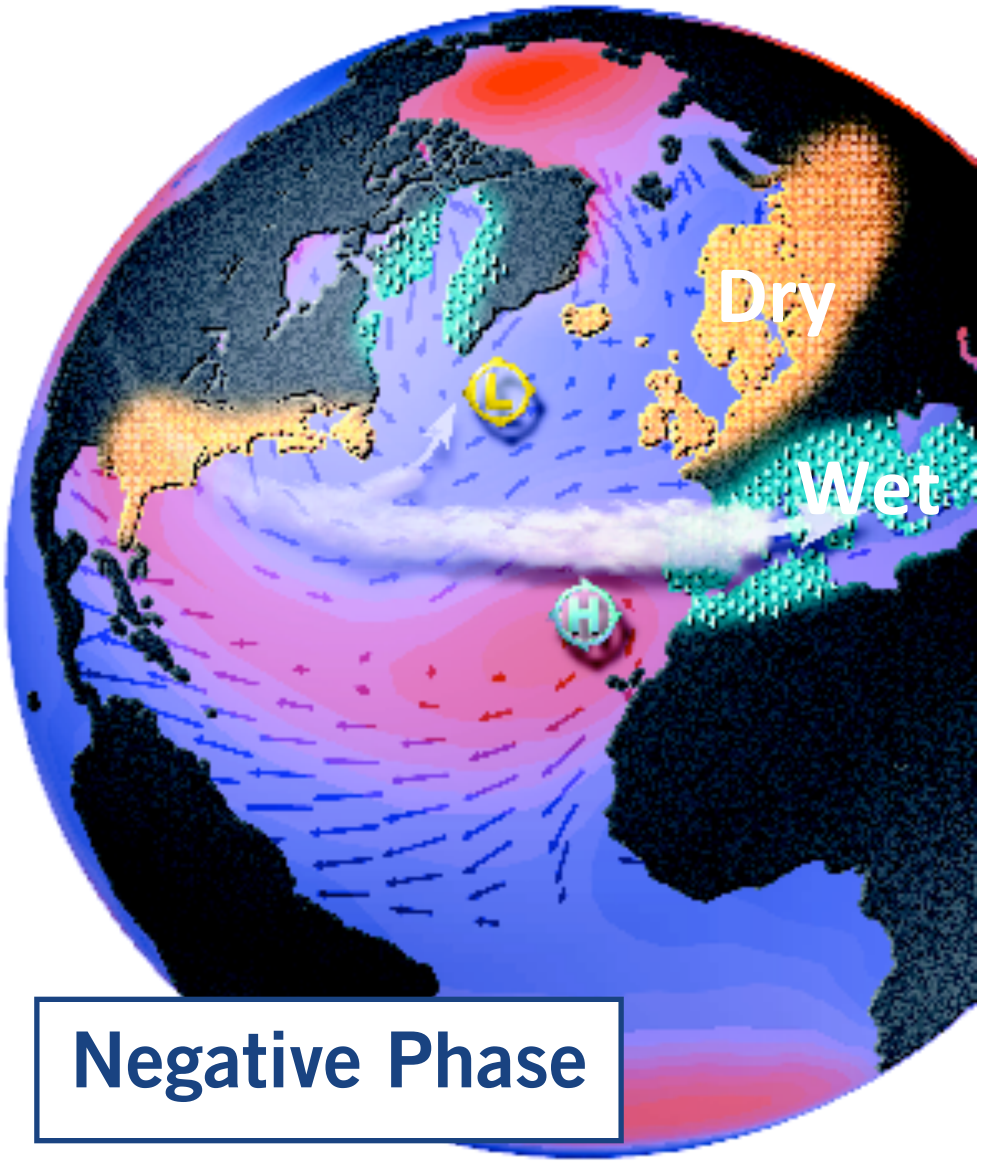

Sometimes the NAO index stays in one phase for several years in a row. This decadal variability was quite strong in the second half of the 20th century.

# The North Atlantic Oscillation




- ✓ The positive NAO index phase shows a **stronger** than usual subtropical **high pressure** center and a deeper than normal Icelandic low.
- ✓ The increased pressure difference results in more and **stronger winter storms** crossing the Atlantic Ocean on a more northerly track.
- ✓ This results in **warm** and **wet winters** in Northern Europe and in cold and dry winters in Mediterranean region.
- ✓ The eastern US experiences mild and wet winter conditions.

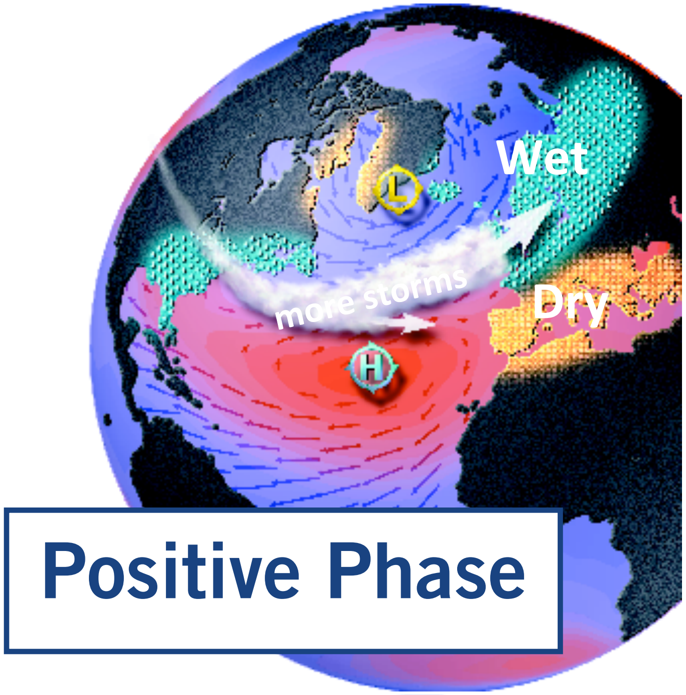
# The North Atlantic Oscillation

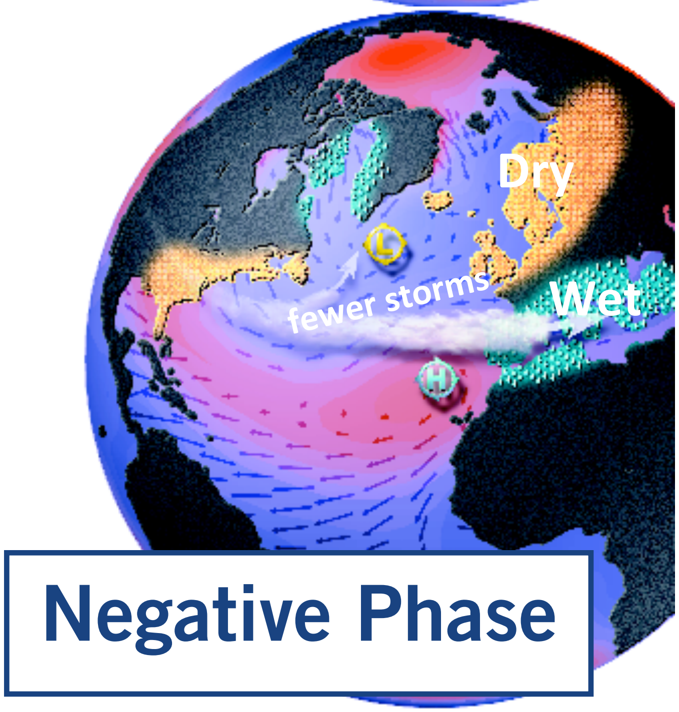


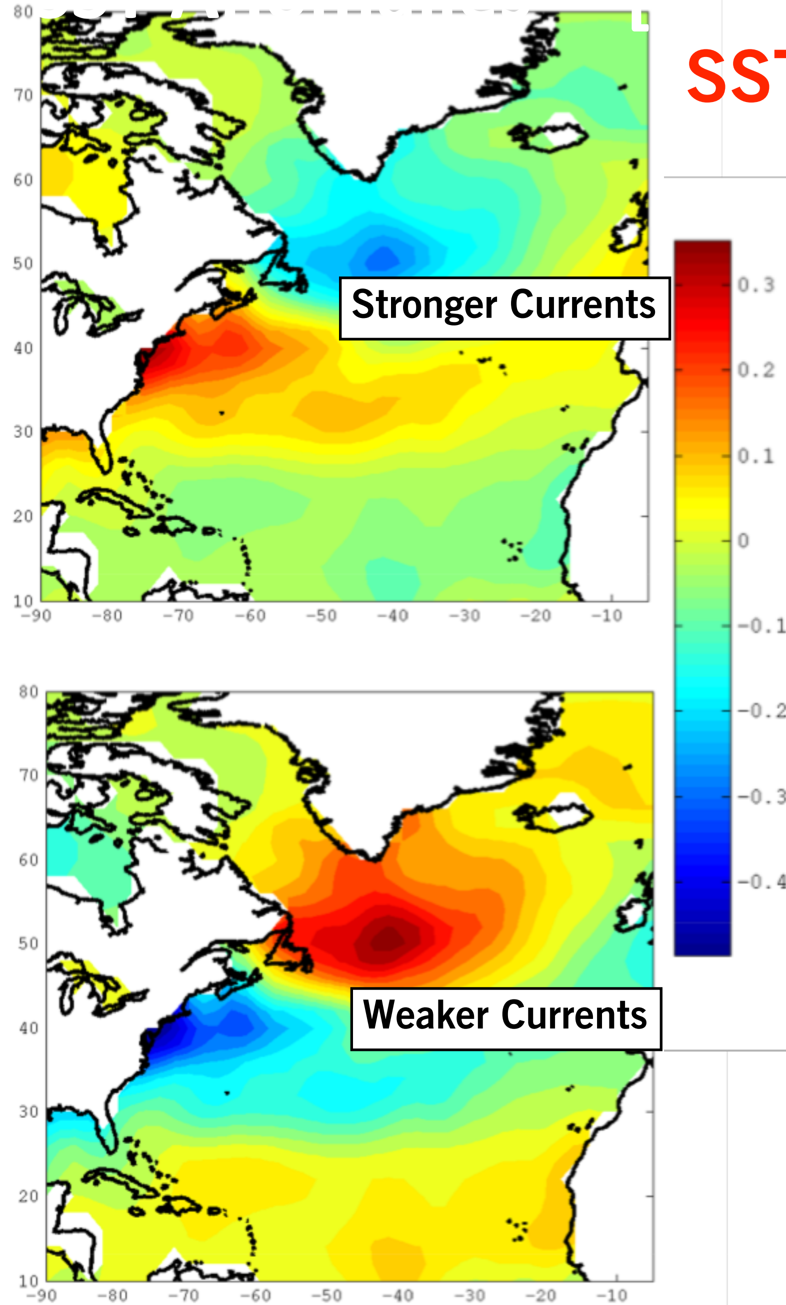

**Negative Phase**

- ✓ The negative NAO index phase shows a weak subtropical high and weak Icelandic low.
- ✓ The reduced pressure gradient results in fewer and weaker winter storms crossing on a more west-east pathway.
- ✓ They bring moist air into the Mediterranean and cold weather to northern Europe.
- ✓ The US east cost experiences more cold air outbreaks and hence snowy winter conditions.

# SST Anomalies



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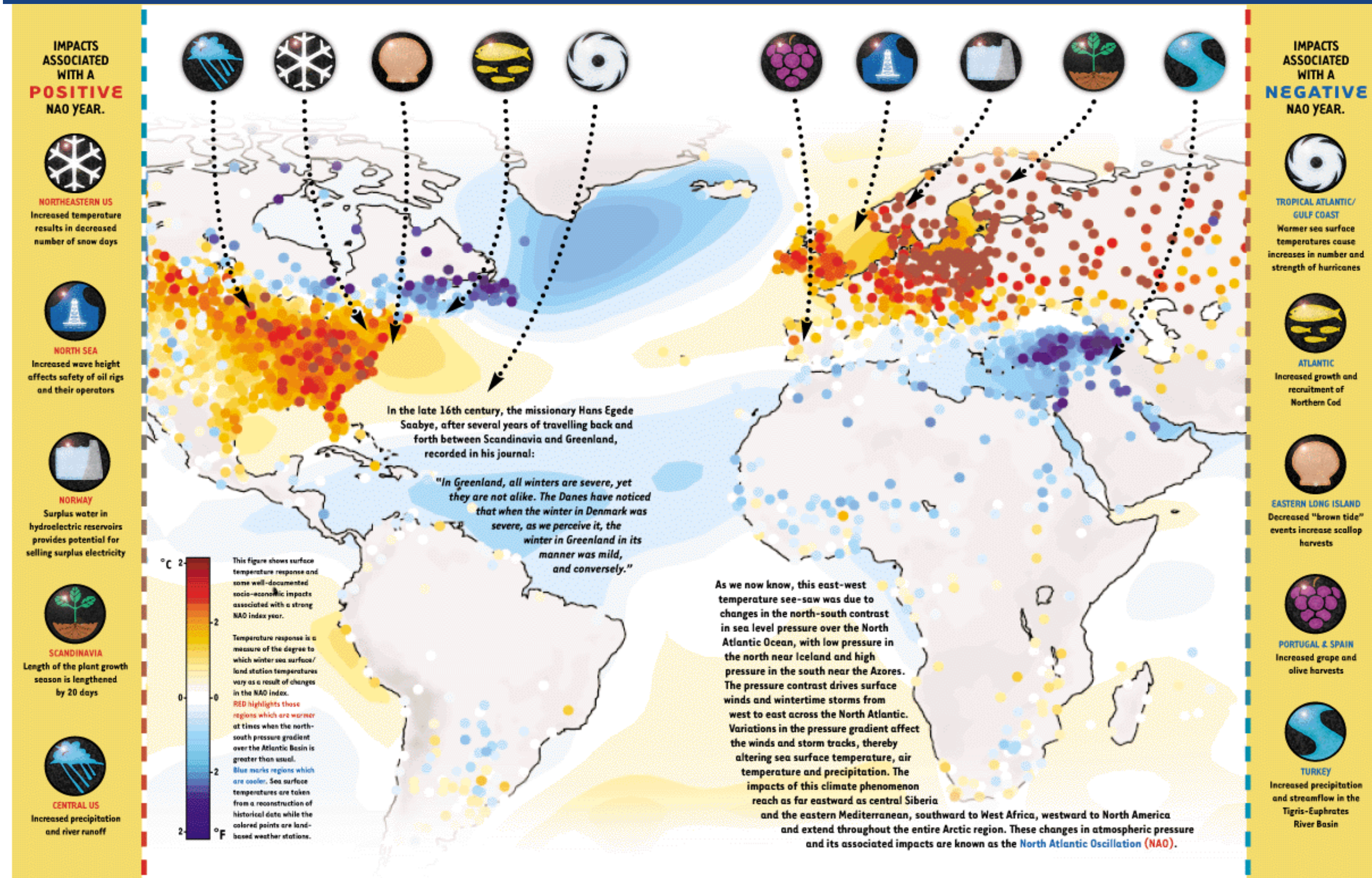
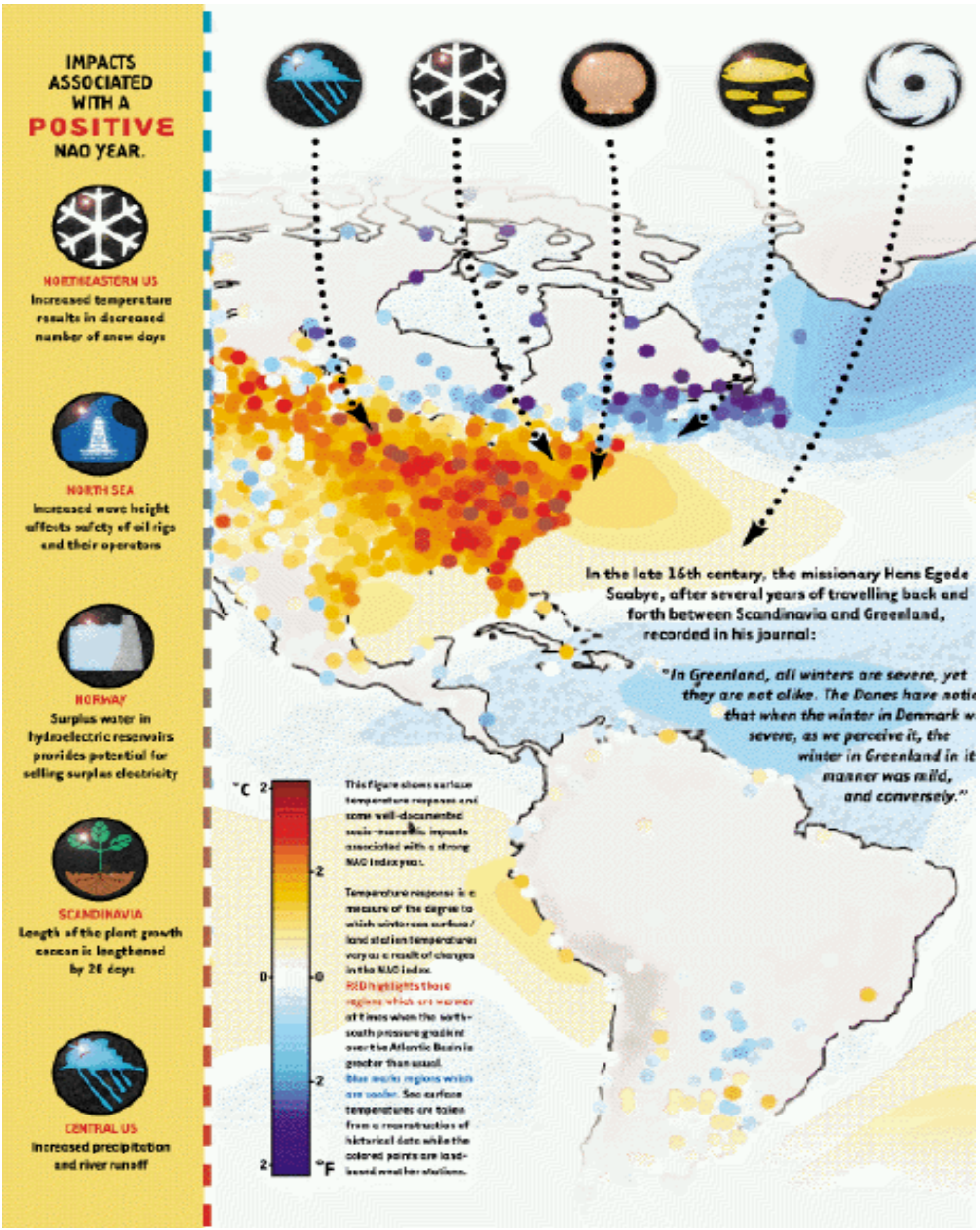



martin visbeck

# The North Atlantic Oscillation



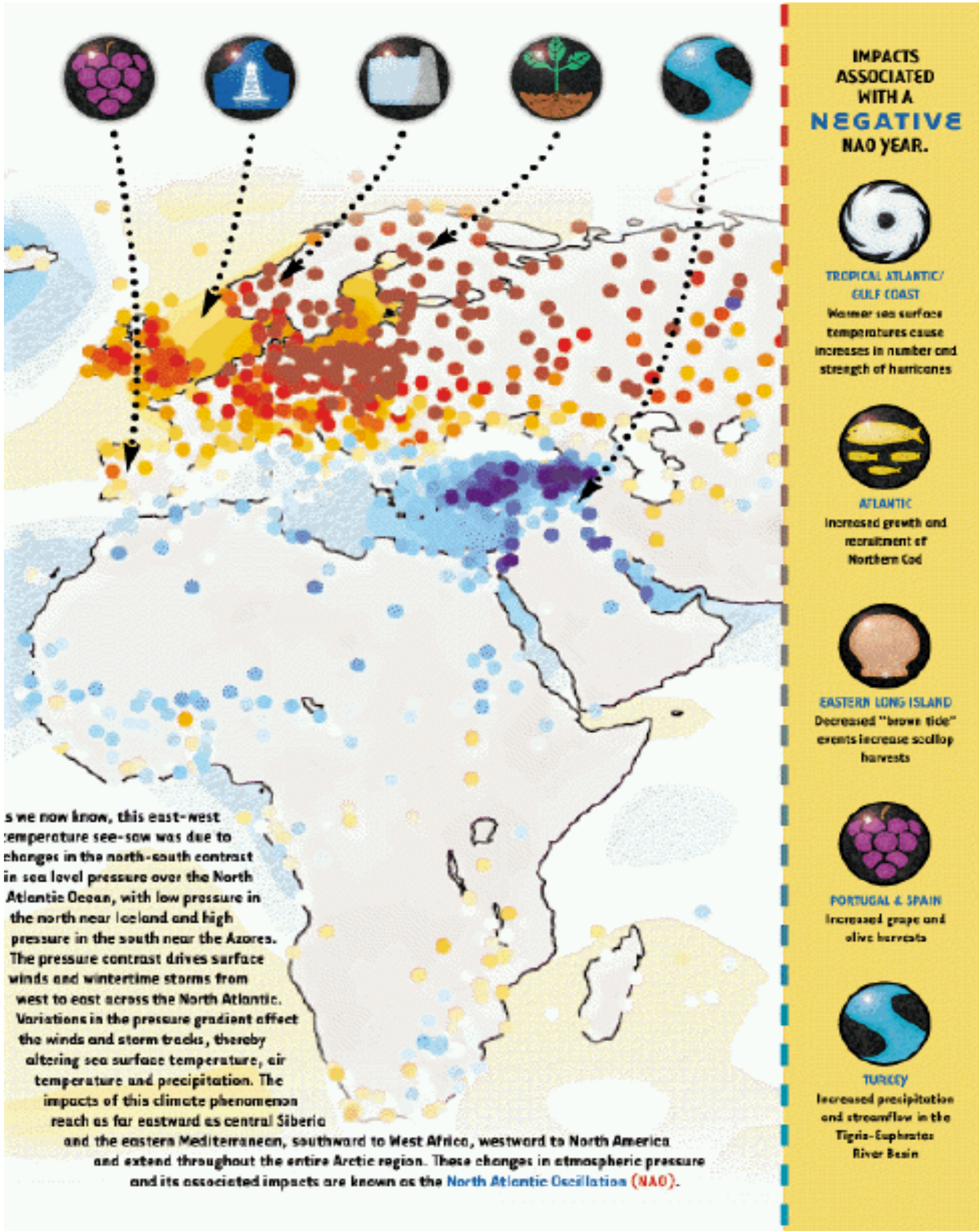

## Negative Phase

- ✓ Less winter outberaks --> Reduced snow cover
- ✓ Warmer temperature --> Red Tides
- ✓ Colder SST --> reduced Hurricanes
- ✓ Colder SST --> less Cod reproduction (Grand Banks)

# The North Atlantic Oscillation

## Positive Phase

- ✓ Mild Winter N Europe --> reduced hydroelectric power
- ✓ Less rain SE Europe --> reduced drinking water & reduced stream flow in Middle East
- ✓ Increased length of growing season
- ✓ Impact on harvest of grapes and olives



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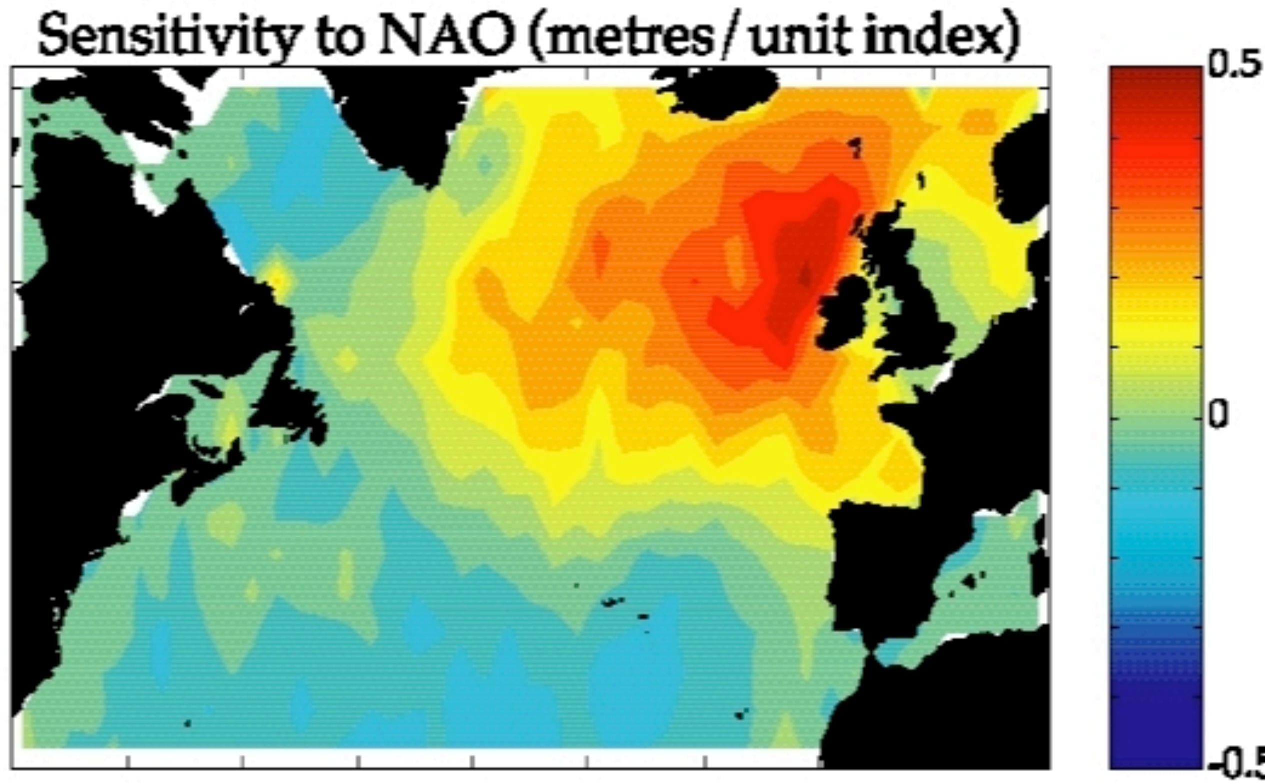
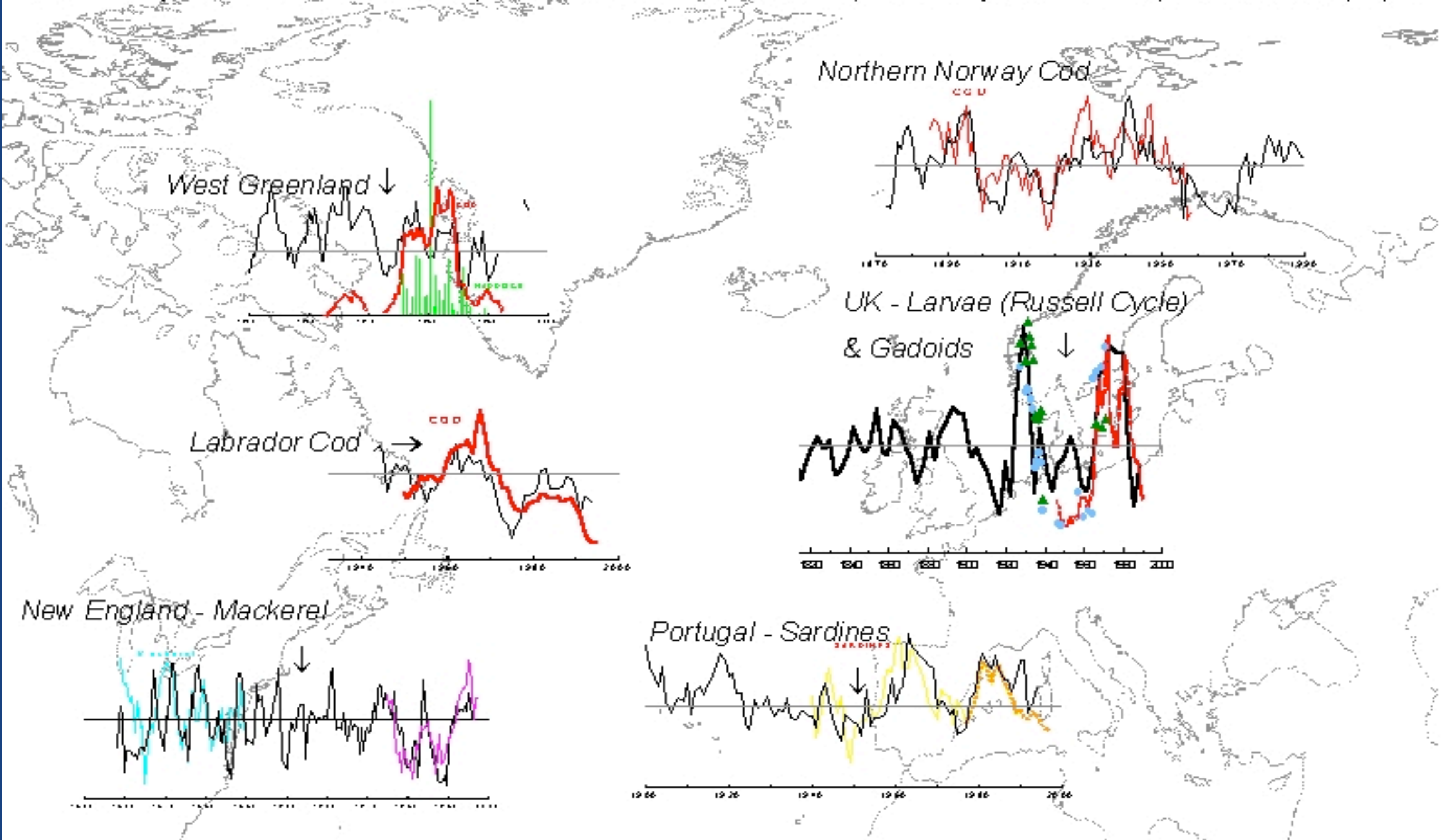



The Sensitivity of Significant Wave Height in the Wintertime (DJFM) to the NAO

# NAO and fish catch in the North Atlantic

**Topliss, BIO, Canada**

Each time series shows a comparison between [coloured lines] historic fish catch records and [black lines] MONACLE, with its zero axis [horizontal black line] indicating positive and negatives feedback in all regions. The autocorrelation time was 7 or 9 years, season start months are those as in world map and season lengths were 3 months except 2 months for the Norway subplot.




B.J. Topliss, Bedford Institute of Oceanography 23/11/00

Fisheries and Oceans Canada Pêches et Océans Canada

Canada

# Ecological effects of the North Atlantic Oscillation

Geir Ottersen, Benjamin Planque, Andrea Belgrano, Eric Post, Philip C. Reid, Nils C. Stenseth

*Posted on class website (12 pages)*

**…more than 100 documented correlation between NAO and marine ecosystems.**

**How to make sense?**

# Ecological effects of the North Atlantic Oscillation

*The response to NAO is classififed into 3 type:*

**DIRECT** - A direct ecological response to one of the environmental parameters synchronised with the NAO.

**INDIRECT** - The indirect effects of the NAO are non-trivial mechanisms that either involve several physical or biological intermediary steps between the NAO and the ecological trait and/or have no direct impact on the biology of the population.

**INTEGRATED** - The integrated effects of the NAO involve simple ecological responses that can occur during and after the year of an NAO extreme. This is the case when a population has to be repeatedly affected by a particular environmental situation before the ecological change can be perceived (biological inertia). or when the environmental parameter affecting the population is itself modulated over a number of years (physical inertia)

# Ecological effects of the North Atlantic Oscillation

## Direct Effects

### Temperature Mediated Response

Length of active growing season, Individual growth (size), growth rate, eggs variability, timing of reproduction, spawning, time of food availability, larval growth and mortality,

## Indirect Effects

### Physically induced by changes in oceanic transport

Changes in spatial distribution of phytoplankton and larvae, alteration in competition between different levels of the trophic chain and alteration in food web

### Effects on Predator-Prey

Through changes/alteration in the food

# Integrated Effects

## *Example of Red Deer*

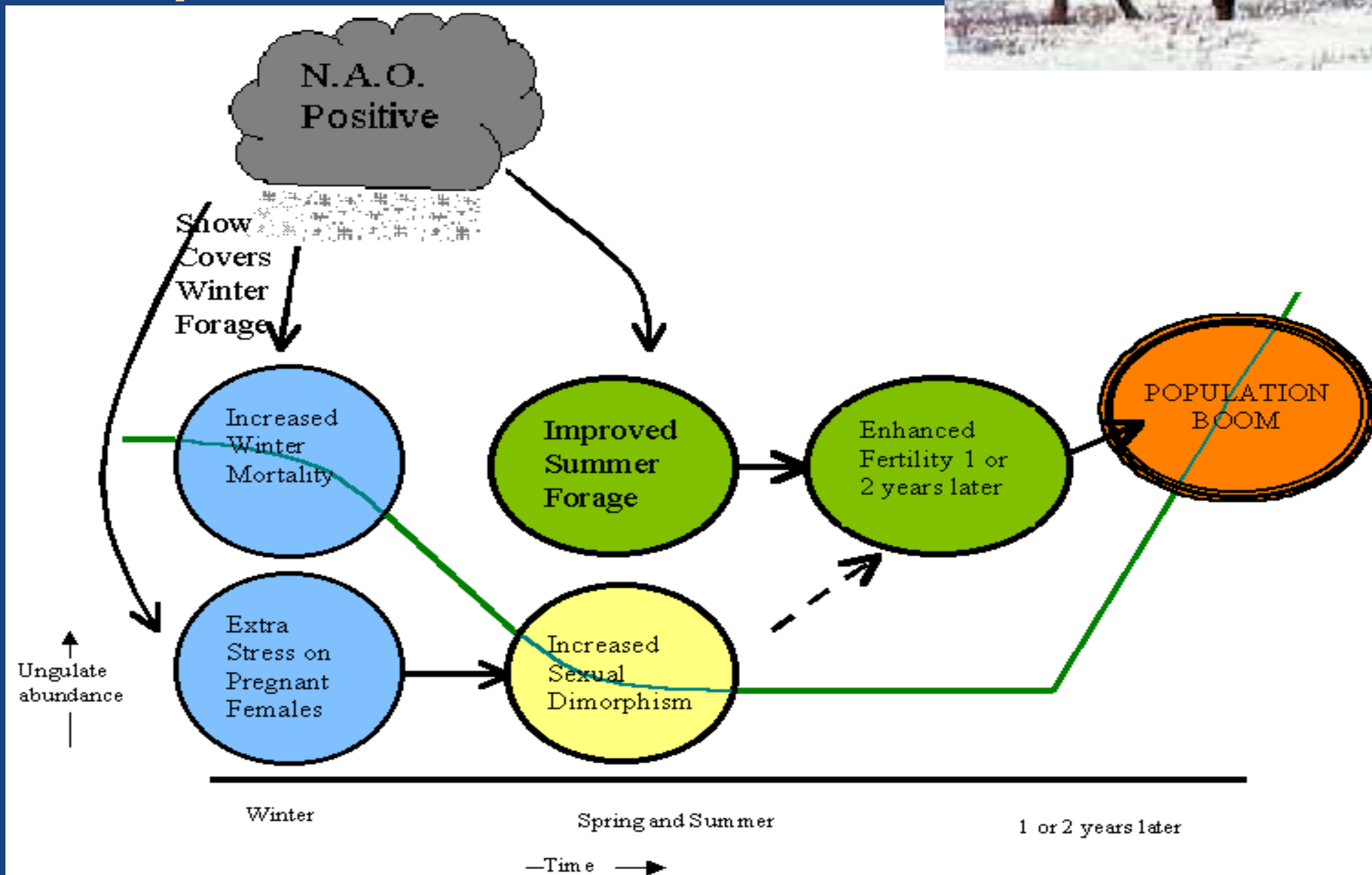
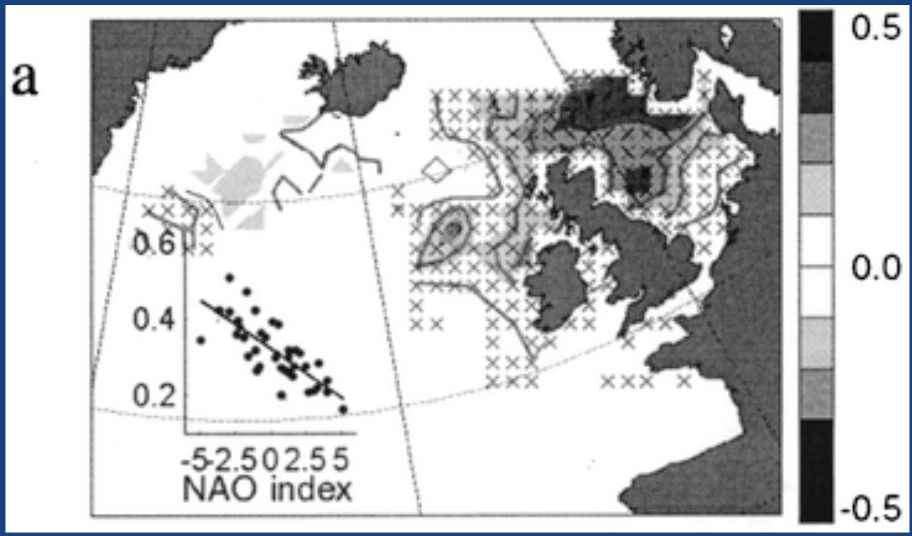



Fig 4.1 shows a schematic diagram of the impact of the North Atlantic Oscillation (+) on ungulant populations in northern Europe. The Thick green line beneath the circles is a rough graph of ungulate abaundance over time, with time along the x axis, and abundance along the y axis.

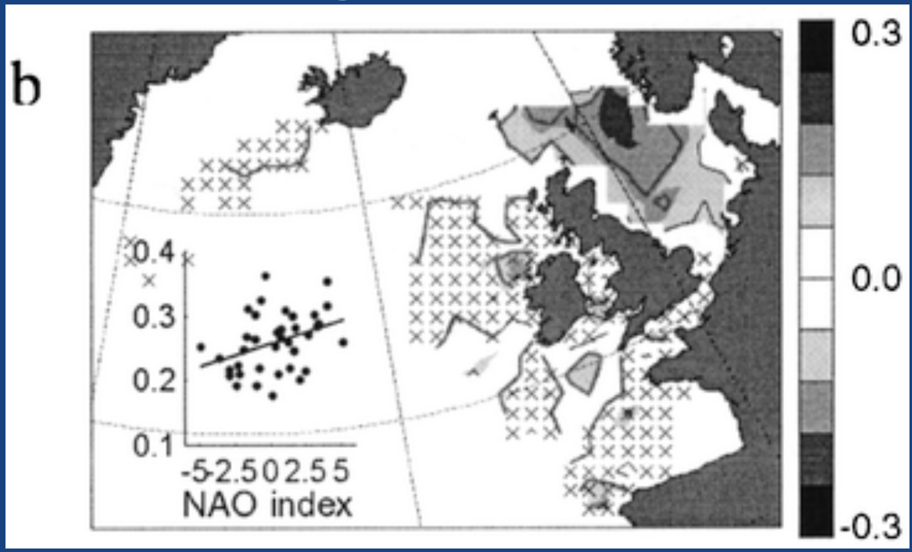
# NAO and Copepods (*Calanus Finmarchicus*)

*Difficult to identify causes of observed relationships*

*Calanus Finmarchicus distribution*




*Calanus Helgolandicus distribution*




***Hypotheses:***

**1) Changes in food availability**

**2) Alteration of competition balance**

**3) Variations in transport of individuals from North Atlantic**

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- ★ It has also been suggested that tropical ocean temperatures can influence the phase of the NAO.