

An Ecosystem Models Response to North Atlantic Oscillation like forcing

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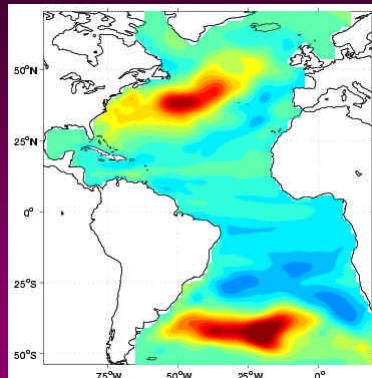
An Ecosystem Models Response to North Atlantic Oscillation like wind forcing

There is significant variability in the ocean on interannual timescales.

Does it impact biogeochemical cycles and how ?

Outline of my presentation

- ◆ NAO
- ◆ Physical model
- ◆ Biogeochemical model

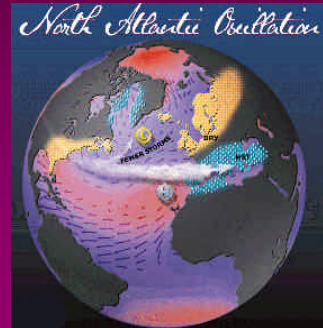


Lamont Ocean Model annual temperature anomalies (0-400m depth) when forced with NCEP/NCAR monthly wind anomalies.

The North Atlantic Oscillation : largest mode of Atlantic climate variability

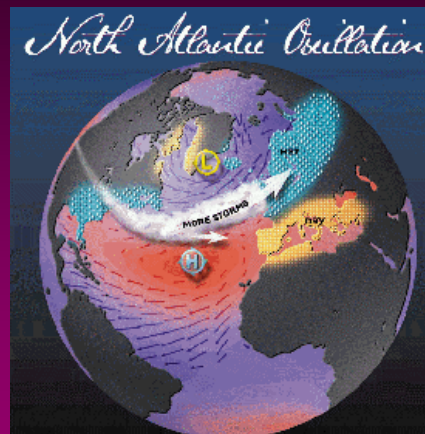
Changes in the Subpolar to Subtropical
Atmospheric Pressure Difference lead to:

- ◆ Changes in strength and position of the westerly winds (storm tracks)
- ◆ Phase can be described by a simple pressure based index

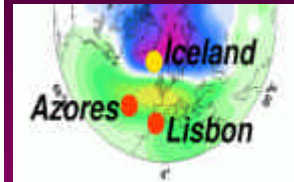
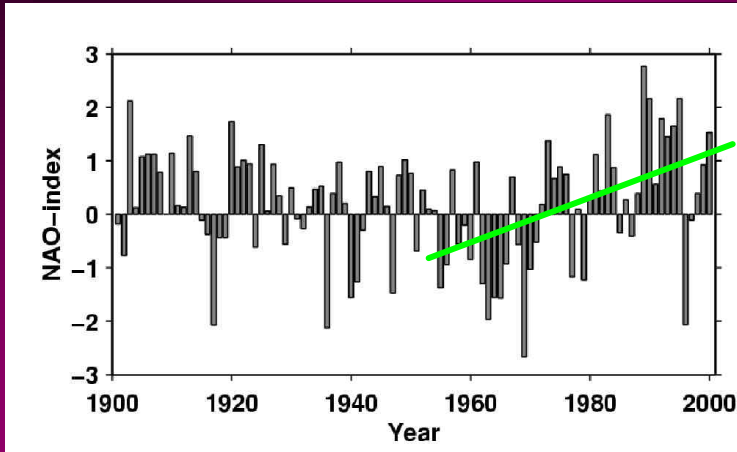


The positive NAO index phase

- ◆ The positive NAO index phase shows a stronger than usual subtropical high pressure center and a deep 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 Europe and in cold and dry winters in northern Canada and Greenland
- ◆ The eastern US experiences mild and wet winter conditions



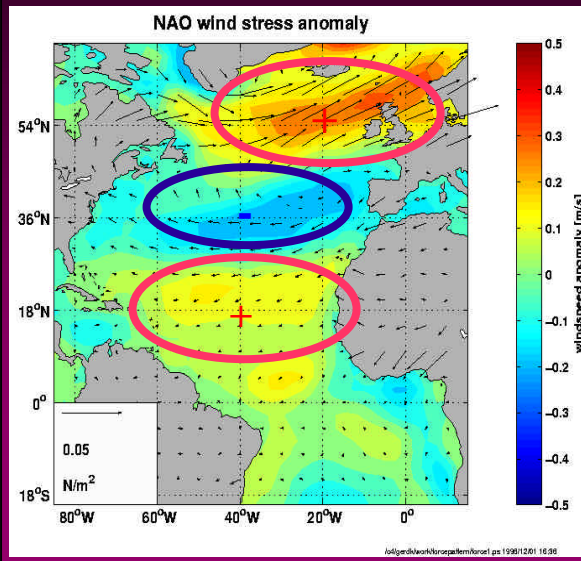
The North Atlantic Oscillation Index



Ocean's response to the NAO: observations

- ◆ Wind anomaly pattern
- ◆ Sea surface temperature
- ◆ Primary production
- ◆ Zooplankton distribution
- ◆ Cod growth

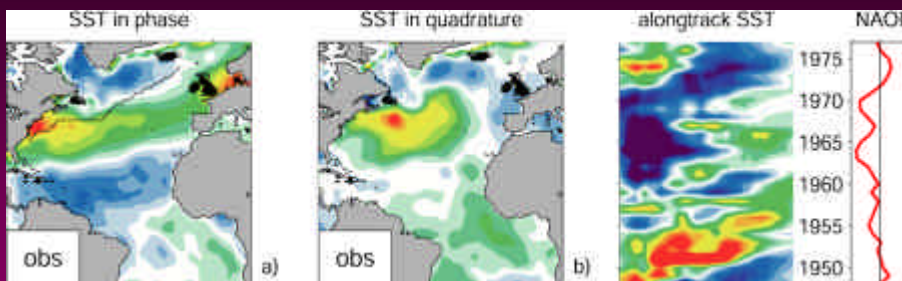
Impacts of the North Atlantic Oscillation: Changes in wind stress and wind speed



Regression of the NCEP/NACR reanalyzed wind speed and wind stress on the NAO index averaged over the winter season (DJFM)

Note the three lobes in wind speed anomalies.

Impacts of the North Atlantic Oscillation: Changes in Sea Surface Temperature

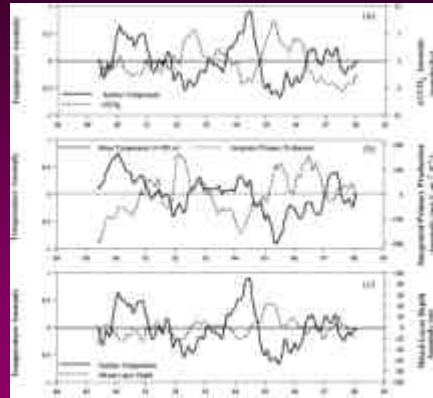


From COADS SST data set

- ◆ Three banded structure : cooling in the subpolar, warming in the Gulf stream region, cooling in the subtropics
- ◆ Direct response to wind anomaly
- ◆ Ocean advection along Gulf stream extension

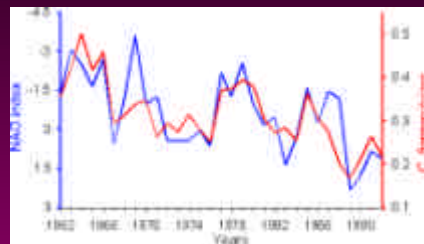
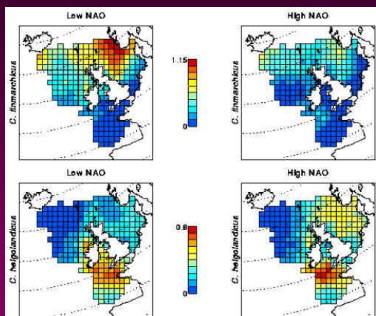
Impacts of the North Atlantic Oscillation: Changes in Primary production

Correlations at station BATS
 NAO/SST : + 0.4
 NAO/MLD : -0.32
 NAO/ PP : -0.33



From Bates (2001)

Impacts of the North Atlantic Oscillation: Changes in Zooplankton



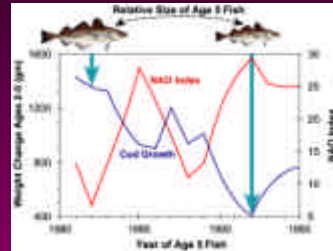
Fromentin and Planque (1998)

High NAO : warmer temperature, enhanced mixing,
 delayed spring bloom -> less *C. Finmarchicus*
 more *C. helgolandicus*

Impacts of the North Atlantic Oscillation: Changes in Cod growth

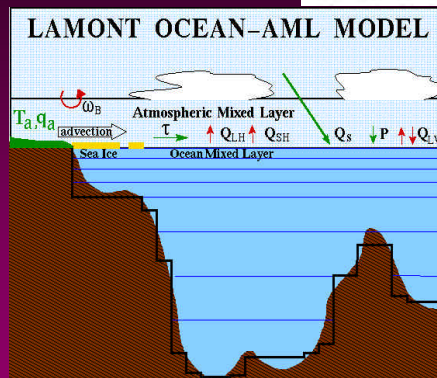
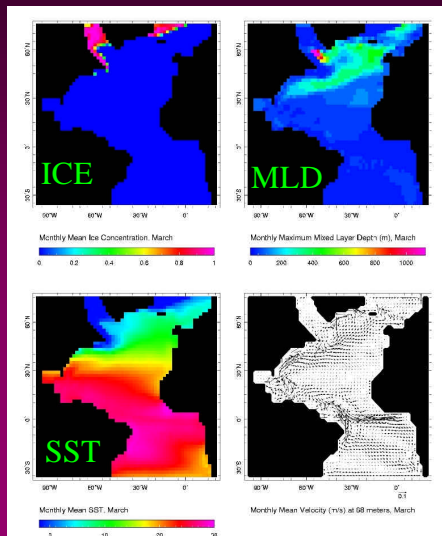
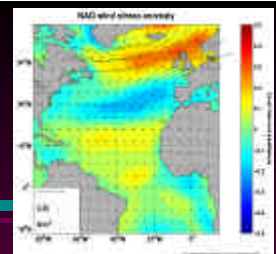
Atlantic Cod off Labrador and off Newfoundland

High NAO : low temperature, lots of ice, low growth



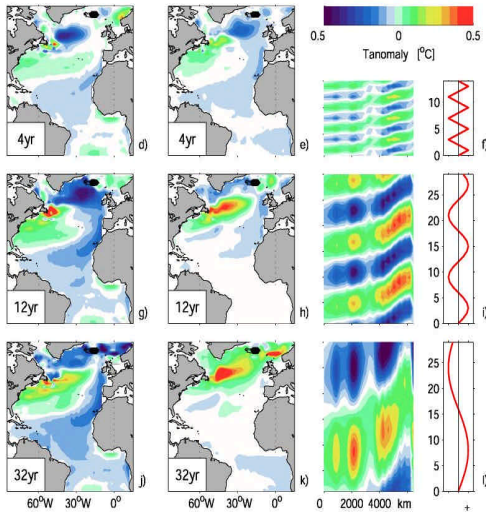
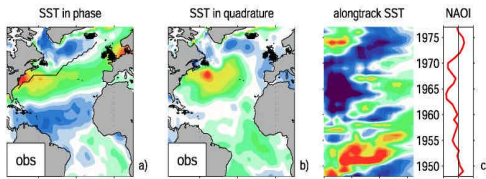
From K. Drinkwater,
AGU Chapman Conference on NAO

Physical Model's response to NAO forcing



2°x2° horizontal resolution
30 vertical layers
monthly forcing

Physical Model's response to NAO forcing



For different forcing periods :

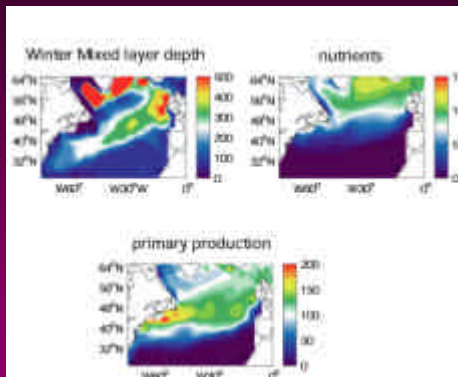
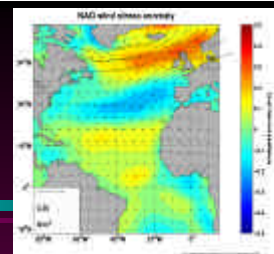
Left panels shows SST anomalies in phase with the NAO

Middle panels shows SSTa in quadrature.

Notice aspects of SSTa propagation along the GS/NAC system

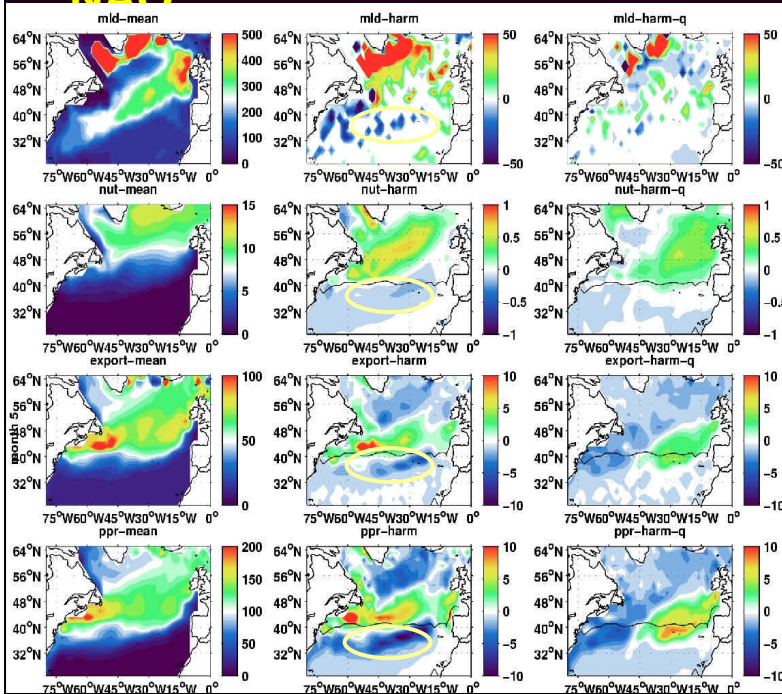
Visbeck et al (1998)

Ecosystem Model's response to NAO forcing



- ◆ LOAM ocean model
- ◆ NAO wind forcing with 8 years period
- ◆ NPZD ecosystem model
- ◆ Initialized with Levitus
- ◆ 20 years spin-up
- ◆ Gent and McWilliams (1990) for lateral mixing
- ◆ TVD advection scheme

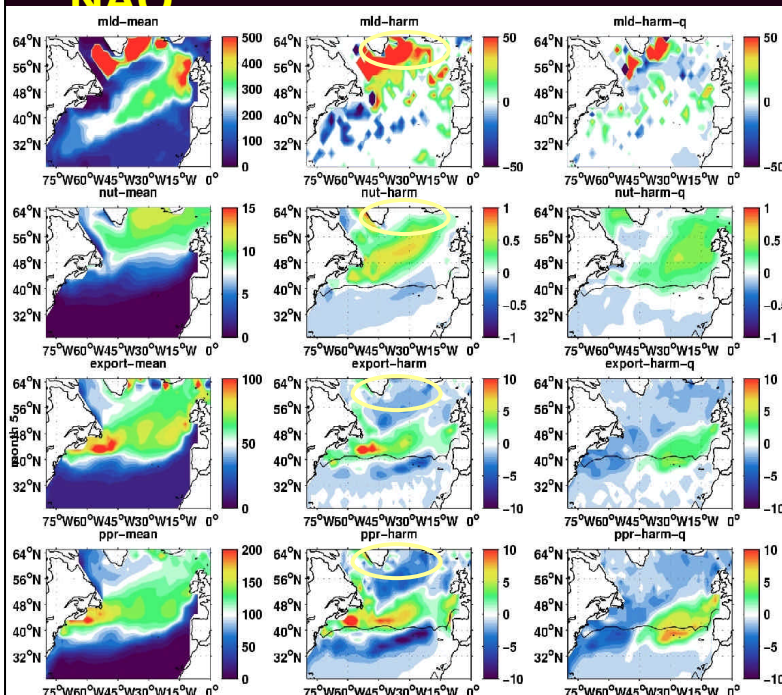
Ocean Models Eco-system response to NAO



From simple nutrient limitation we expect:

- a) shallow ML in subtropics
- b) less winter nutrient supply
- c) less productivity and export

Ocean Models Eco-system response to NAO



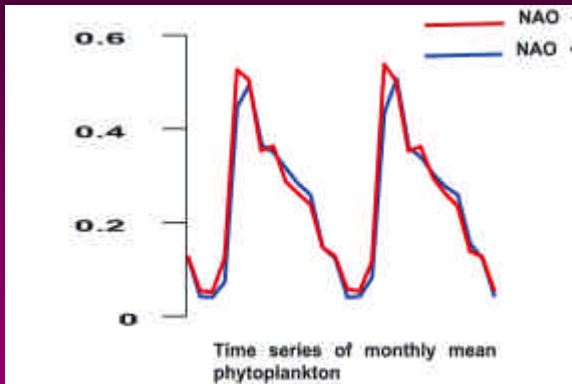
From light limitation we expect:

- a) deep ML in subpolar
- b) more winter nutrient supply
- c) bloom is delayed
- d) less productivity and export

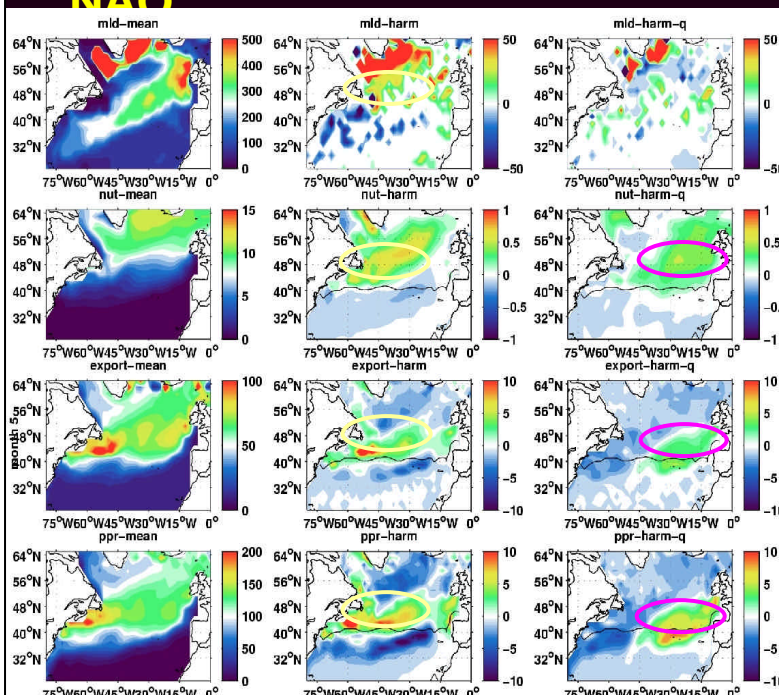
Ocean Models Eco-system response to NAO

From light limitation we expect:

- a) deep ML in subpolar
- b) more winter nutrient supply
- c) bloom is delayed
- d) less productivity and export



Ocean Models Eco-system response to NAO



- a) But what happens at 40-50N?
- ML neutral
- more nutrients
- more productivity & export
- b) 4 years after the NAO the gyre advection of nutrients is important

Summary and Conclusions

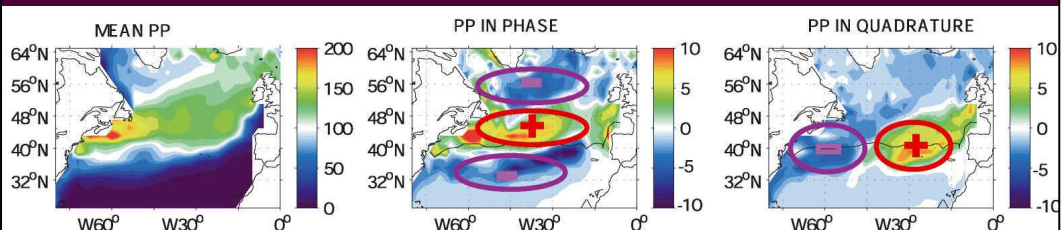
We have shown that the NAO impacts on PP through different processes :

- ◆ In the subpolar gyre: NAO+ is associated with stronger winds, increased MLD which delays and shorten the bloom
- ◆ In the subtropical gyre : NAO+ is associated weaker winds, with decreased MLD which decreases the nutrient inputs and PP
- ◆ In the interboundary region : NAO+ is associated with increased nutrient inputs, ML not too deep, and PP is increased.
- ◆ Nutrients in quadrature with the NAO originate from the gyre recirculation of the extra nutrients from the subpolar gyre

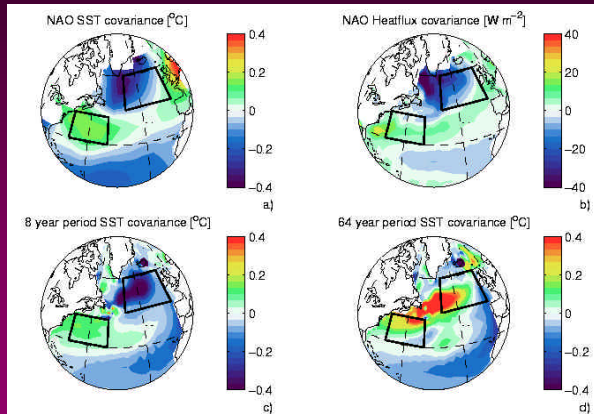
in agreement with Dutkiewicz et al. (2001)

Summary and Conclusions

Primary production pattern :



Oceans Model's response to NAO forcing: Dipole or Monopole ?



Dipole
8 year

Monopole
64 year

What causes the shift from a dipole to monopole SST response ?

Visbeck and Krahnemann argue that it is the advection of temperature anomalies by the mean current.

Does the PP response pattern depends on the frequency of the forcing and how ?