Response of the North Atlantic Basin to Characteristic High and Low NAO Phases

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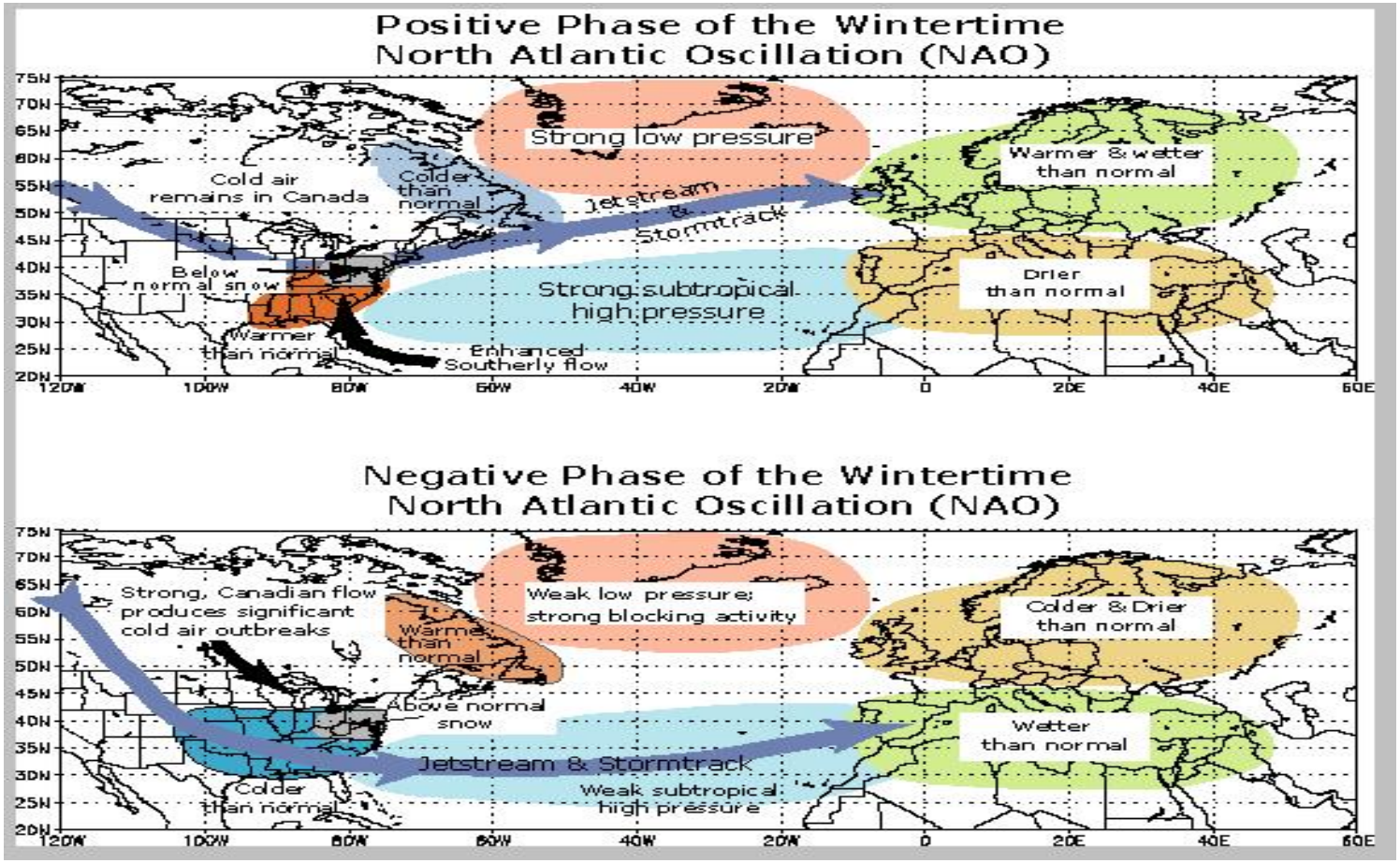
Outline

- Overview
- North Atlantic Basin-scale Model (NABM)
- NABM Forcing
- NAO influence on Gulf Stream Position and Transport
- NAO influence on basin circulation
- Summary

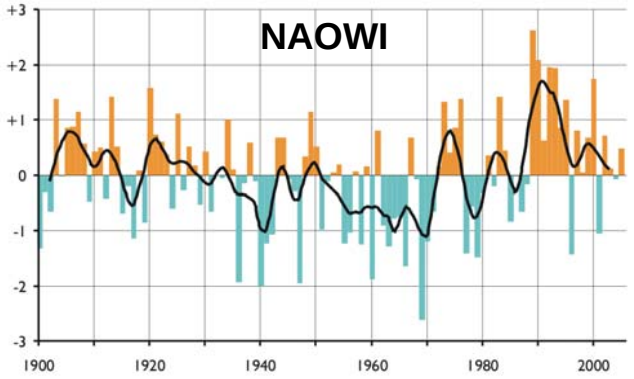
Overview: NAO



Source: www.ncdc.noaa.gov

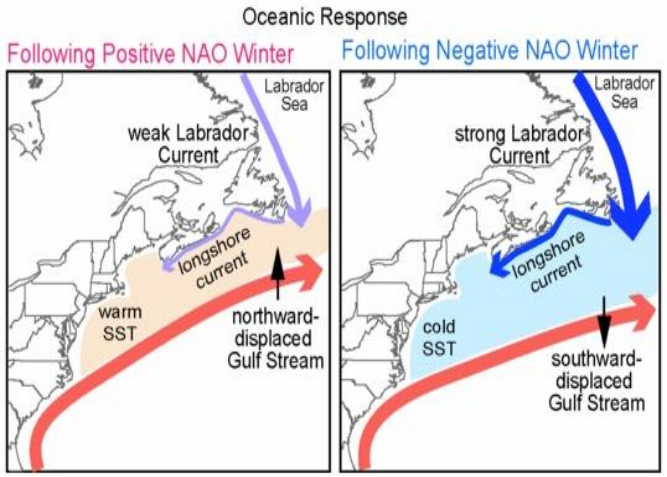
Overview: NAO, GS Position and Transport

- NAO winter-time index (NAOWI) is used to study NAO variability.



- *Taylor and Stephens* [1998] suggest response of GS to NAO-induced integrated wind stress variability whereas *Rossby and Benway* [2000] suggest NAO-induced Labrador current inflow variability as likely forcing mechanisms.

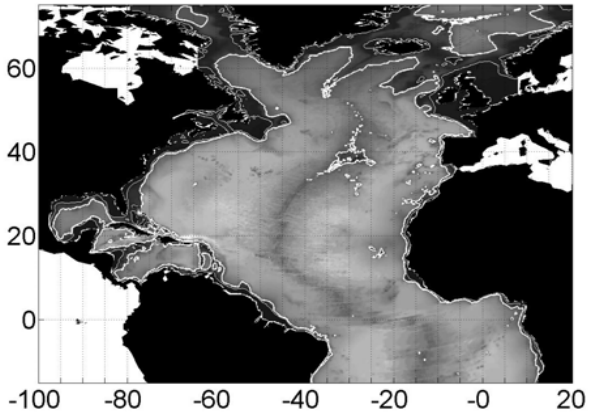
- Studies by *Gangopadhyay et al.*, [1992] and *Baringer and Larsen*, [2001] suggest higher transport in low NAO phases in the Florida Current.

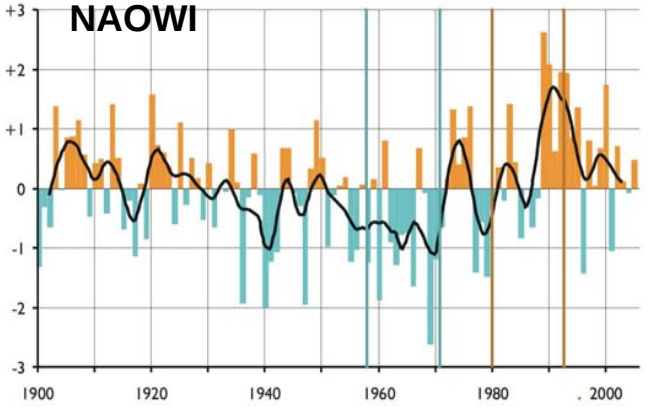


- Other studies by *Curry and McCartney* [2001], *Sato and Rossby* [1995] and *deCoetlogon et al.*, [2006] suggest higher transport in high NAO phases.

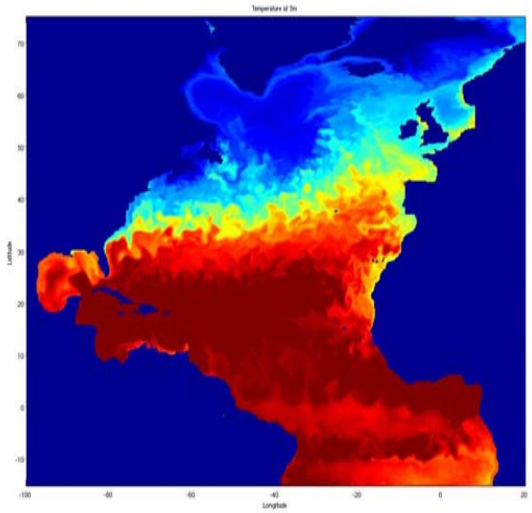
North Atlantic Basin-scale Model (NABM)

- The NABM is implemented using a 1/6º ROMS model. 50 vertical levels.
- NCEP-derived atmospheric fields (wind stress, heat flux, shortwave radiation) were initially chosen to force the model. No freshwater components.
- Initial fields (Temperature and Salinity) derived are from Levitus dataset.
- NAO forcing induced by averaging atmospheric fields from (i) 1958-1971 to represent the low NAO phase and (ii) 1980-1993 to represent the high NAO phase. Each NAO phase is simulated separately.

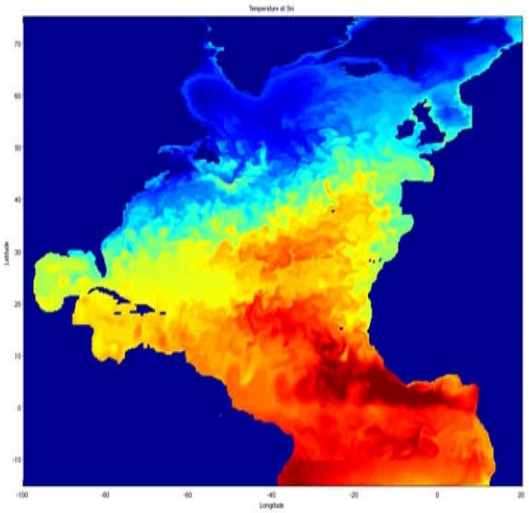




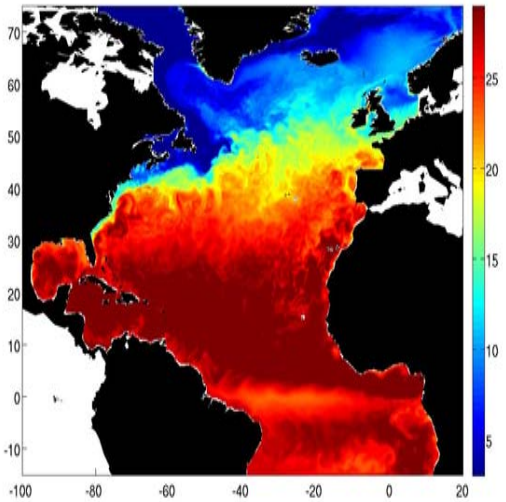
NABM : Initial Runs



High NAO Model Simulation using SOC Climatology (1980-1993), January 6



Low NAO Model Simulation using NCEP Climatology (1963-1971), January 6



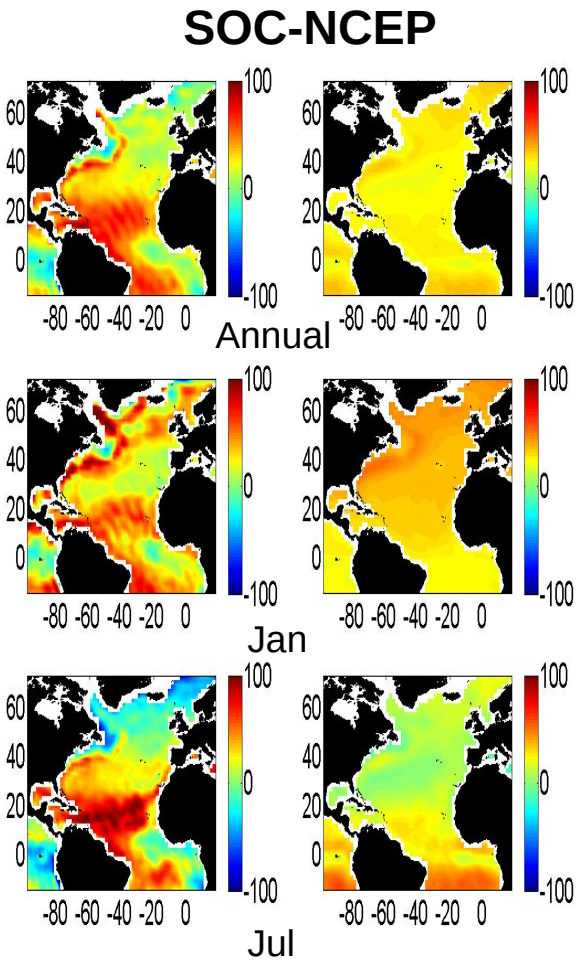
North Atlantic Model Simulation January 6. by McGillicuddy et. al Source: www.whoi.edu

Excess heat loss in high and low NAO simulations

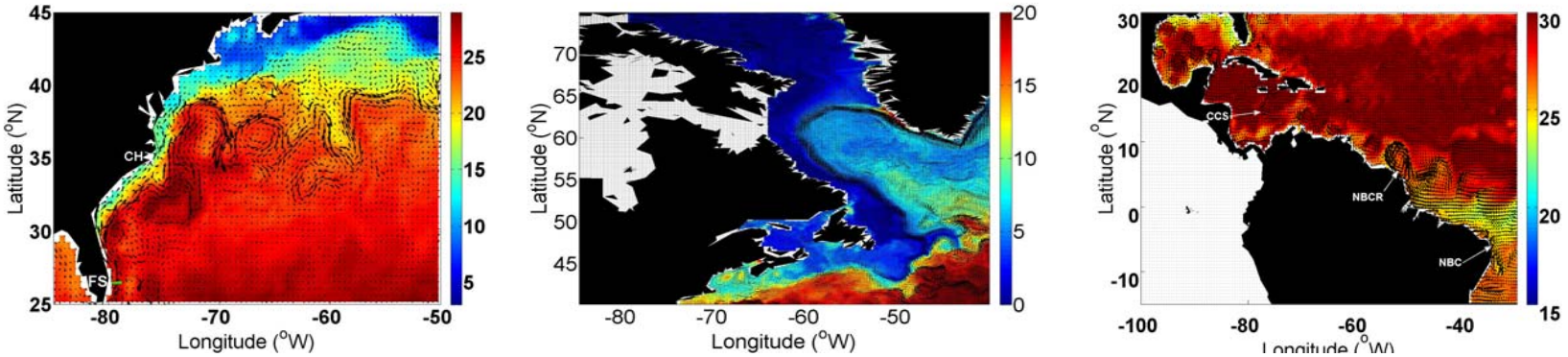
Is the NCEP climatology overestimating the heat loss in the system ?

NABM: Heat Flux Summary

- Comparison of high NCEP climatology with another dataset from Southampton Oceanographic Center (SOC) showed large discrepancies in net heat flux (Q_{net}) for high NAO climatology.
- Differences in Q_{net} on the order of 50-100 W m^{-2}. *Josey et al.* [2001] show similar differences of NCEP Q_{net} values with observational data.
- Low NAO climatology could not be compared as SOC data only starts from 1980.
- In order to overcome the observed bias in NCEP data we adjust the high and low NAO Q_{net} climatologies with the SOC Q_{net} climatology.
- Adjustment is done by using functional regression [*Ricker*, 1973].
- "Adjusted" NCEP Q_{net} values show acceptable differences of 10-30 W m^{-2} with the SOC climatology.



NABM: Simulations

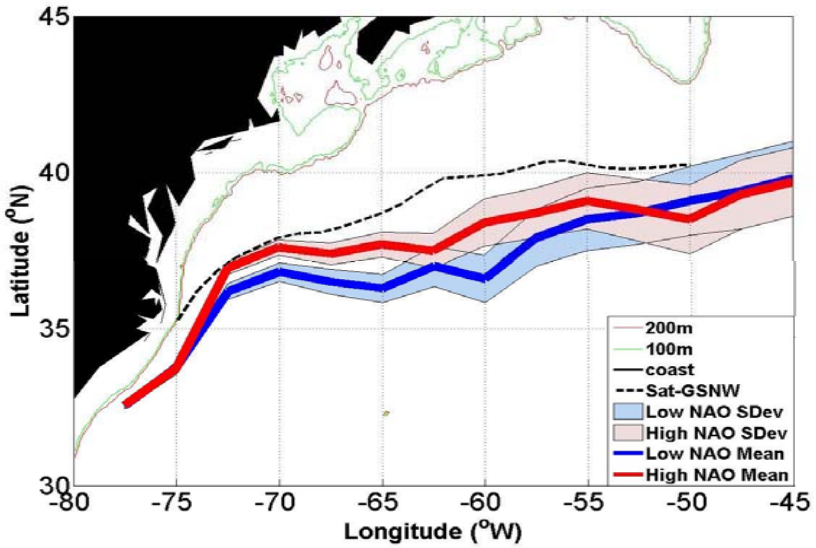


- Monthly mean NCEP high and low NAO NCEP-derived wind stress, adjusted Q_{net} and shortwave radiation climatologies (averaged over 1958-71 for low and 1980-93 for high NAO) are used to force the NABM. The high and low NAO phases are simulated separately.

- NABM is initialized with 0% forcing in the 1st year, 25% in the 2nd year, 50% in the 3rd year, 75% in the 4th year and 100% from the 5th year of simulation. 8 years of spin-up.

- NABM output is stored at 3-day intervals, thus providing a 120-point annual time-series of temperature, salinity, zonal and meridional velocity fields.

NAO: GS Position

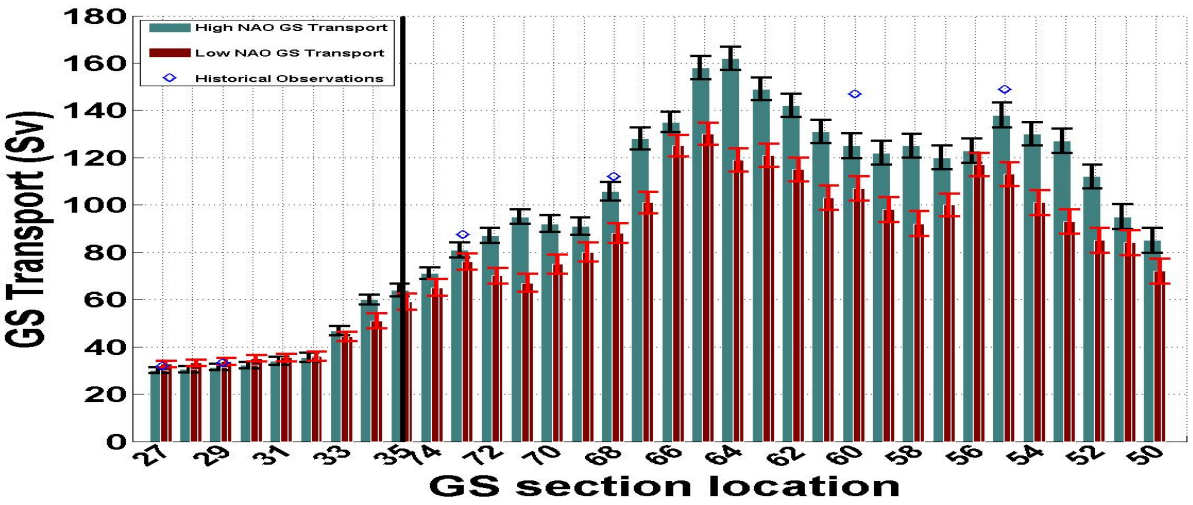


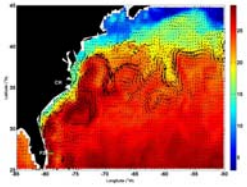
- The position of the GS is initially obtained at depths of 50m, 100m, 200m and 400m by following the 17º,16º,15º and 12º isotherms respectively. These positions are in depth averaged to obtain the mean GS position for high and low NAO simulations.

- Mean GS position remains northward (southward) during high (low) NAO phases. Also the GS separates later (earlier) from the coast during high (low) NAO phases.

- Mean difference of the GS between high and low NAO phases in 55 km.

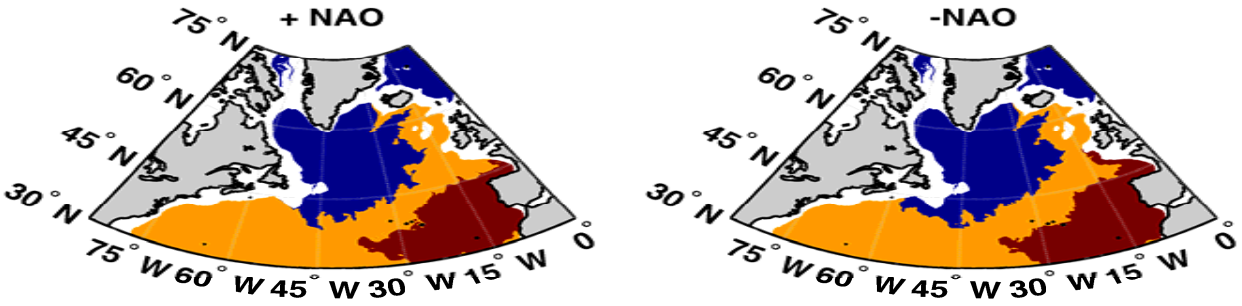
NAO: GS Transport





- Model-derived GS transport is computed by taking sections across the GS from 27^{o}N (Florida Straits) to 50^{o}W (south of Tail of Grand Banks).
- GS transport is estimated by computing the magnitude of the vector sum of velocity. The horizontal and vertical extent of the section is defined by 0 m sec^{-1} contour of the vector sum.
- Higher transport during low NAO from 27^{o}N to 32^{o}N (Florida Current). Mean difference of 1.1 Sv
- Higher transport during high NAO from 75^{o}W to 50^{o}W (after GS separation). Mean difference of 20 Sv.

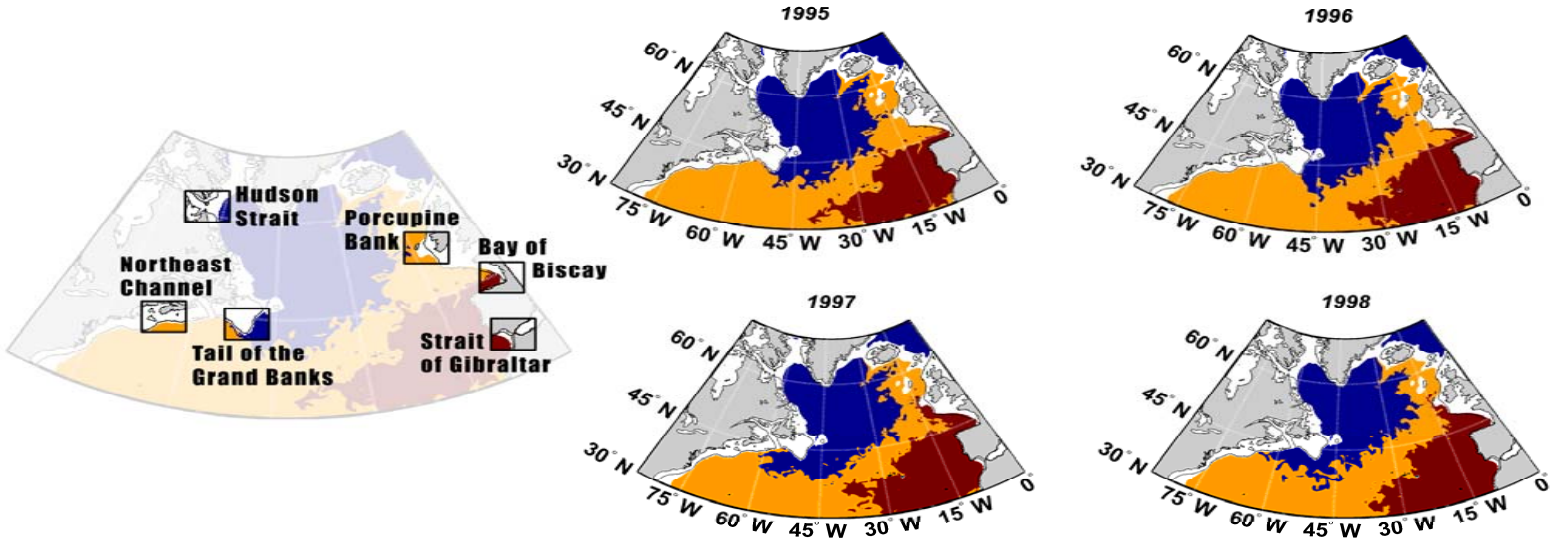
NAO: Basin Circulation



- Climatological mean model-derived salinity fields for characteristic high (left panel) and low (right panel) NAO phases at 1000 m. Sub-polar water (blue) < 35 psu < Sub-tropical water (orange) < 35.6 psu < Mediterranean outflow (brown).

- Concurrent southwestward outflow of low-salinity sub-polar water in the west and northward penetration of high-salinity Mediterranean outflow water in the east are observed during the low NAO phase.

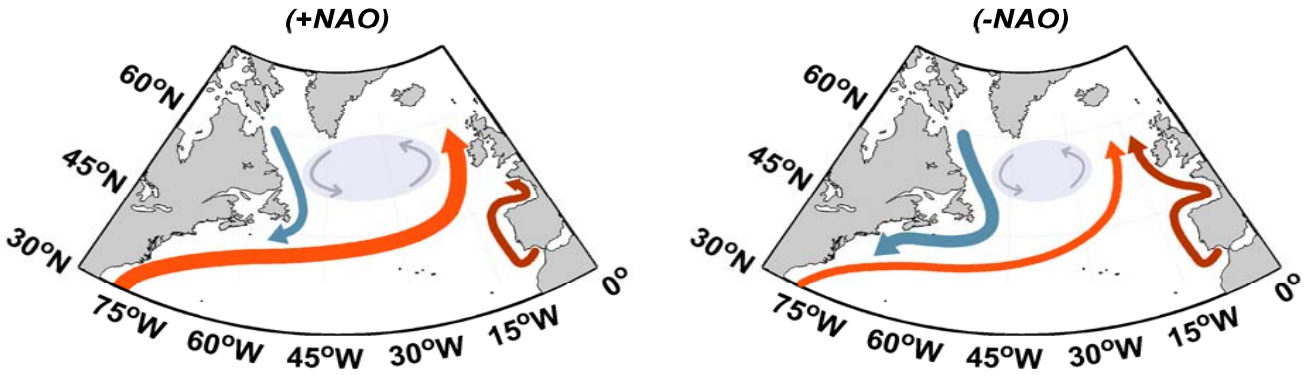
NAO Basin Circulation



- Mean model-derived salinity signature for July (a conservative summer month) at 1000 m during 1995-1998. 1000 m depth is chosen to resolve the Mediterranean outflow water.

- Simultaneous southward advection of low-salinity sub-polar water in the WNA and northward advection of high-salinity Mediterranean outflow water in the ENA from 1995 through 1998 is clearly evident.

NAO: Basin Circulation



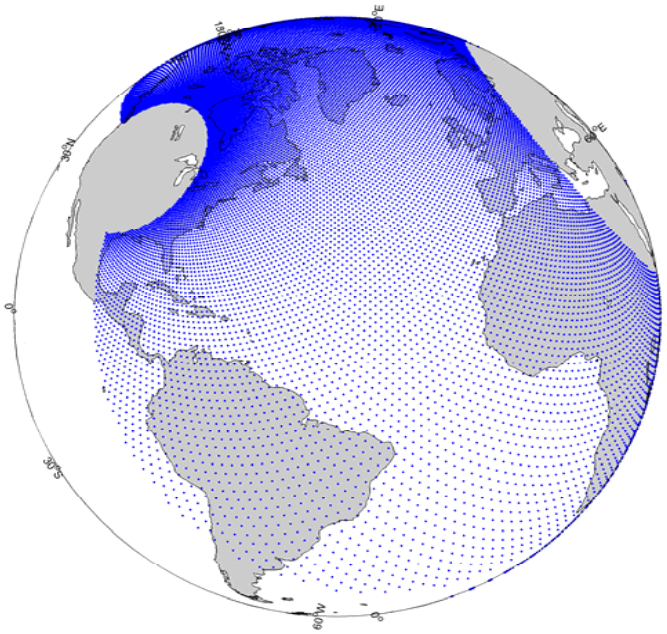
- Thick (thin) lines signify enhanced (diminished) transport.

- Shrinking (expanding) sub-polar gyre, coincident with a westward (eastward) shift of its center and further augmented by a weaker (stronger) North Atlantic Current flow, allows for enhanced (diminished) northward penetration of Mediterranean outflow water within the ENA during negative (positive) NAO phases.

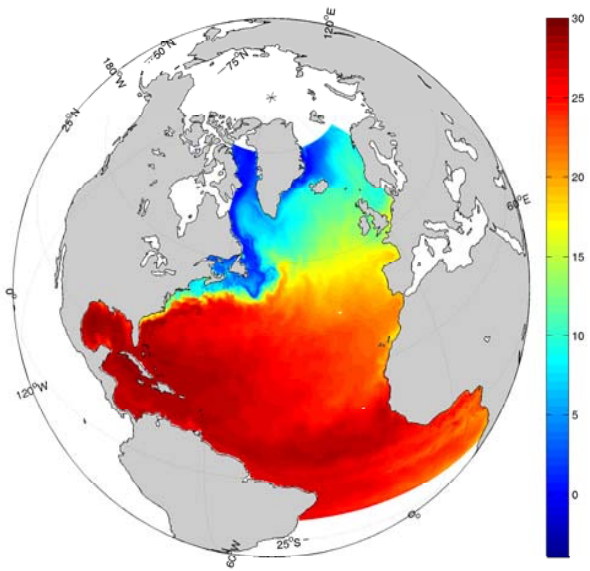
Summary

- Gulf Stream moves northward (southward) during high (low) NAO phases.
- Gulf Stream transport before separation is enhanced (diminished) during low (high) NAO phases.
- Gulf Stream transport after separation is enhanced (diminished) during high (low) phases.
- Concurrent southwestward outflow of low-salinity sub-polar water in the east and northward penetration of high-salinity Mediterranean outflow water in the west are observed during the low NAO phase.

Arctic-North Atlantic High Resolution Model



- The model is implemented using a 1/8^{o} ROMS model. 50 vertical levels.
- Grid size [1258 x 780 x 50].
- In collaboration with Rutgers (Curchitser, Levin, Haidvogel). Model includes sea-ice and riverine outflow. Planned hindcast simulations from 1985-2007 and forecast simulations from 2008-2028.


180°W
120°E
60°N
75°N
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25
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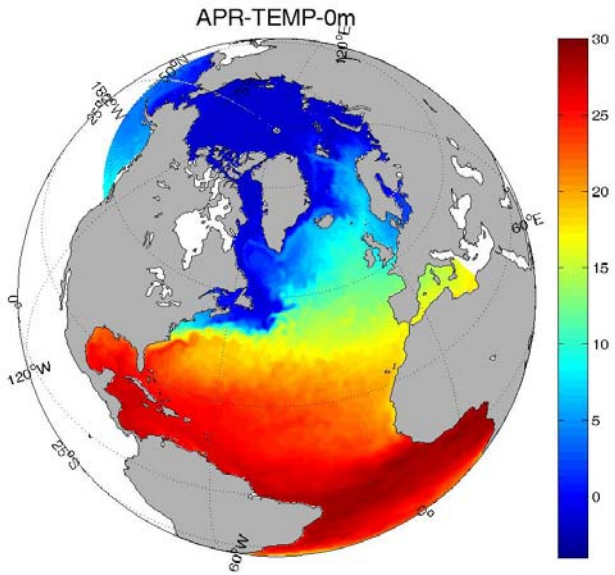
APR-TEMP-0m
120°E
60°N
150°W
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25°S
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10
5
0

Thank You

Questions?