

Multi-decadal simulation of Atlantic Ocean climate variability driven by realistic high-frequency atmospheric reanalysis

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Discussions with B. Molinari, J. Metzger, T. Townsend, A. Wallcraft, F. Schott

Interannual North Atlantic simulations With HYCOM

One main simulation was done,
1/3 degree, for period 1948-2003.

Mediterranean Sea not resolved
Explicitly, but as a marginal sea boundary
Condition as in Price-Young-(Baringer).
KPP mixed layer.

*(Future 1/3 deg experiments: for comparison, salinity
relaxation in the Gulf of Cadiz , GLSS mixed layer.*

One simulation at 1/12 degree will be started.
Large computer allocation was granted. Will
Cover 1960-present.

Specified P-Y Model

Parameters:

Bathymetry

Gibraltar Width: 20km

Gibraltar Sill depth: 280m

Shelf-slope break depth: 625m

Slope of continental slope: 0.012

Specified Atlantic Ocean Water Properties

- model • T, S of Gibraltar inflow water
- model • T, S of entrained interior water at shelf-slope break

P-Y Model Output

Gibraltar inflow transport (Mi)

Gibraltar outflow T, S, transport (Ms)

Med. Surf. Fluxes

E-P over Mediterranean

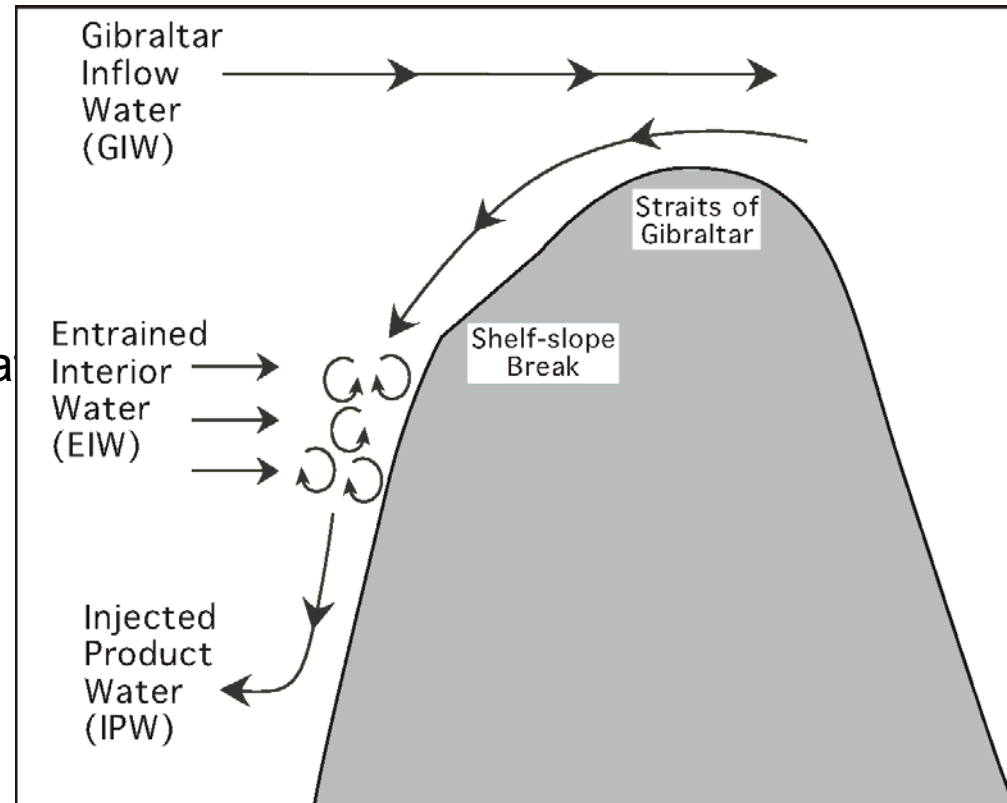
Net Q over Mediterranean

(-13 W/m²)

Entrained interior water transport (Me)

Mp – final product water T

Price-Yang- (Baringer)-Model



- E-P, Q over Med kept constant

HYCOM Atlantic 1/3° interannual simulations (1948-present)

Initialization from year 20, ATLn0.32

with Price and Young Parameterization for
Mediterranean overflow

Expt 30.3

NCEP forcing from 1948

wind stress anomalies, wind speed, airtemp,
radiation, water vapor

Rivers

More details, forcing and parameters:

- used ncep ocean land mask
- ncep wind stress anomalies, with ECMWF long term wind stress mean (ERA15, which was used for spin-up).
- SSS relax, no E-P, no SST relax.
- biharmonic and laplacian diffsn.

Start with:

SSH and NAO index

Florida Current transport

Sea Surface Height

NAO⁺(strong westerlies)

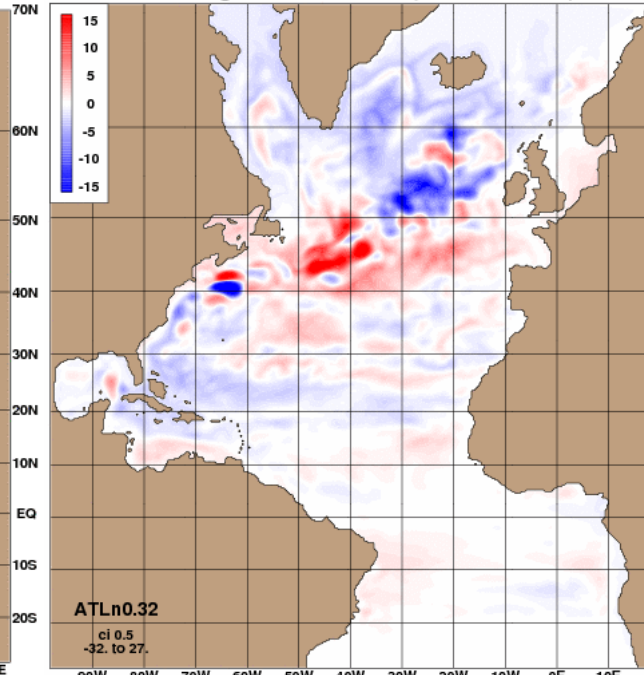
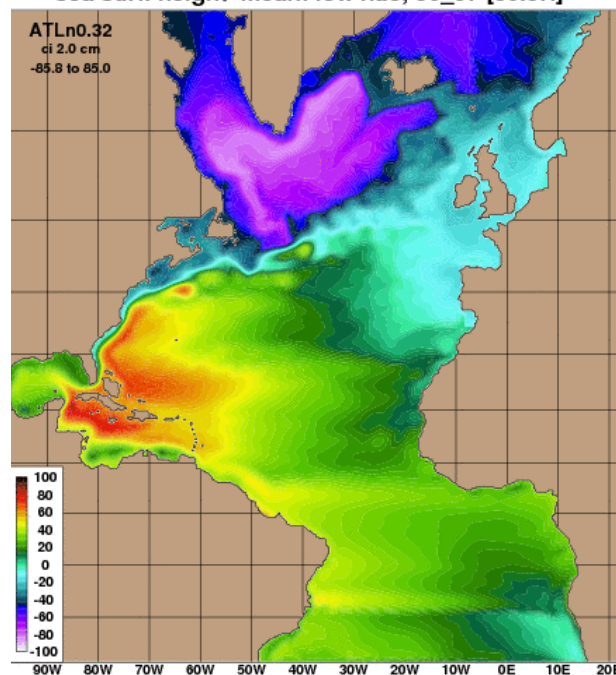
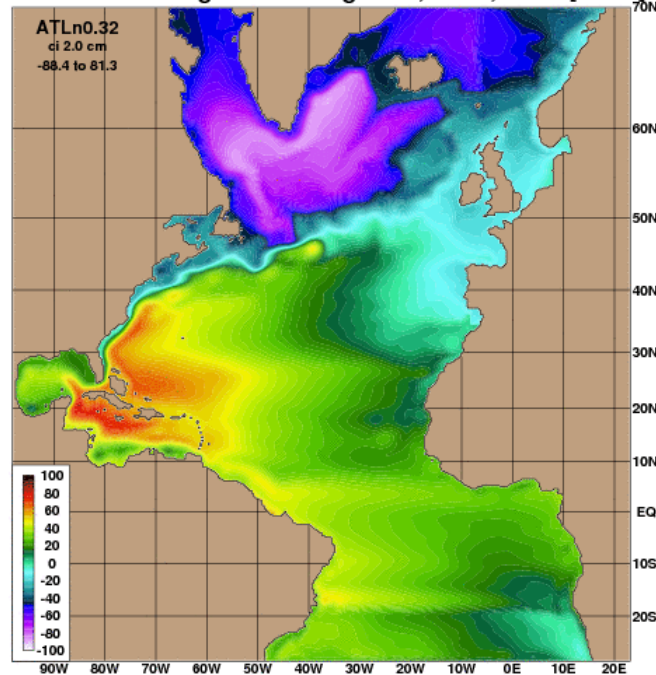
NAO⁻ (weak westerlies)

NAO⁺-NAO⁻

sea surf. height mean: high nao, 82-84, 89-96 [30.3H]

sea surf. height mean: low nao, 86_97 [30.3H]

ssh high nao - low nao (after1982, cm)



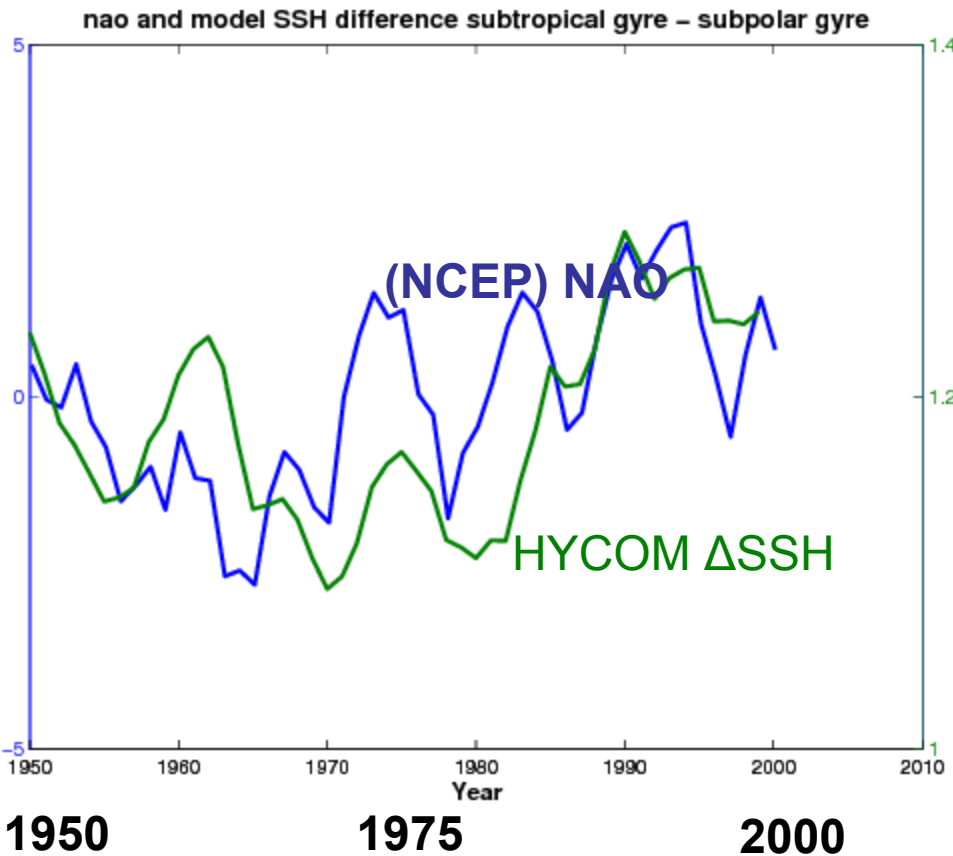
1982-1984, 1989-1996

1986, 1997

Expt 30.3, SSH vs NAO (3yr running mean)

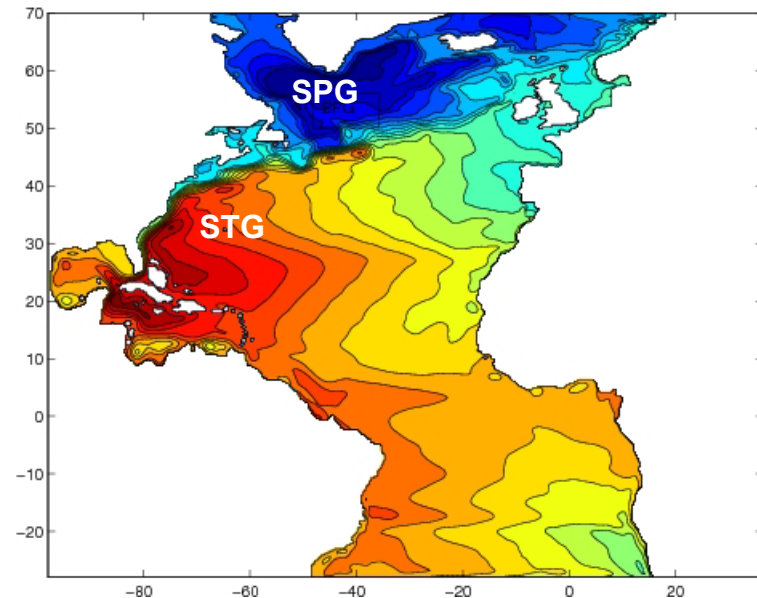
Following Curry-McCartney baroclinic transport index

(SPG:47W 57N
STG:62W 32N)



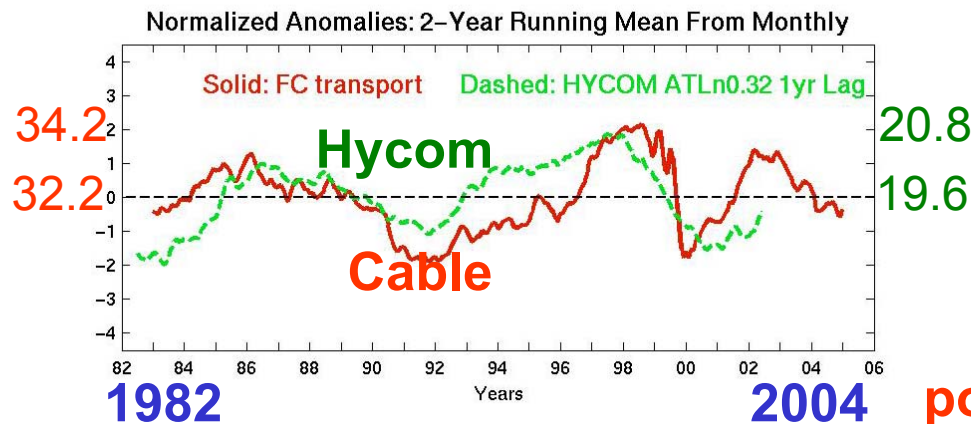
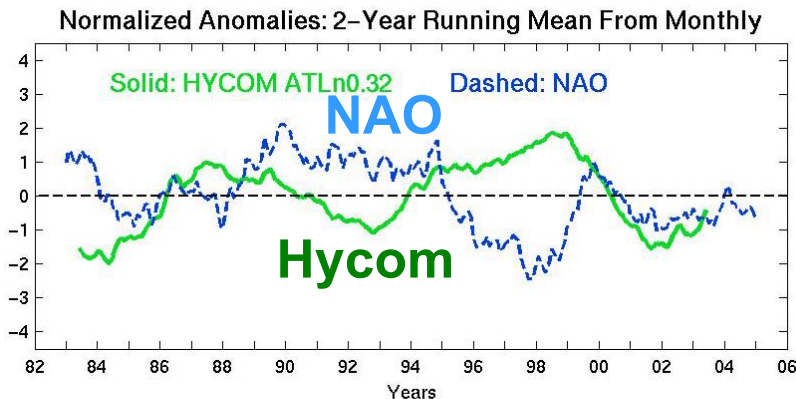
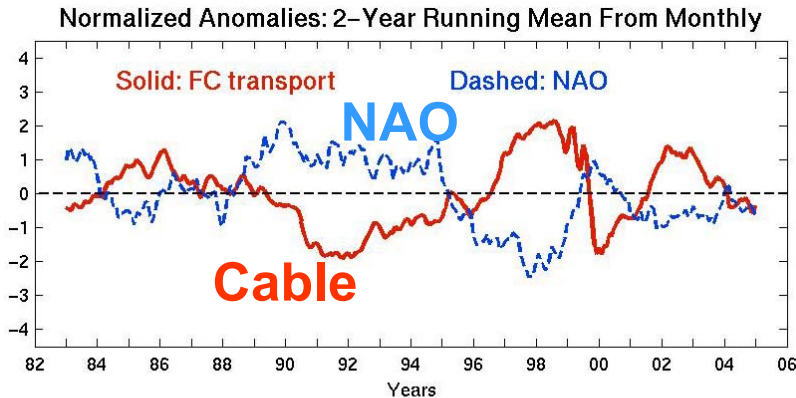
Generally model lags NAO, as in Curry-McCartney

30.3: Mean SSH



After 1960, minima in agreement with Curry-McCartney transport index minima in 1970, 1981, 1989.

Following Baringer and Larsen, 2001



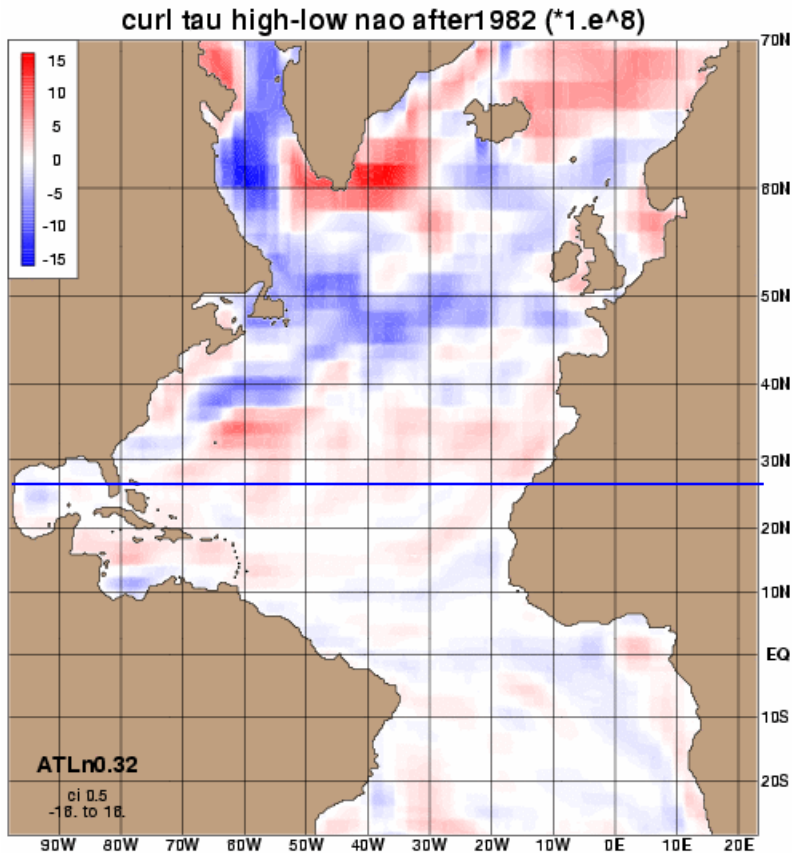
Florida current transport anomalies, (de-measured values divided by standard deviation), for cable data vs NAO, hycom vs NAO, hycom vs cable data

Good agreement in the phase of the observed and simulated transport anomalies

(Sv)	Cable	hycom
mean	32.2	19.6
std	1	0.65

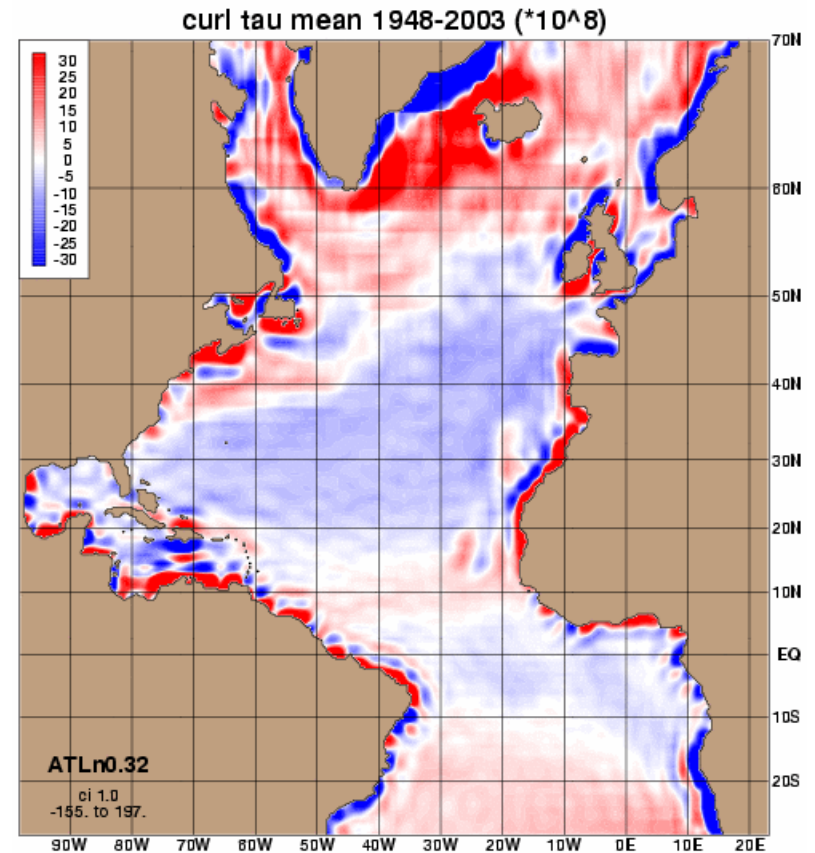
poor resol. FI St, (also MOC too weak)

Curl Tau, NAO⁺-NAO⁻ (after 1982)

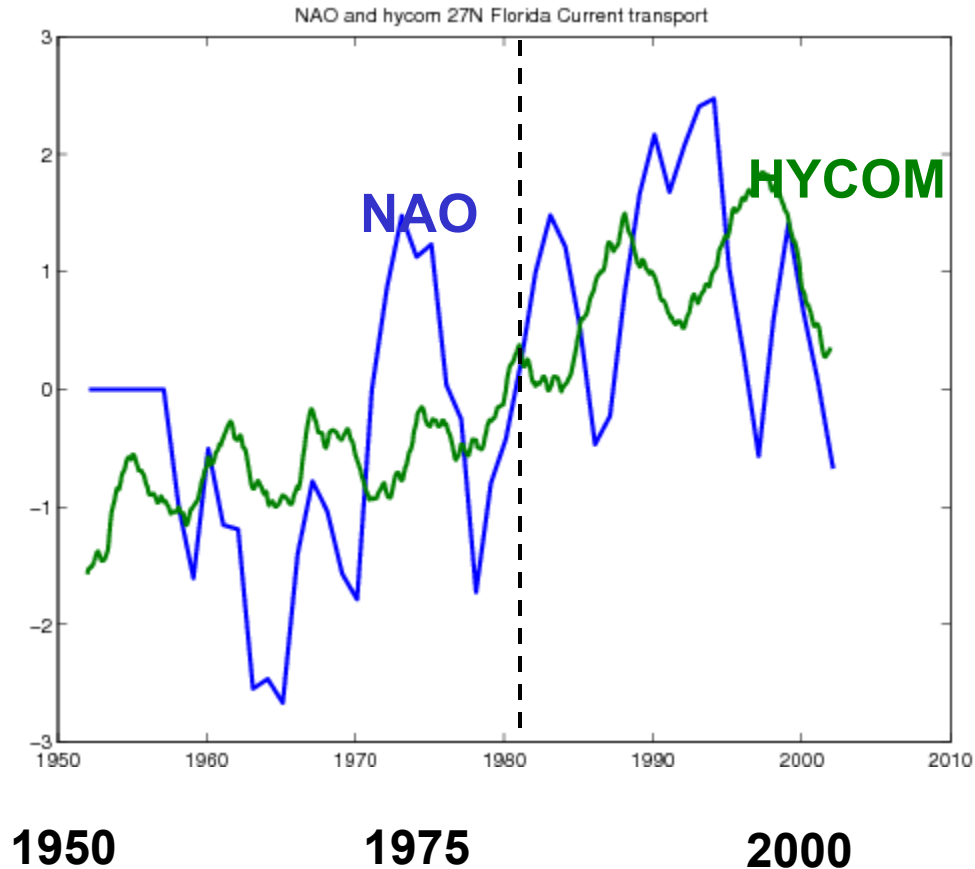


Positive wind curl anomaly
(weaker curl tau) at 27N

For comparison, Curl Tau (mean 1948-2003)



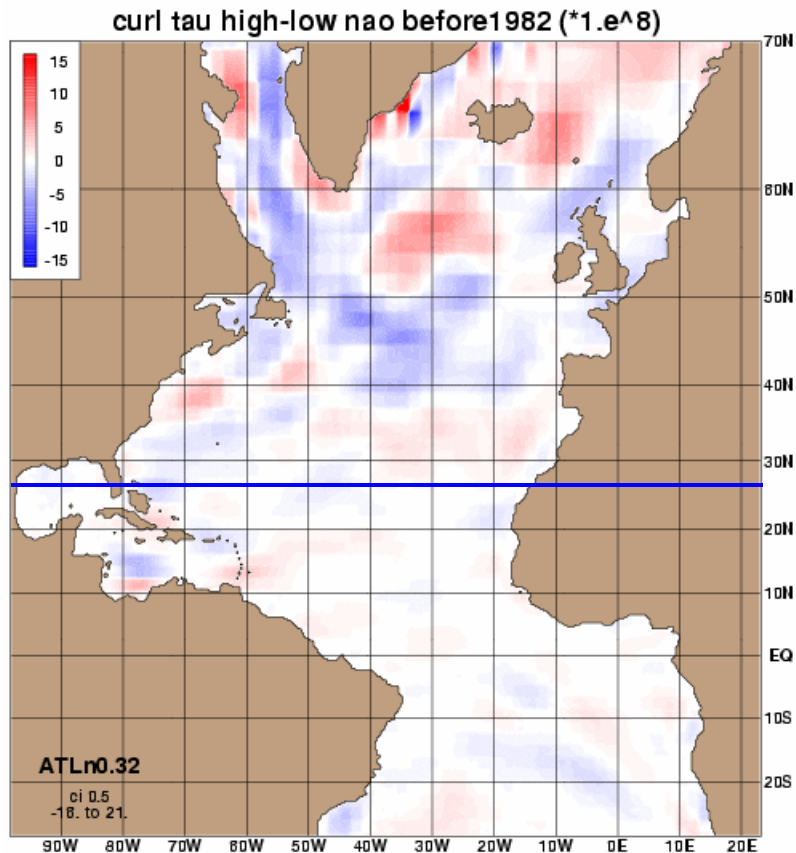
Following Baringer-Larsen, NAO and Florida Current transport (27N)



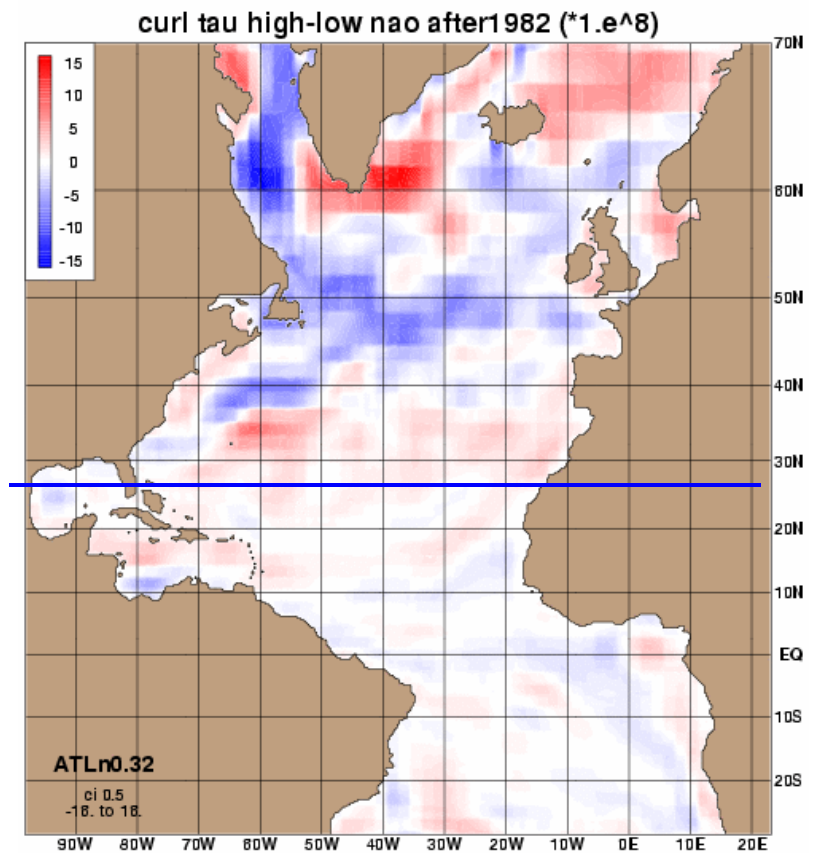
After 1980, in opposite phase to NAO,
But not before 1980.

Curl Tau, NAO+-NAO-

Before 1982

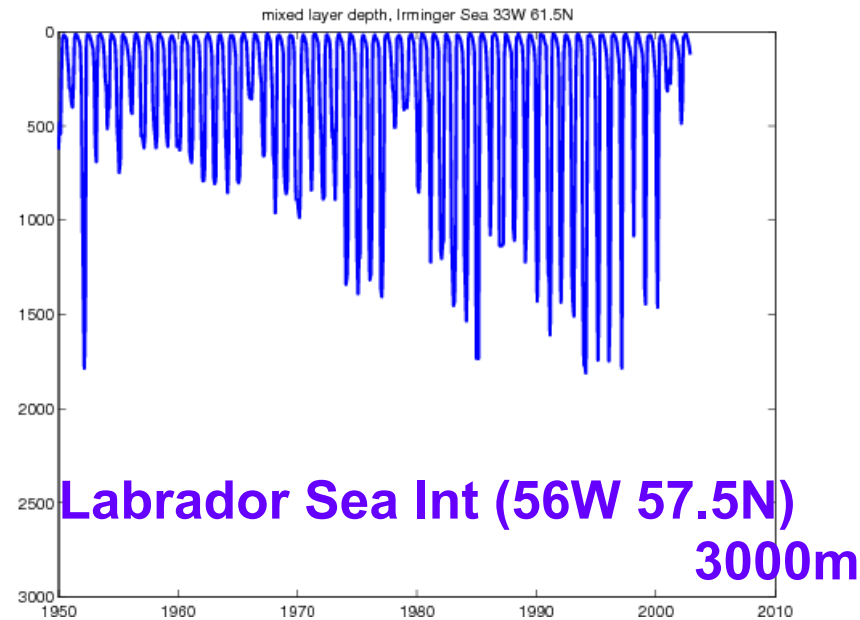
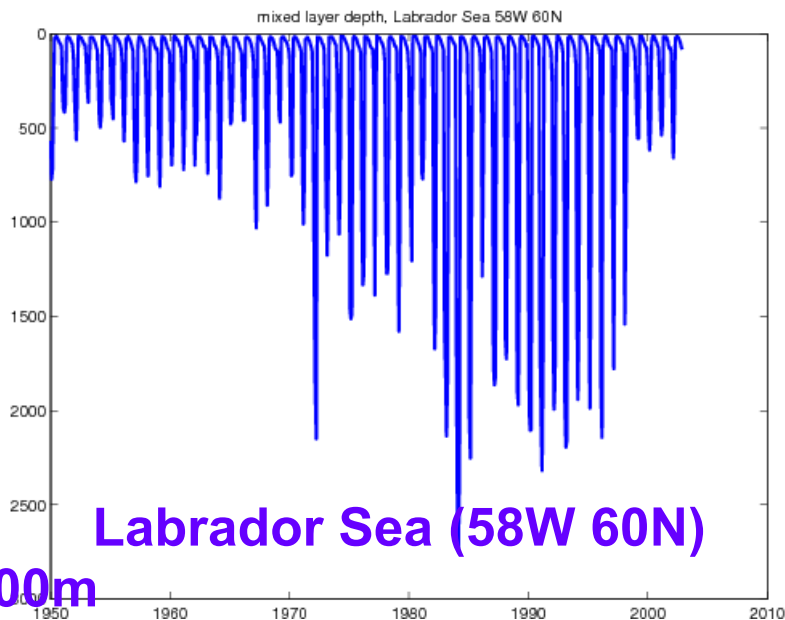
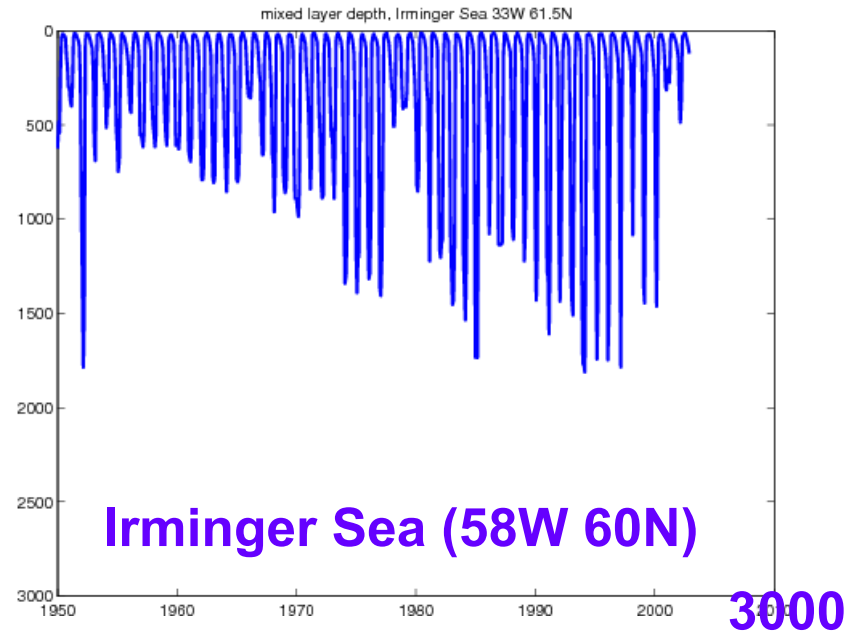
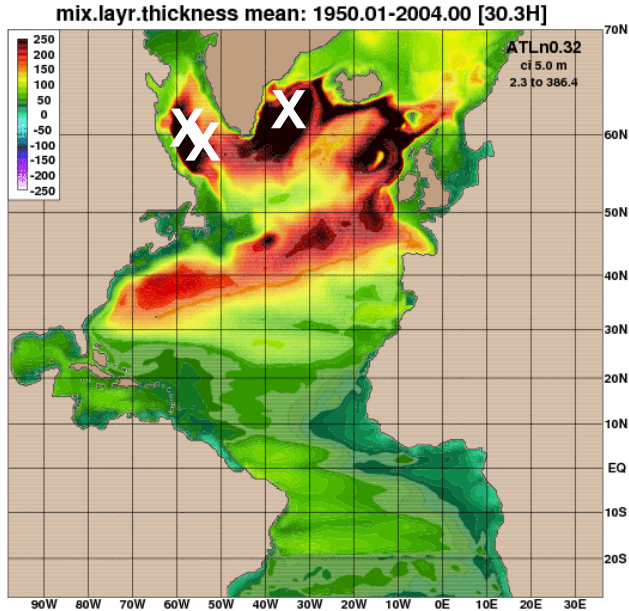


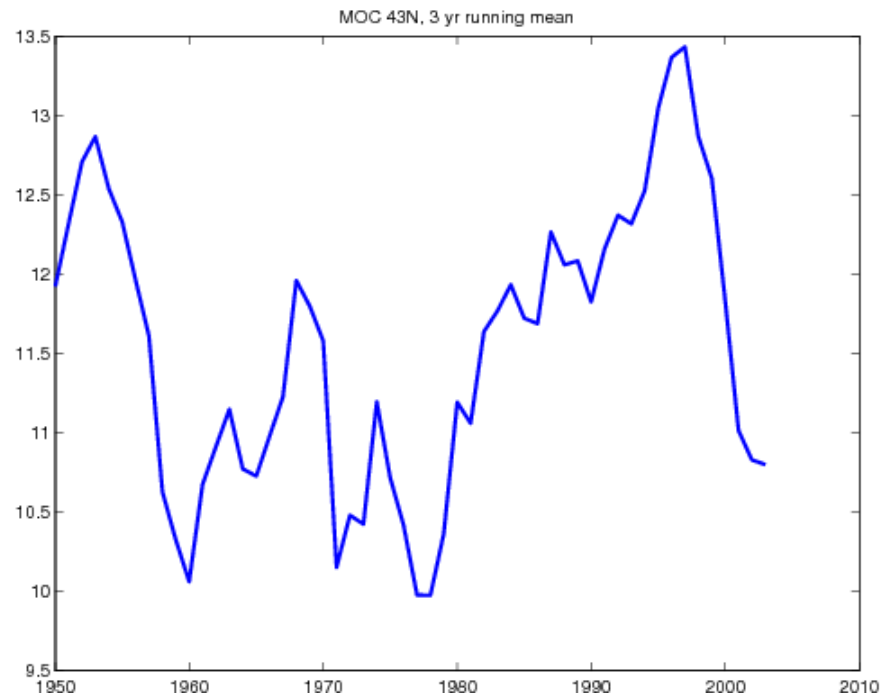
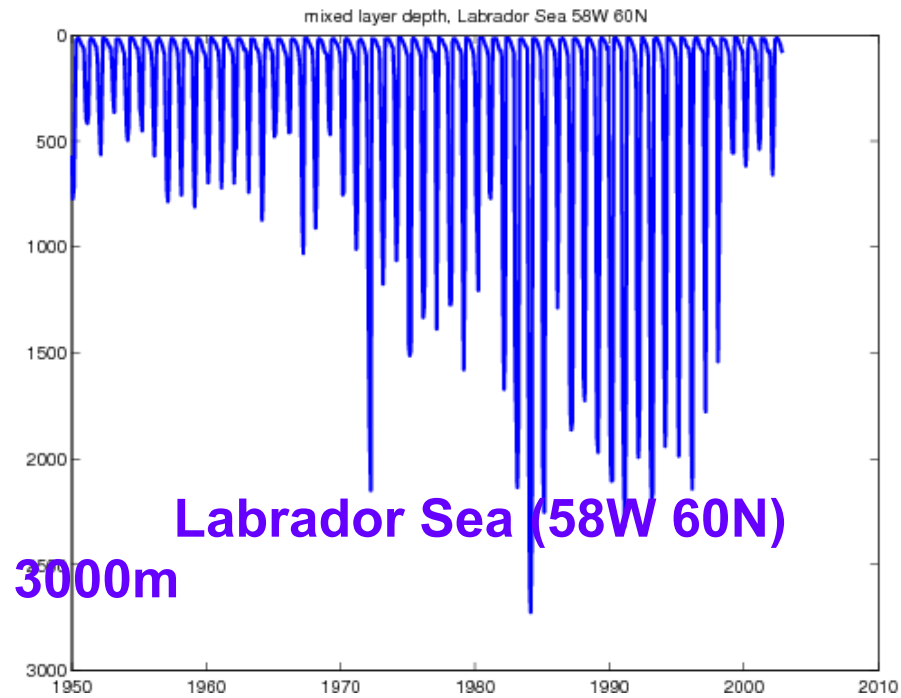
After 1982



First results on convection And MOC

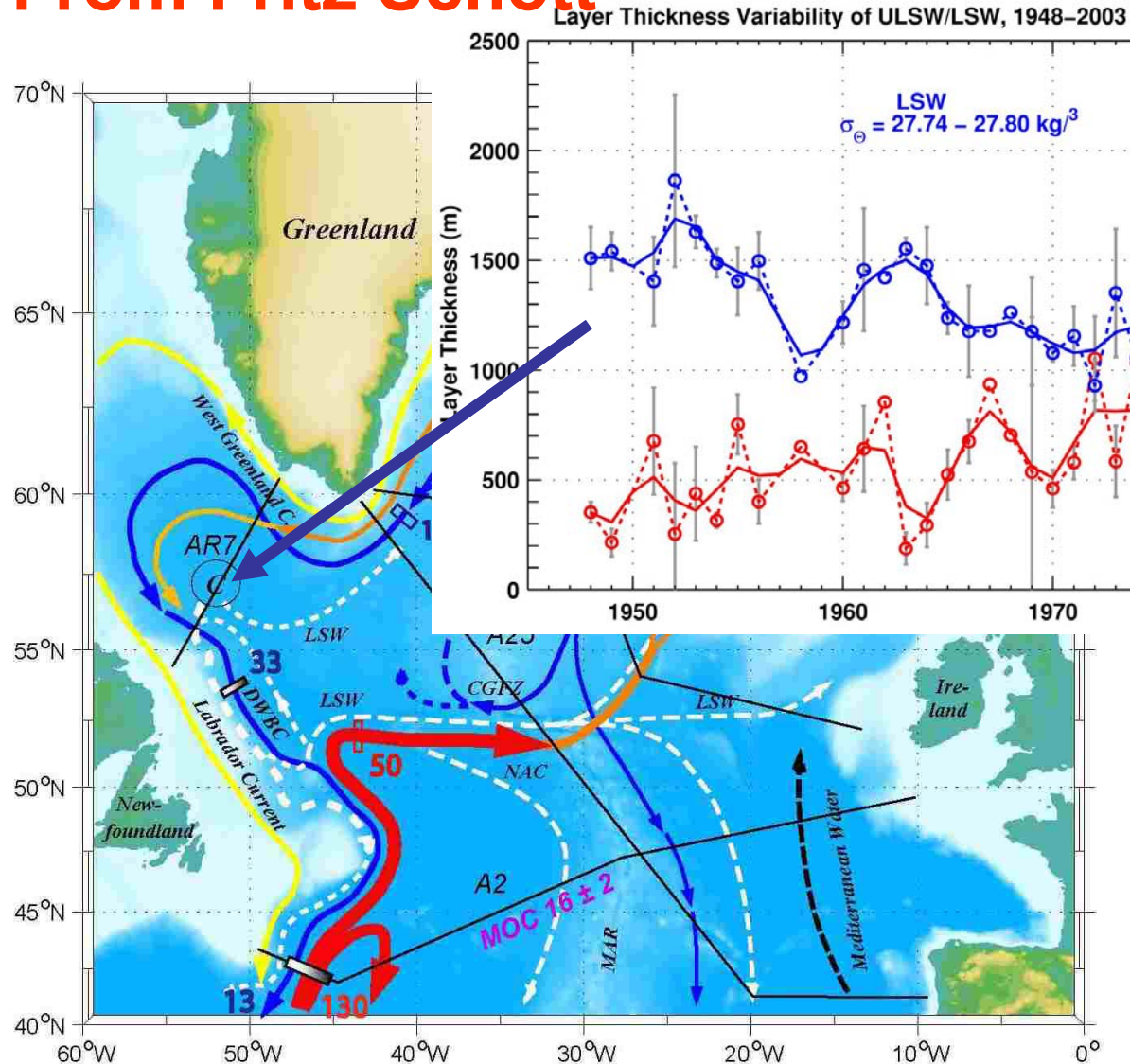
Convection: Mixed layer depth





MOC 43N

From Fritz Schott



Big pulse of LSW in 1992-4, then decline of deep convection and shallow upper LSW formed

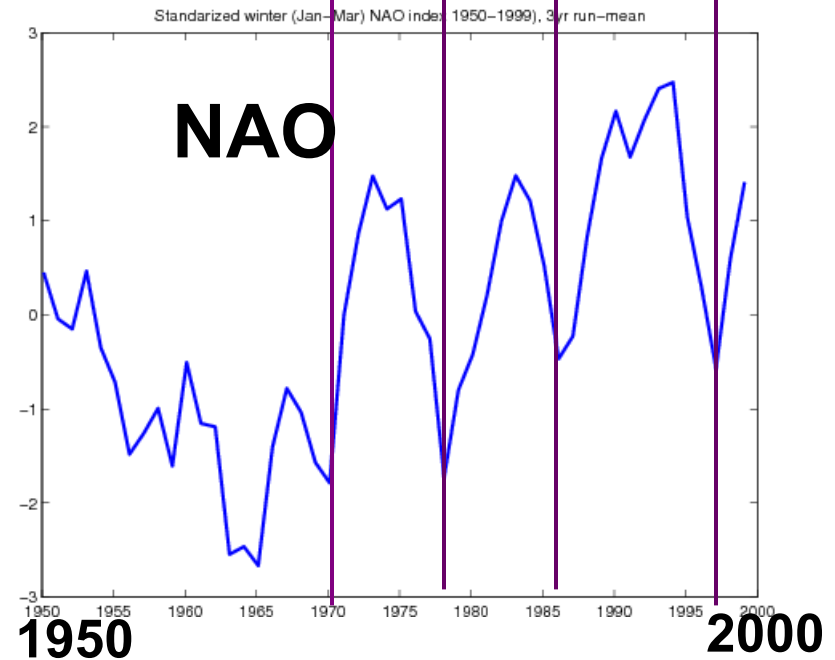
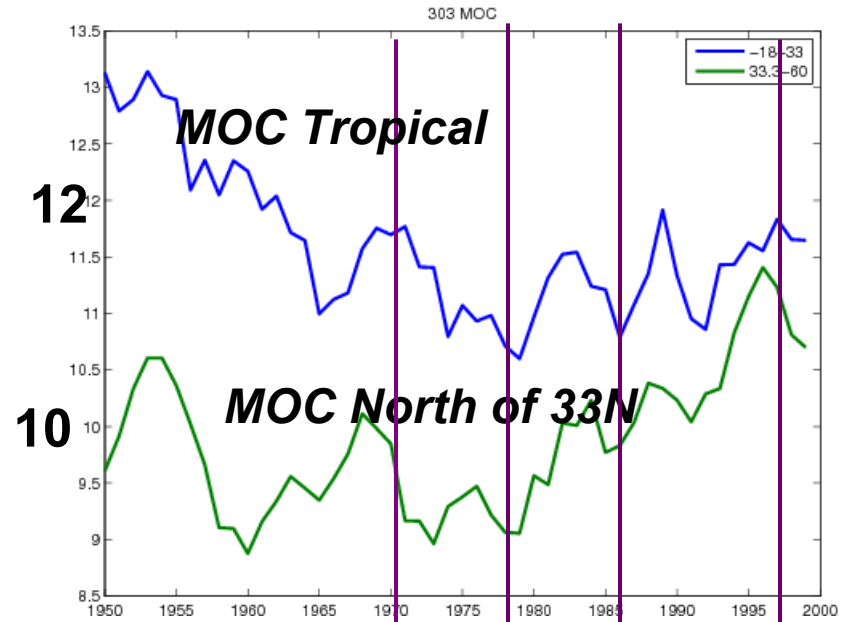
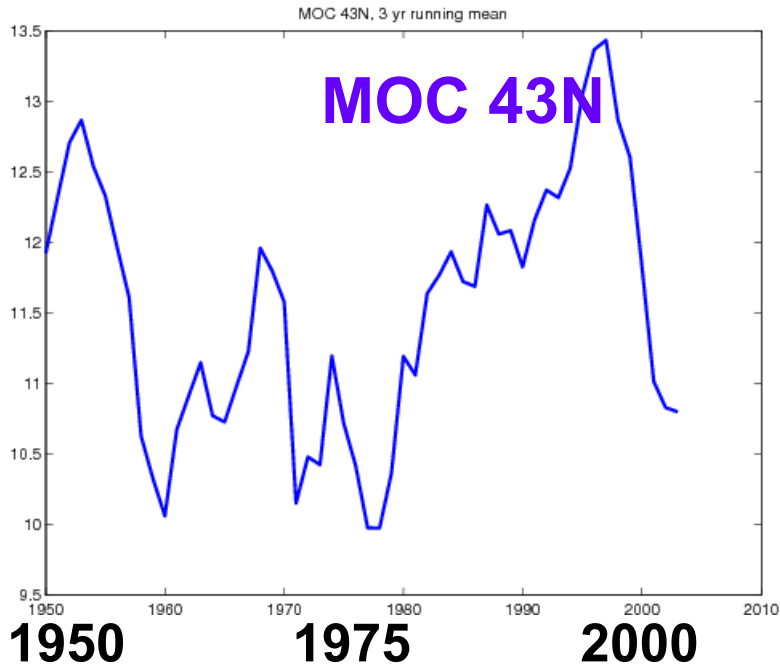
- warming of Labr. Sea!

E: Entrainment C: Convection CGFZ: Charlie Gibbs Fracture Zone MAR: Middle Atlantic Ridge

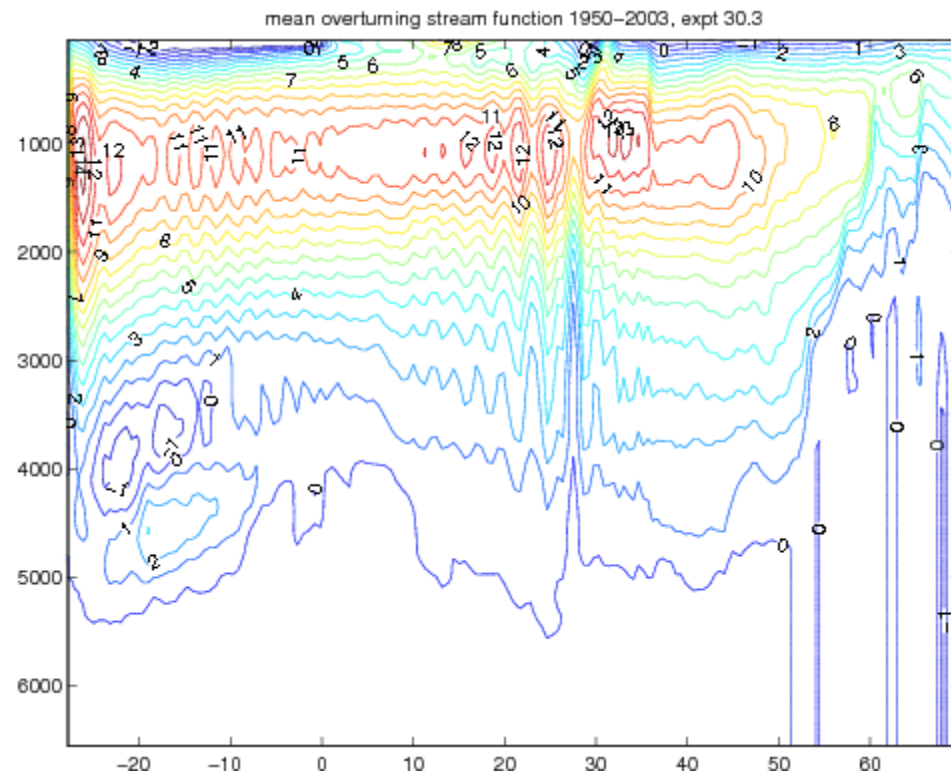
DWBC: Deep Western Boundary Current NAC: North Atlantic Current

LSW: Labrador Sea Water ISOW: Iceland Scotland Overflow Water DSOW: Denmark Strait Overflow Water

Expt 30.3 overturning (z coord)



Mean overturning stream function, 1950-2003, expt 30.3



Model SST variability vs observations

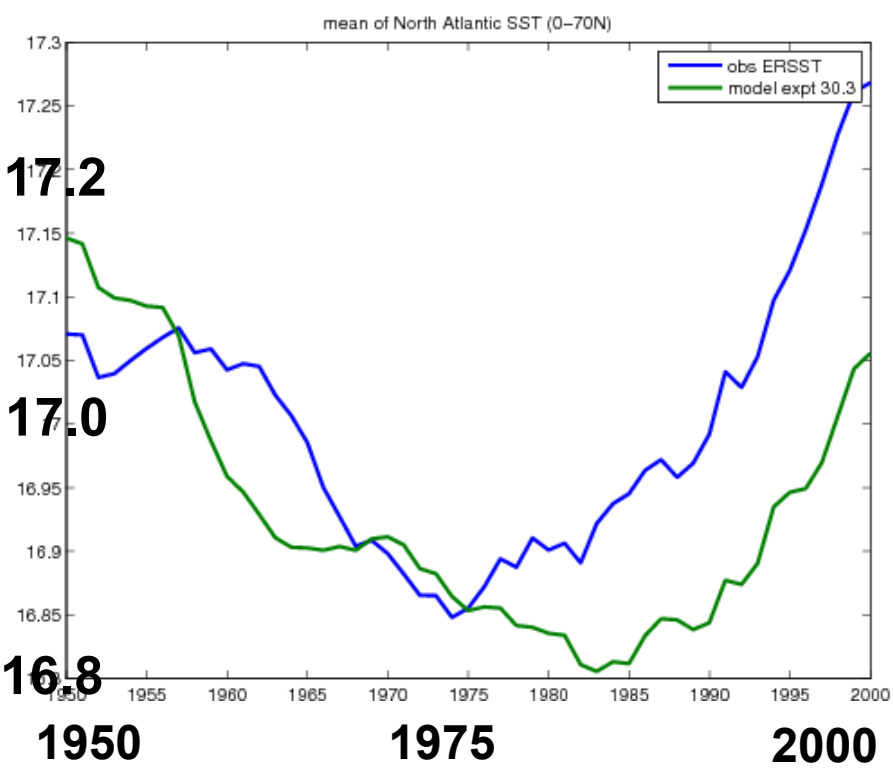
Mean N.Atlantic SST

SST eofs

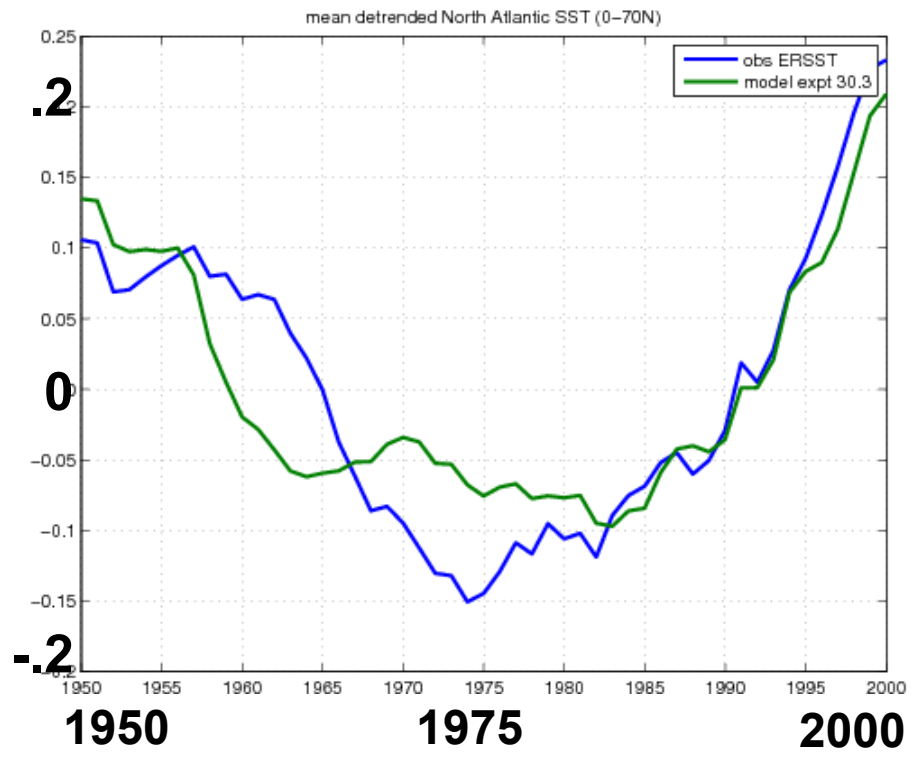
**Propagating SST anomalies as in
Sutton-Allen (1997)**

**Similar analysis to that of Molinari,
Garraffo, Snowden (2007), for GFDL
coupled model**

Observed and model mean winter North Atlantic SST, 0-70N

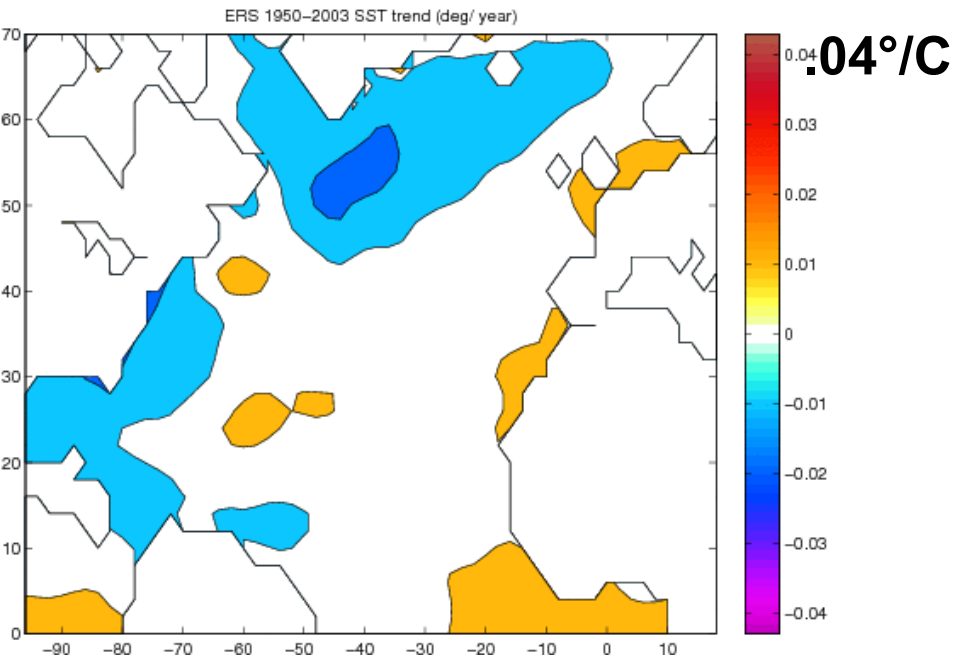


Detrended (AMO)

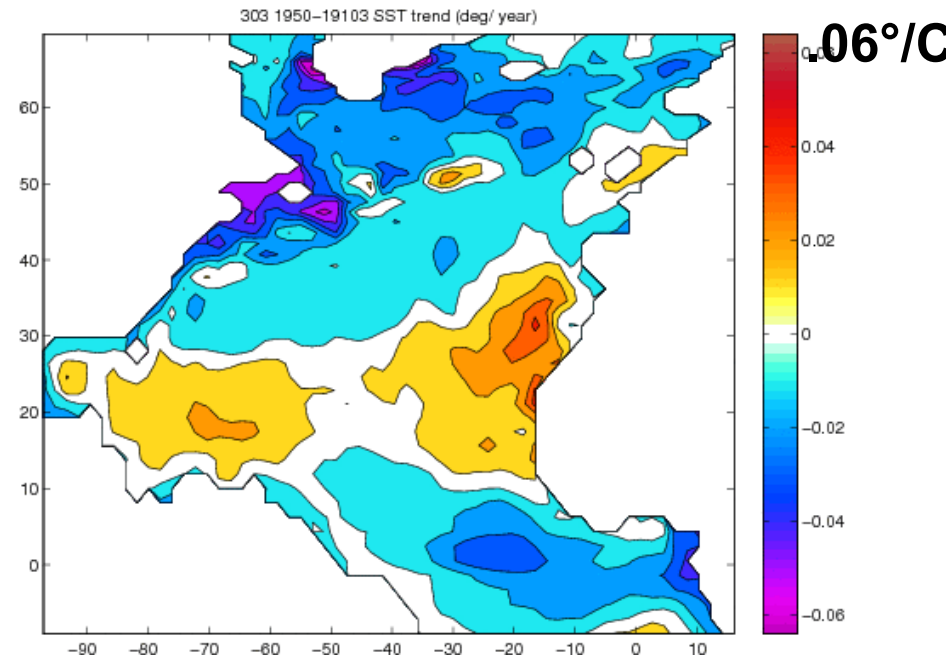


1950-2003 trend, observed ERSST vs model.

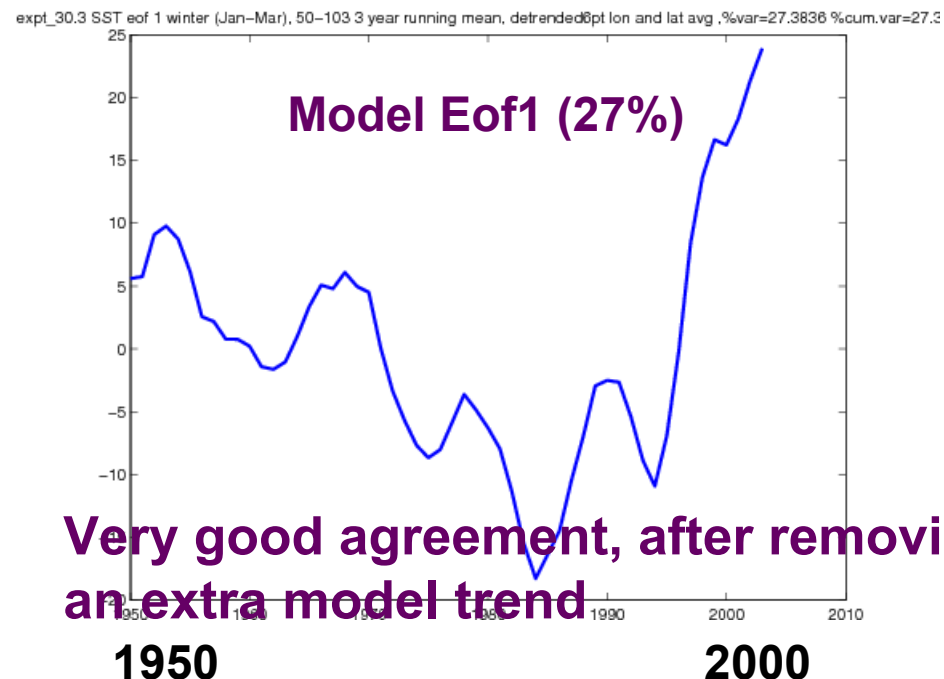
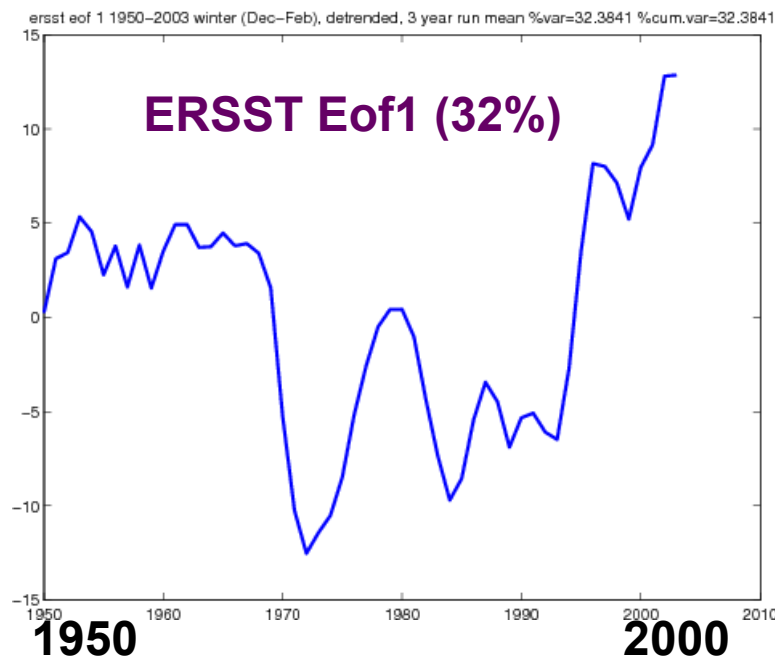
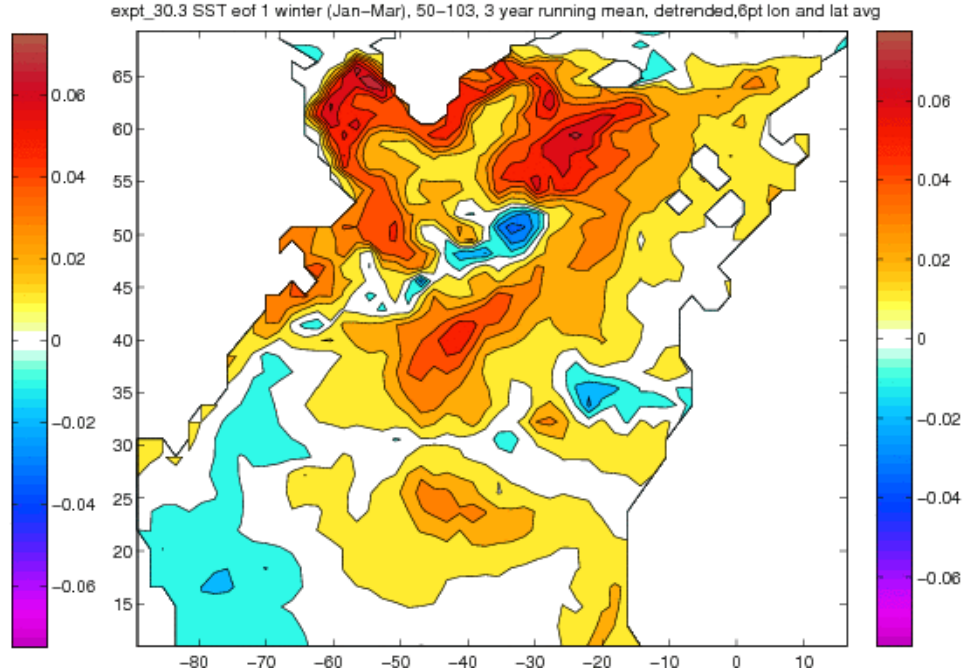
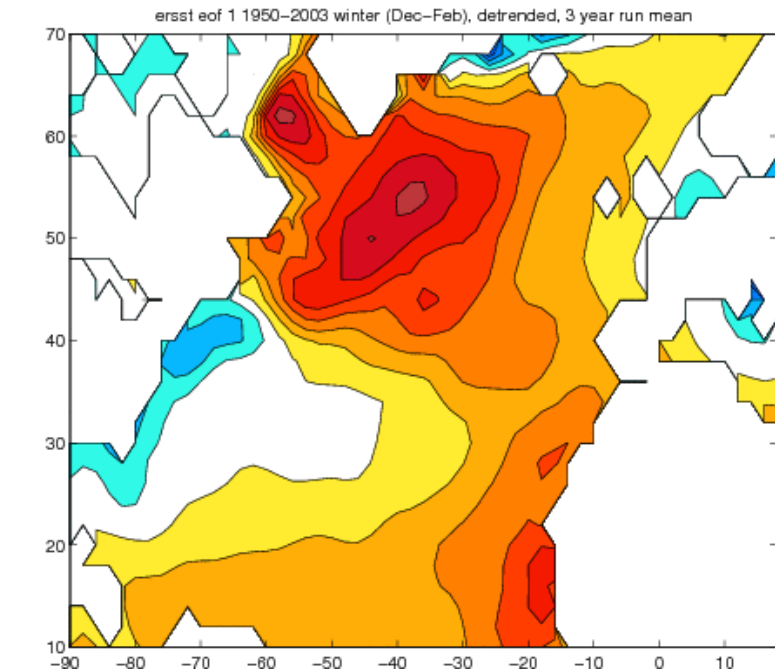
ERSST



Model

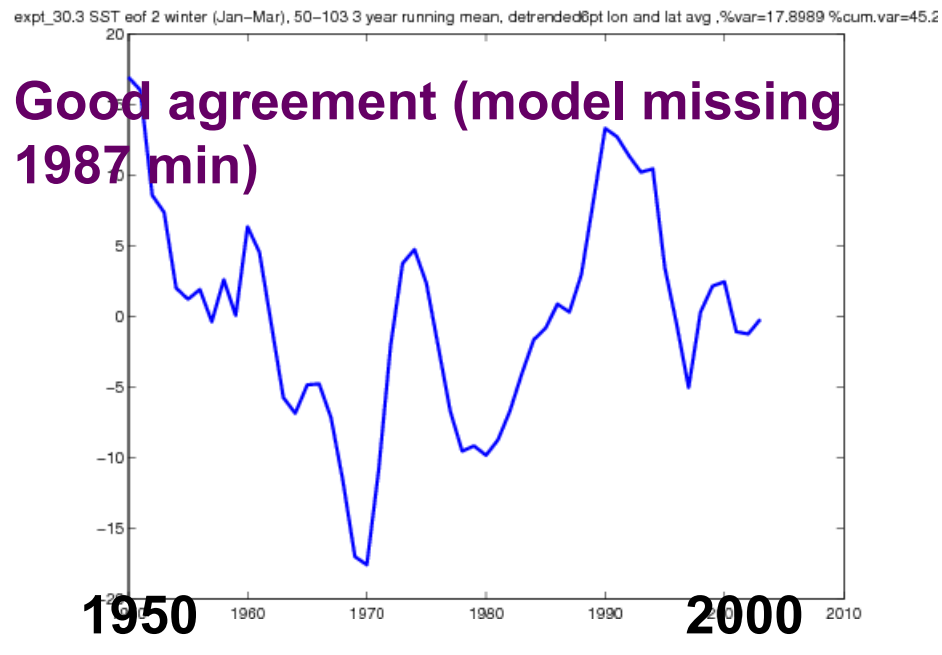
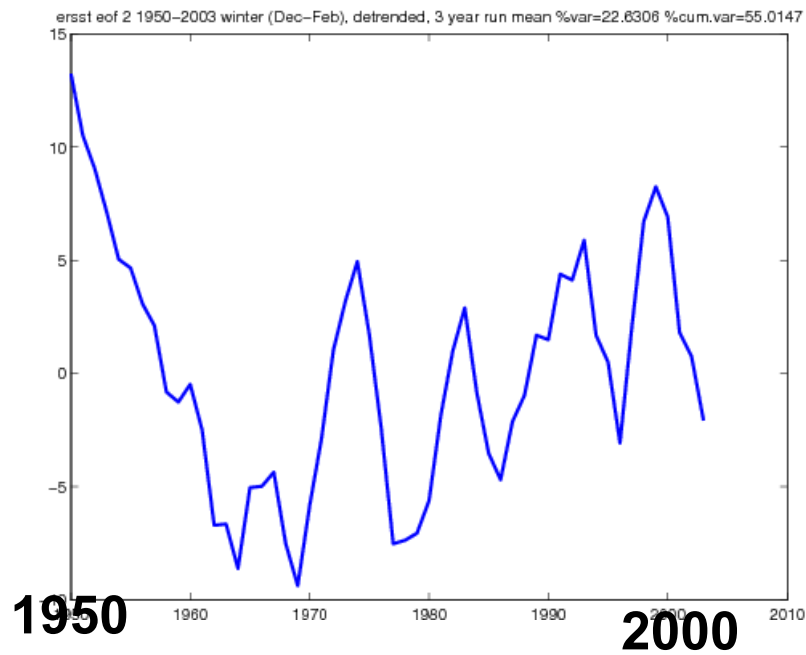
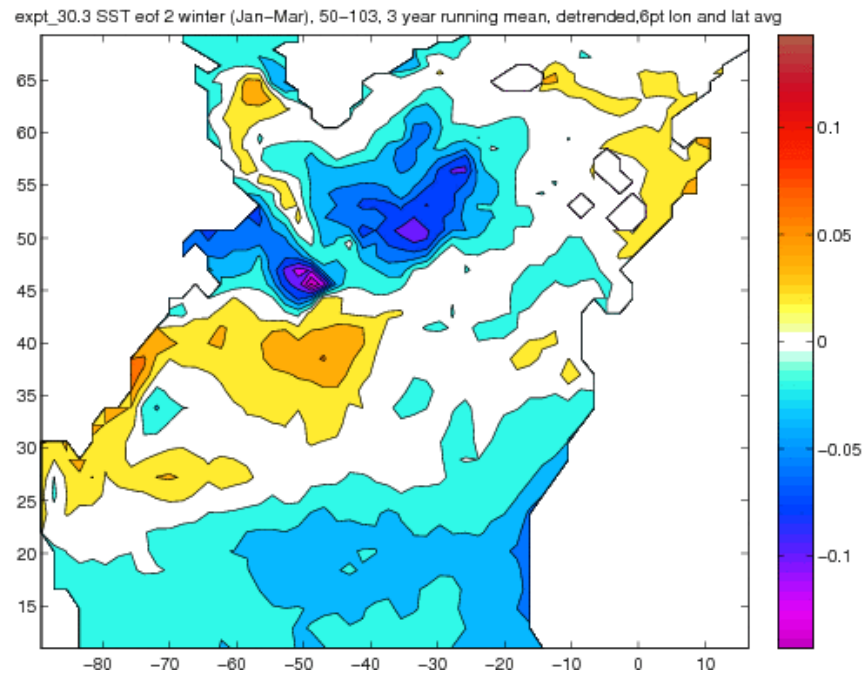
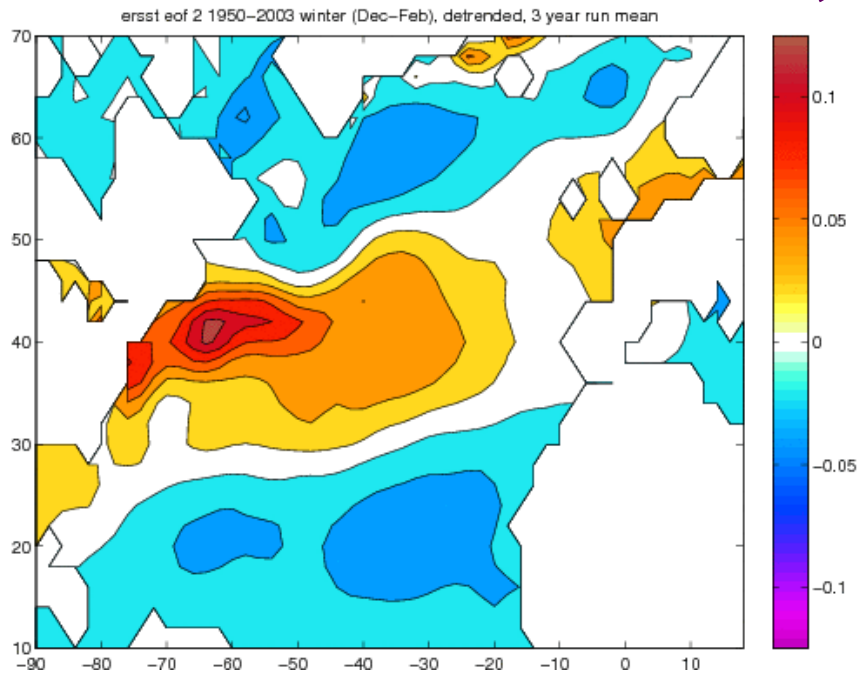


1st eof of detrended SST, observed ERSST vs model.



Very good agreement, after removing an extra model trend

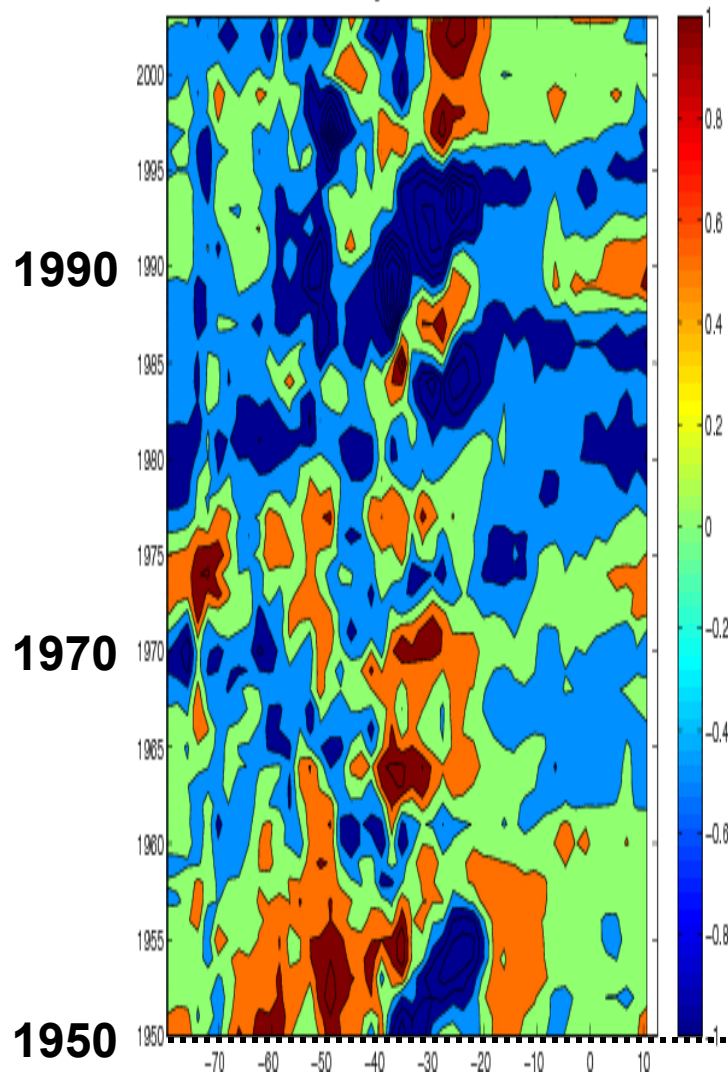
2nd eof of detrended SST, observed ERSST vs model.



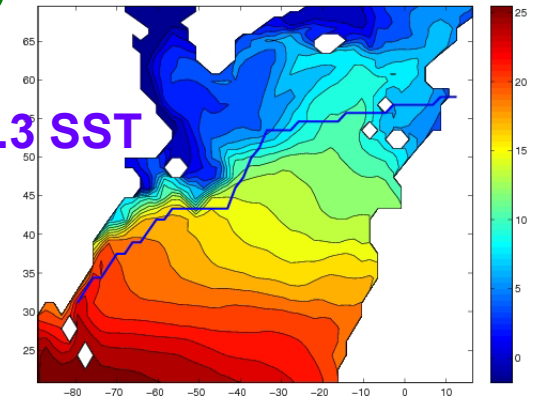
SST: Hovmuller diagram on Curve by Gulf Stream

Expt 30.3

303hovmuller diagram on curve as Sunton Allen



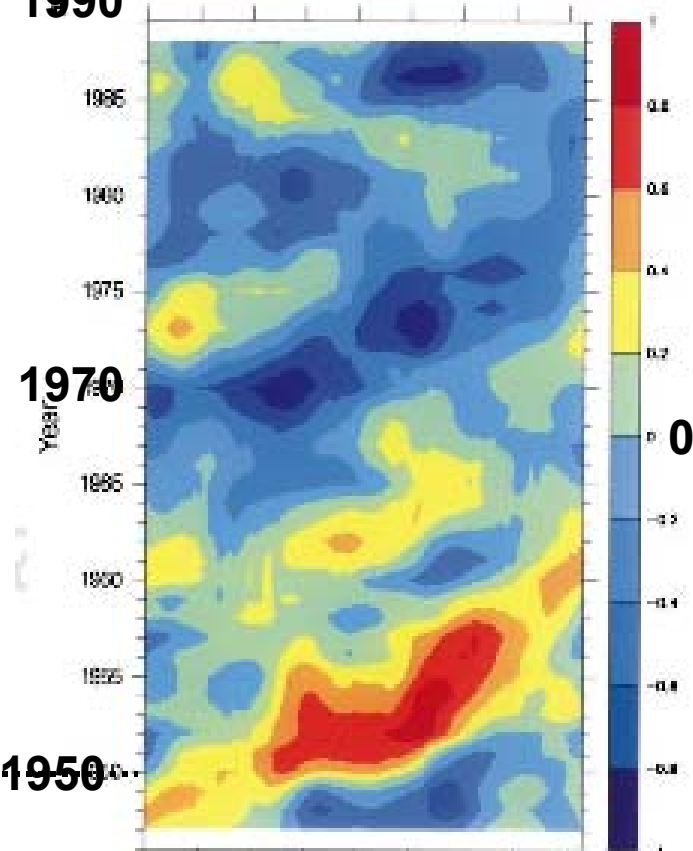
30.3 SST



1990

1970

1950



Sutton Allen observed SST

Distance (1000 km)

Simulations done at Pittsburgh
Supercomputing Center and at ERDC.