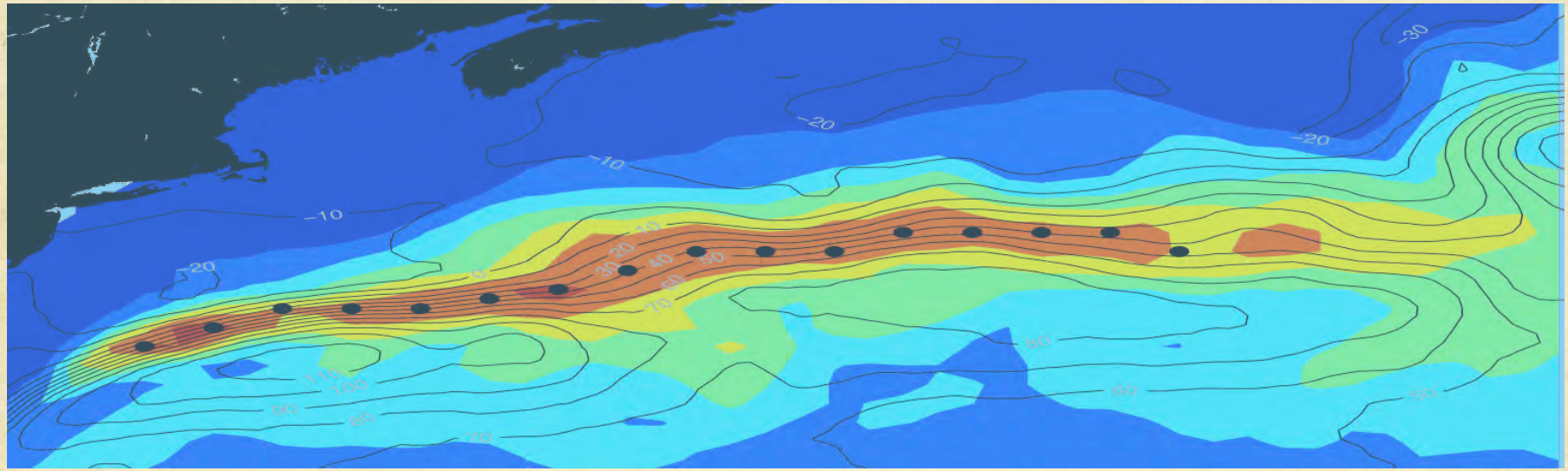
Variabilidad de la Corriente del Golfo en dos décadas de datos de altimetría



M. Dolores Pérez-Hernández[1] and Terrence M. Joyce[2]

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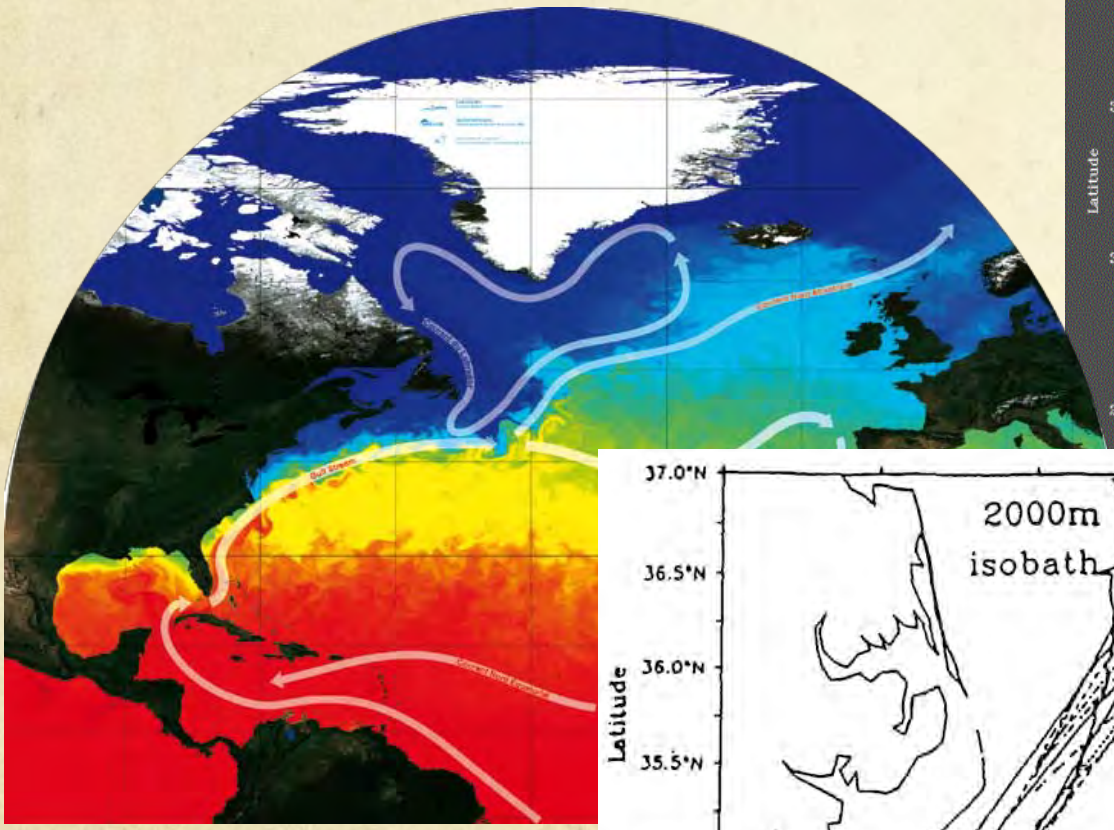
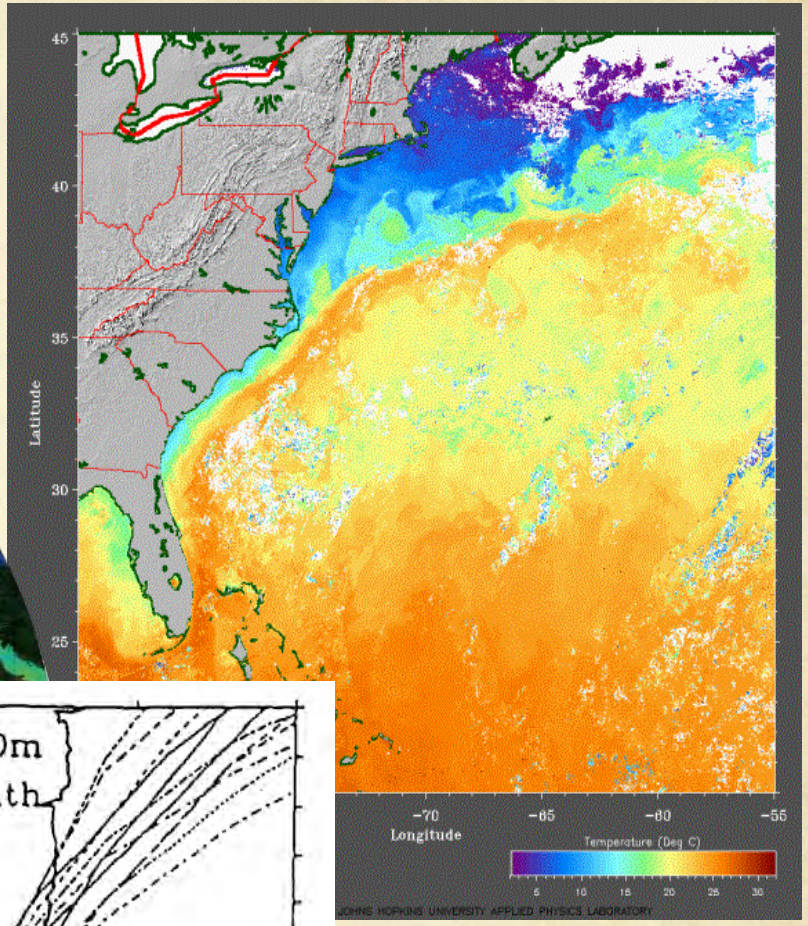
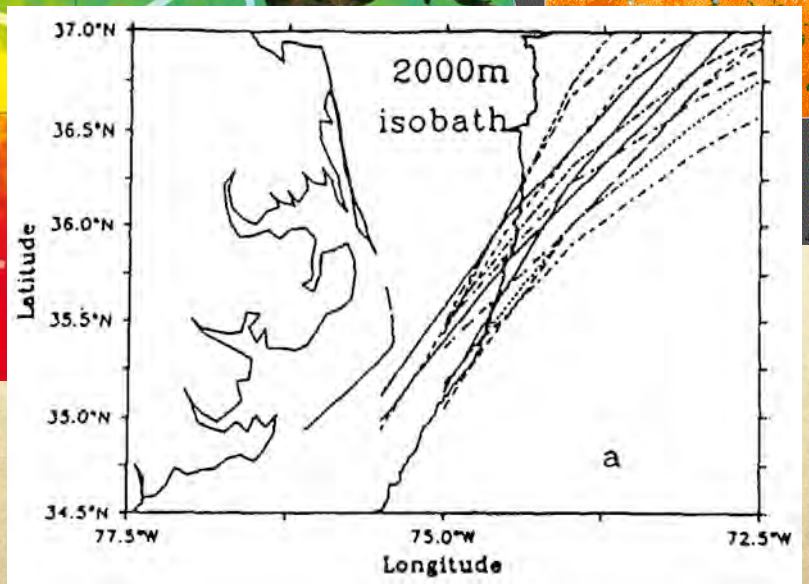
Introduction

- After the GS leaves the continental shelf fluctuations have been characterized as meanders and lateral large-scale shifts [*Lee and Cornillon*, 1995].







Gangophadhyay et al. (1992)

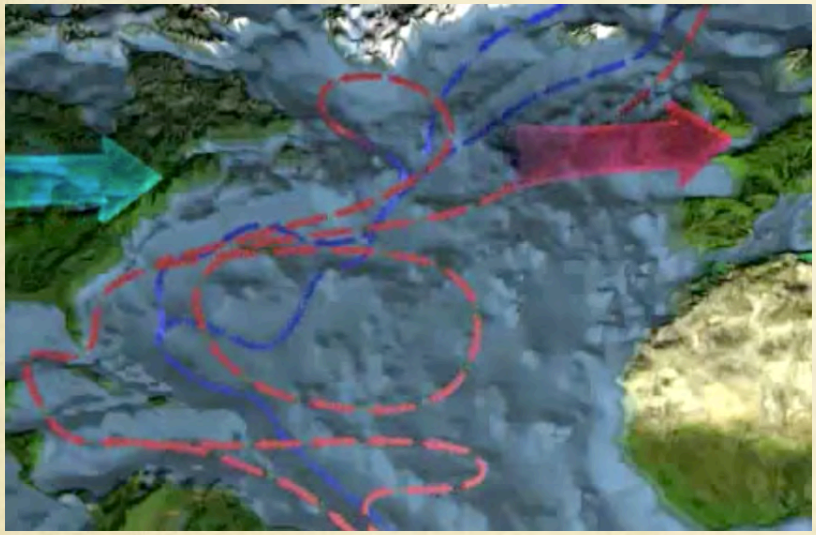
Why to study the Gulf Stream and its latitudinal shifts?

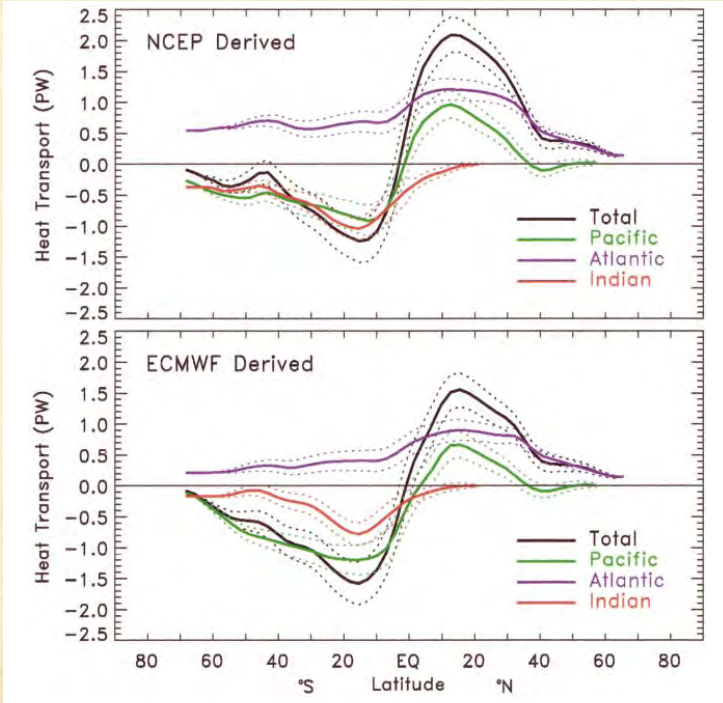
In the beginning, <u>for sailing</u>:

-Ponce de León observed a very strong, warm current coming from the Caribbean Sea carrying his ships towards Florida.

-Then in 1770, while trying to improve the transport of mail to the UK, Benjamin Franklin carried out the first detailed study and mapping of the Gulf Stream.

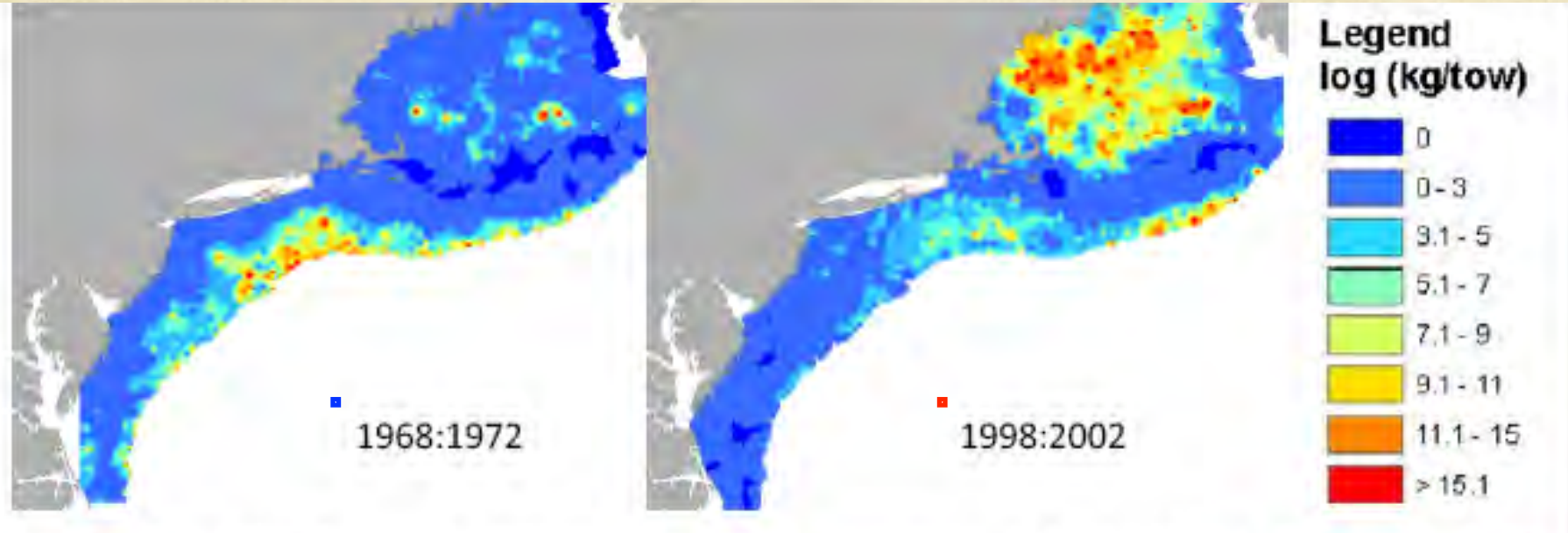
Plays a key role in the <u>climate system</u>





Significant changes are found in the atmospheric variability following changes in the paths of these currents, sometimes in a local fashion such as meridional shifts in measures of local storm tracks, and sometimes in nonlocal, broad regions coincident with and downstream of the oceanic forcing

Changes in fish stocks

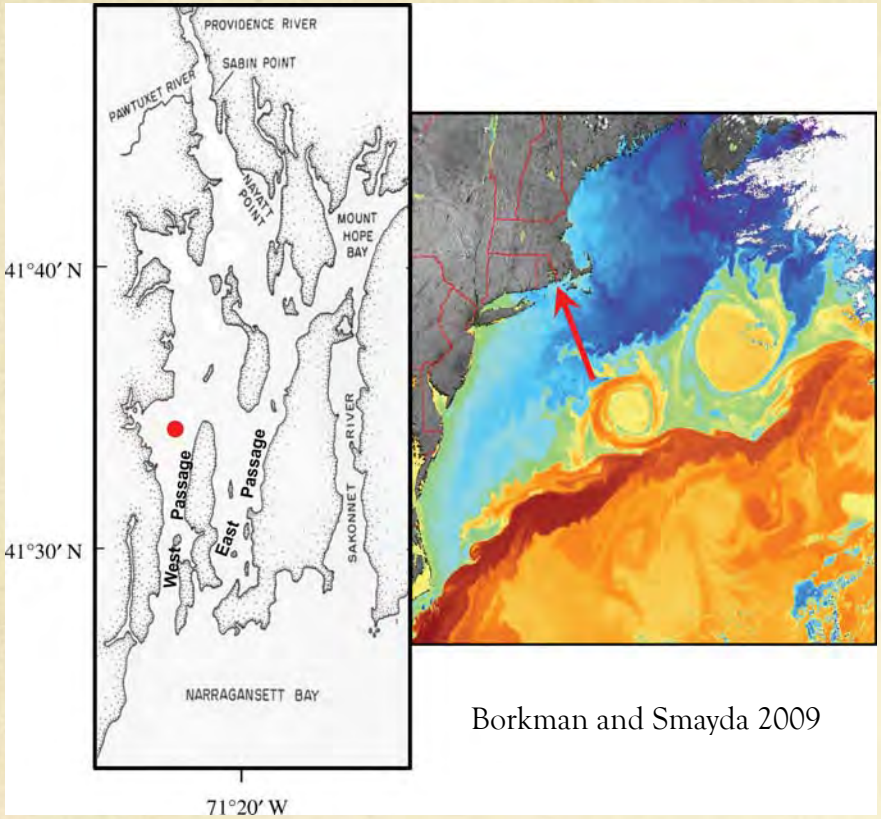


Nye et al. 2011

Silver hake biomass and location for fall survey data in two contrasting periods of cold Slope Water/southerly GS (1968:1972, left) and warm Slope Water/northerly GS (1998:2002, right). Color codes represent biomass and are indicated at the far right. From J. Nye (personal comm. 2010).

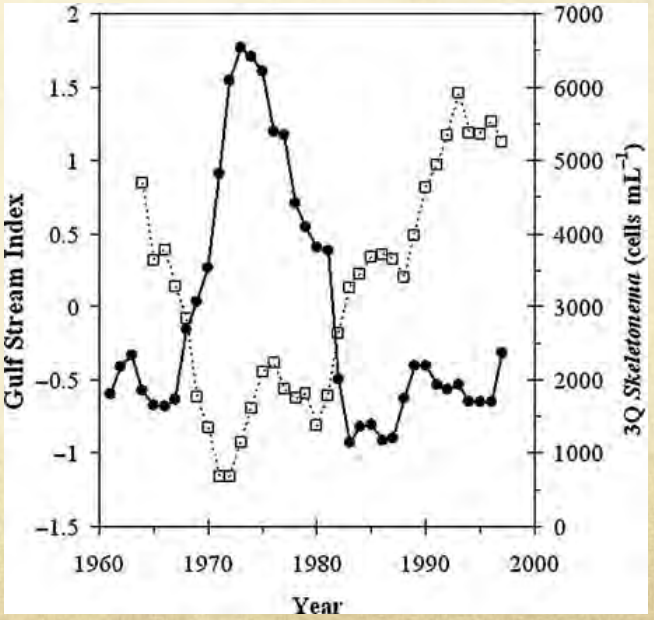
Silver hake=Merluza

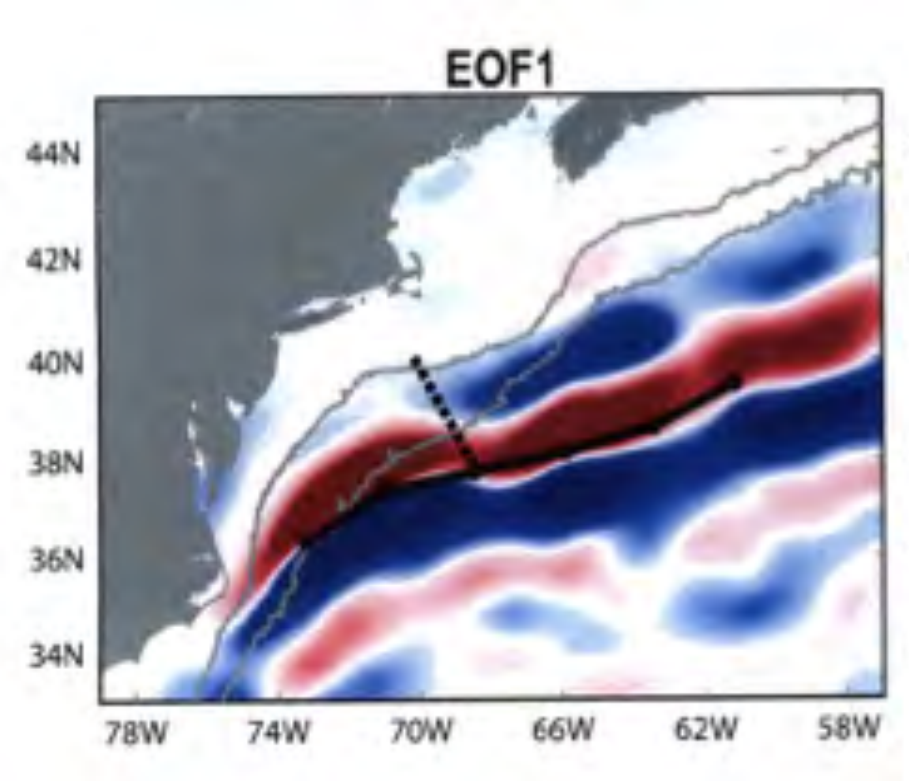
Keystone Species



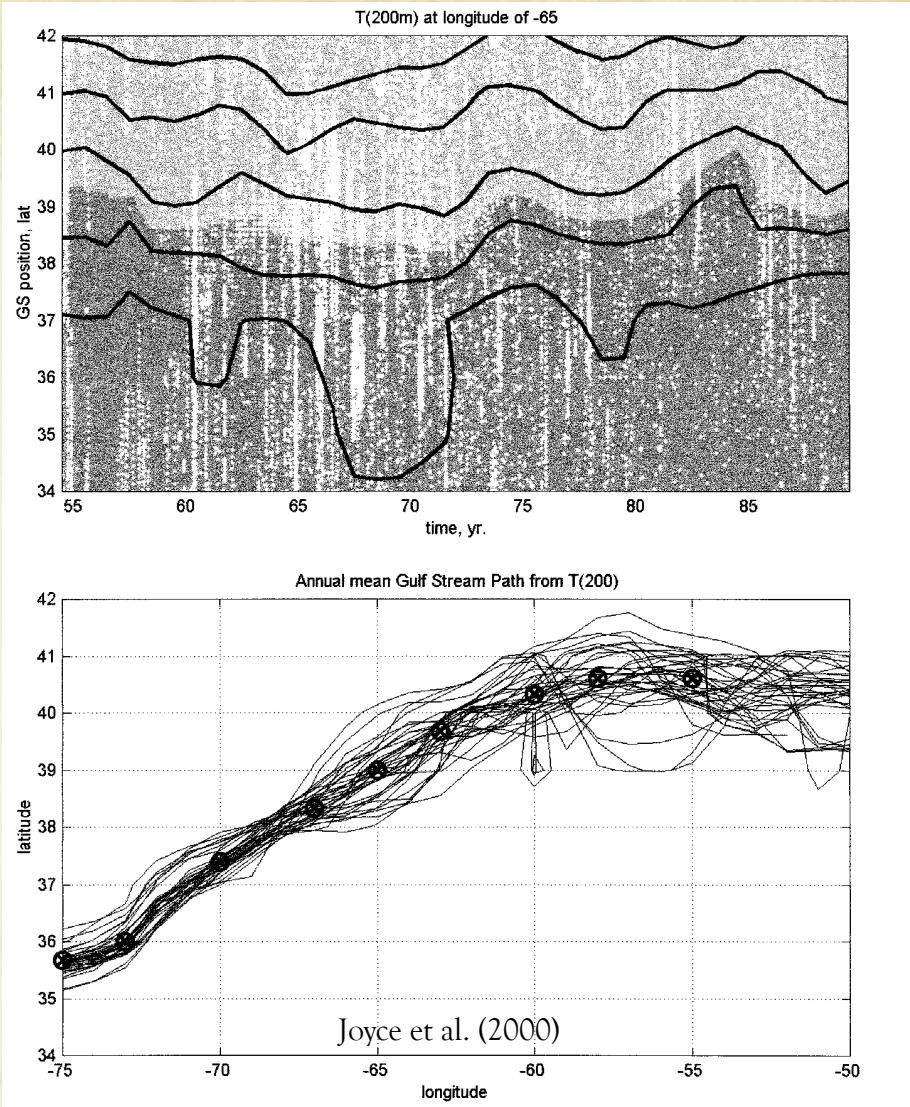
Borkman and Smayda 2009

Skeletonema costatum "species-complex", a keystone diatom cluster, in Narragansett Bay , USA, during a 39-year (1959–1997) time series was statistically related to variations in the path and latitudinal position of the north wall of the Gulf Stream (GSNW).





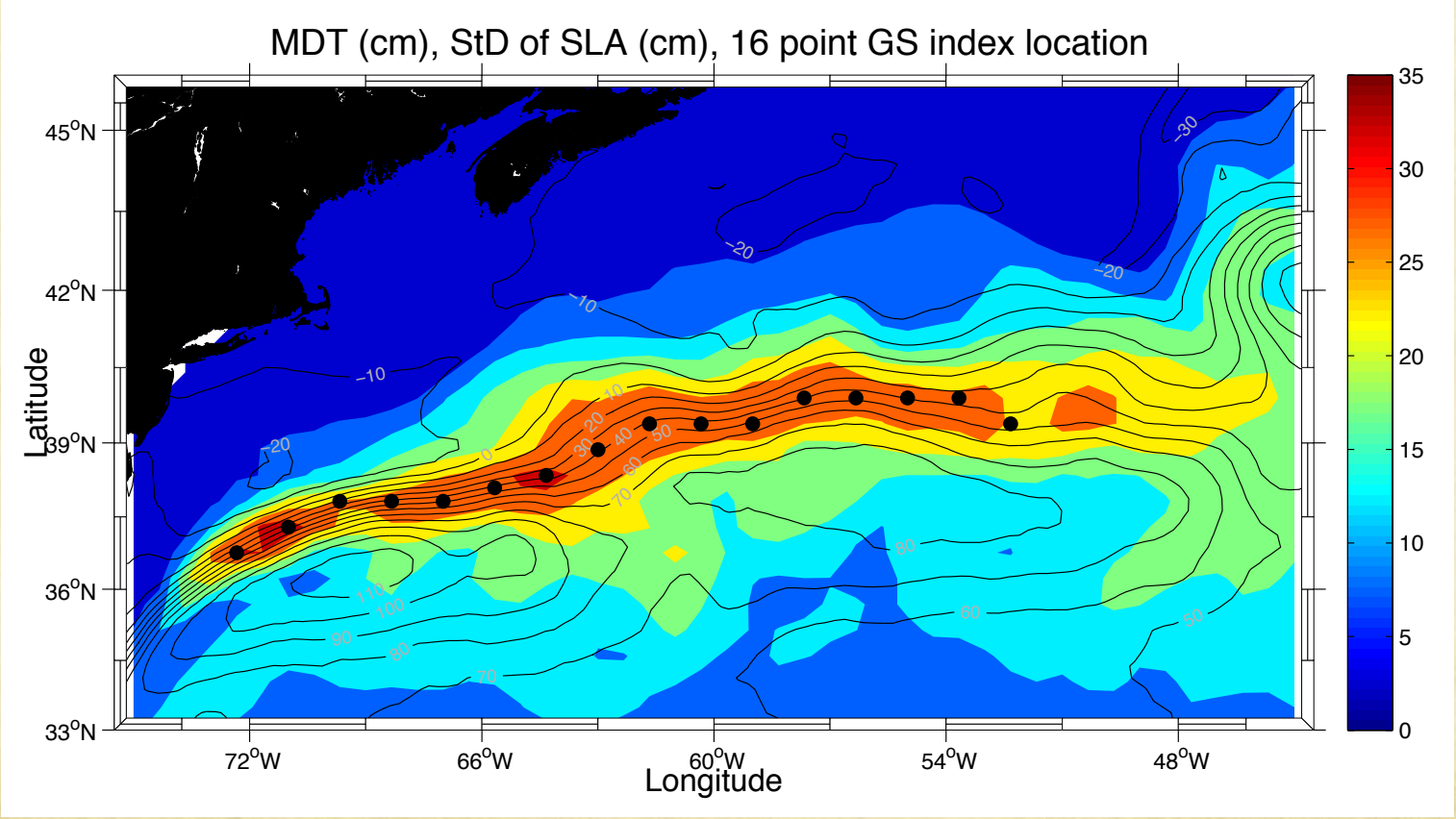
Peña-Molino and Joyce (2008)



- The GS position has been recorded in many ways:
  - The 15° C isotherm at 200m [*Fuglister*, 1955; *Gangopadhyay et al.*, 1992; *Joyce et al.*, 2000]
  - Searching for the maximum along-track SSH gradient [*Kelly and Gille*, 1990; *Frankignoul et al.*, 2001; *Peña-Molino and Joyce*, 2008; *Lillibridge and Mariano*, 2012].

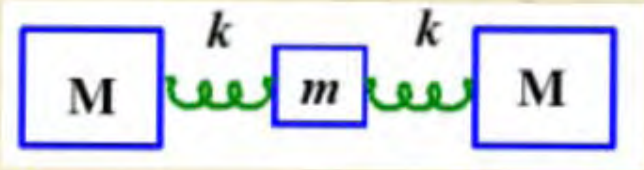
Data and Methods

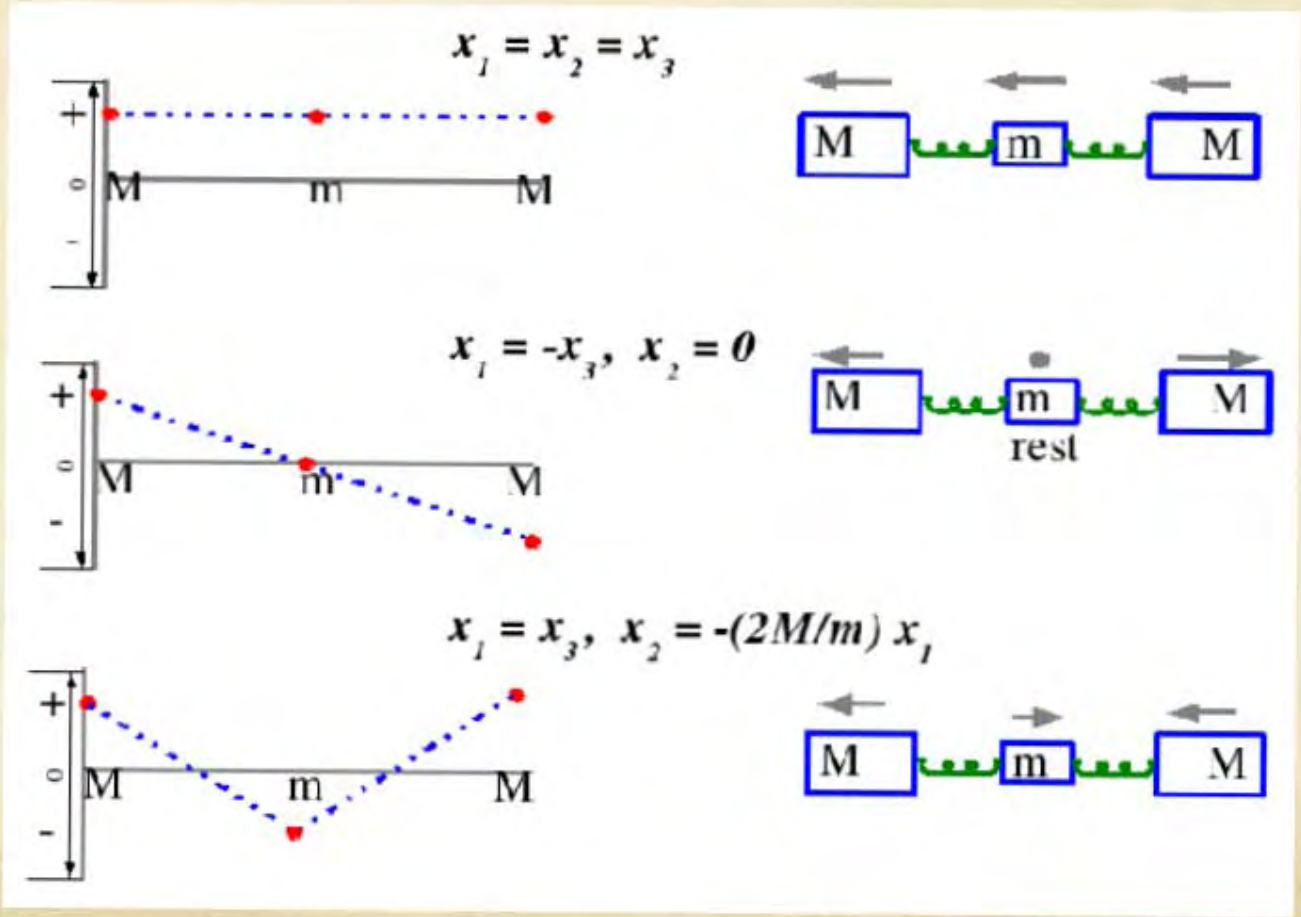
- Gridded Sea Level Anomalies (MSLA) weekly data for October 1992-December 2010 and Mean Dynamic Topography (MDT) from the AVISO remote sensing service (http://www.aviso.oceanobs.com/).
- The 16 point GS Index: selecting grid points following the maximum standard deviation of Sea Level Anomalies (SLA), every 1.33° longitude between 52-72° W.



- A temporal Empirical Orthogonal Function (EOF) analysis
- To study the periodicity of the first modes, the Welch method of spectral analysis is used.

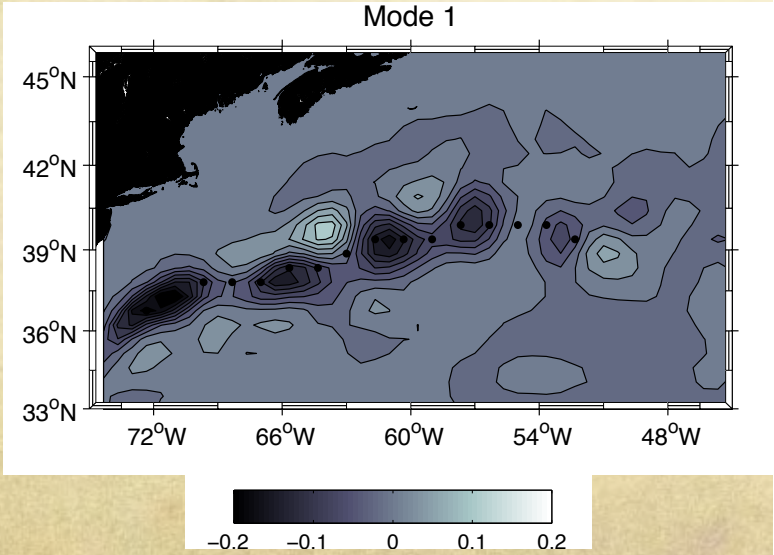
What does a EOF does conceptually?

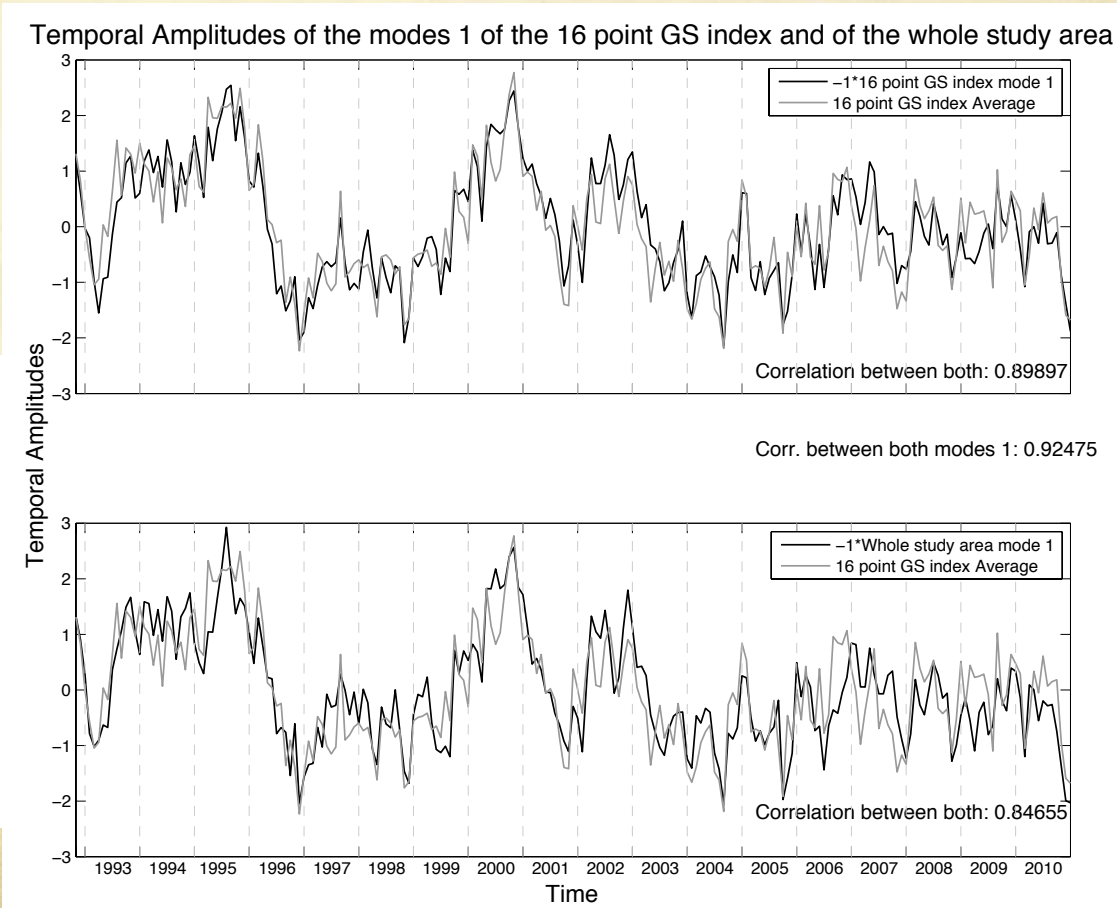




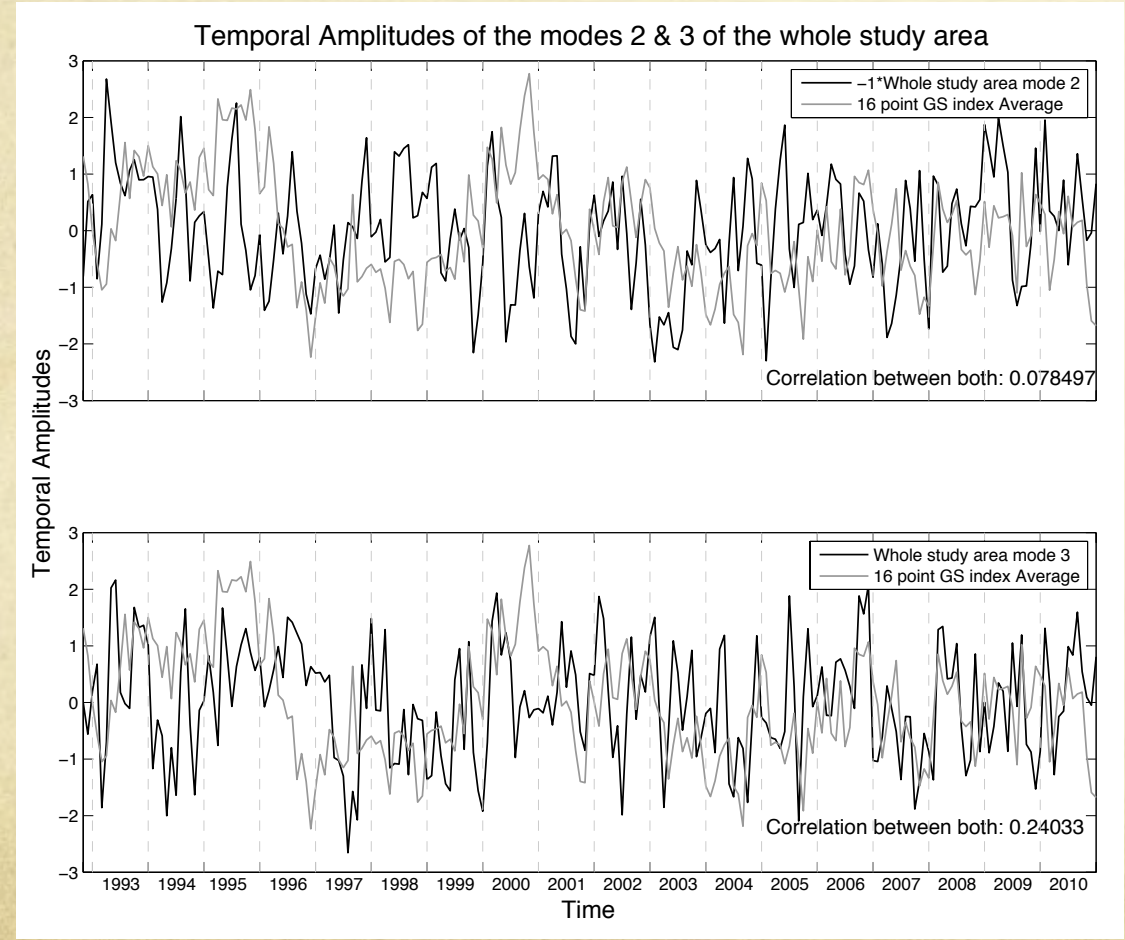
Results from the EOF

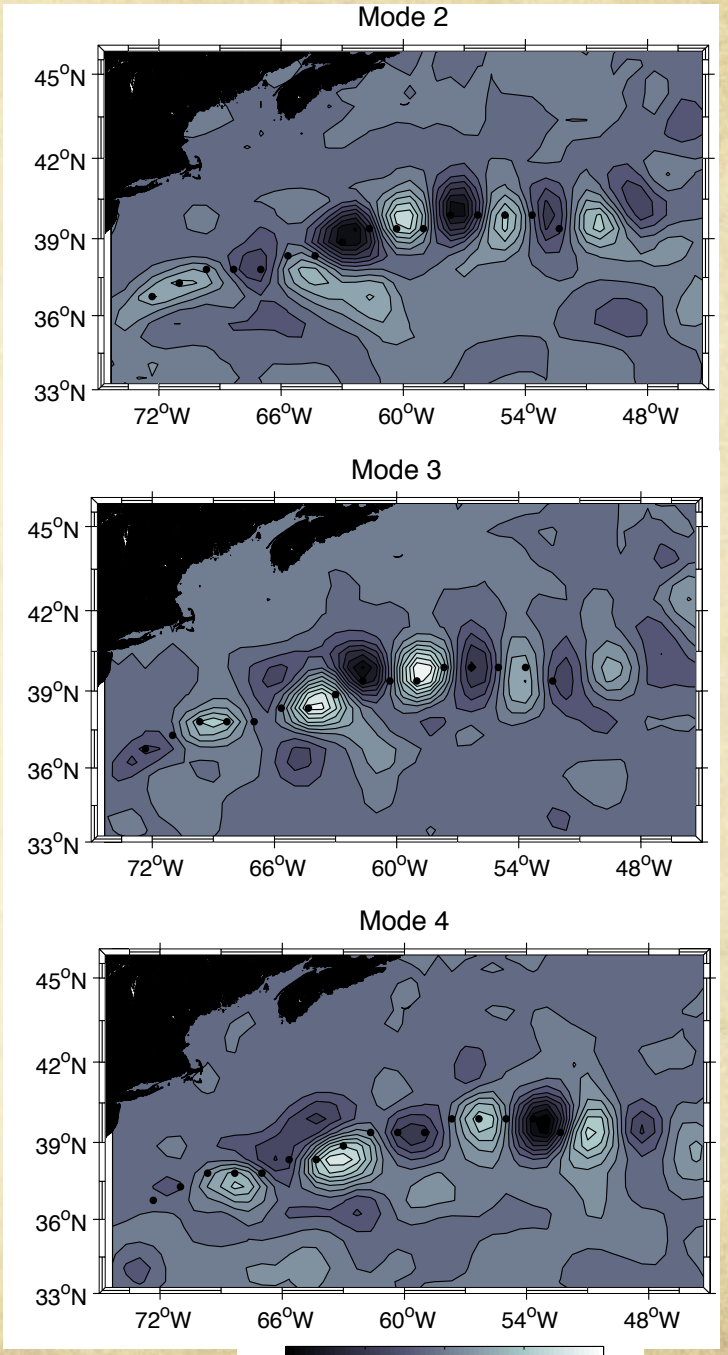
- Following the rule of *Overland and Preisendorfer* [1982], for the 16 point GS index, 3 modes are above the noise level and for the whole region the first 19 modes are significant
- The 1 mode characterizes the north-south shifts of the GS. Similar to an index created from the mean of the 16 point SLA
  - 16 point array (36% of variance)
  - the whole region (17% of variance)
- July 1995 and October 2000: the GS was in its most northward position, shifting between 50-110 km from its mean position.



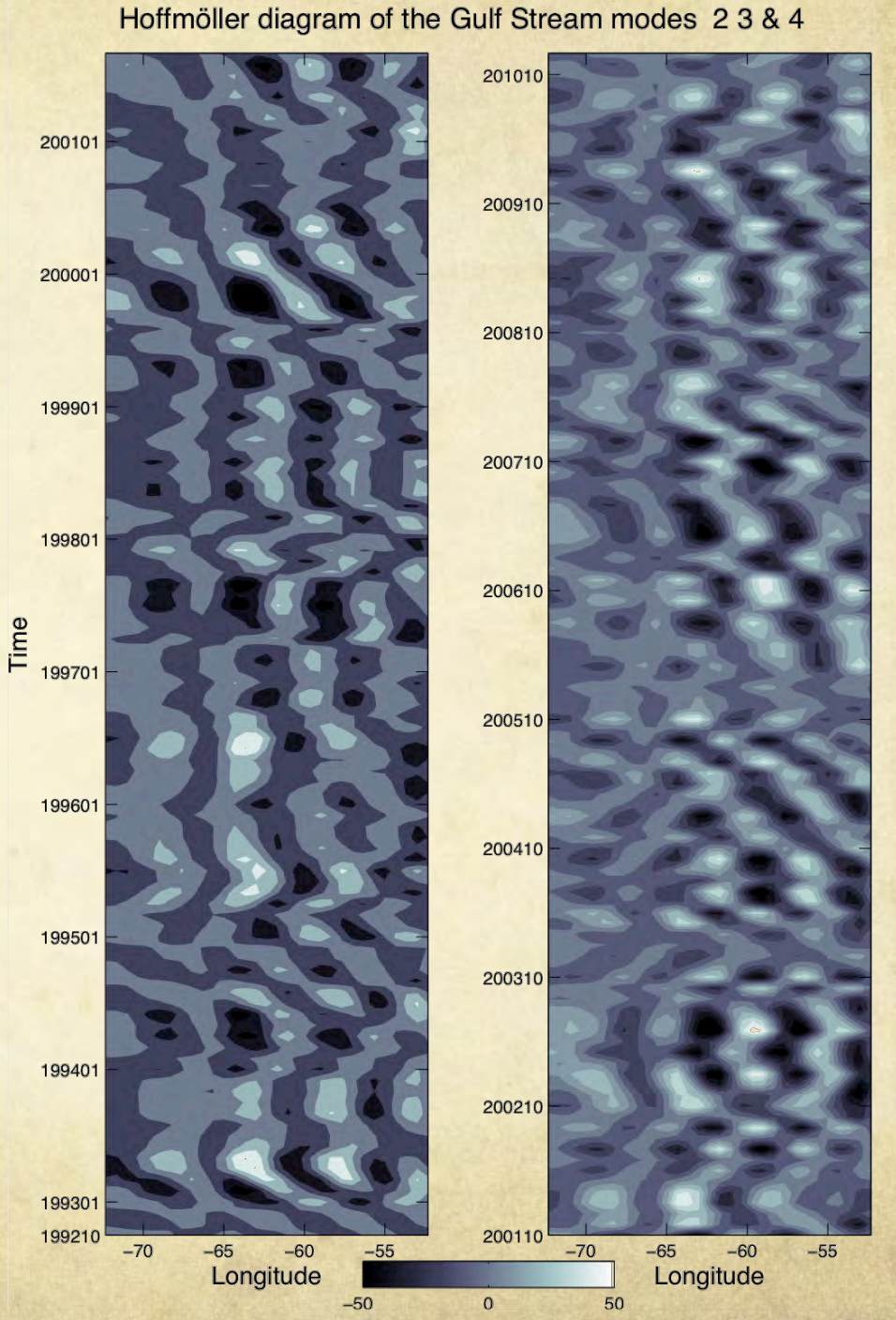


- The other modes exhibit alternating high positive to negative structures.
  - Contain the 20.9 % of the total variance of the whole study area.
  - Both modes are orthogonal in time, but they seem to be different phases of the same phenomenon, suggesting a propagating signal.



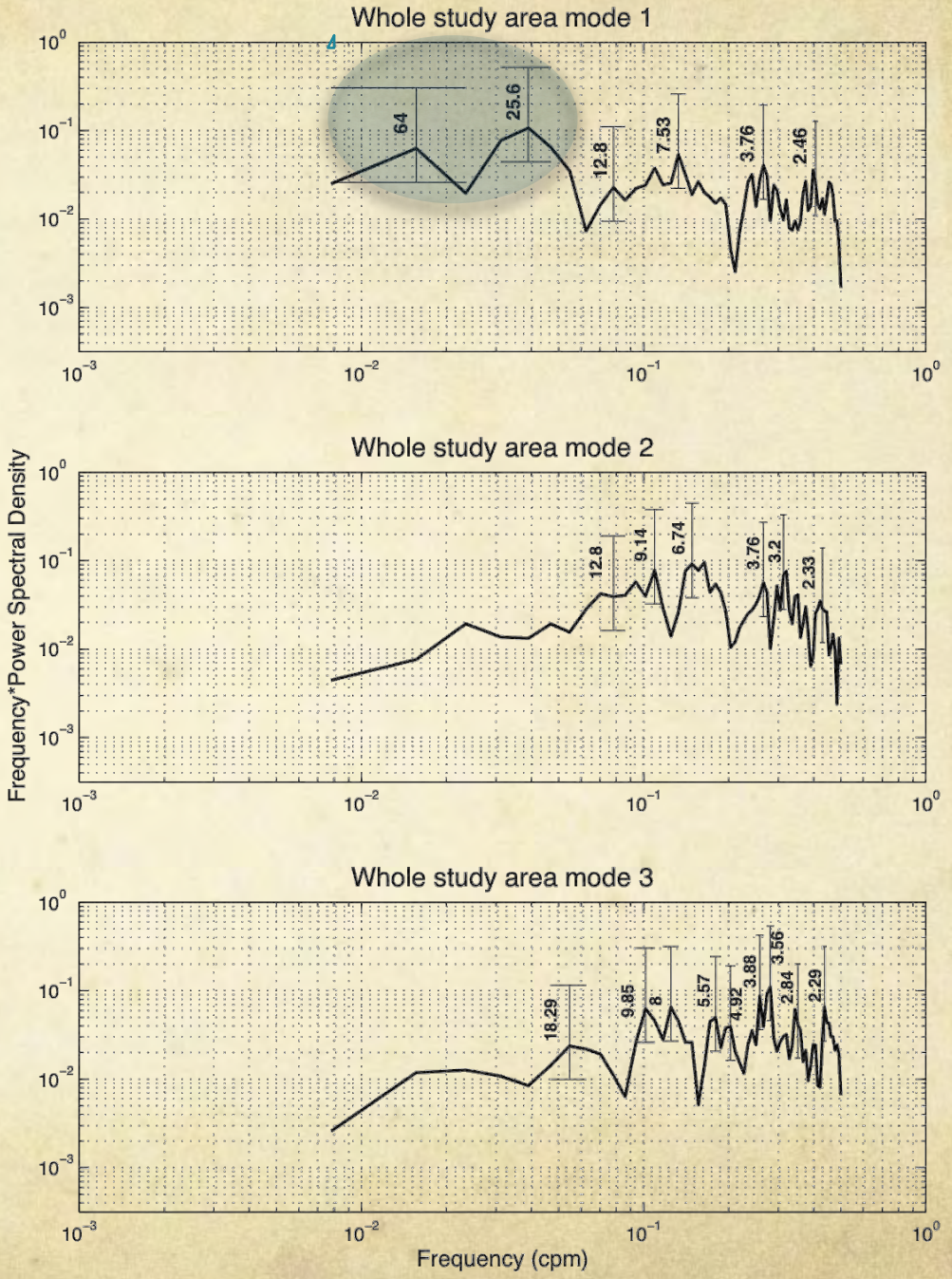


- Based on the reconstructed time series from the 3 meander EOF modes.
- From 75° W to 65° W a low energy area can be distinguished in both plots.
- Westward propagation pattern
- Limited periods of eastward and stationary meanders.
  - Quasi-steady meanders: *Fuglister and Worthington*[1951] near Nova Scotia.
  - Eastward or downstream meander propagation in the vicinity of Cape Hatteras [*Bane et al.*, 1981].

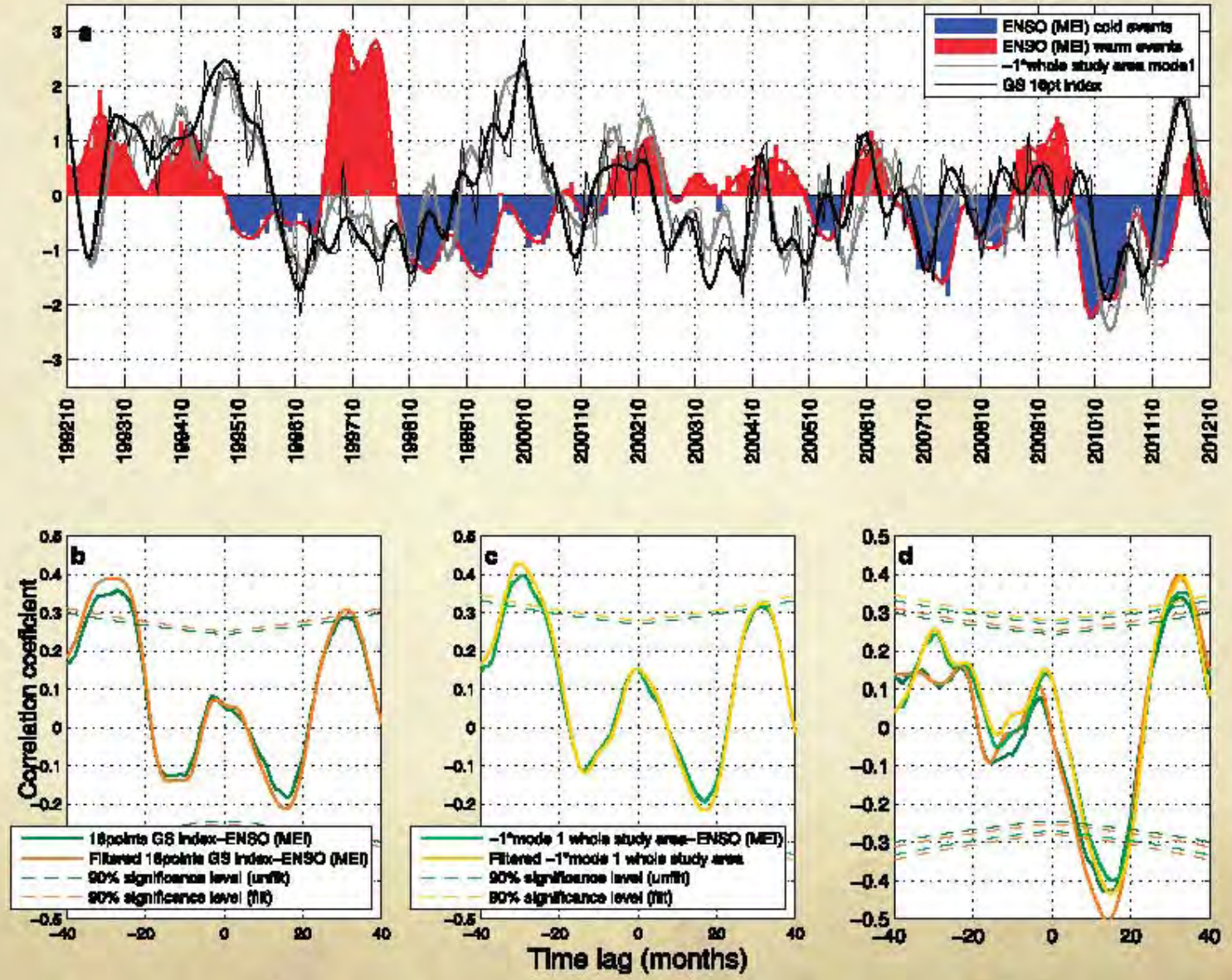


Results from the Welch method

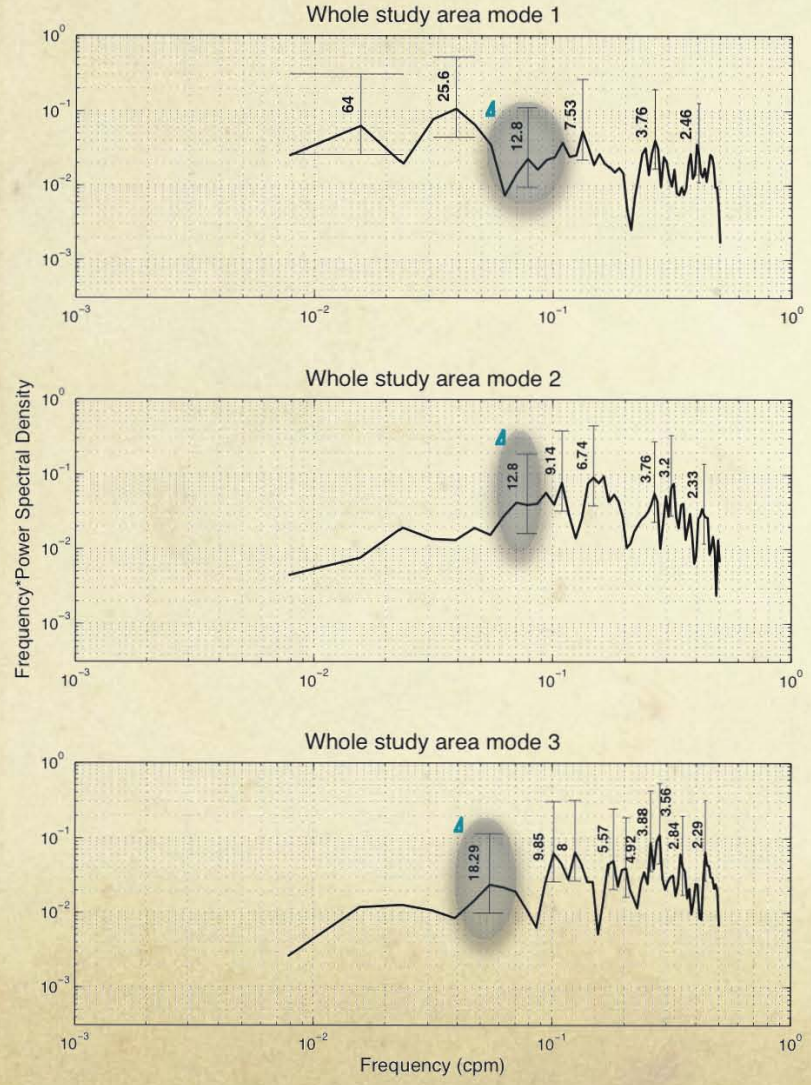
- modes were rescaled according to their percentage of total variance.

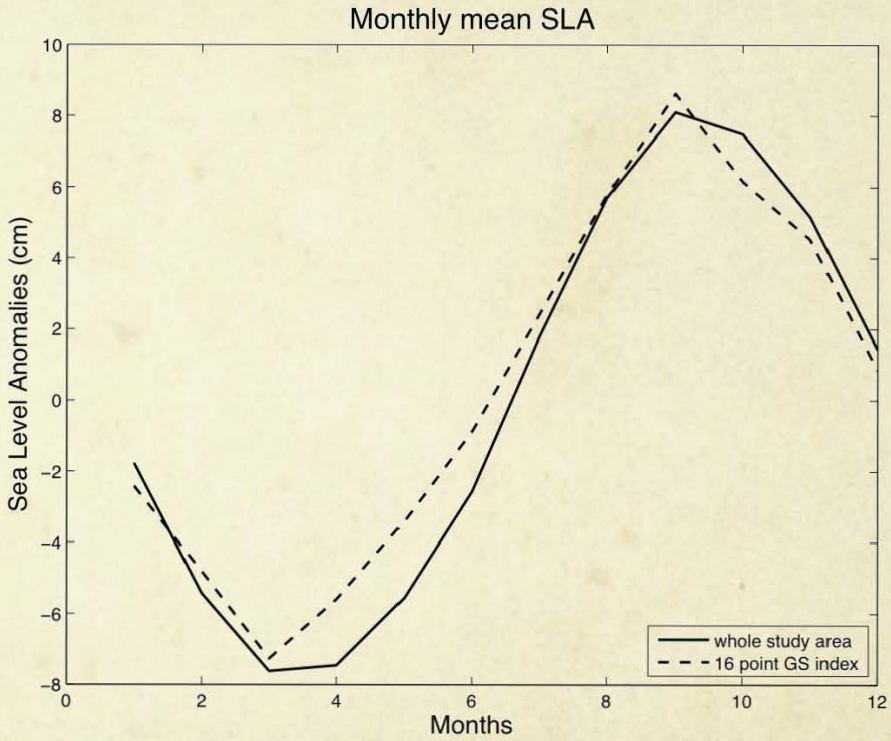


- multivariate ENSO index (MEI) (October 2012, http://www.esrl.noaa.gov/psd/enso/mei/).
- ENSO, affects the trade wind belt, could be a source of fluctuations for the GS [*Taylor et al.*, 1998].
- In *Young-Oh-Kwon et al.* [2010] the winter after the ENSO peak the GS presents strong negative SST anomalies

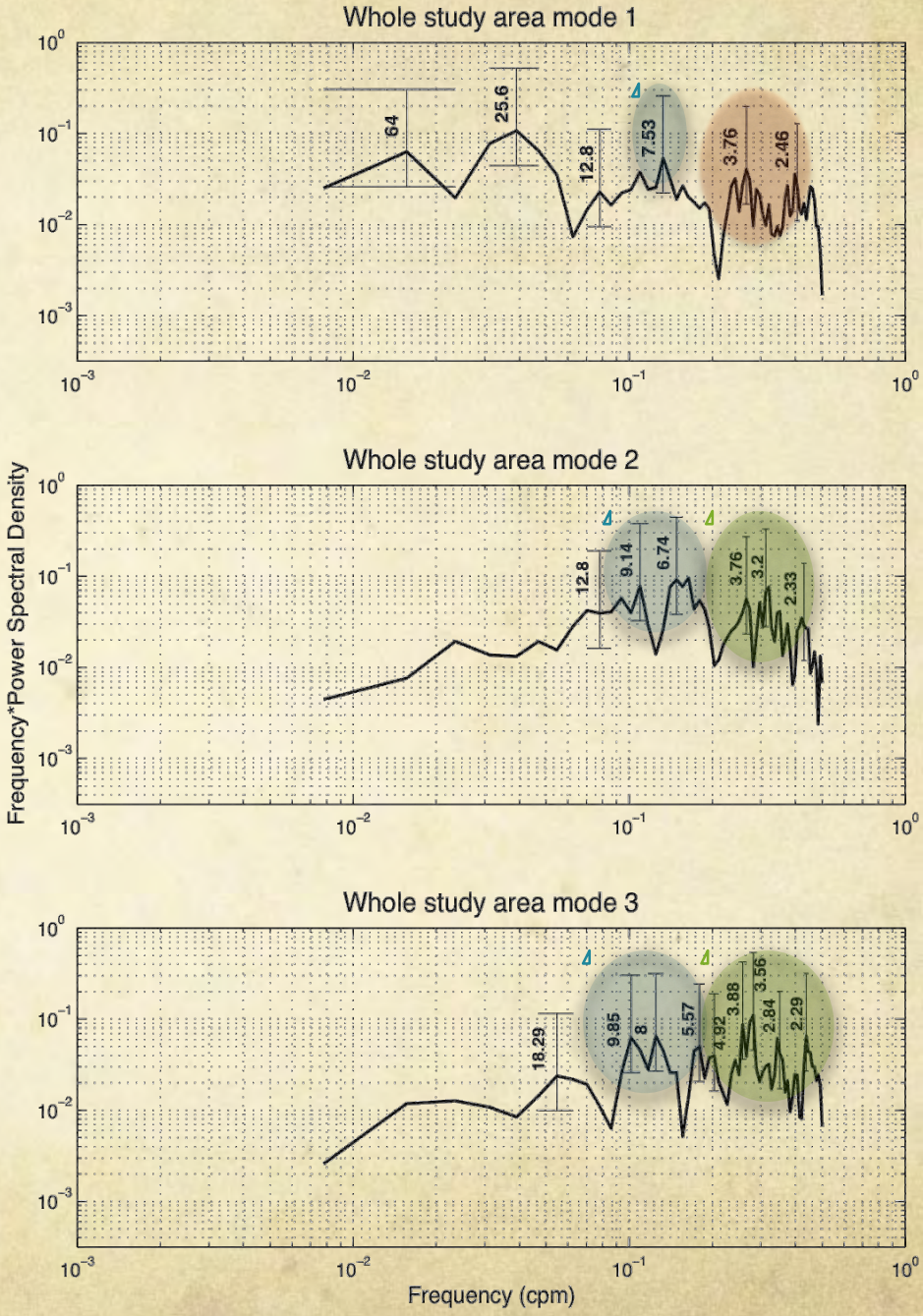


- Previous studies suggest that the GS varies annually, being more northerly in fall, more southerly in spring [*Tracey and Watts*, 1986; *Lee and Cornillon*, 1995; *Rayner et al.*, 2011] and in its northernmost position in September [*Lillibridge and Mariano*, 2012].
- This signal is masked with the seasonal steric heating that expands the ocean as it heats

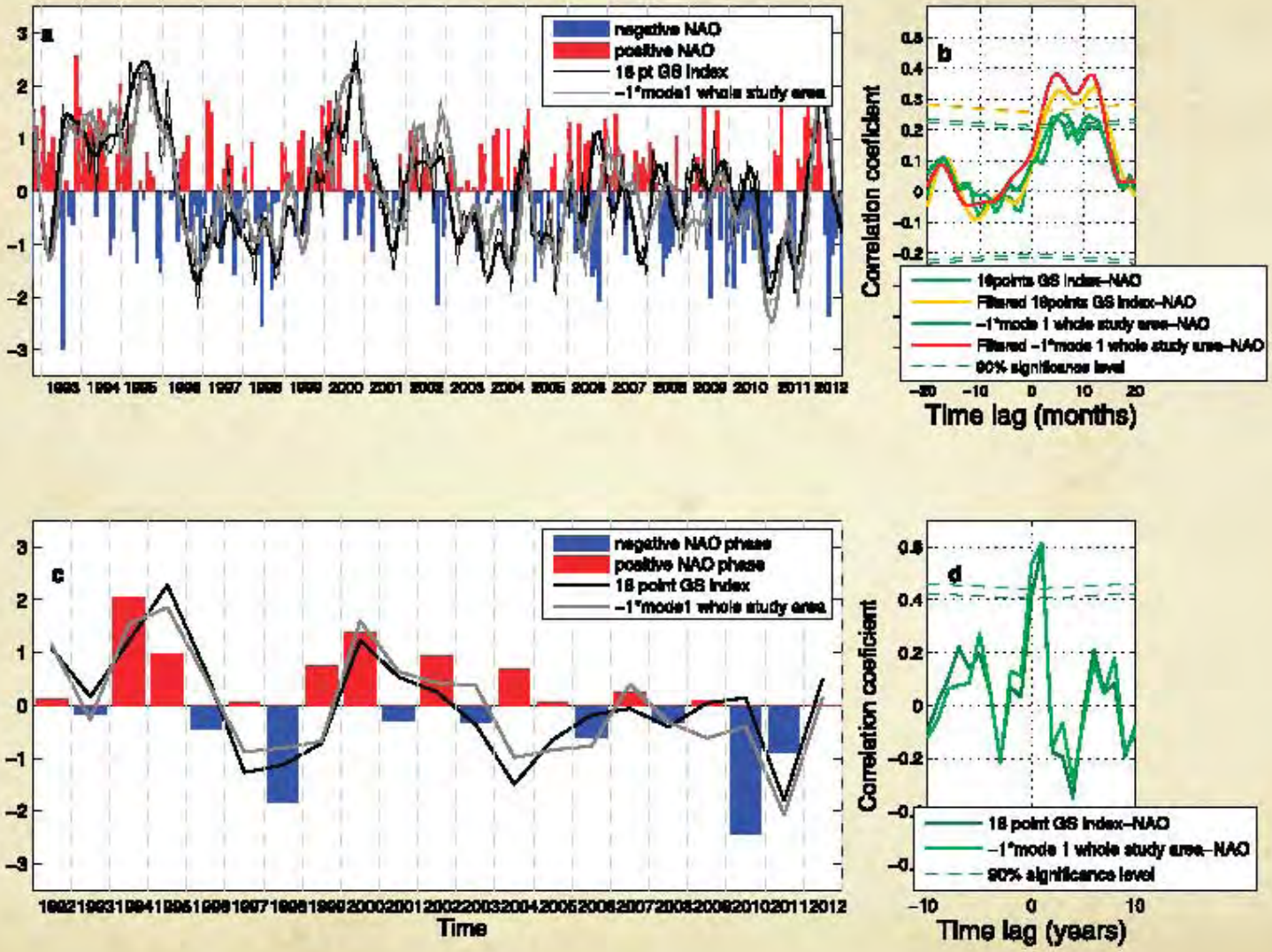




- Periodicities of 6 to 10 months:
  - Relate GS meanders with Rossby waves.
    - *Osychny and Cornillon* [2004] periods from 7 to 11 months between 34-40° N
- Modes 2 and 3, periodicities 1-5 months:
  - *Lee* [1994] between 75°-45°W, most probable period of meanders was 46 days.
  - *Savidge* [2004] meanders have a period of 30-120 days
- Influence of DWBC over the GS:
  - *Dewar et al.* [1985] the DWBC supplying some of the energy necessary to develop the GS meanders
  - *Thompson and Schmitz*[1989]: the GS at the separation point is influenced by the DWBC.
  - *Savidge* [2004] determined that the dominant DWBC energy is in the range of 20-60 days.

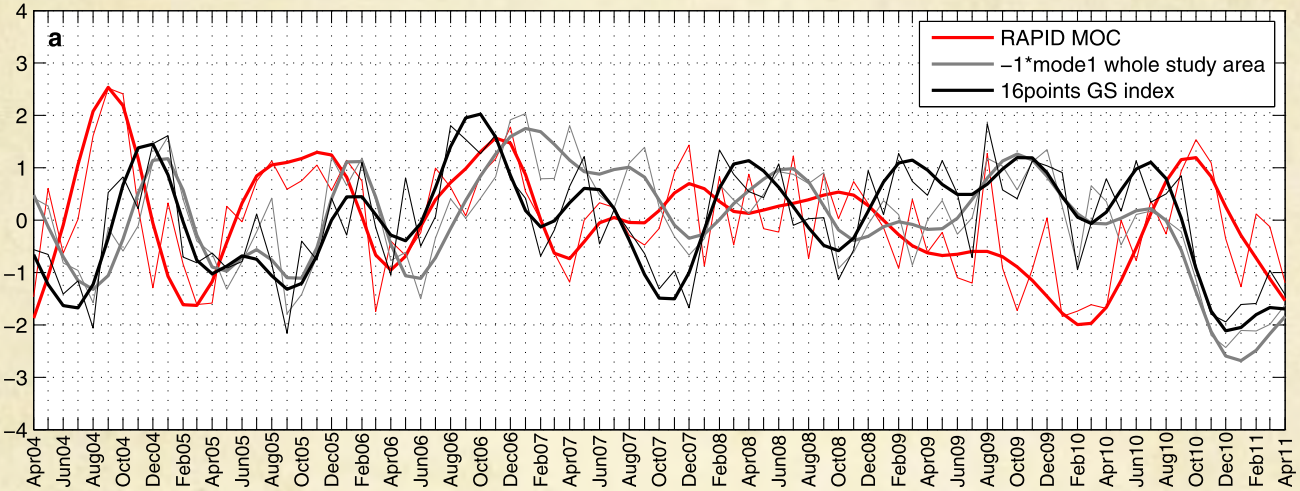


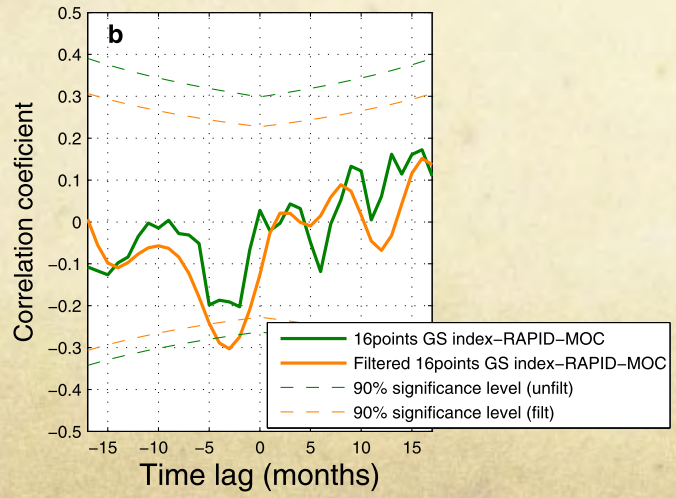
- Mode 1 was compared with the North Atlantic Oscillation (NAO) index (October 2012, http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao.shtml)

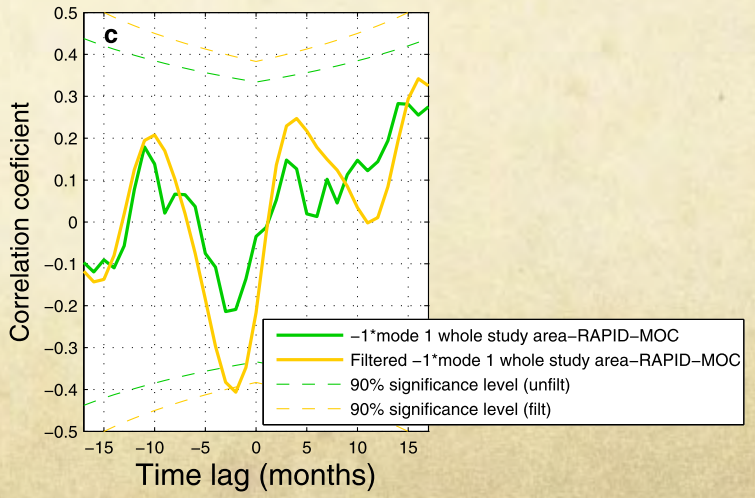


- It has been previously recorded that during positive phases of the NAO the GS shifts north with lags from 1 year [*Joyce et al.*, 2000] to 2 years [*Taylor et al.*, 1998; *Hameed*, 2004].

- *De Coëtlogon et al.* [2006], *Zhang and Vallis*, [2007] and *Joyce and Zhang*, [2010] argued for a connection between the AMOC and the GS path.
- The AMOC estimated at 26º N by the RAPID program (http://www.noc.soton.ac.uk/rapidmoc/).
- This would mean that a southward/northward path of the GS occurs when the AMOC is strong/ weak as found in Joyce and Zhang [2010].

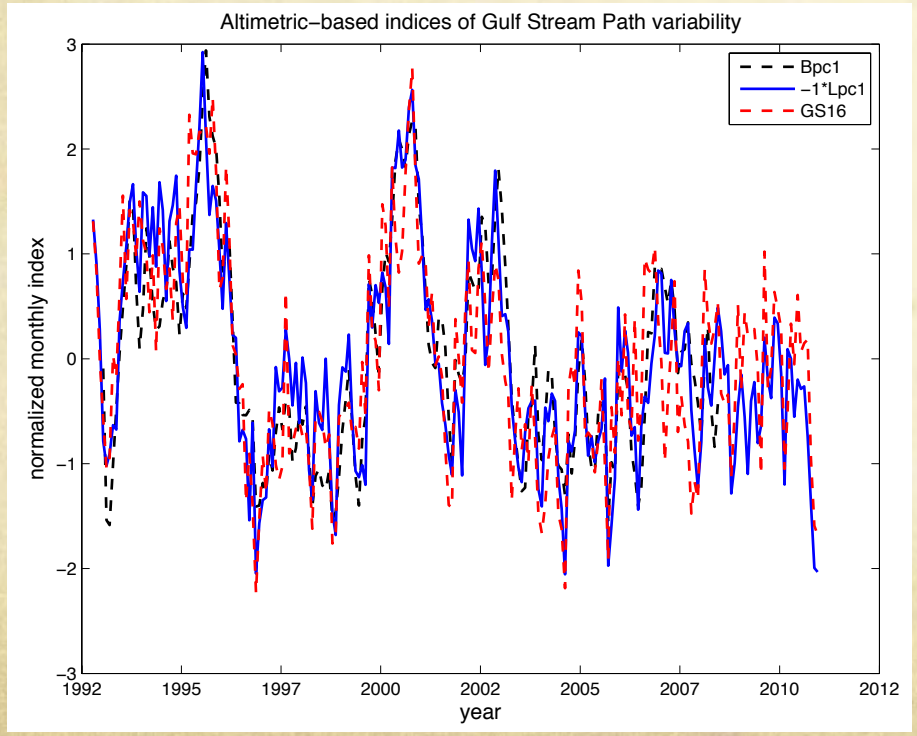


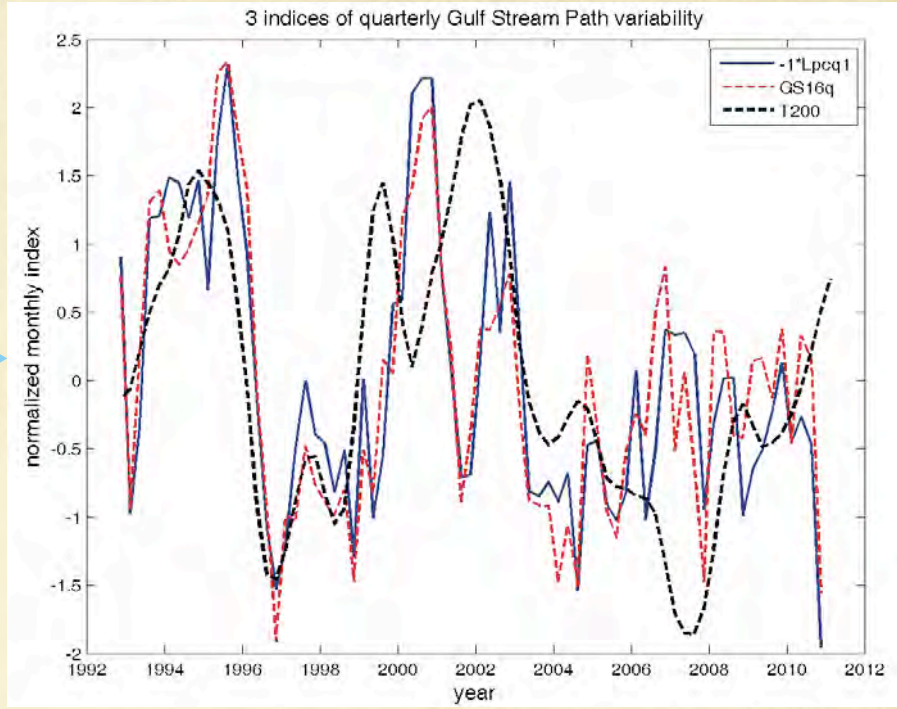




Comparison with other indexes for the GS

- The 15° C isotherm at 200 m is in the center of the strong horizontal temperature gradient of the GS [*Fuglister*, 1955; *Joyce et al.*, 2000]. As it lies just to the north of the maximum flow at the surface, it is a good indicator of the northern side of the stream [*Fuglister*, 1961].

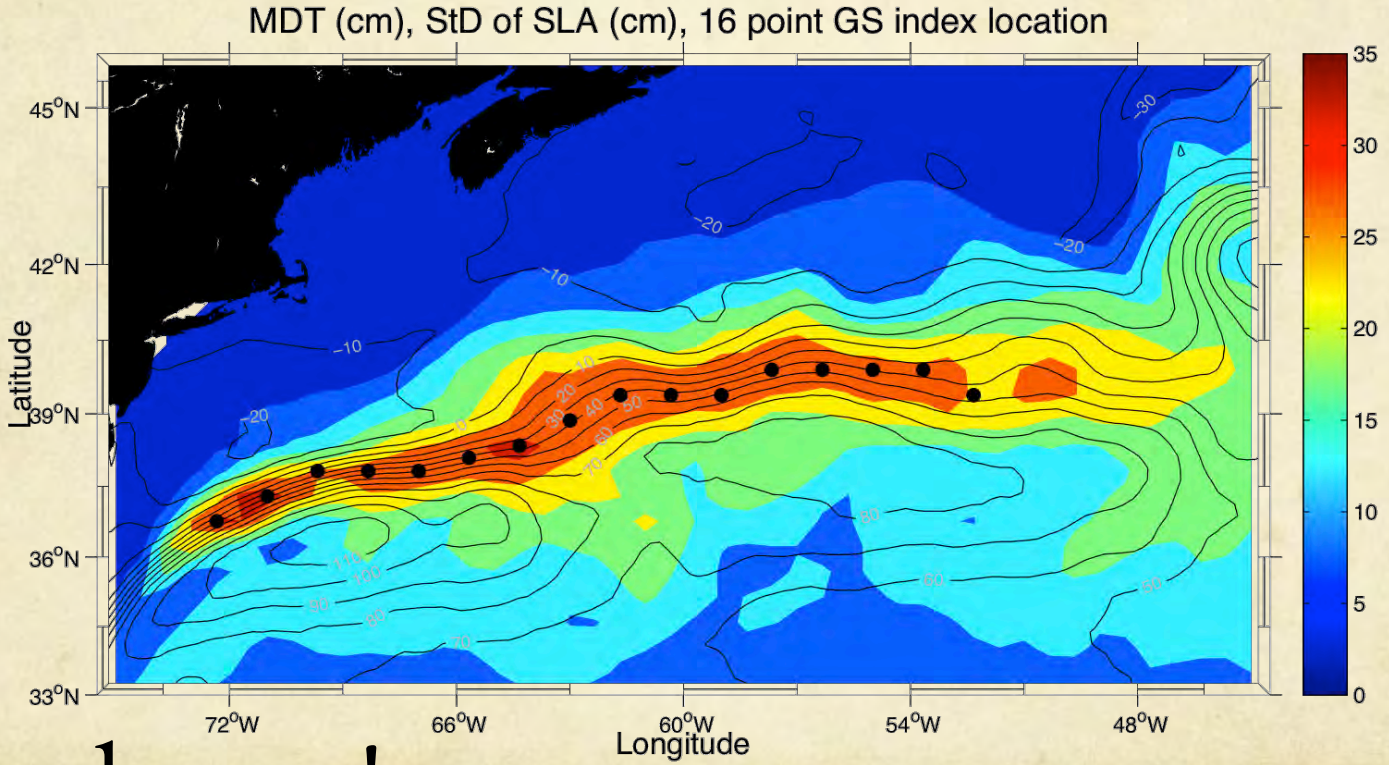




- In *Peña-Molino and Joyce* [2008] the GS path was made from 10 day SSH anomalies along 6 descending tracks by searching for the maximum gradient.
- Our indices are in agreement: they are also indicative of changes in the SST anomalies and velocities in the Slope Water (positive temperature anomalies precede northward shifts)

Conclusions

To conclude, we propose a simple 16 point altimeter-based GS index as a good indicator of the latitudinal shifts of the GS. The index can be quickly estimated and updated without changes in previous estimates and is a useful measurement of the large-scale shifts in the GS path, which can be related to climate variability [*Joyce et al.*, 2009], to changes in some fish stocks [*Nye et al.*, 2011] and keystone species [*Borkman and Smayda*, 2009].



Thank you!

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