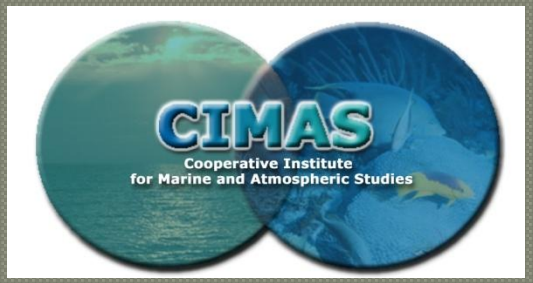
The variability of the upper circulation of the Tropical Atlantic during 1993-2010

Marlos Goes, Gustavo Goni,
Molly Baringer

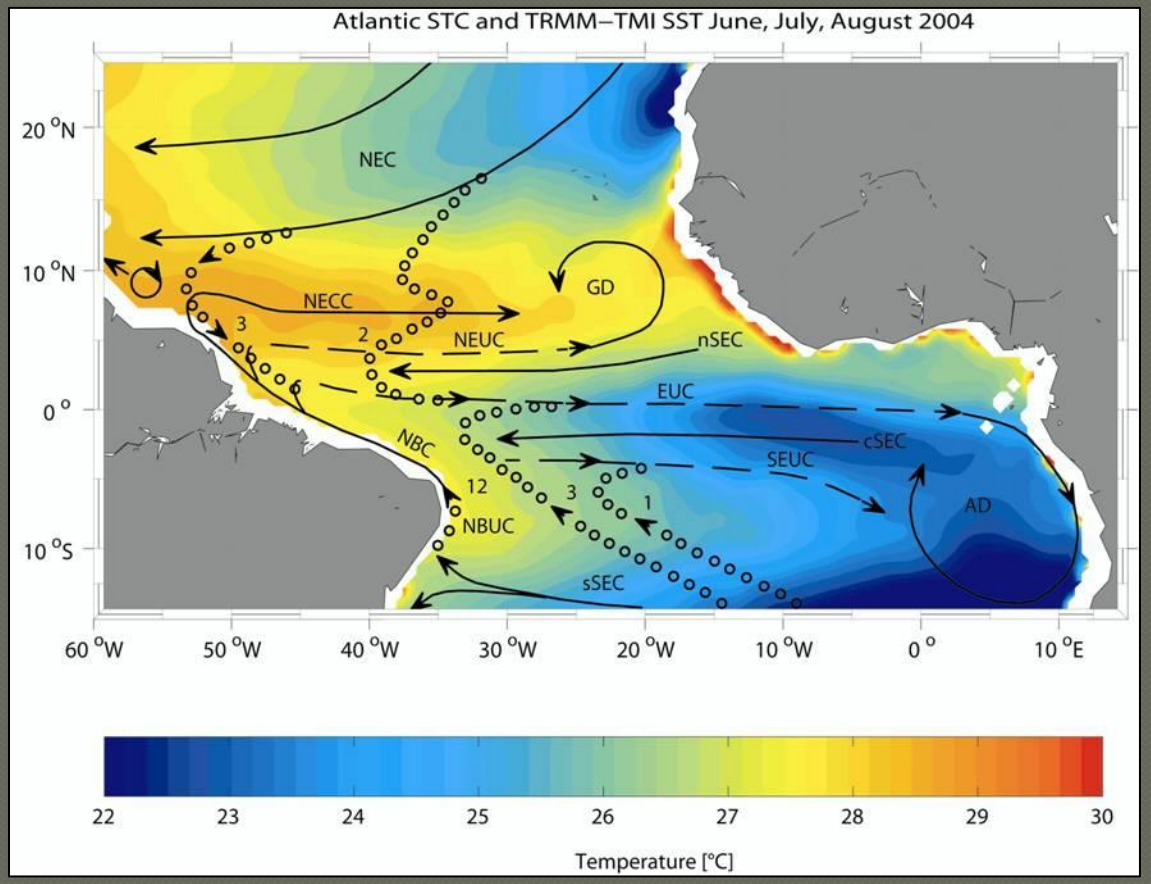
XSW 2011, Melbourne, Australia

Thanks to:
Verena Hormann, Rick Lumpkin, Greg Foltz



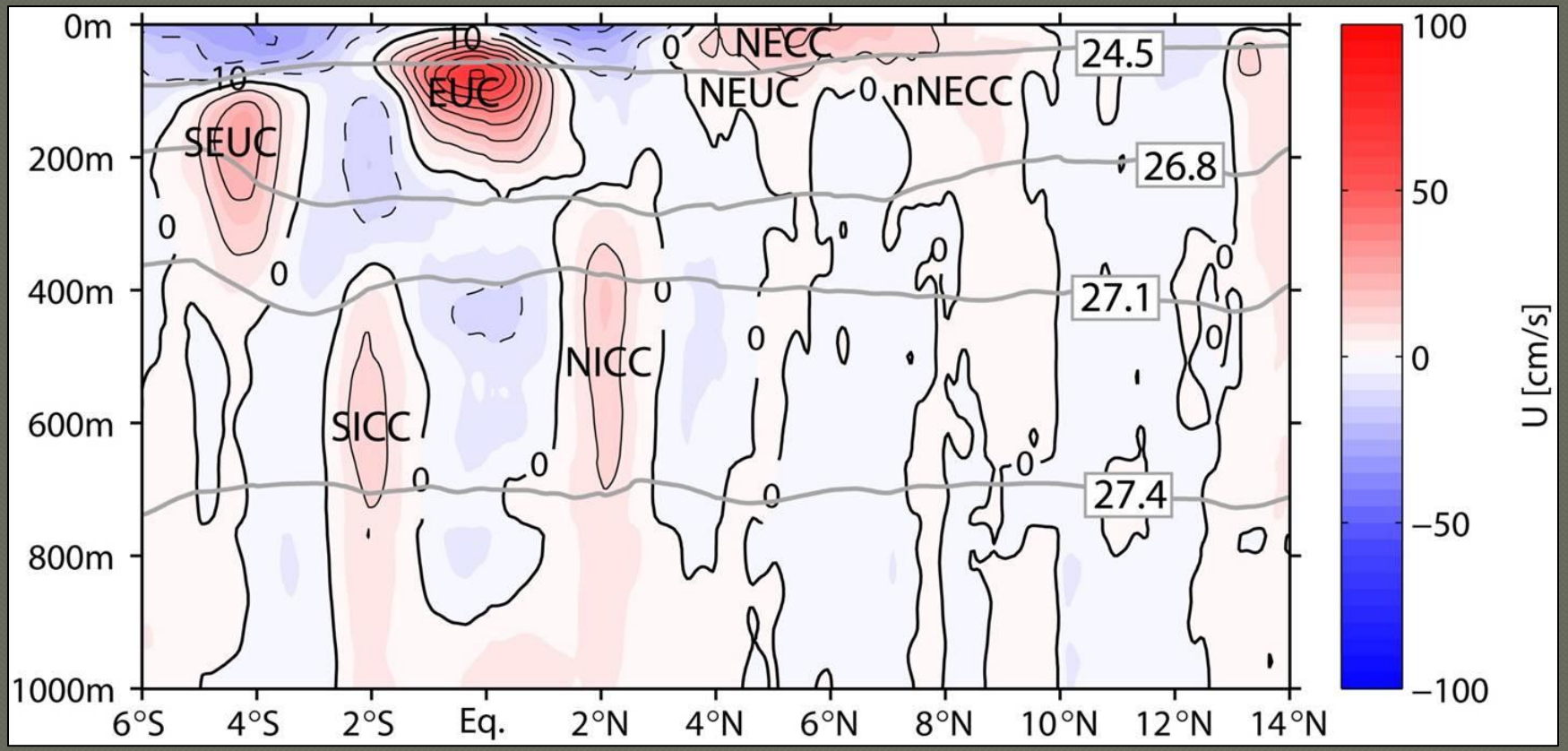
University of Miami, CIMAS
NOAA/AOML

Upper Circulation of the tropical Atlantic



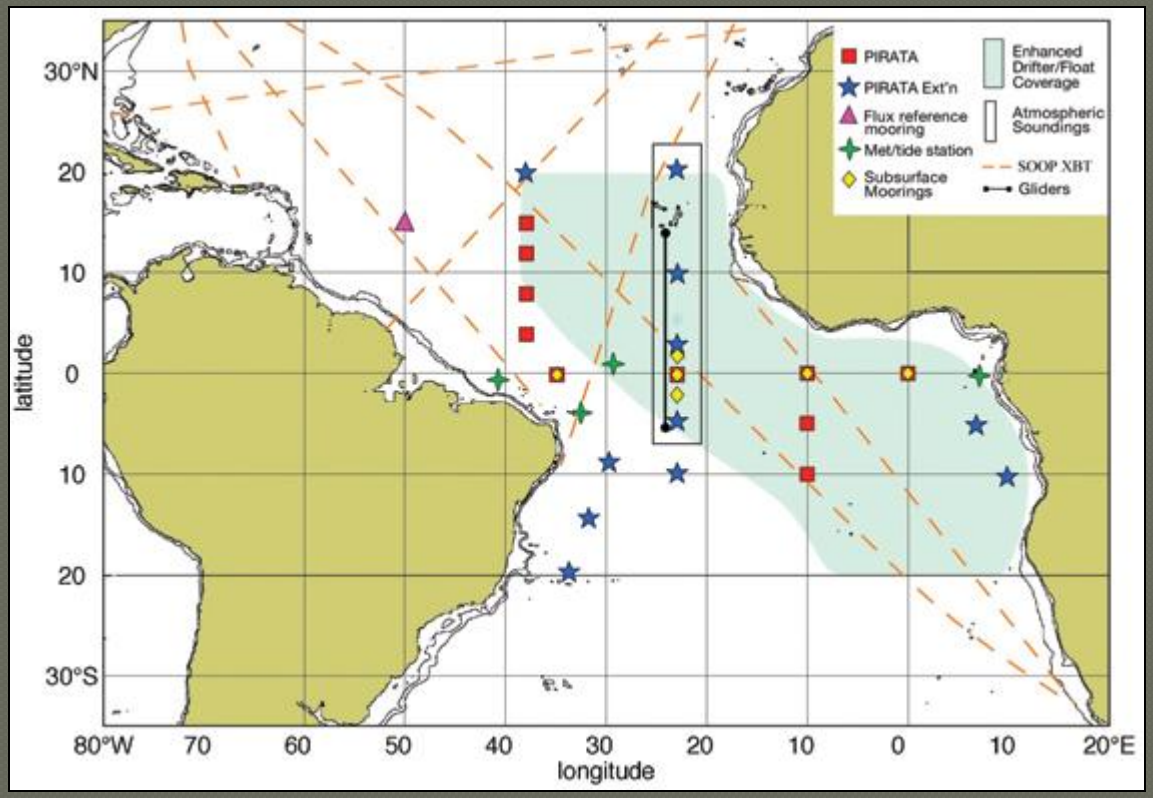
Brandt et al. 2011

Mean zonal velocity at ~23W



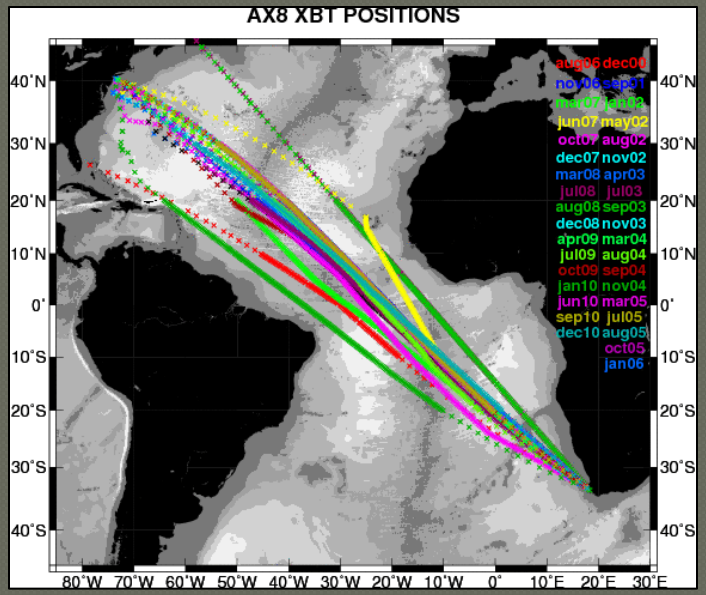
Brandt et al. 2010

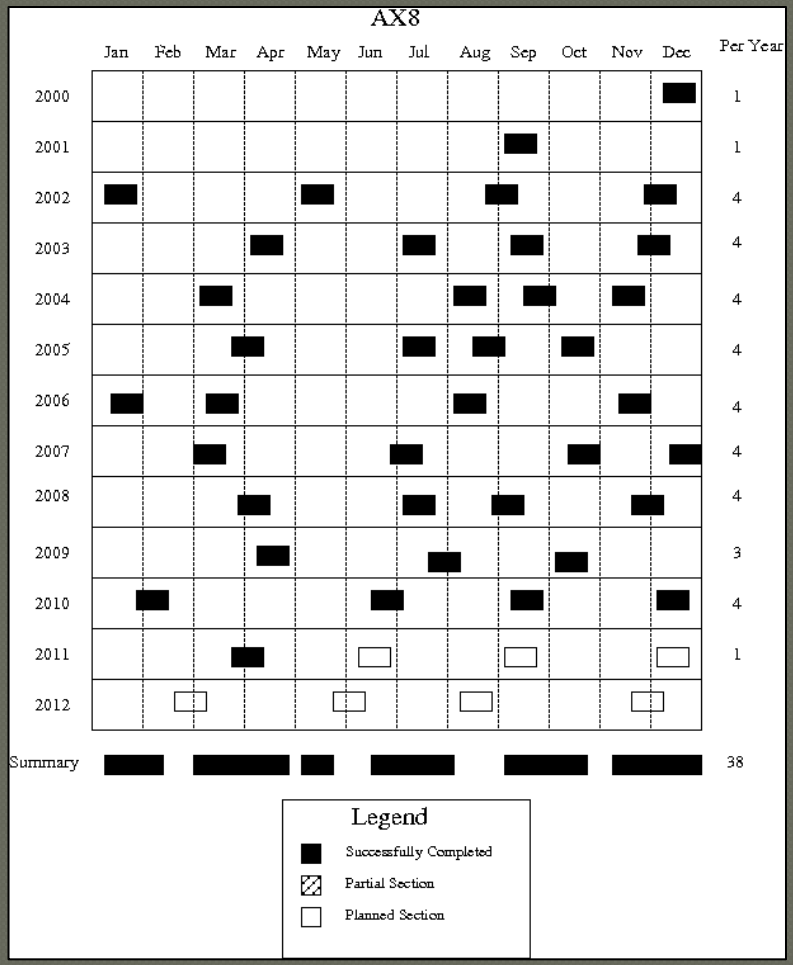
TACE GOAL is to advance the understanding of coupled ocean-atmosphere processes and improve climate prediction for the Tropical Atlantic region



http://www.clivar.org/organization/atlantic/TACE/tace.php

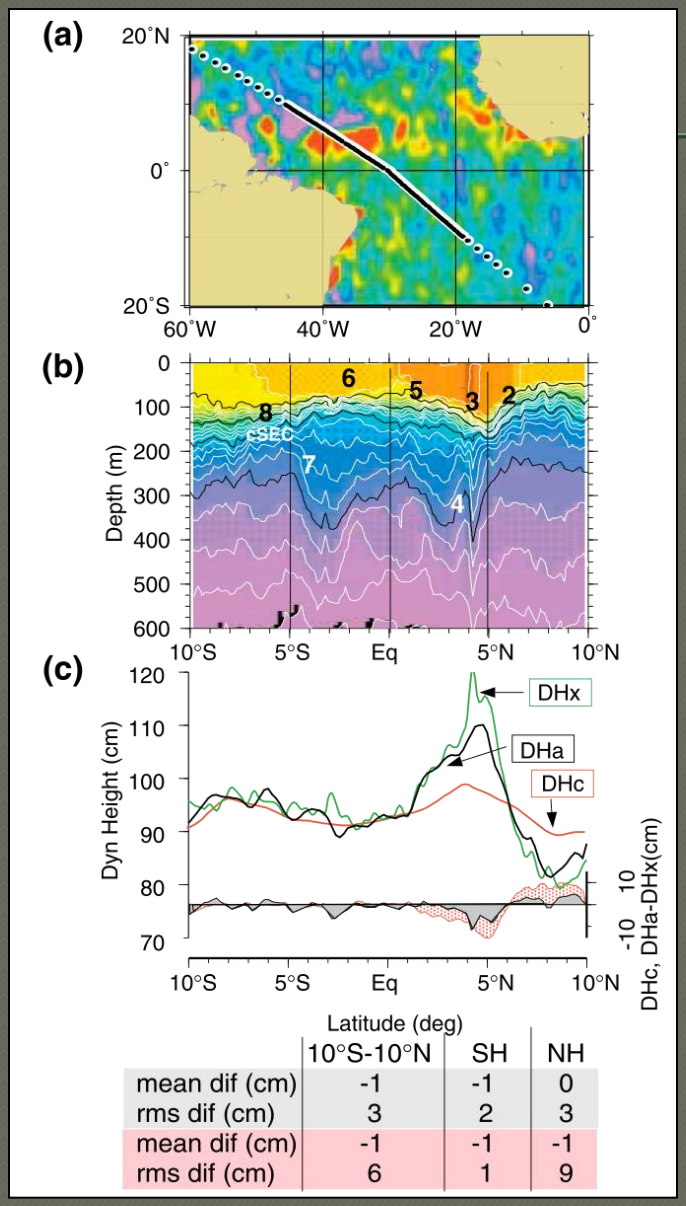
The AX08 transect





- High density data from 36 cruises across the Atlantic since 2000.
- Average of 4 transects a year since 2002.
- About 200-300 XBTs deployed in each cruise.
- Resolution of 25km for the upper 800m.

Motivation



	10°S-10°N	SH	NH
mean dif (cm)	-1	-1	0
rms dif (cm)	3	2	3
mean dif (cm)	-1	-1	-1
rms dif (cm)	6	1	9

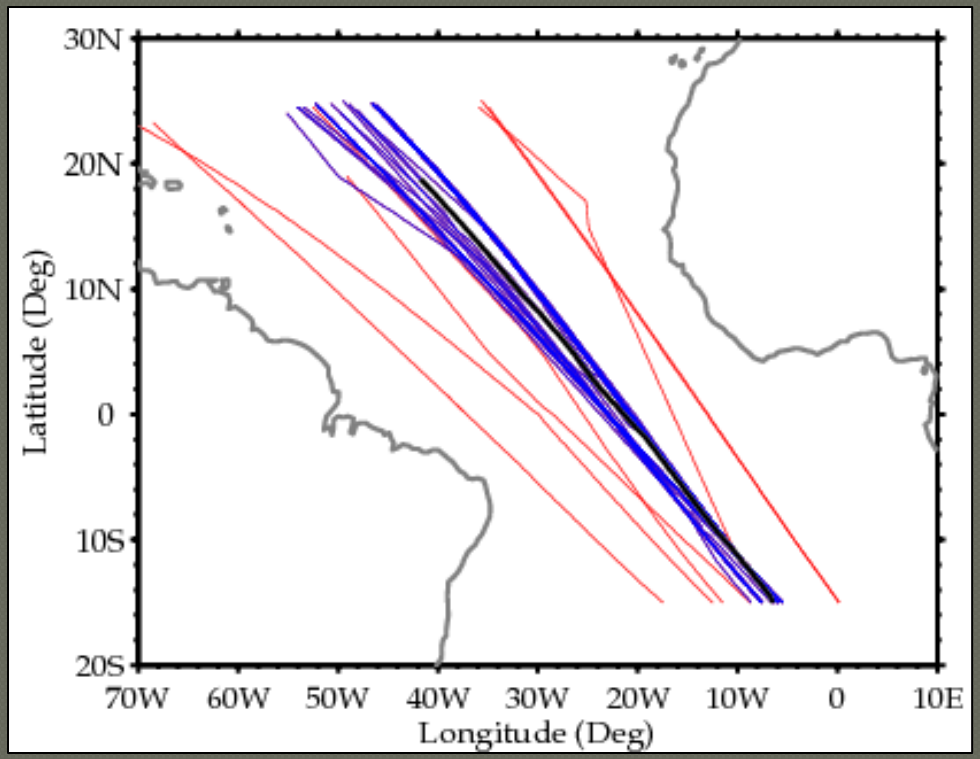
- There are substantial tropical upper ocean currents with very weak surface signature and spatial variability that cannot be resolved from surface topographic fields alone.
- Future XBT sections will aid in establishing a relationship between each current and their characteristic sea height signature to establish a monitoring system to investigate their spatial and temporal variability in more detail.

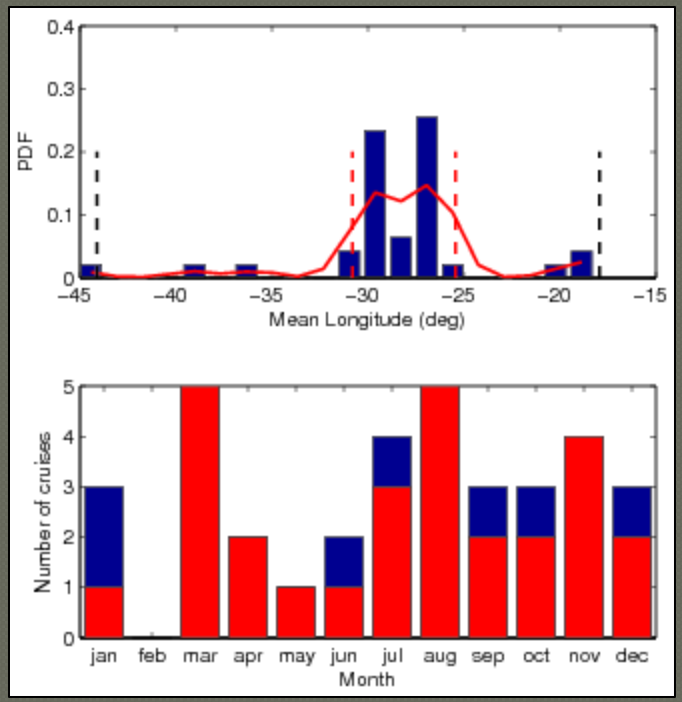
Goni & Baringer (2002)

Goal: study the variability of the TA using XBTs and altimetry data

- Can we monitor the equatorial currents using XBT data?
- In which scales?
- What are the mechanisms of the variability of these currents?
- What is the surface response to this variability?

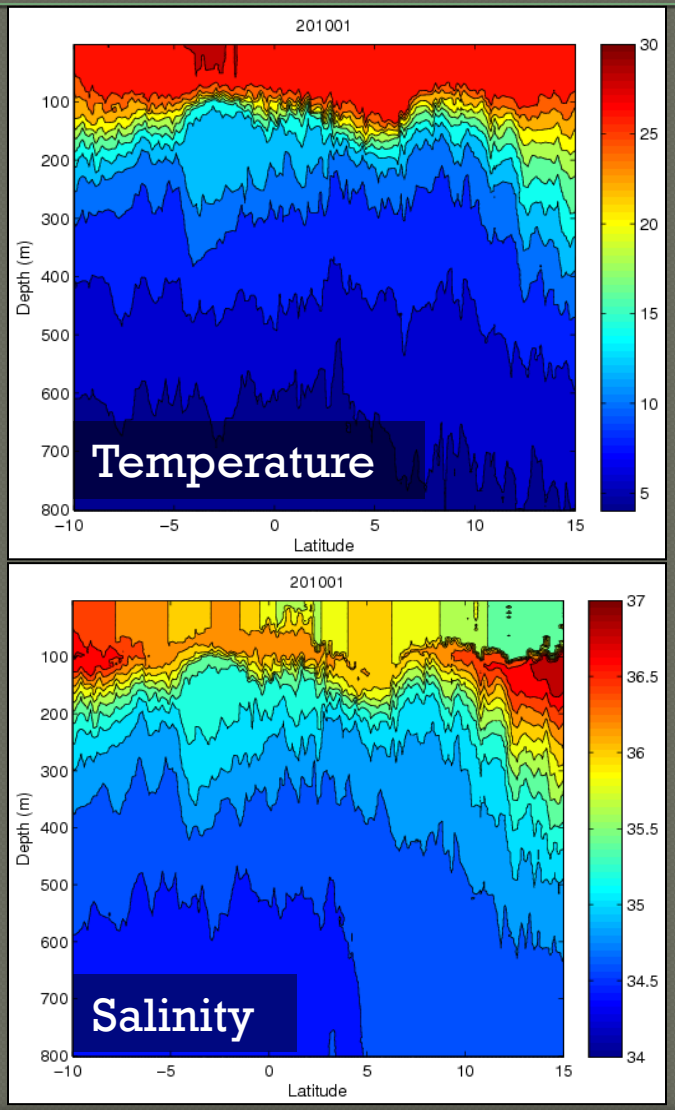
Region of Interest

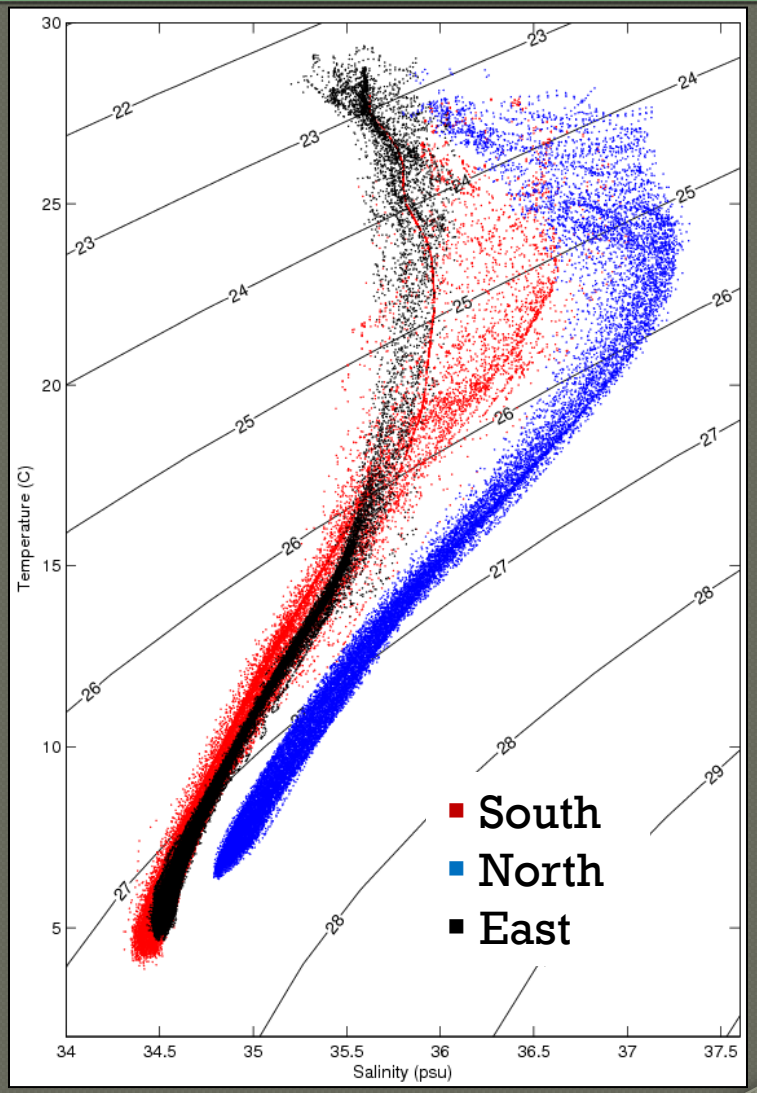




The selected transects are located around the median value.

Typical Sections





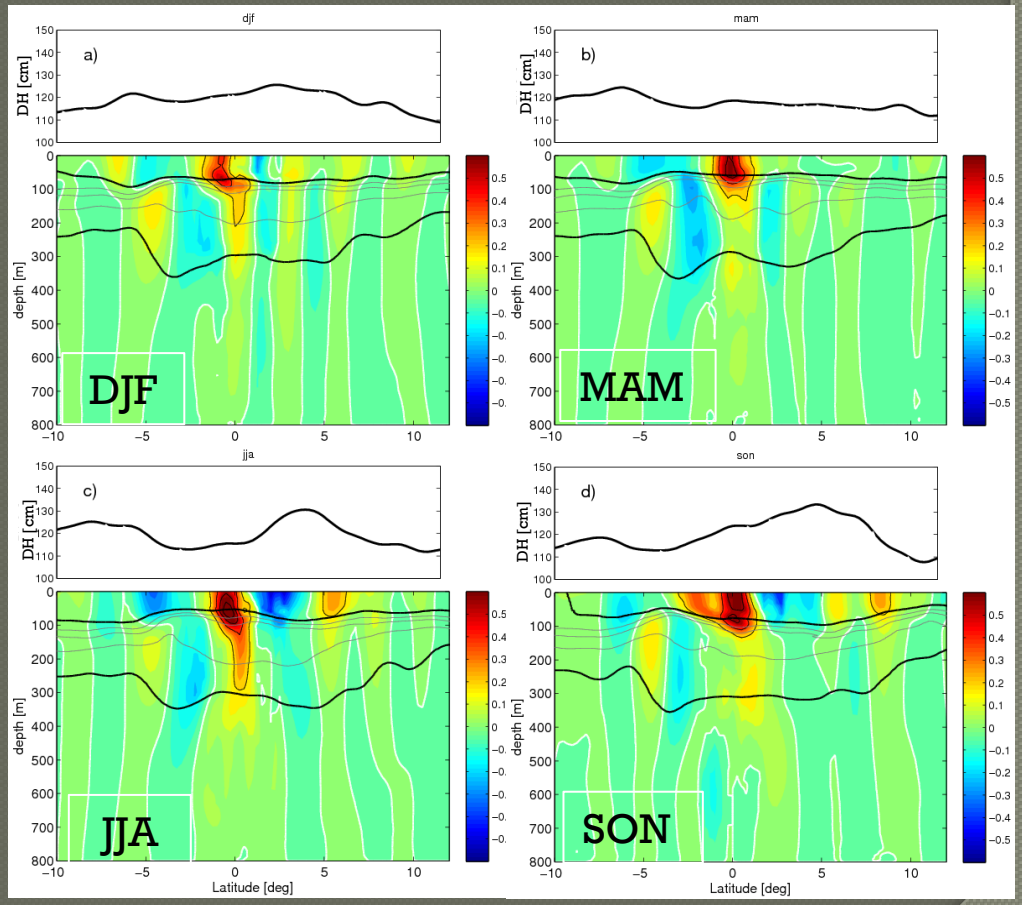
Velocities and Transport

- Velocities referenced to 800m.
- The transport between:
  σ_θ = 0 - 24.5: surface currents.
  σ_θ = 24.5 - 26.8: undercurrents.

- Equatorial currents according to Vianna & Menezes, (2005).

- The latitude of the currents according to the literature:

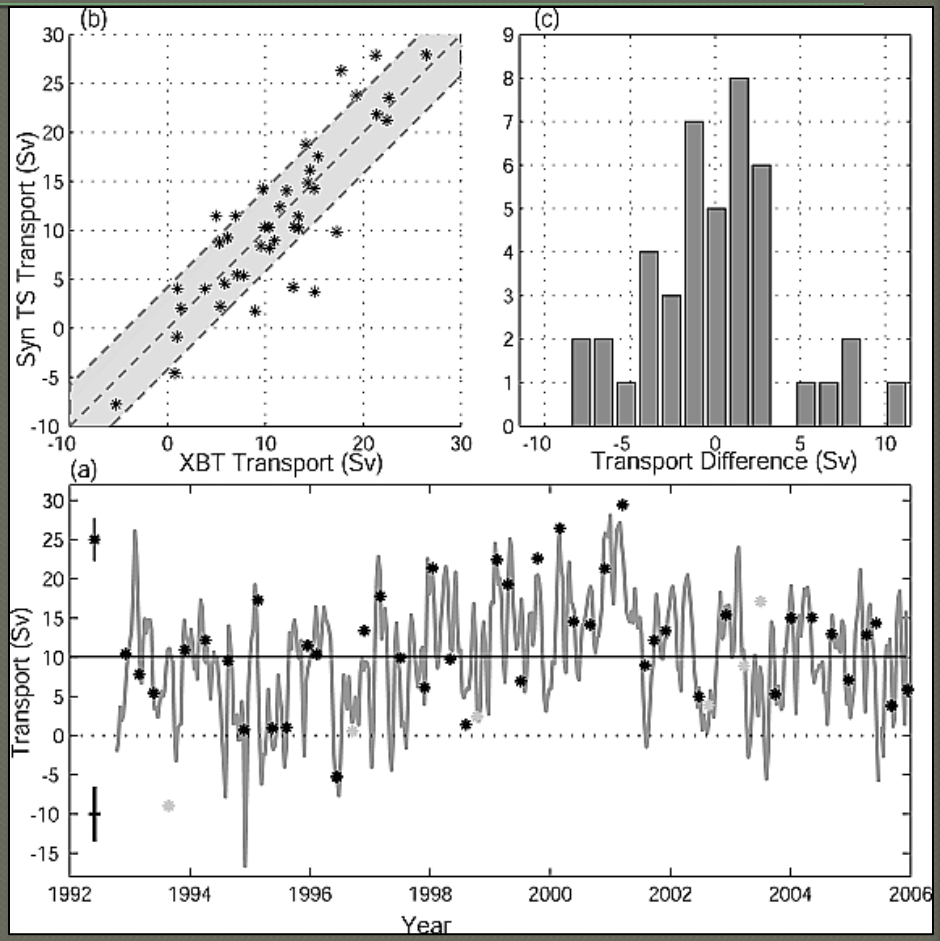
NECC = 3N-10N (Richardson &Walsh 1986)
NEUC = 3N-7N (Bourles et al. 2002)
SEUC = 7S-3S (Fischer et al. 2008)



Synthetic profiles from Altimetry

- Gilson et al. (1998); Ridgway et al. (2002); Phillips and Rintoul (2002), etc.
- Data series can be extended until 1993 on a 7-day resolution.

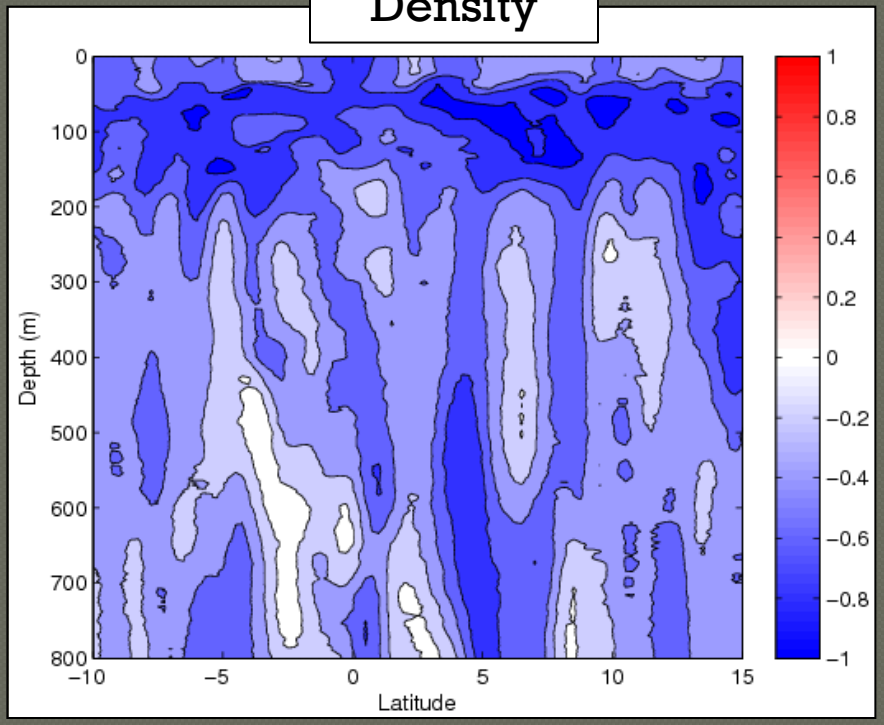
- We apply similar method to estimate potential density (σ_θ) and dynamic height (Dh) from a linear fit between SSH and Dh at the surface.



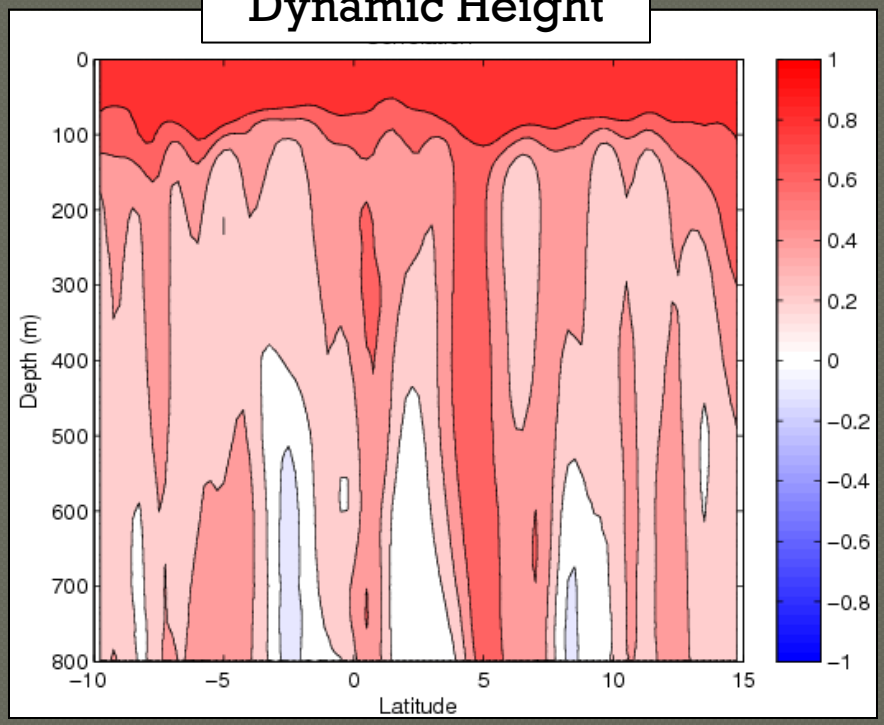
PX34 transport between Sydney and Wellington. Ridgway et al. (2008)

Correlation of Anomalies of σθ and DH with DH_0

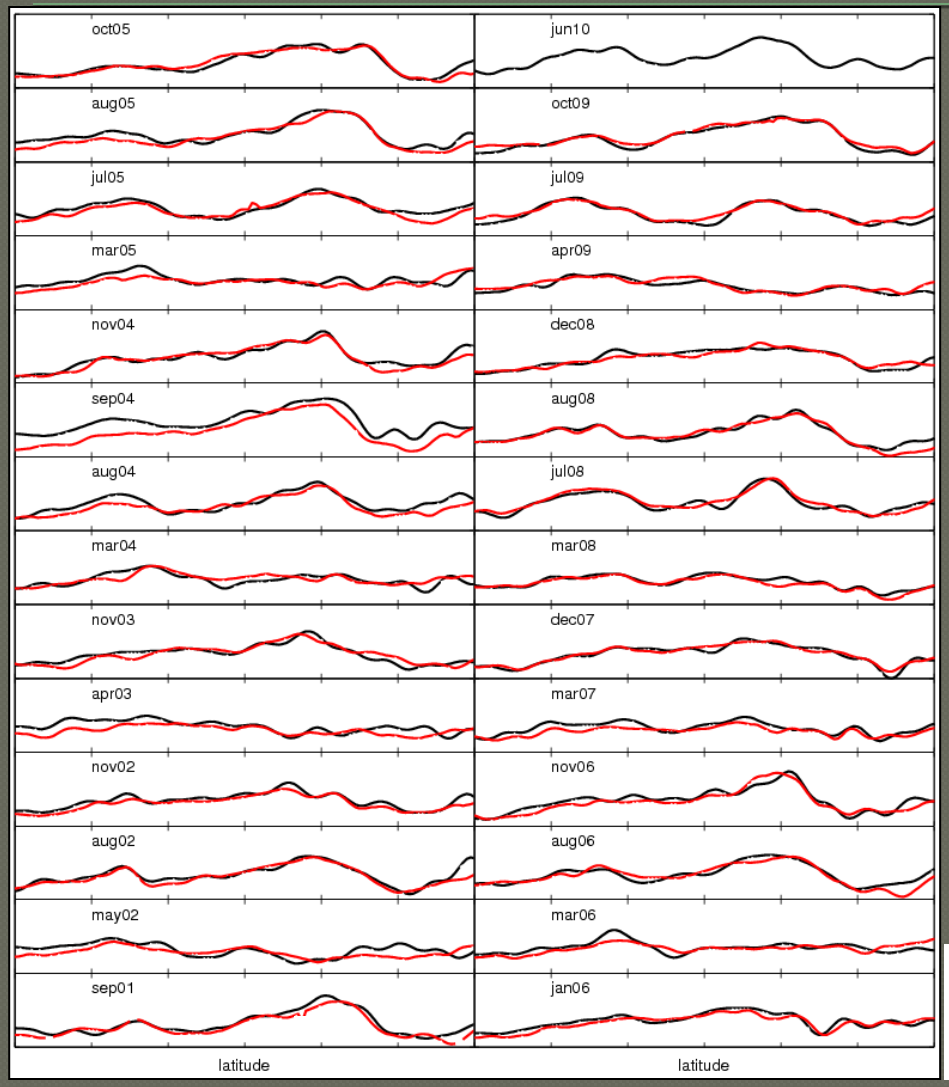
Density

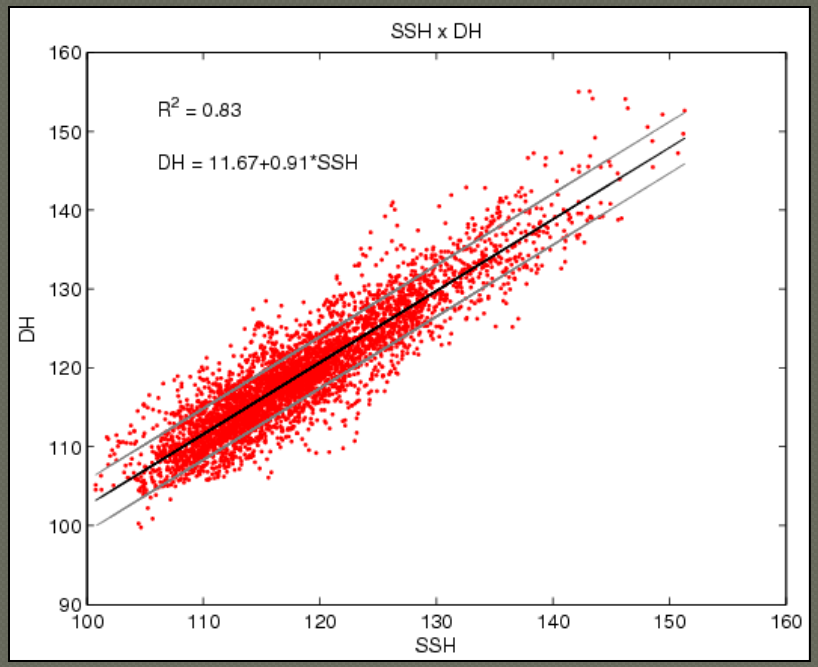


Dynamic Height



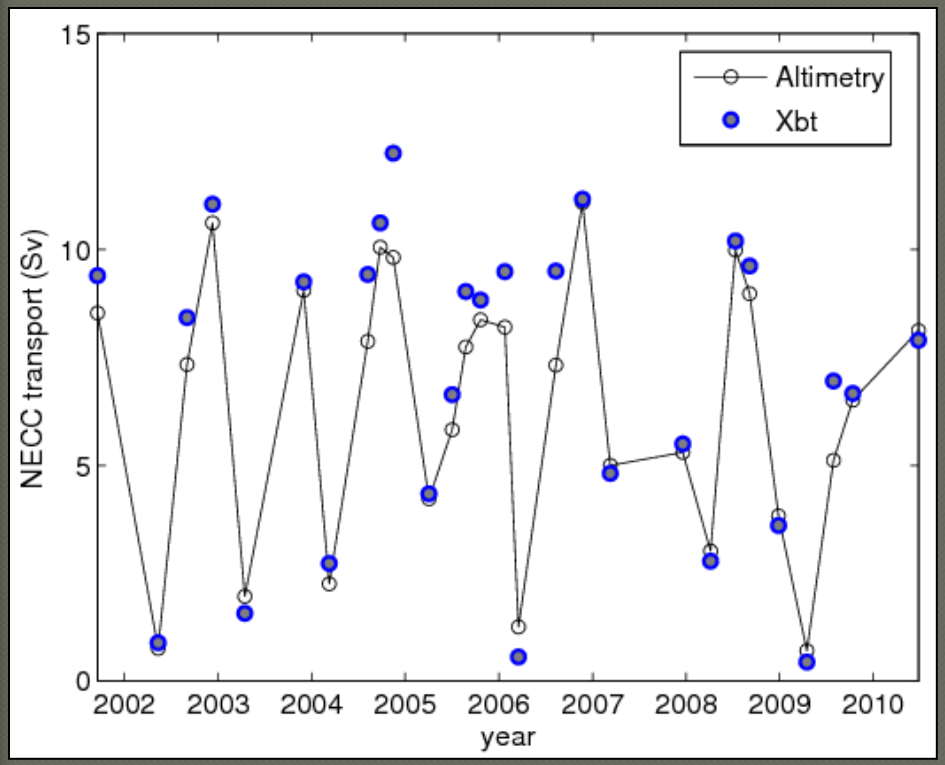
SSH x Dynamic Height

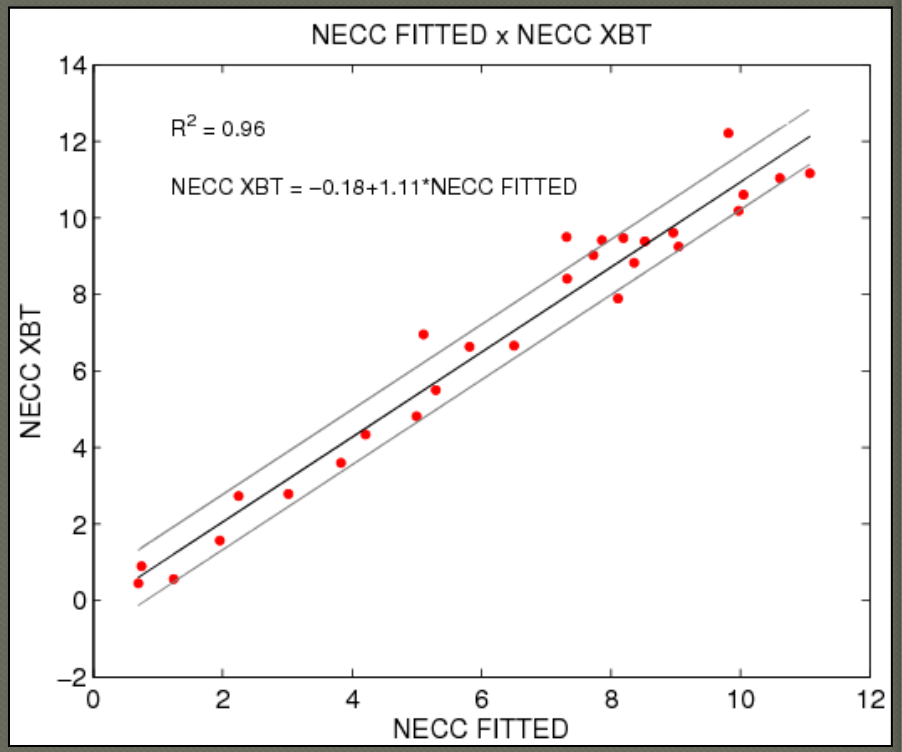




- SSH (Alt)
- DH (XBT)

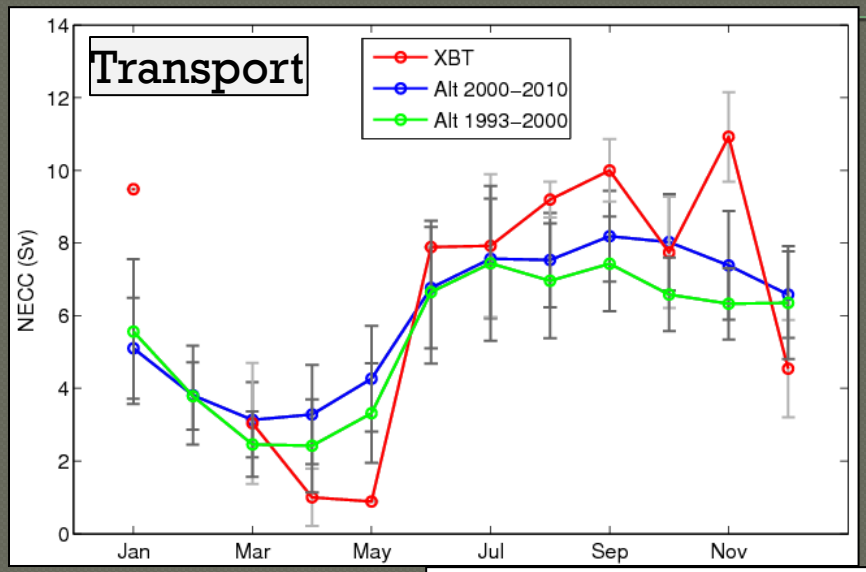
NECC transport/ validation

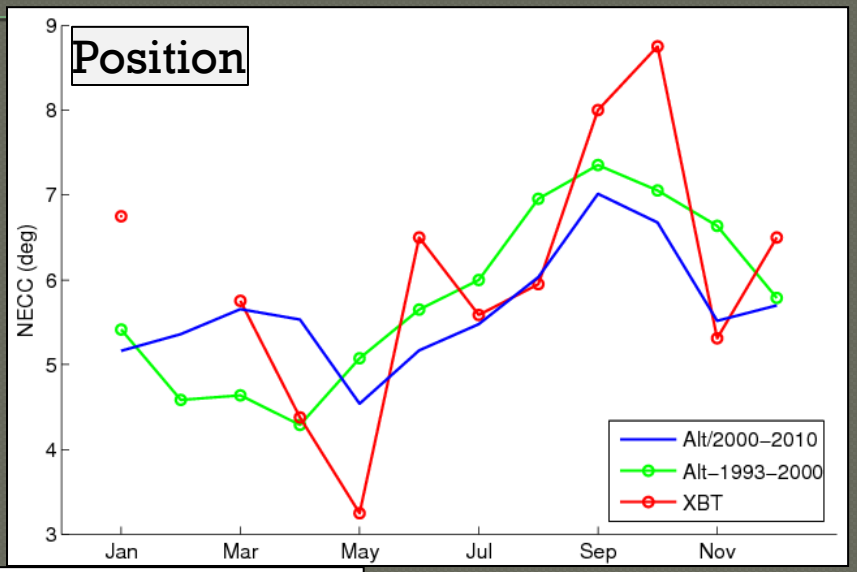


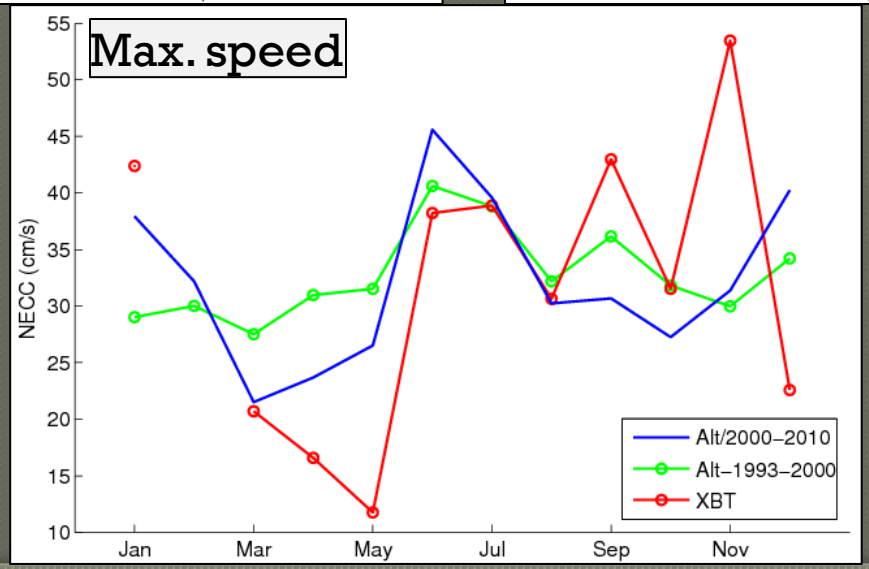


- Good comparison with xbt measurements.

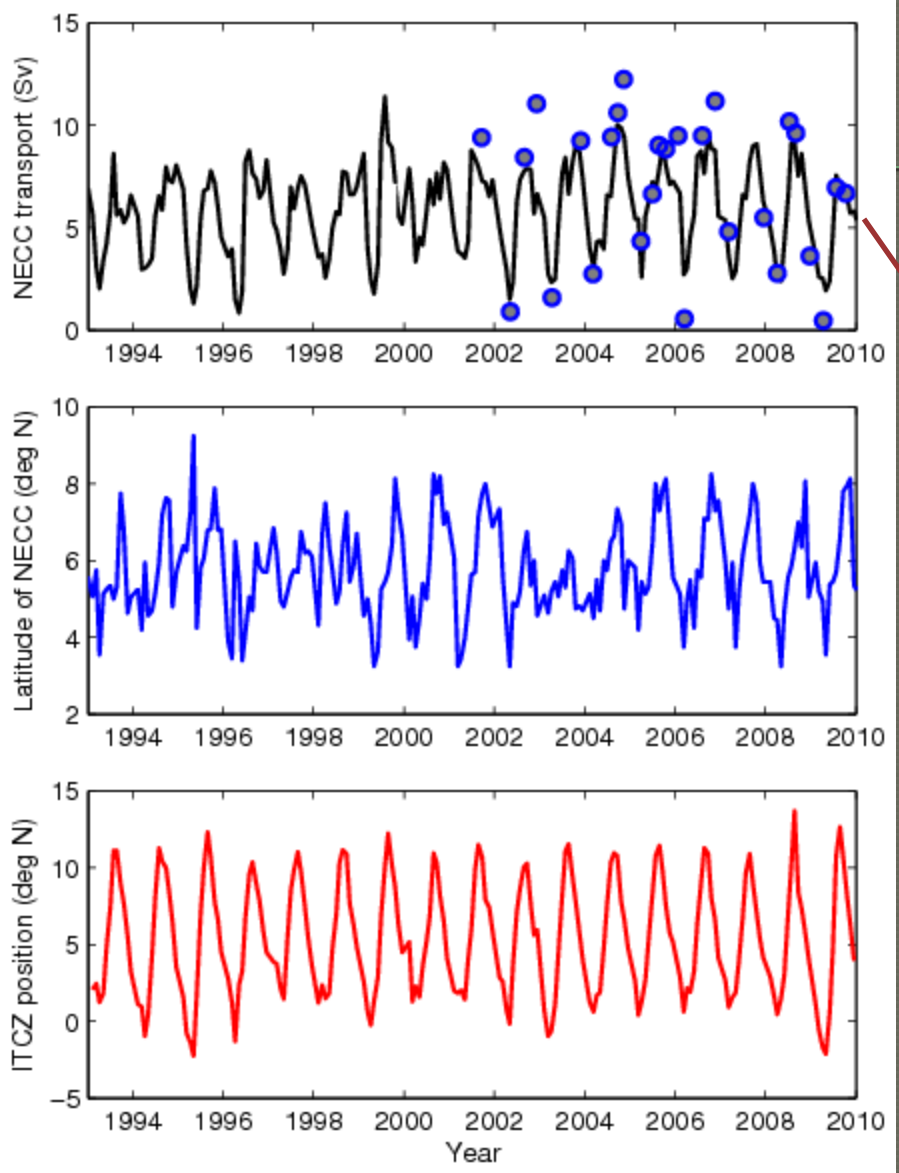
NECC

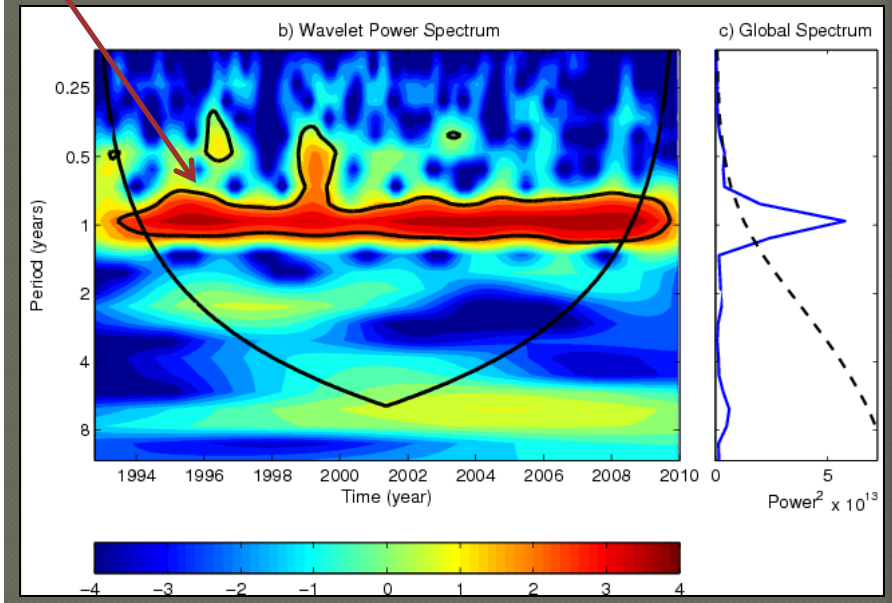

Transport
XBT
Alt 2000–2010
Alt 1993–2000
NECC (Sv)
0
2
4
6
8
10
12
14
Jan
Mar
May
Jul
Sep
Nov


Position
NECC (deg)
3
4
5
6
7
8
9
Alt/2000–2010
Alt–1993–2000
XBT
Jan
Mar
May
Jul
Sep
Nov

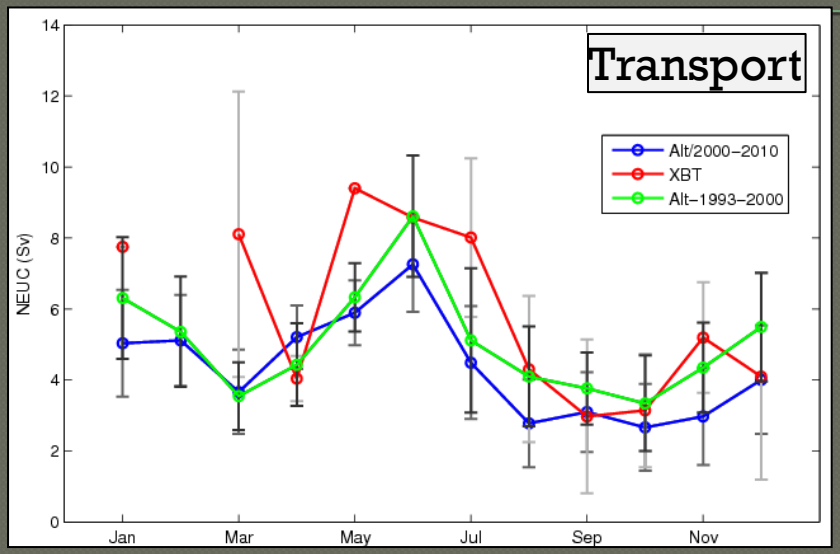

Max. speed
NECC (cm/s)
10
15
20
25
30
35
40
45
50
55
Alt/2000–2010
Alt–1993–2000
XBT
Jan
Mar
May
Jul
Sep
Nov

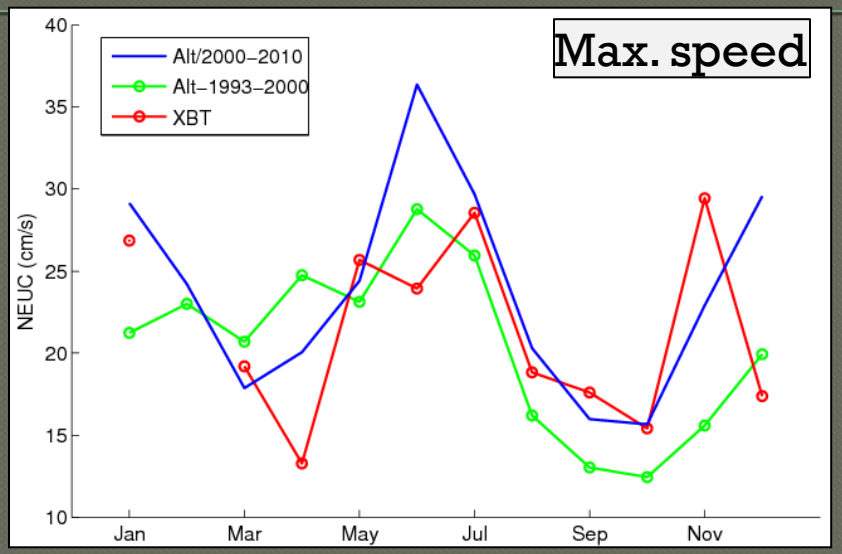
NECC

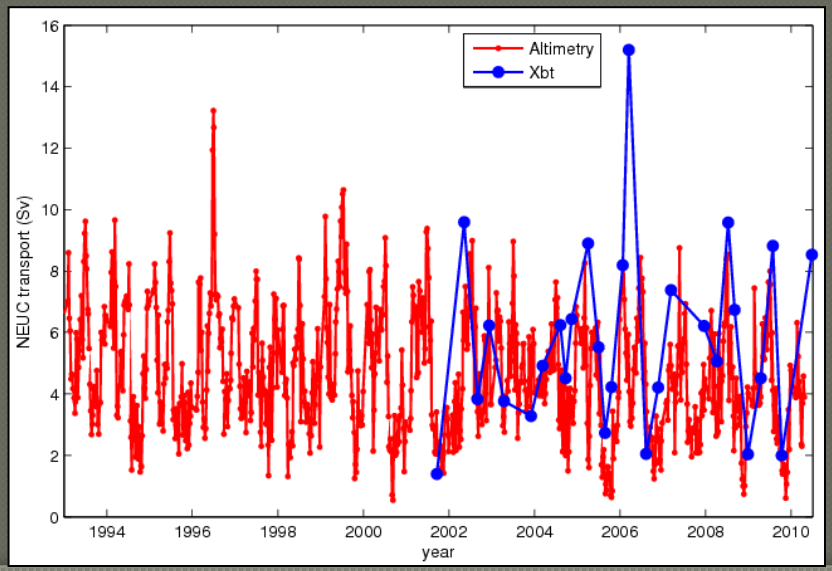

NECC transport (Sv)
Latitude of NECC (deg N)
ITCZ position (deg N)
Year
1994
1996
1998
2000
2002
2004
2006
2008
2010

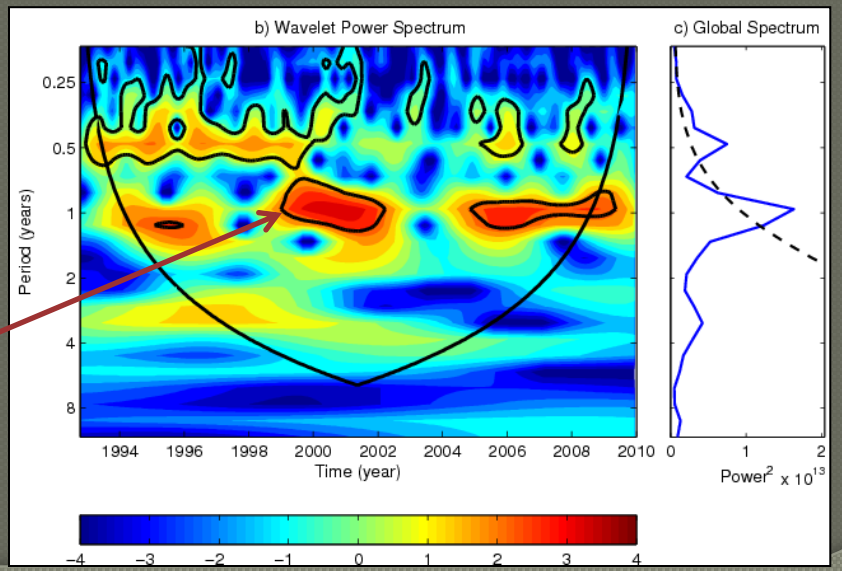

b) Wavelet Power Spectrum
c) Global Spectrum
Period (years)
Time (year)
Power^2 x 10^{13}

NEUC

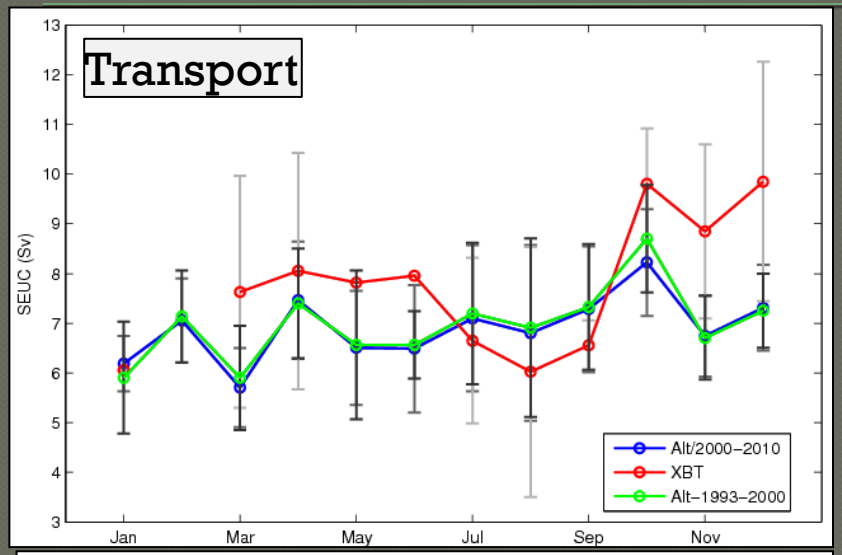

Transport
NEUC (Sv)
Alt/2000–2010
XBT
Alt–1993–2000
Jan
Mar
May
Jul
Sep
Nov

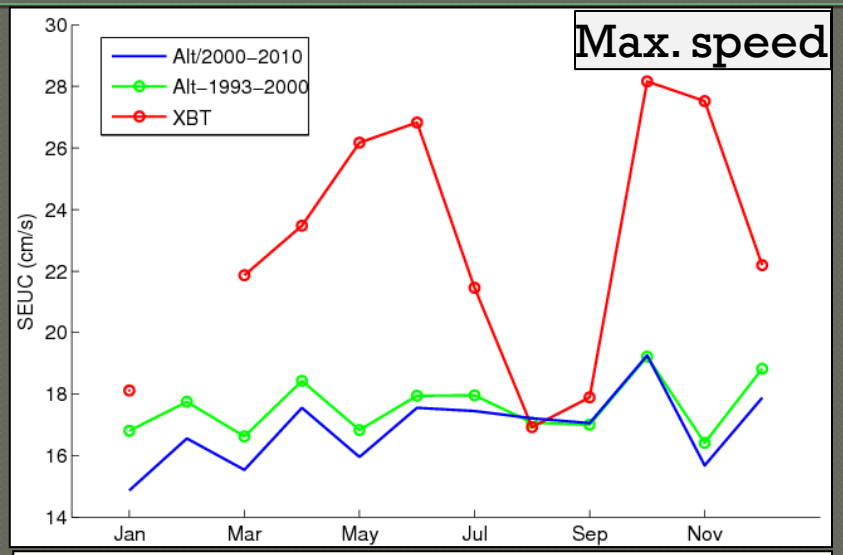

Max. speed
NEUC (cm/s)
Alt/2000–2010
Alt–1993–2000
XBT
Jan
Mar
May
Jul
Sep
Nov

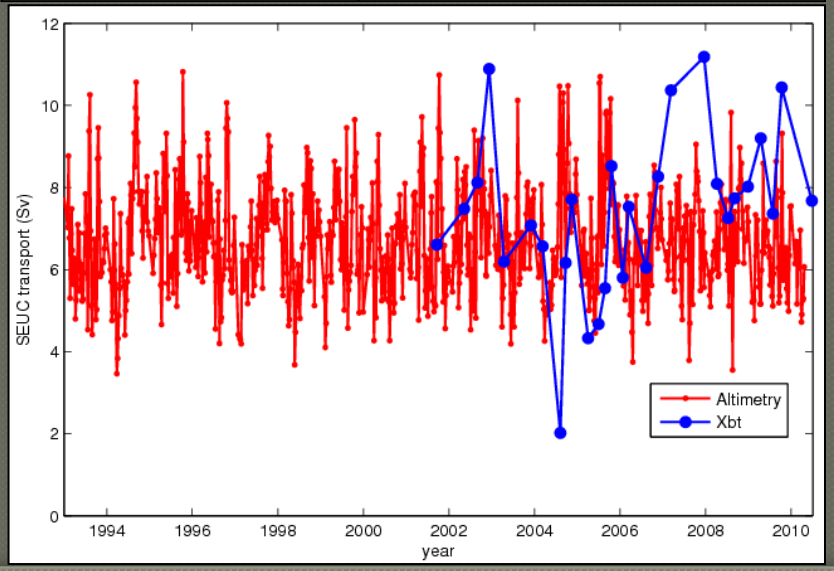

NEUC transport (Sv)
Altimetry
Xbt
year

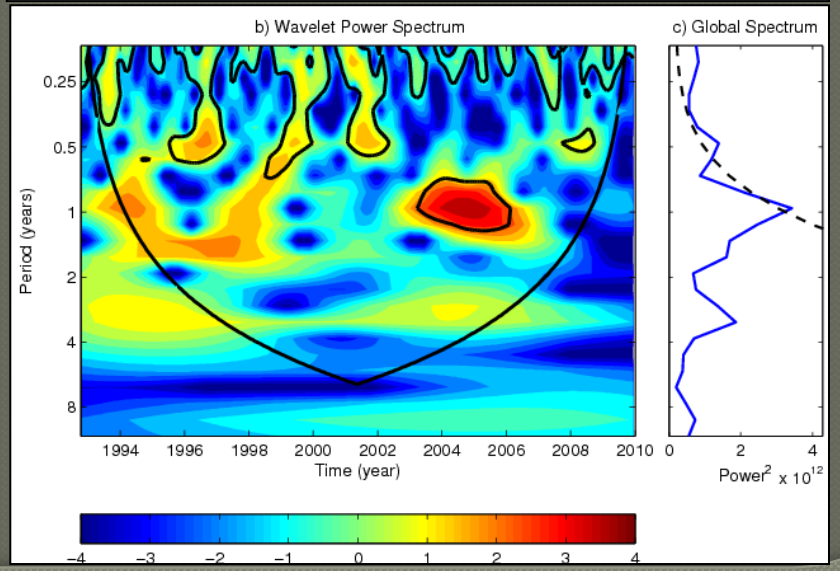

b) Wavelet Power Spectrum
c) Global Spectrum
Period (years)
Time (year)
Power^2 x 10^{13}

SEUC


Transport
SEUC (Sv)
Alt/2000–2010
XBT
Alt–1993–2000
Jan
Mar
May
Jul
Sep
Nov

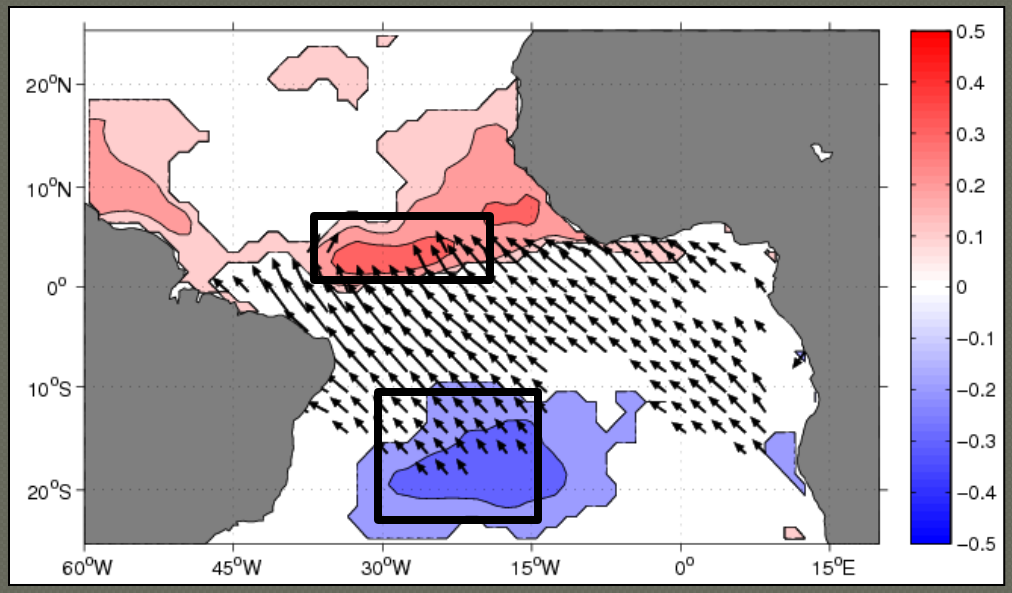

Max. speed
SEUC (cm/s)
Alt/2000–2010
Alt–1993–2000
XBT
Jan
Mar
May
Jul
Sep
Nov


SEUC transport (Sv)
Altimetry
Xbt
year

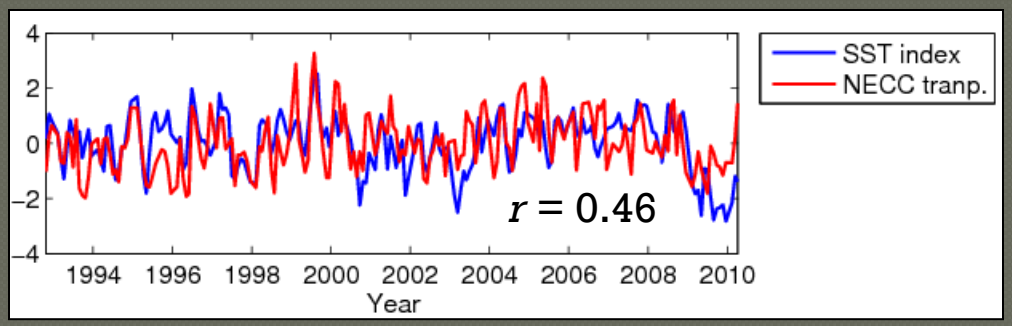

b) Wavelet Power Spectrum
c) Global Spectrum
Period (years)
Time (year)
Power² x 10¹²

NECC x wind stress

- NECC transport in **interannual** timescales linked to strengthening of the trade winds in the SA



Point-wise correlation between anomalies of gridded **wind stress** (arrows), **SST** (contours) with the **NECC transport**.

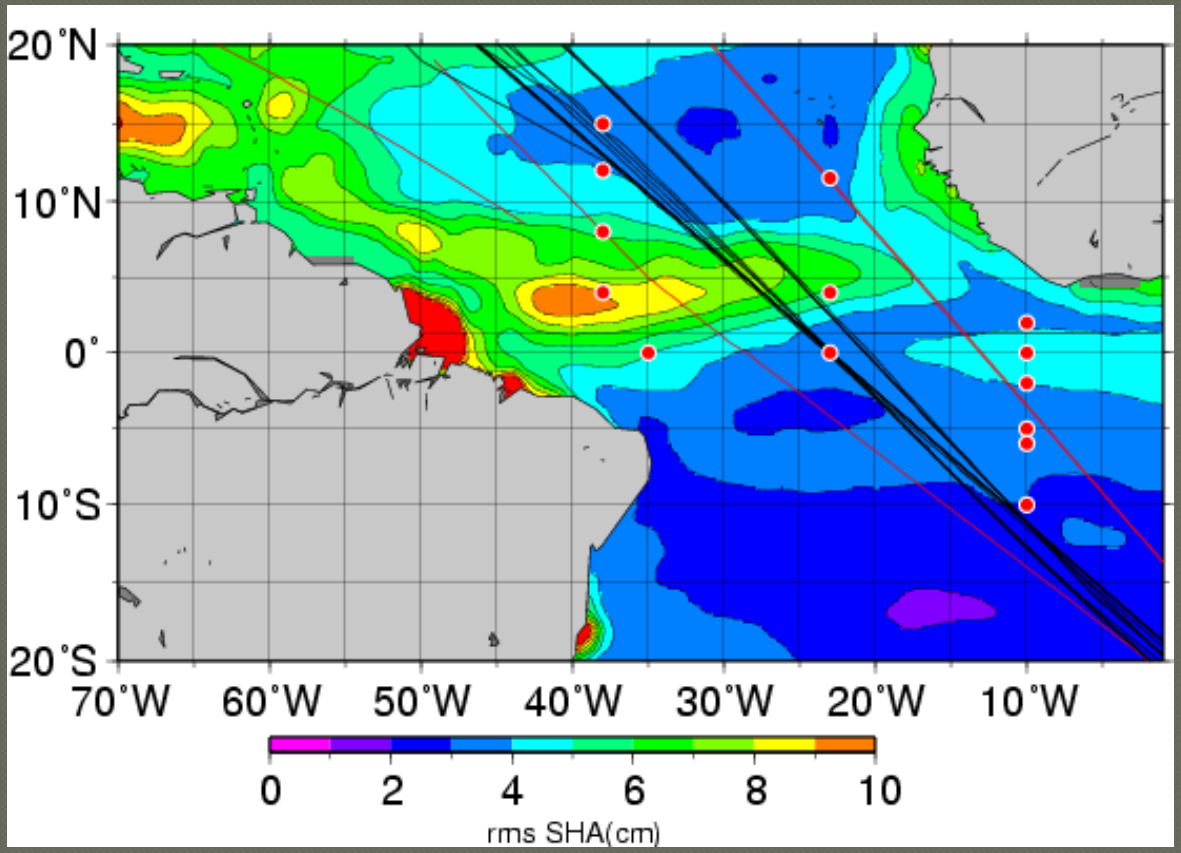


Time series of the standardized NECC transport and the SST index.

Conclusions

- XBT data at this sampling is able to represent well the seasonal cycle of the currents.
- XBT + altimetry can produce a good representation of the upper 200-300m.
- **NECC**: Strong annual cycle. No significant trend, but may present recent strengthening.
- **NEUC**: possibly shifting from semi-annual to annual variability. Potential for improvement.
- **SEUC**: The method so far represented well the mean flow but not its variability. This may be a shortfall of the methodology since the variability in the SSHA in the region is not strong enough.

RMS of SSHA and AX08 Line



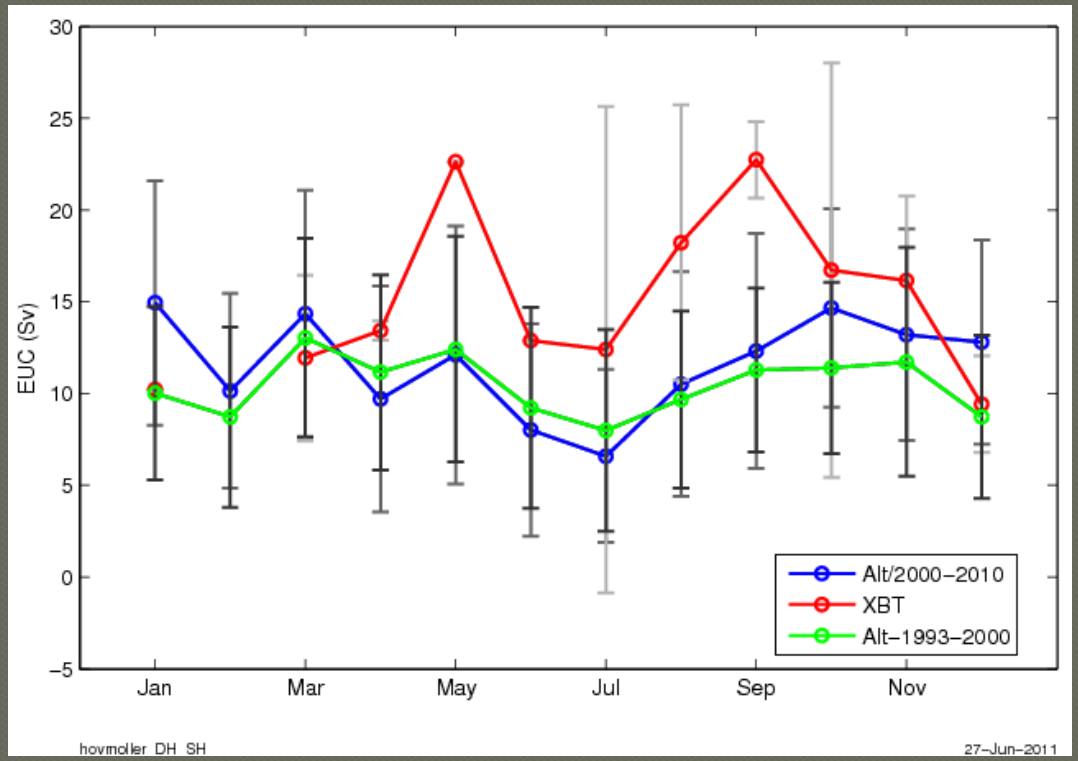
Future Work

- Calculate absolute velocities and transport instead of referenced to 800m.
- Add results for the EUC. So far EUC too strong and too shallow.
- Improve the statistical method, adding cross-latitudinal correlation and other observational constraints.
- Modeling.

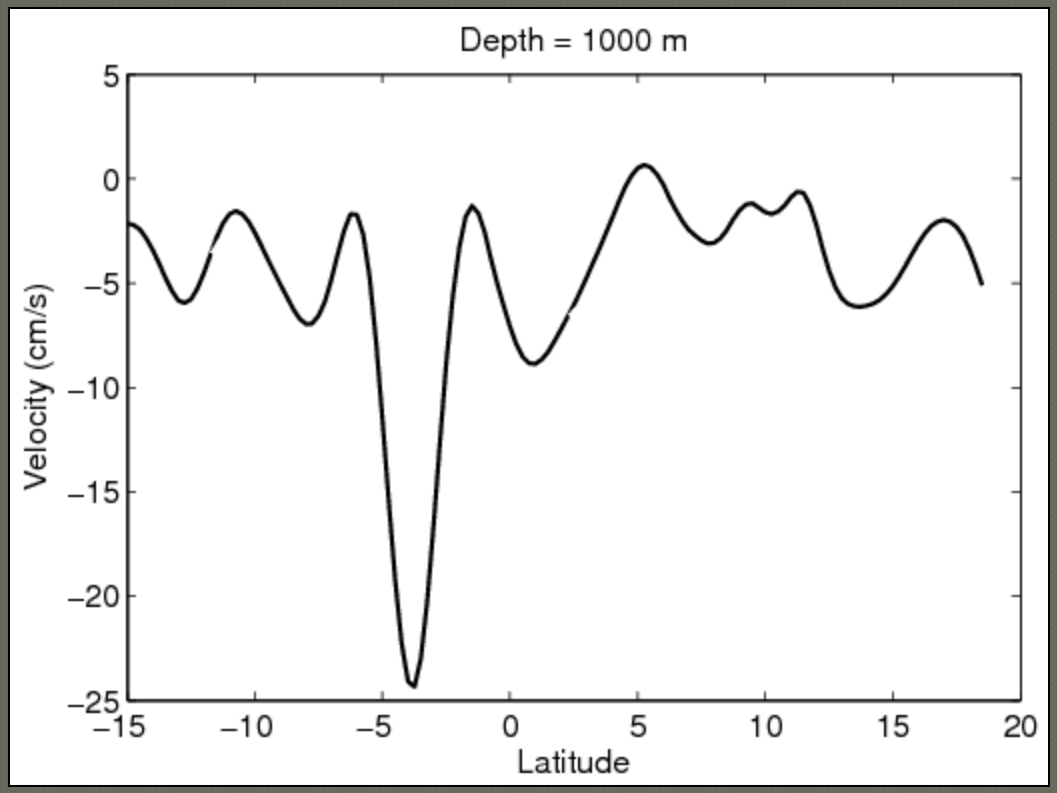
Thank you

EUC transport

- Transport for the upper layer ($\sigma\theta$ = 24.5)

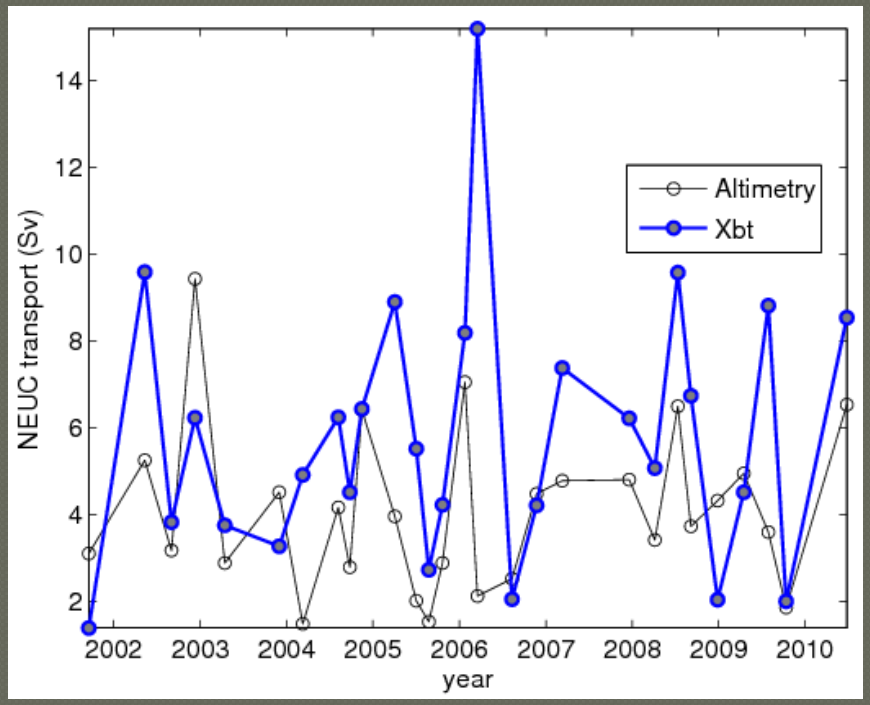


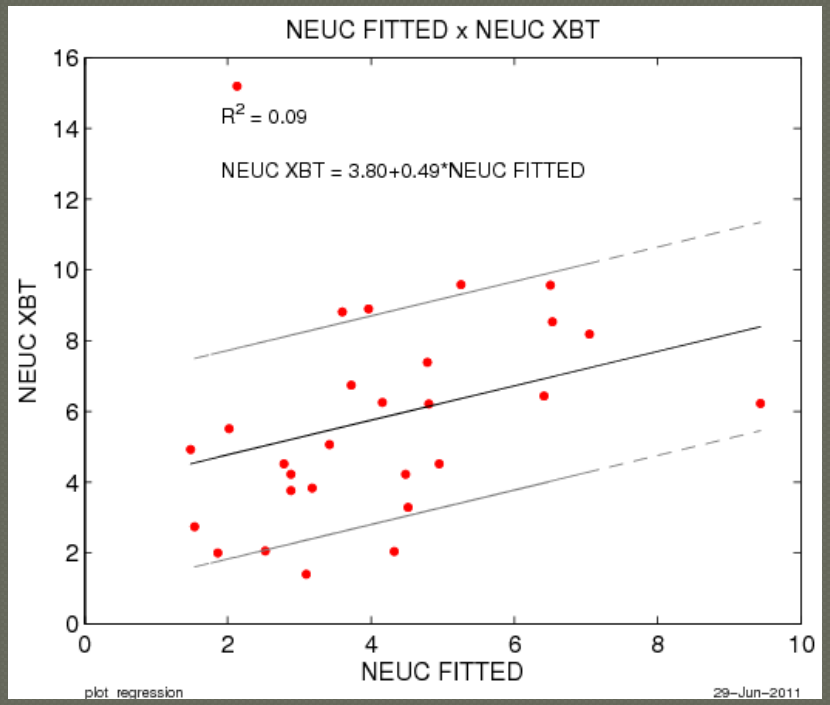
Reference to 800m



- Fig: Velocity across the mean XBT section at 1000m from Argo.

NEUC validation





SEUC validation