

“ On the variability of 43°N section water masses off Cape Finisterre”



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Introduction.-

- Intense monitoring observing program of the Finisterre section since 2003, in the framework of VACLAN/COVACLAN projects.

Main points:

- ➔ Analyze the presence of seasonality in every water mass and in the overall section.
- ➔ Analyze the interannual variability of the water masses.
- ➔ Try to find the causes of both kind of changes.

North Atlantic variability .-

• NORTH ATLANTIC WARMING TRENDS

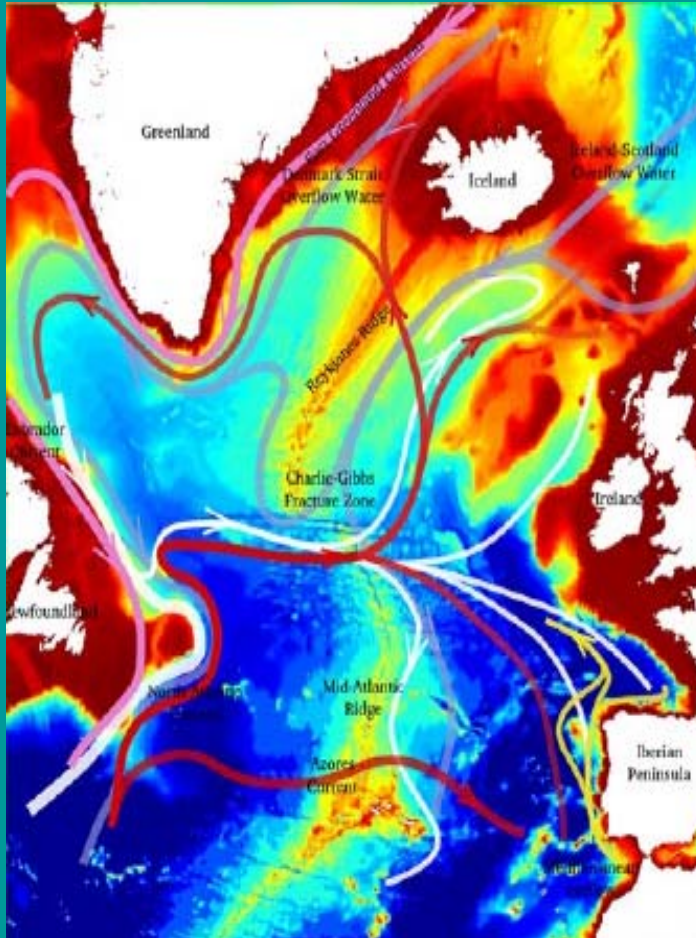
- $\uparrow 0.1^{\circ}\text{C}$, 800-2500 m layer, 25 year period 1957-1981. (Antonov,1993)
- $\uparrow 0.012^{\circ} \pm 0.009^{\circ}\text{C /decade.}$
- $\downarrow 0.0008$ psu/decade , upper-3000 m, last 55 yr of the 20th century (Polyakov et al., 2005)
- Since 1992, central waters: $\uparrow 0.02\text{-}0.03^{\circ}\text{C/year}$; permanent thermocline: $\uparrow 0.27^{\circ}\text{C/10 years}$ (González-Pola et al., 2005)
- Upper 300 m global-ocean: $\uparrow 0.006^{\circ}\text{C/year}$, 1948-1998 (Levitus et al.,2000)
- 1000-2000 m,32°S-36°N: $\uparrow 0.005^{\circ}\text{C /year}$, 1920s-1990s (Arbic & Owens, 2001)
- MW(1100dbar), 24°N: $\uparrow 0.009^{\circ}\text{C/year}$ (Bryden et al., 1996); $\uparrow 0.01^{\circ}\text{C/year}$, 1955-1993, Gibraltar Strait (Potter & Lozier,2004)

• Seasonal variability at the eastern boundary

1. Seasonal Iberian slope-circulation changes , due to IPC and upwelling regimes (Ambar, 1984;1985. Haynes and Barton,1990; Torres and Barton, 2006)

2. Seasonal variability at the eastern boundary due to changes in wind stress. RAPID/MOCHA array at 26.5°N (Chichidimo et al., 2010; Kanzow et al., in press, 2010)

VACLAN/COVACLAN projects

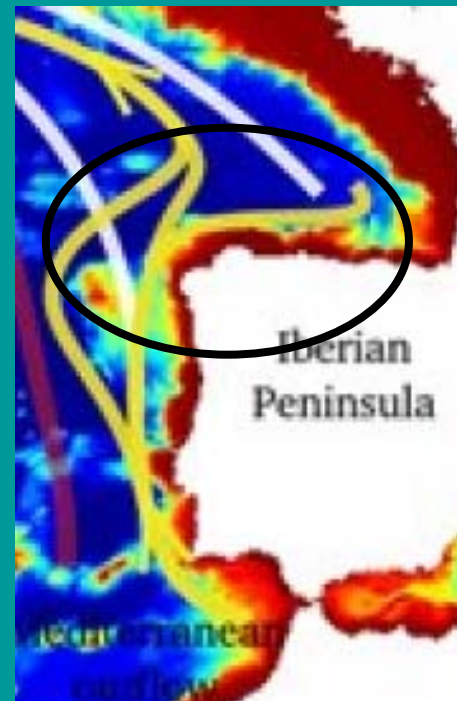
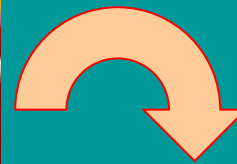


North Atlantic Ocean

“Coordination and Observation of Northeast Atlantic Climate Variability”

<http://www.vaclan-ieo.es>

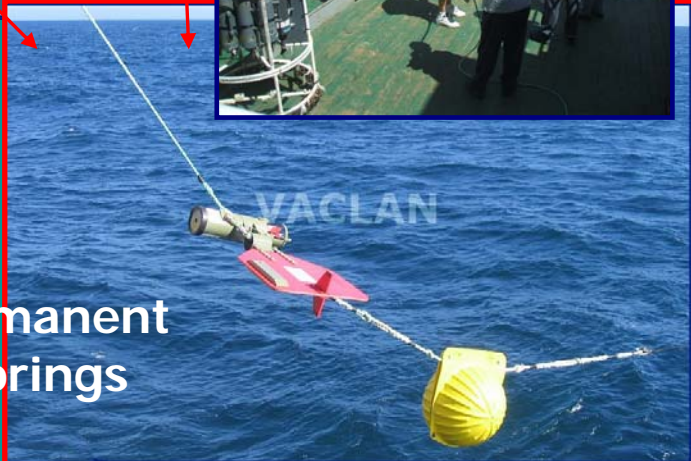
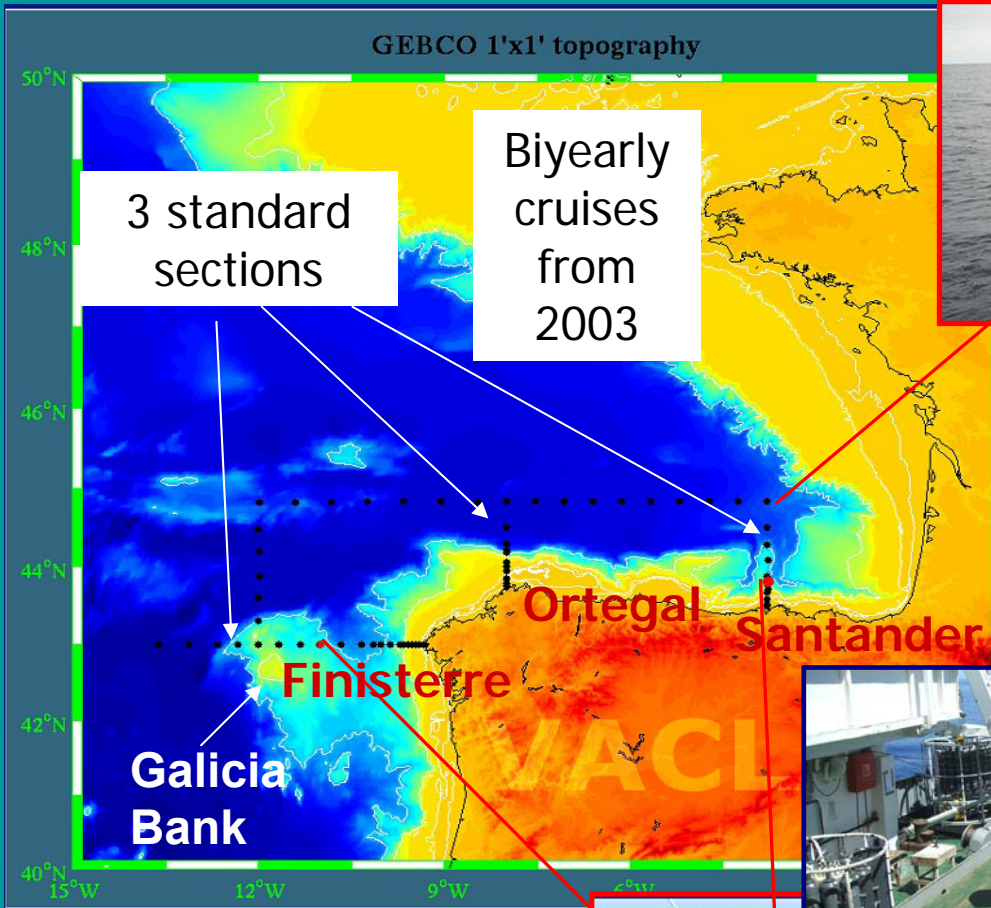
<http://www.ieo.es>



Region: Bay of Biscay

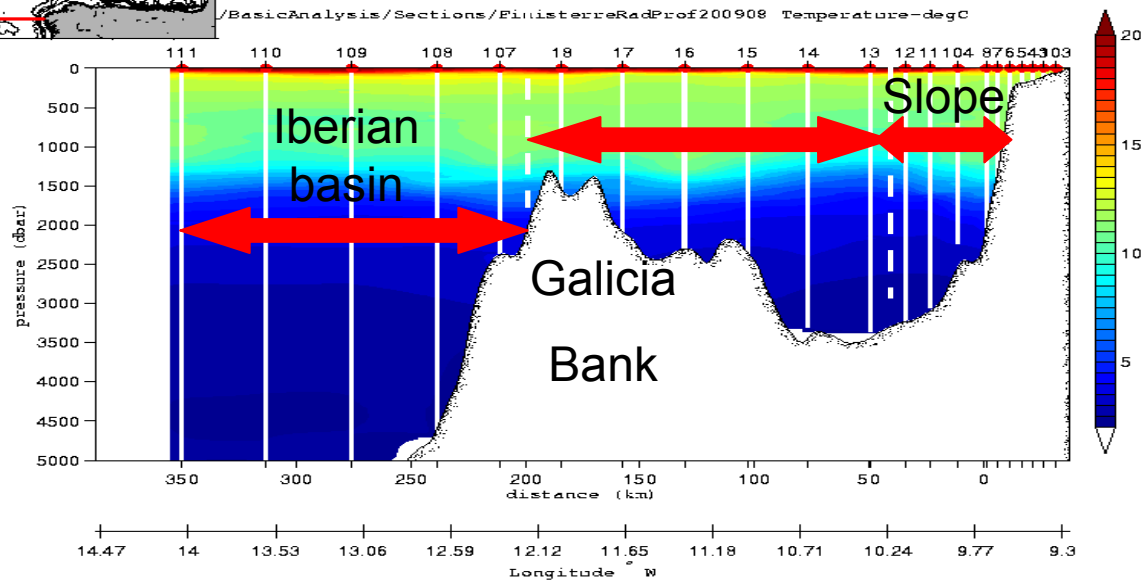
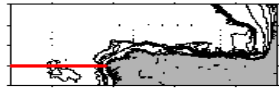
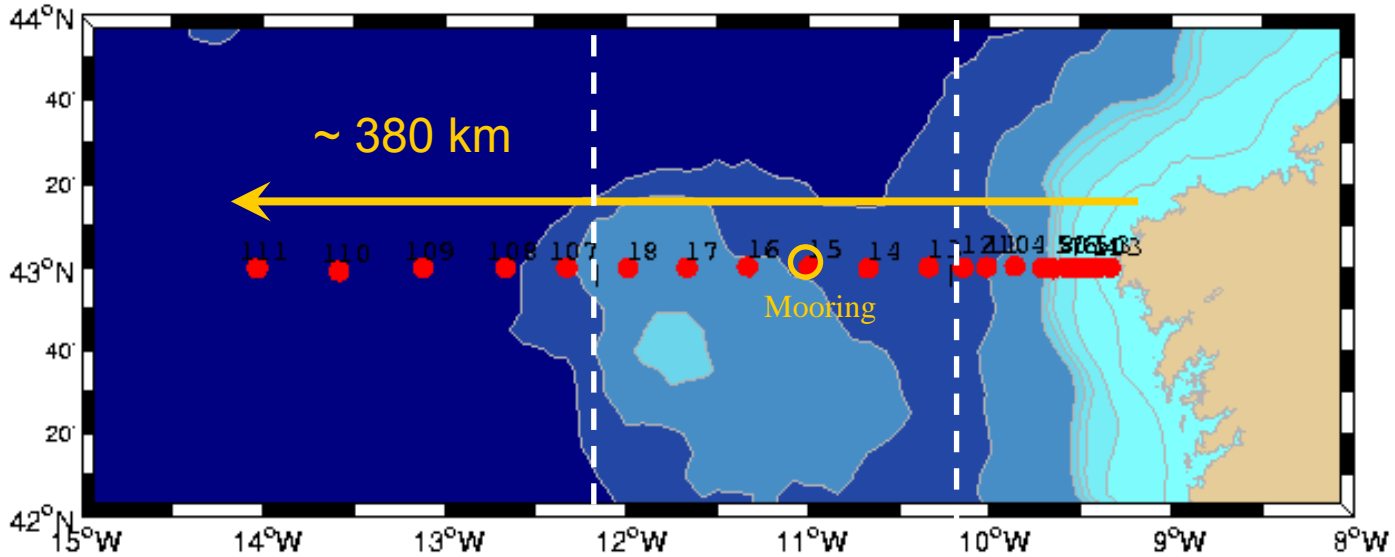
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North West Iberian margin



Finisterre Section.-

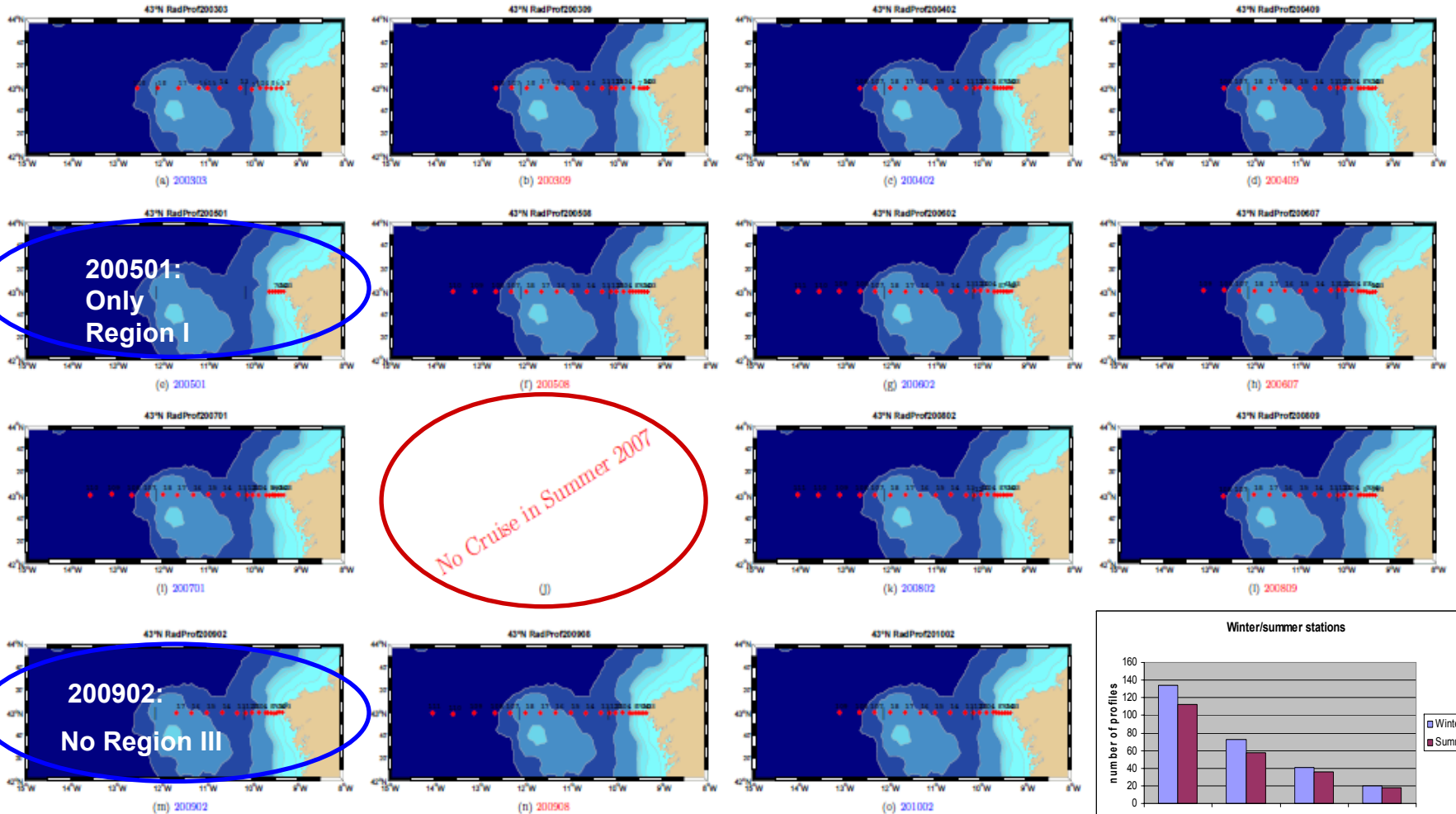
43°N Prefixed Stations



Data Set: 14 RadProf cruises

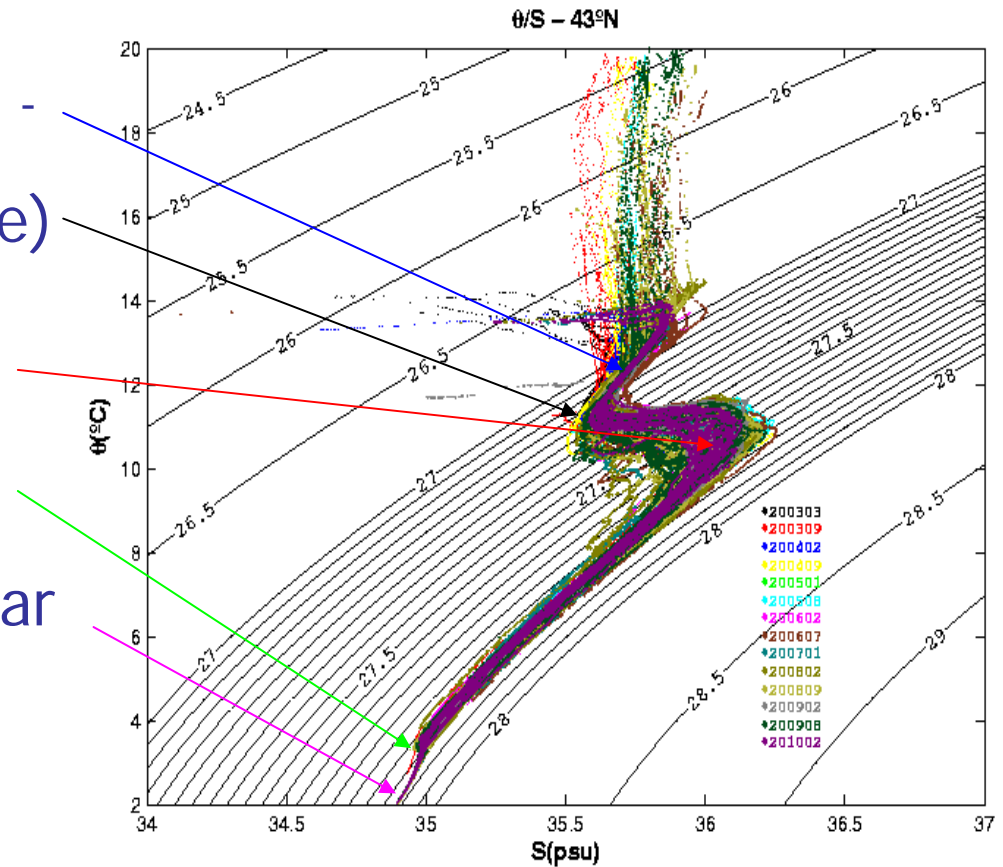
CTD database

8 winter + 6 summer



Water masses Θ/S diagram

- ENACW : ~ 350 dbar (27.1 - 27.2)
- Salt Min (thermocline base) : ~ 500 dbar
- MW : ~ 1100 dbar (27.6 - 27.7)
- LSW : ~ 1850 dbar (27.8-27.9)
- ENADW : ~ 2000-4000 dbar
- LDW : : > 4000 dbar



HydroIEO S summer and winter sections

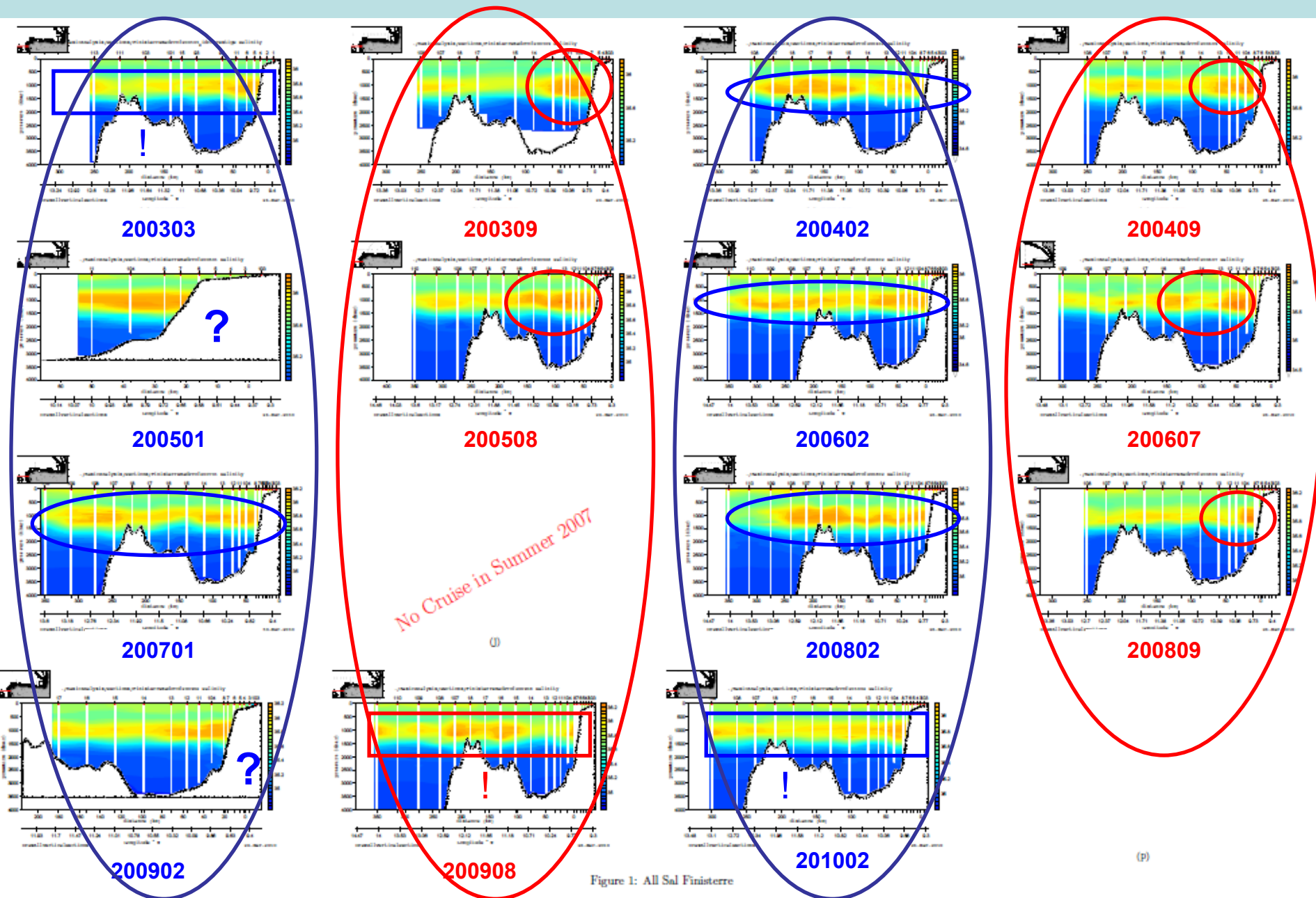
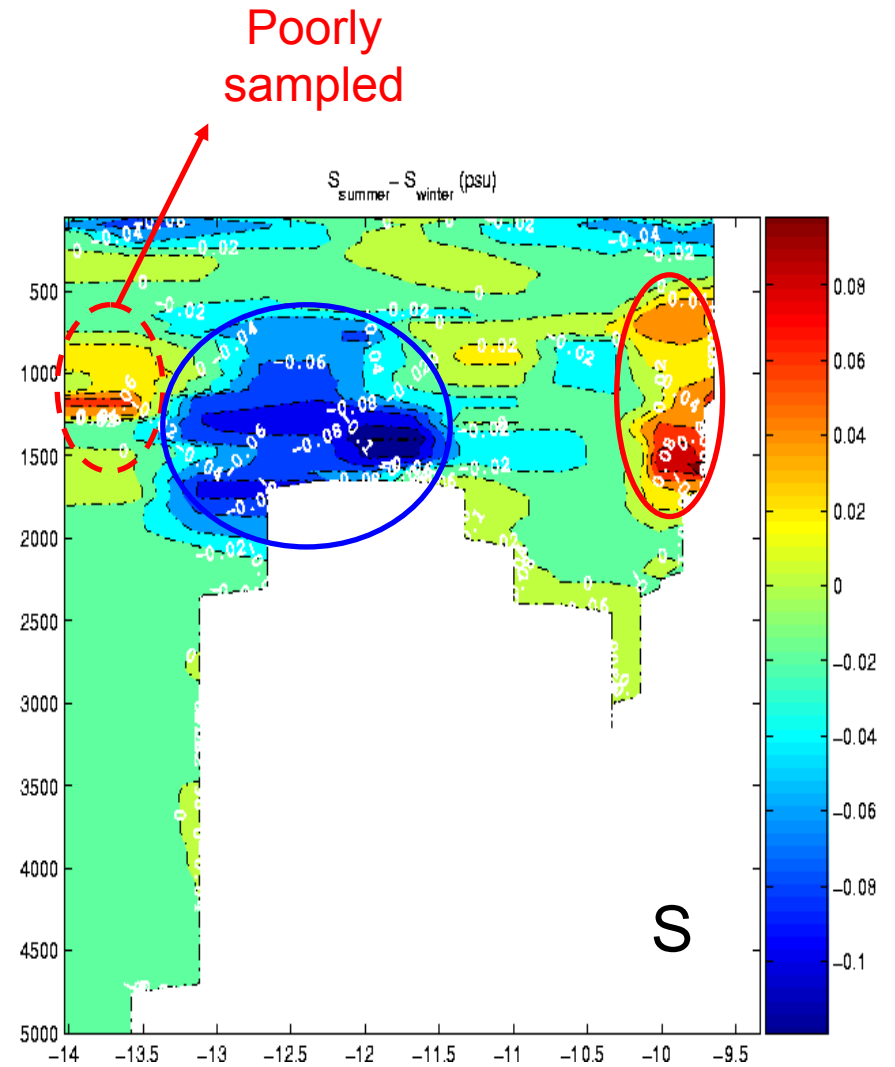
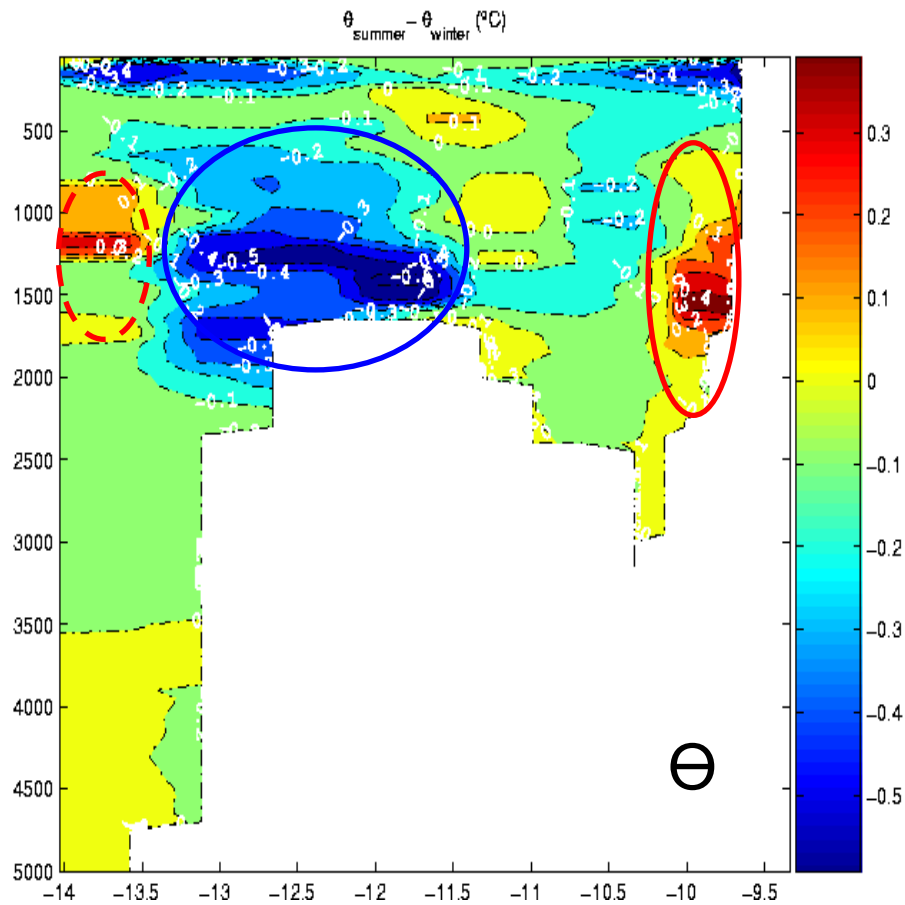


Figure 1: All Sal Finisterre

Summer - Winter mean fields



Methodology

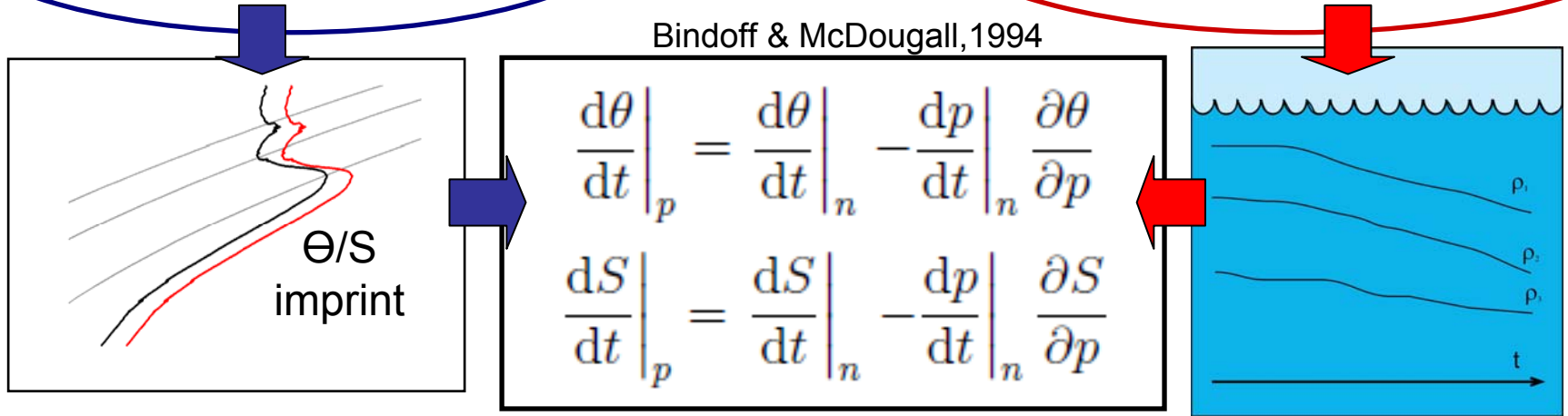
Isopycnal

Isobaric changes =

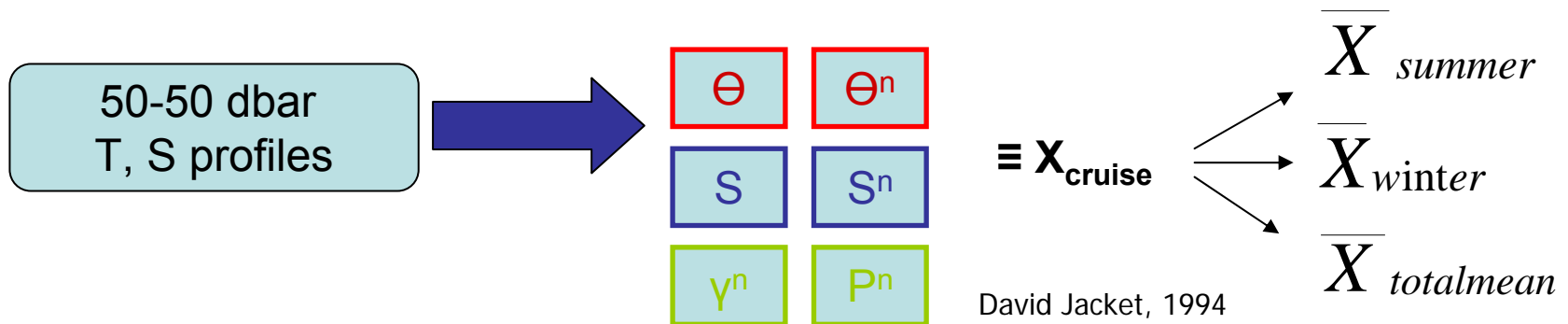
Heave

Properties changes related with heat and freshwater fluxes in the formation region

Isopycnal depth changes related with changes in the circulation or in the renewal rates



14 cruises => Consider changes respect to a mean, instead between two cruises



Methodology

Water column
seasonality



$$\overline{X}_{winter/summer_mean} - \overline{X}_{totalmean}$$

Interannual changes
(seasonality removed)

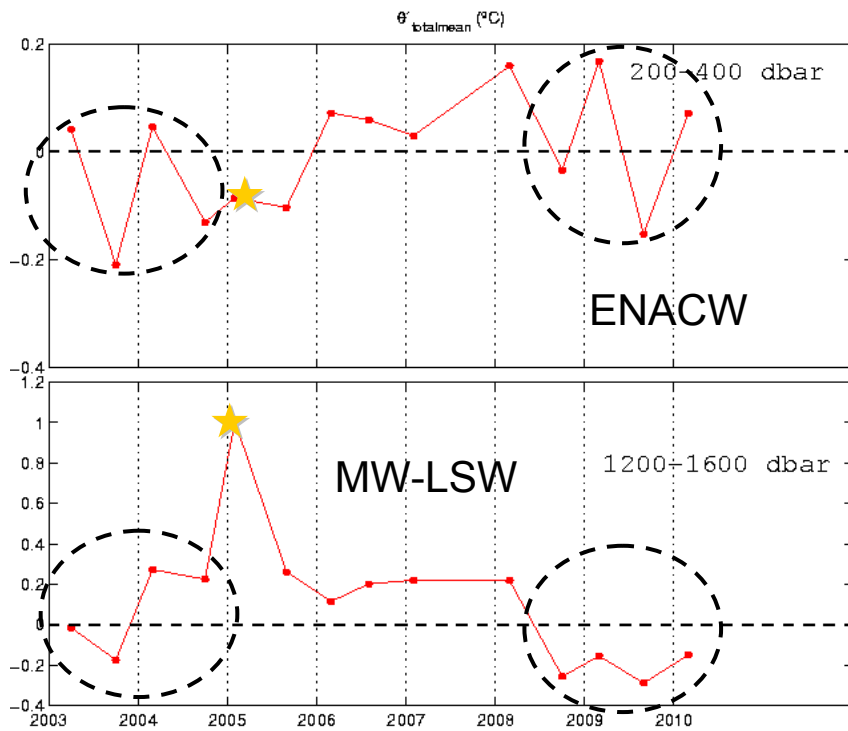


$$X_{cruise} - \overline{X}_{winter/summer_mean}$$

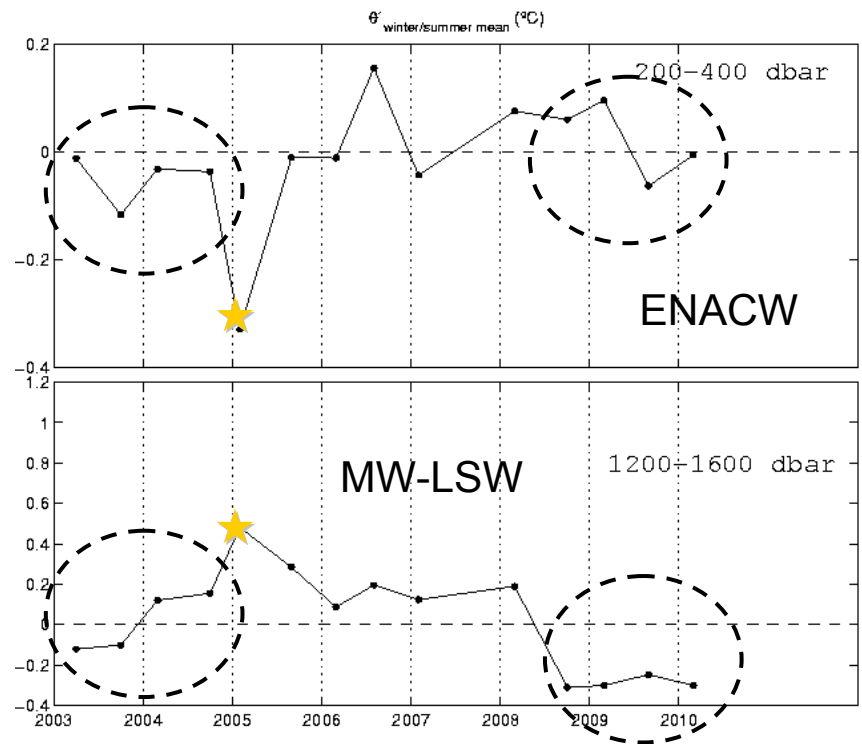


Zonal and vertical averages on
50-200, 200-400, 400:400:4800 dbar

Results

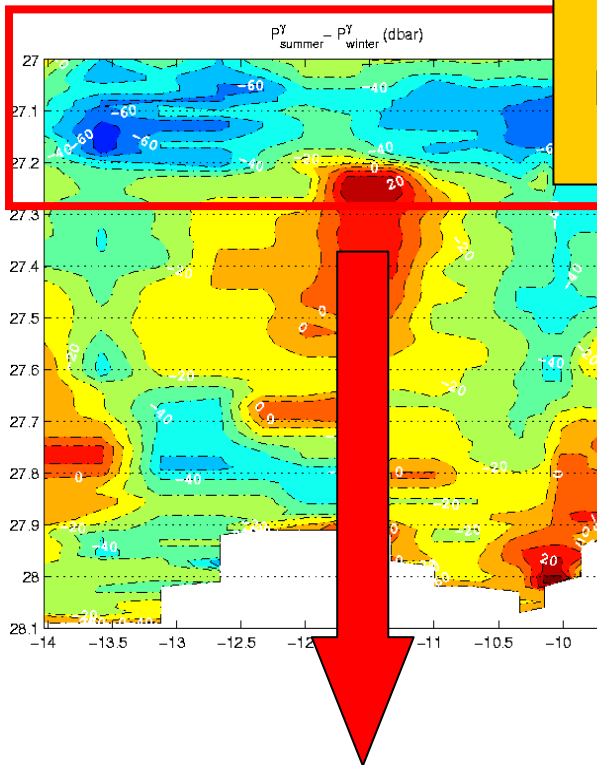


De-seasonalized



Results: Annual cycle at depth

Isopycnal depth seasonal change



Greater values at surface, central and intermediate waters.

Results buffered when consider the whole section

Amplitude of the mid-ocean annual cycle at 43°N :

~ 0.13 °C

~ 0.03 psu

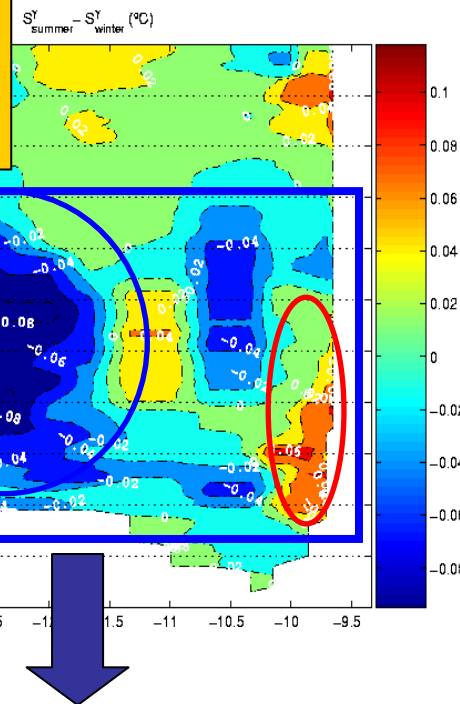
* Up to ~0.5°C and ~0.08 psu

at lower MOW levels

over Galicia Bank (Reg III)

• Same pattern as isobaric change at intermediate depths

change. True change in water mass properties.



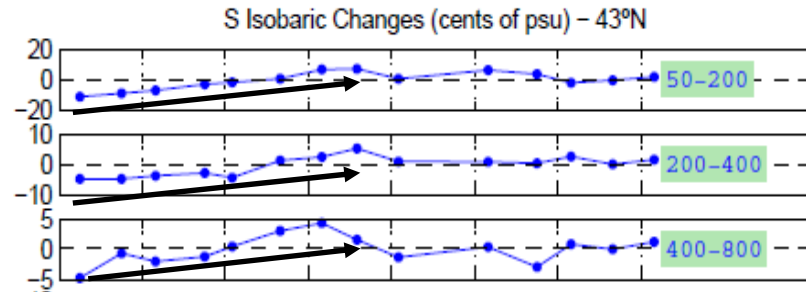
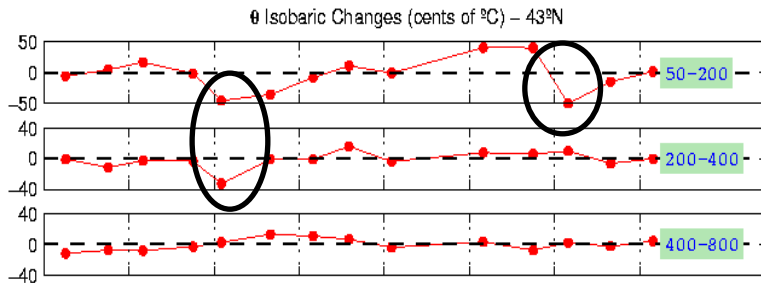
• Heave (~50 dbar => 0.15°C 0.03 psu)

• Modal water yearly r (Rios et al, 1992)

Same order of decadal rates at MOW levels in 1950-2000 (Potter and Lozier, 2004)

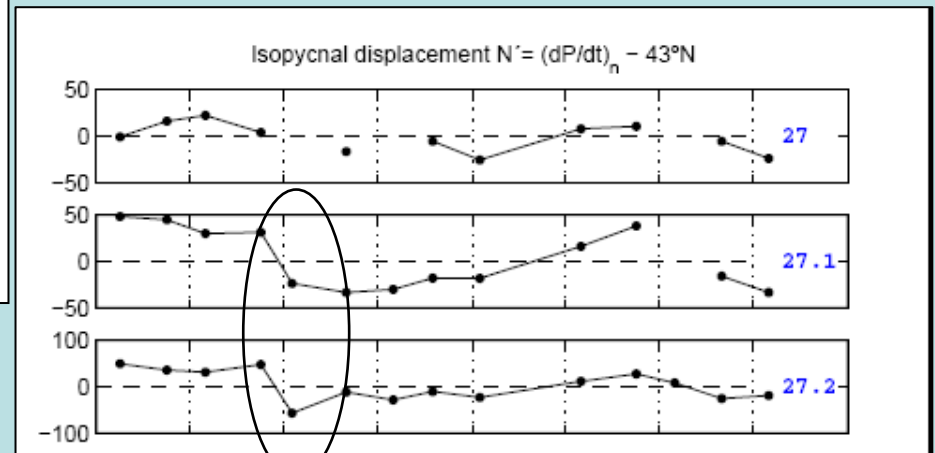
Change in circulation regime?

Results: Interannual variability



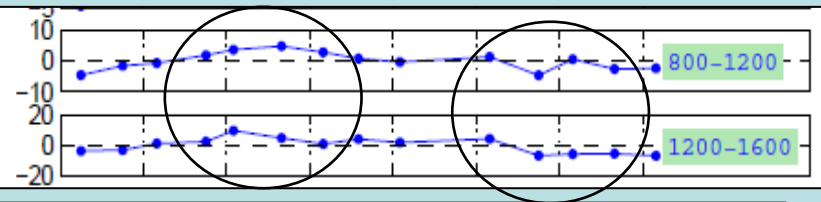
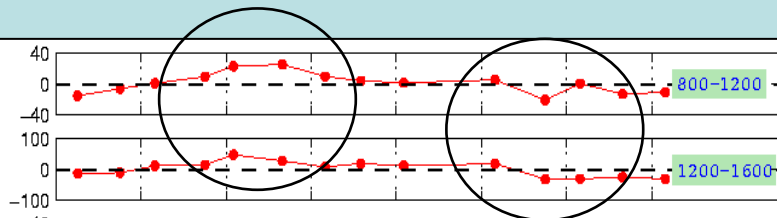
Central Waters:

Sustained salinification until mid-2006.
 Effect of crude winters (isopycnal 27)
 Shift in the isopycnal levels in 2005.



Coherence in patterns in time and in the whole water column (autocorrelation).
 Marked shifts.

Results: Interannual variability

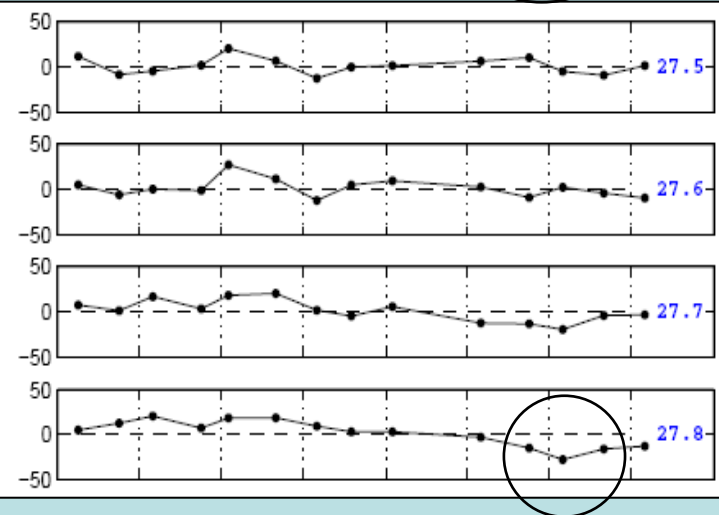


Mediterranean Waters:

Shift in 2005-06 (Cooling-freshening
Isop:Heave \approx 1:1)

Drop about autumn 2008 by isopycnal
change (isop:heave \approx 8:1).

Later heave in the lower bound (c.a.
1300 dbar, 27.8) (peaking in 200902)

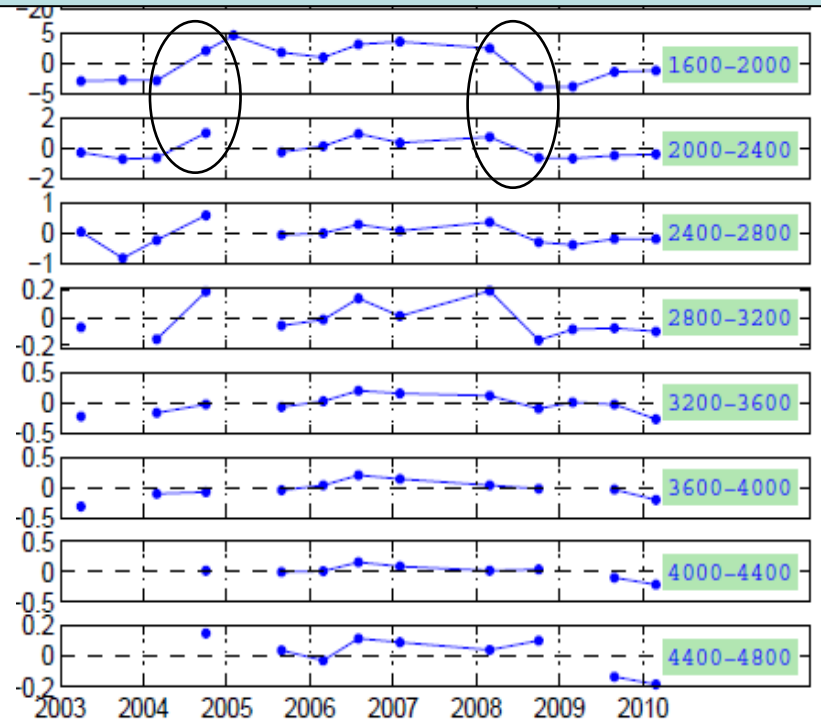
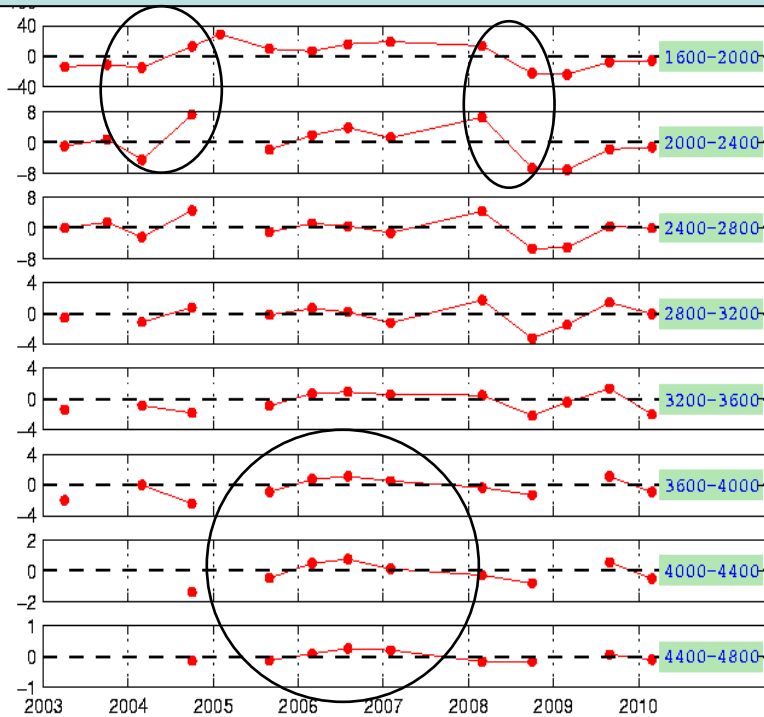
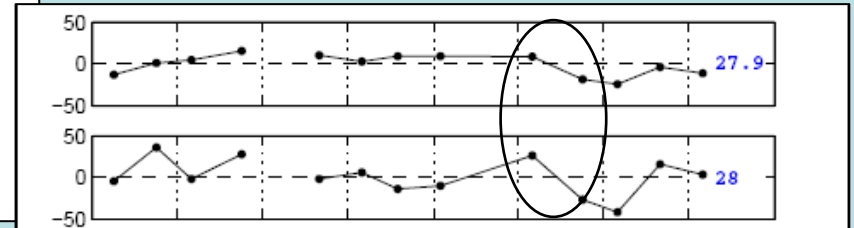


Results: Interannual variability

LSW and ENADW:

Shifts in autumn 2004 (isop:heave \approx 1:1) and autumn 2008 (heave).

ENADW-LDW : warm cycle peaked in mid-2006



Conclusions

- Seasonal signal at 43°N off Cape Finisterre exists not only at sea surface but also at depth, being important down to intermediate waters, with amplitudes up to $\sim 0.2^{\circ}\text{C}$ and ~ 0.04 psu at MOW levels in the whole section. There exist a quite consistent zonal dipole pattern with MOW tight against the slope in summer and more sparse and concentrated at Galicia Bank region in winter.
- At seasonal time-scales, isobaric changes associated with the displacement of isopycnals dominates surface and thermocline waters, whereas changes on the intermediate waters properties are mainly explained by isopycnal change. Both contributions appear at deeper levels.
- Interannual variability: series of properties for different water masses present progressive changes interrupted by marked shifts either of isopycnal or heave origin. Possibility of tracking the causes of these changes : correlation with atmospheric patterns and LADCP measurements (Ongoing work) .