National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

Argo

Interannual Variability of Intermediate and Thermocline Waters in the South Atlantic informed by Argo Floats

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Overview

1. Context of Changes seen in the South Atlantic
   - Long Term Trends
   - Shorter Variability

1. Long term record in Hydrographic Data
   - Comparison of Zonal Sections

1. Short term variability in Argo Data
   - Optimal Interpolation of Argo Data
   - Short-term variability revealed

1. Conclusions and Discussion

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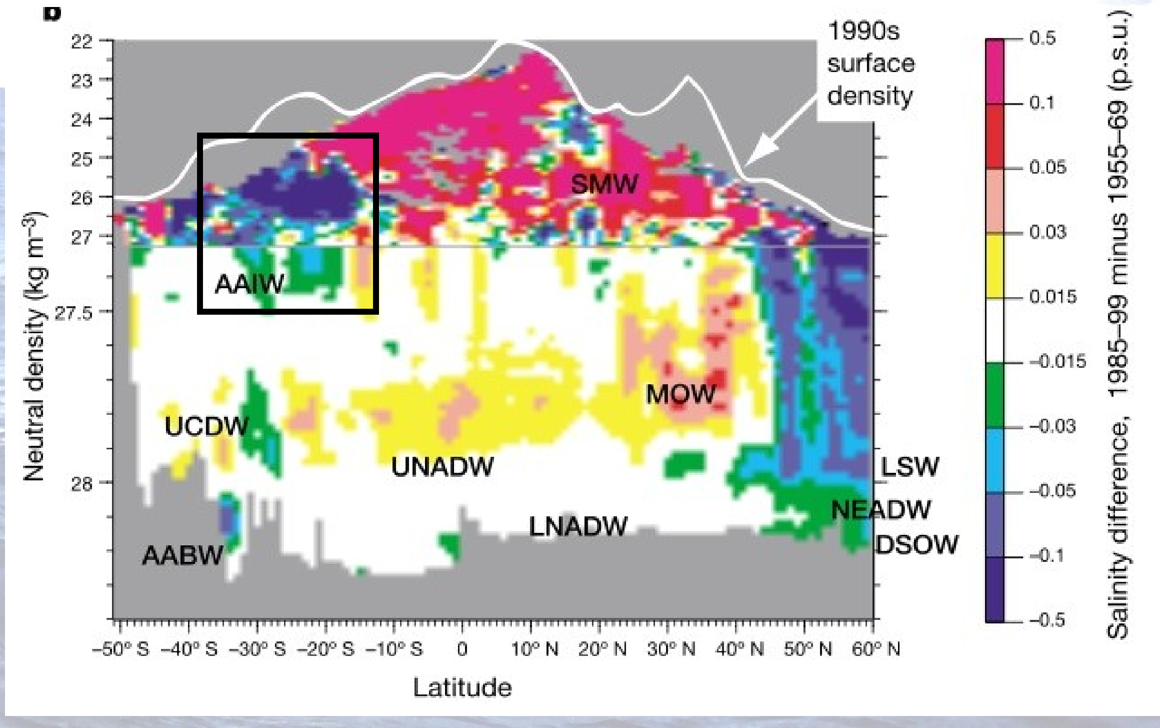
Long Term Trends in the South Atlantic

- Methods of investigation:
  - Comparison of repeat Hydrographic Sections (Arbic and Owens [2001])
  - Averaging of different time blocks (Curry [2003], Helm [2008])

- In subtropical SA, intermediate and thermocline waters are freshening



Shorter Timescale Variability

- Recent Modelling work highlights how event timescales in the Agulhas region impact decadal MOC variability (Biastoch et al. [2008], Marsh [2007], Weijer [2002])
- How do longer timescale variations tie in with these shorter timescale events?

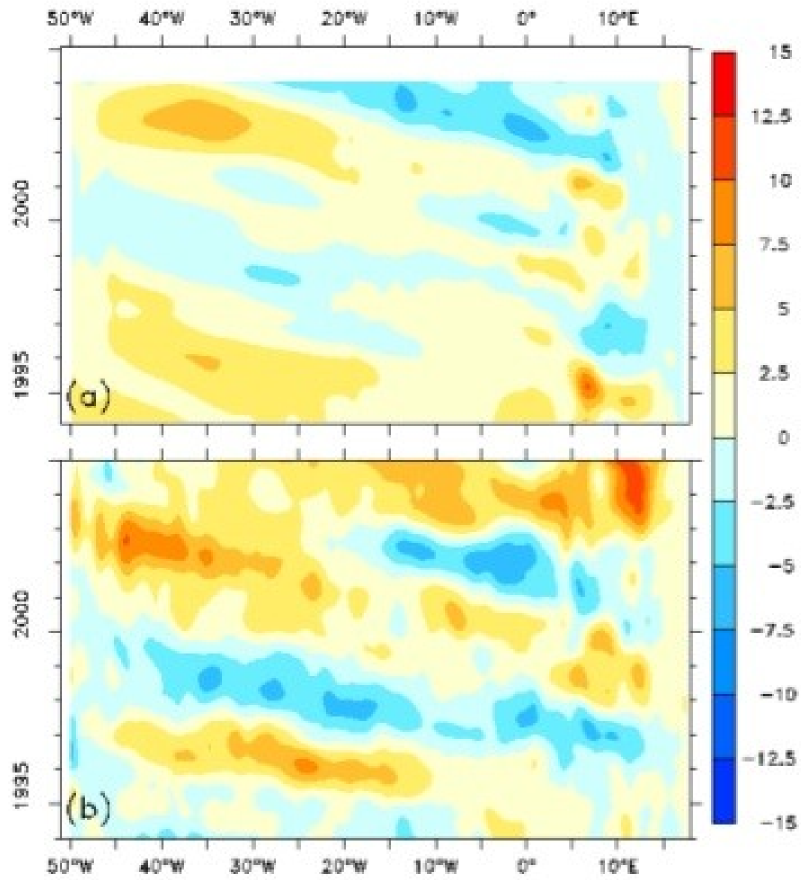


Fig. S6 Decadal variability of the sea surface height at 30°S.

Hovmoeller diagram of the (23-months) low-pass filtered SSH anomalies (in cm) at 30°S in **a** the global model including a high-resolution Agulhas nest and **b** Aviso satellite data (relative SSH).

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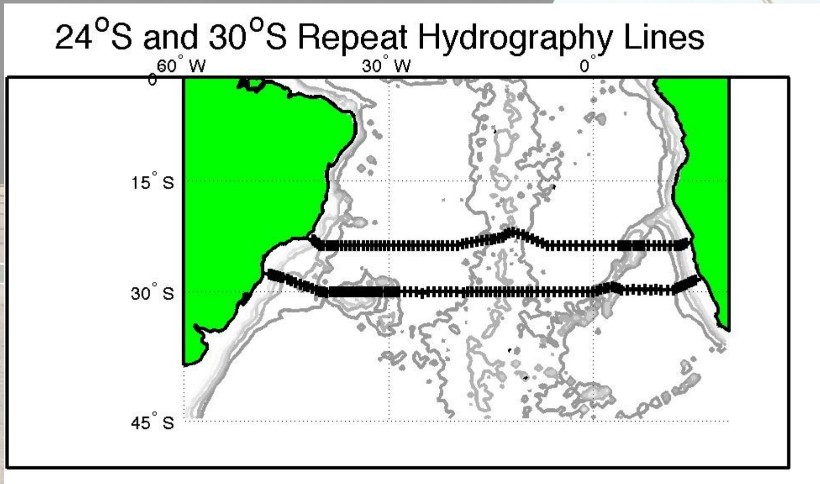
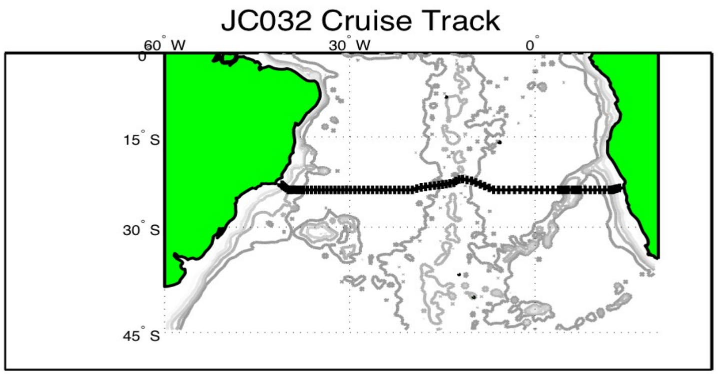
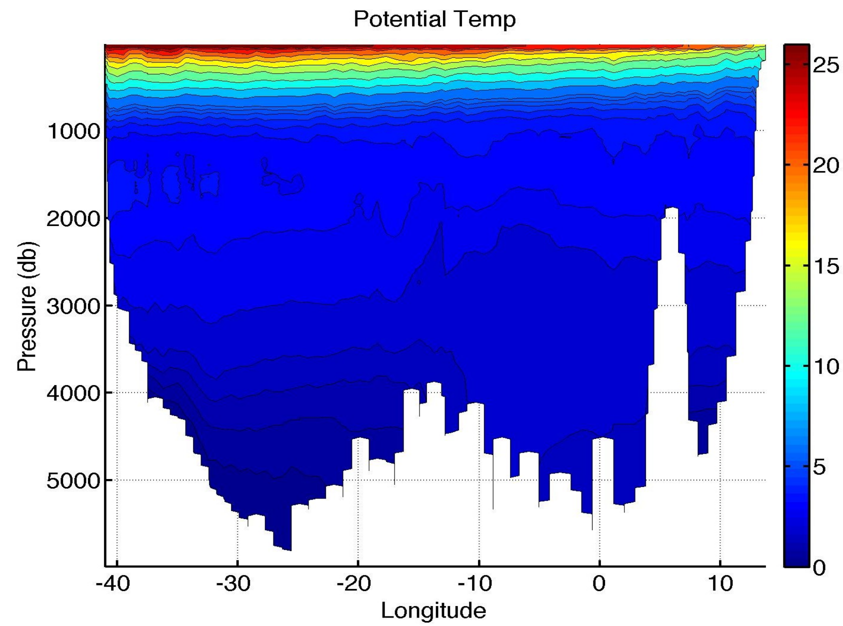
Hydrography of the South Atlantic

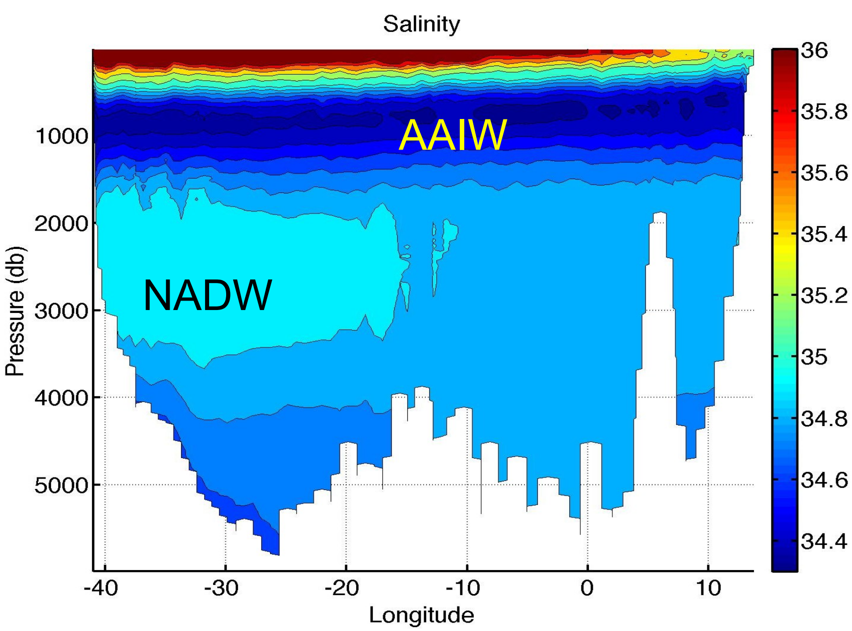
- At 24ºS
  - 2009: JC032
  - 1983: OC133
  - 1958: IGY Section
- At 30ºS
  - 2003 & 1993
- WOCE, SAVE, GEOSECS, IGY, Meteor and other programs

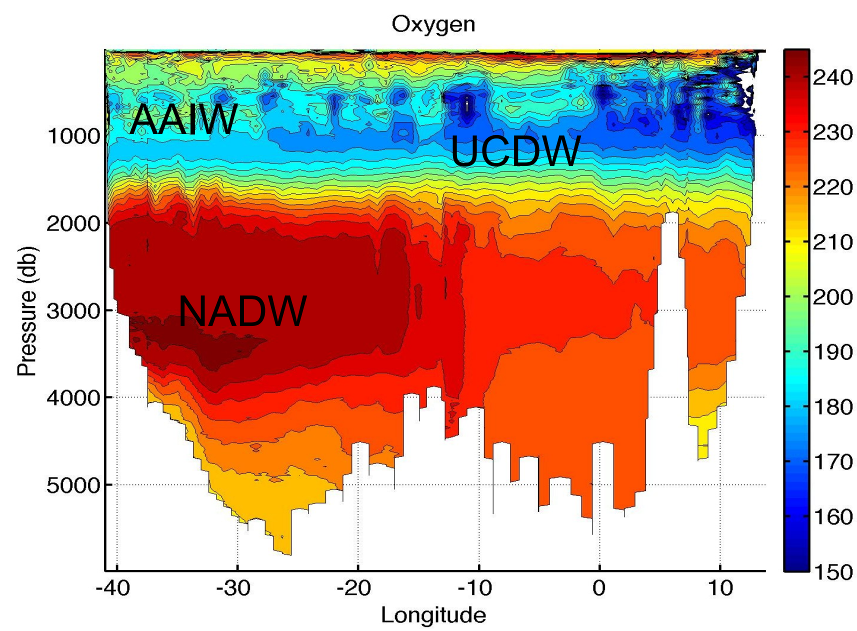


Hydrography of the South Atlantic

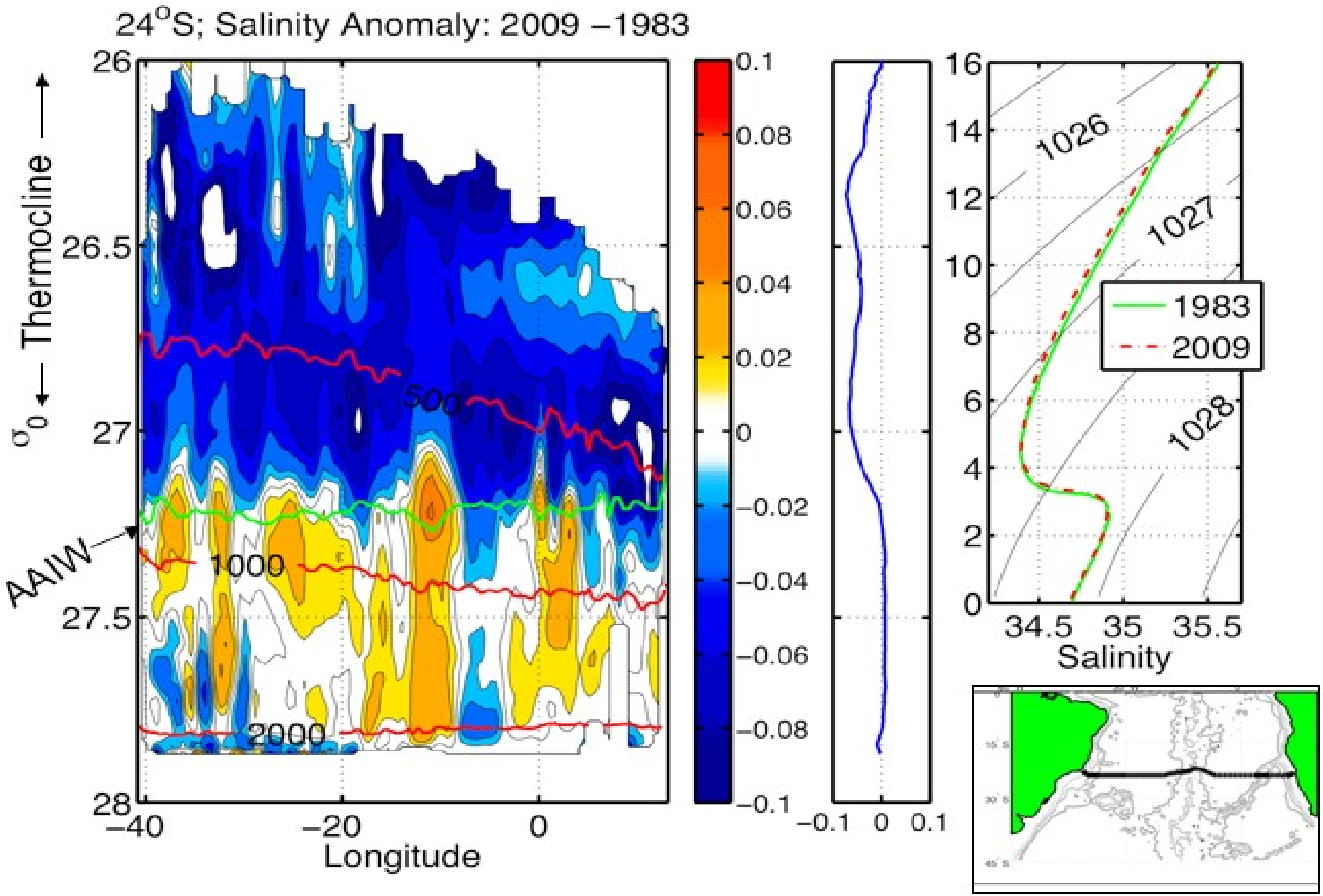




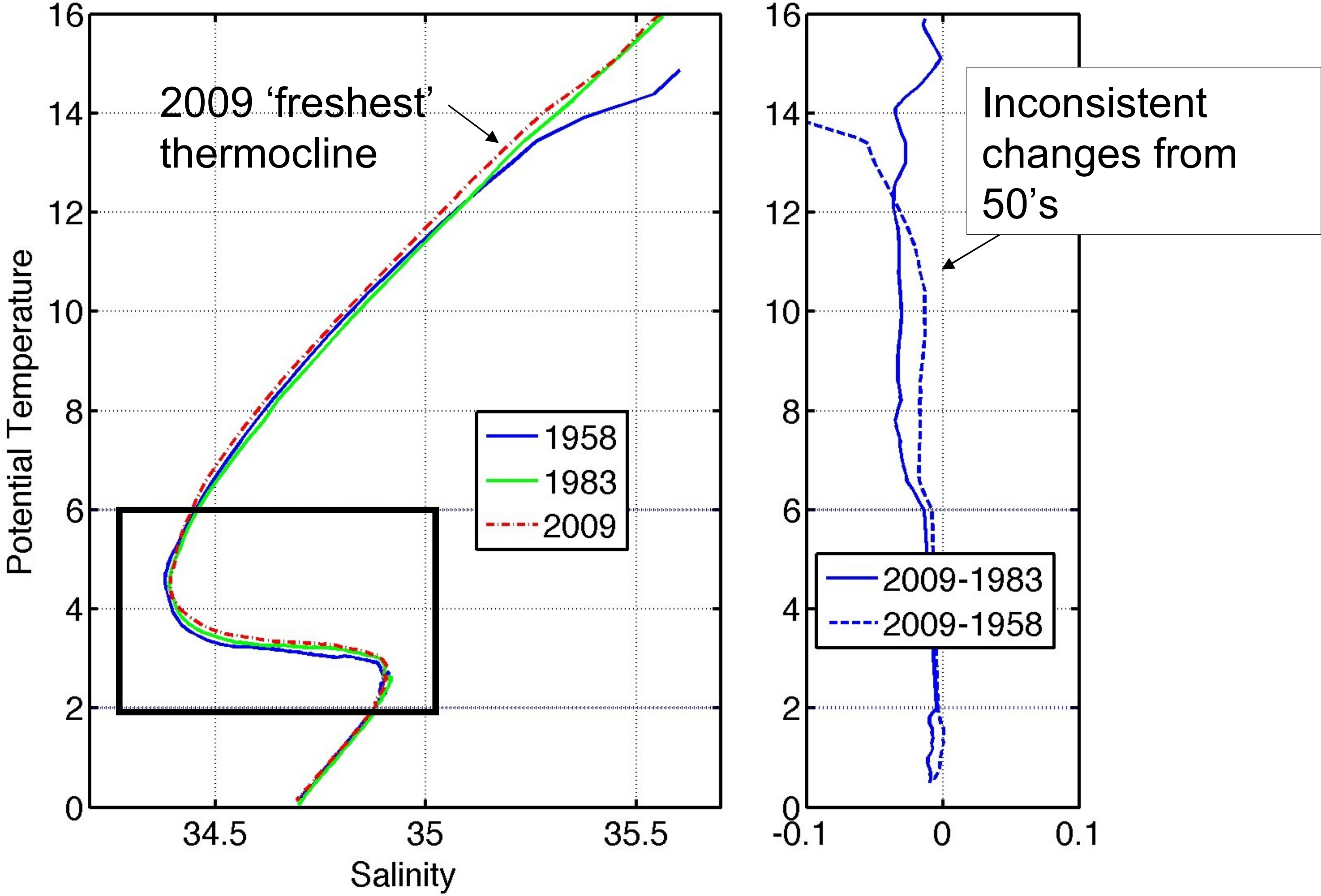




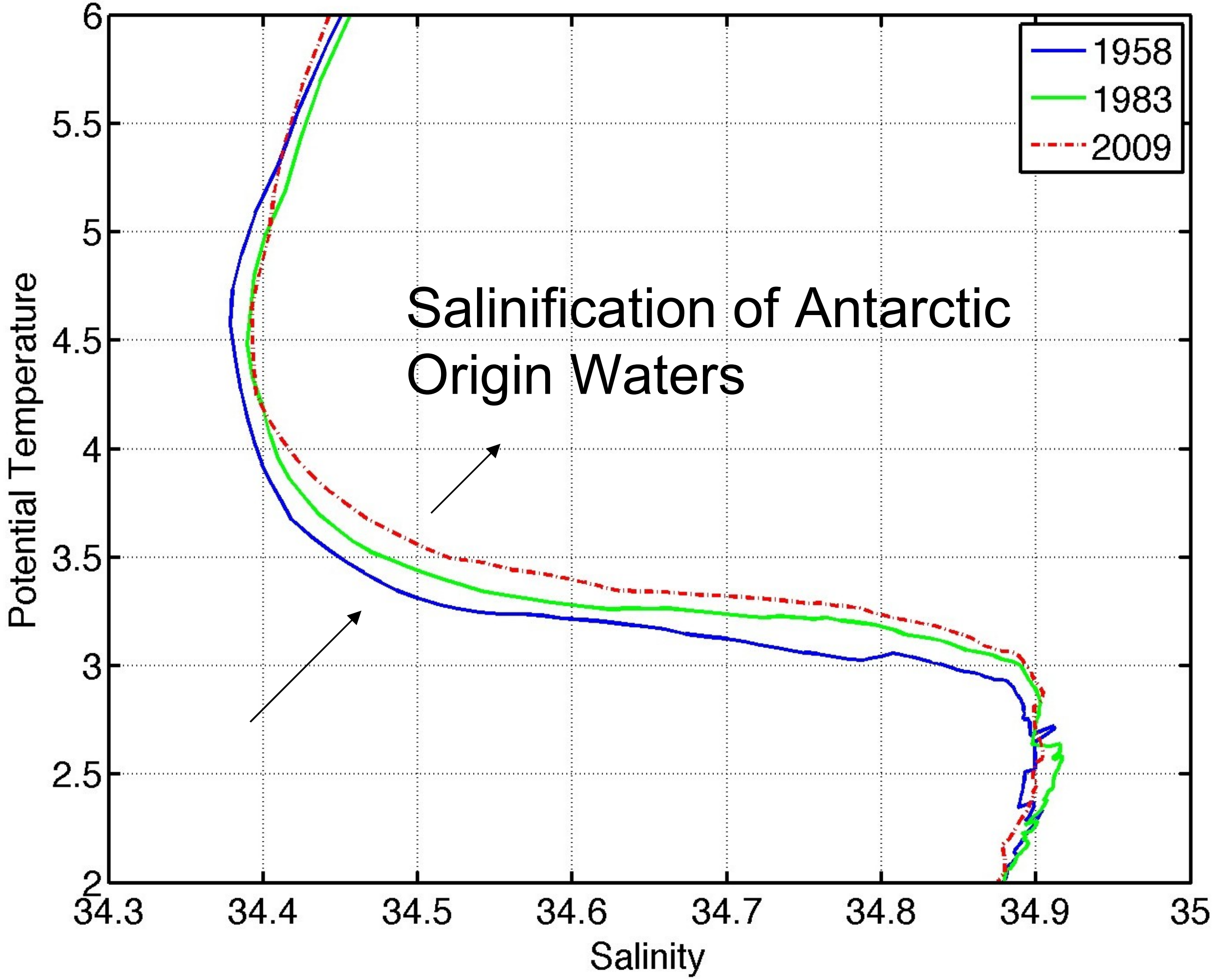
Changes at 24ºS: 2009 - 1983



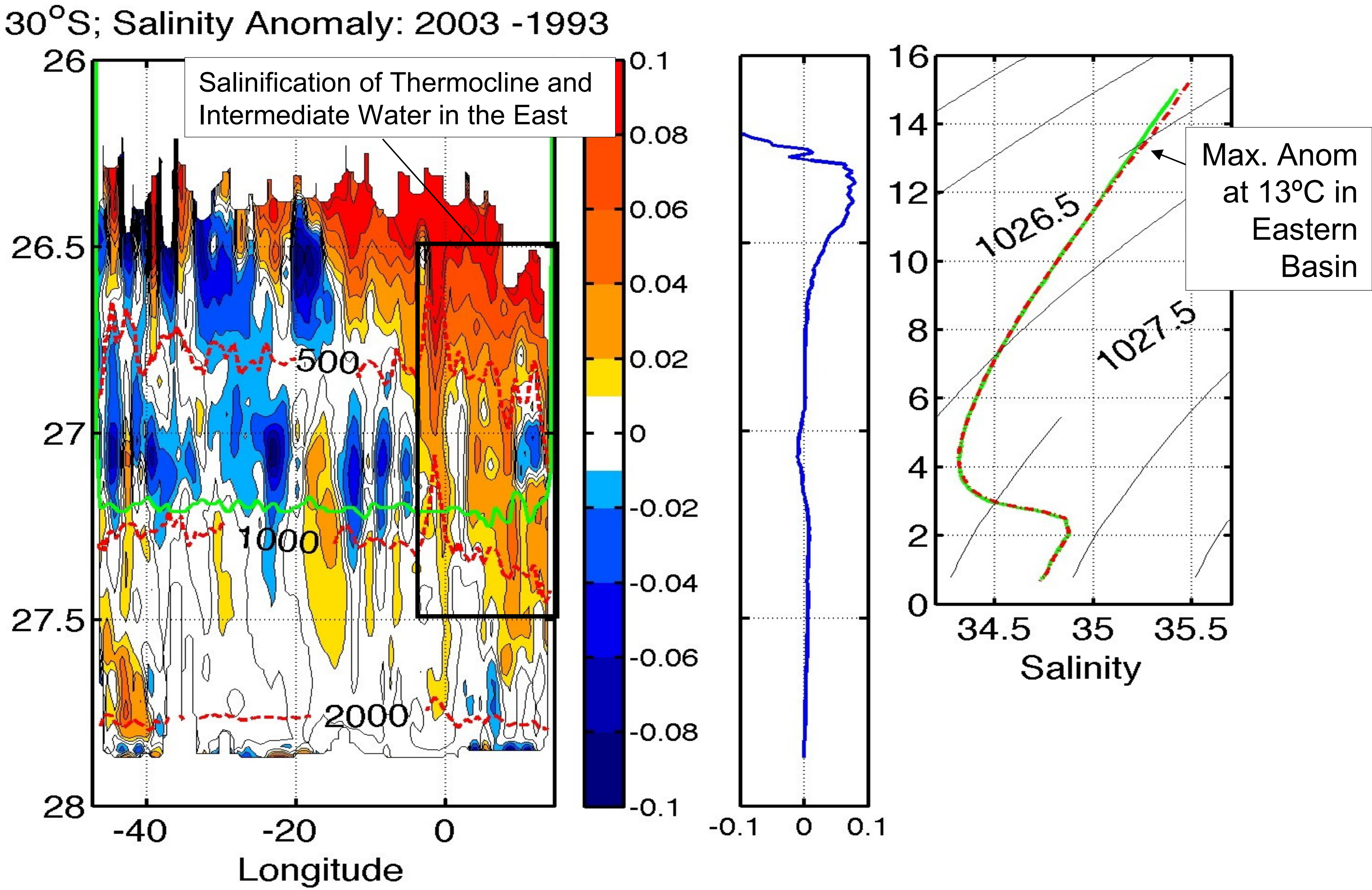
Changes at 24ºS: 2009 - 1958



Changes at 24ºS: 2009 - 1958



Changes at 30ºS: 2003 - 1993



Summary of Changes

- At 24ºS:
  - 2009 Thermocline is freshest and the change is coherent across the basin
  - Salinification of Antarctic Origin Waters 2009 -1983 -1958
- At 30ºS:
  - Salinification of Thermocline and Intermediate Water in Eastern Basin 2003 - 1993
- Can better temporal resolution provided by Argo identify shorter term signals thus aiding our identification of longer term, climatic signals?

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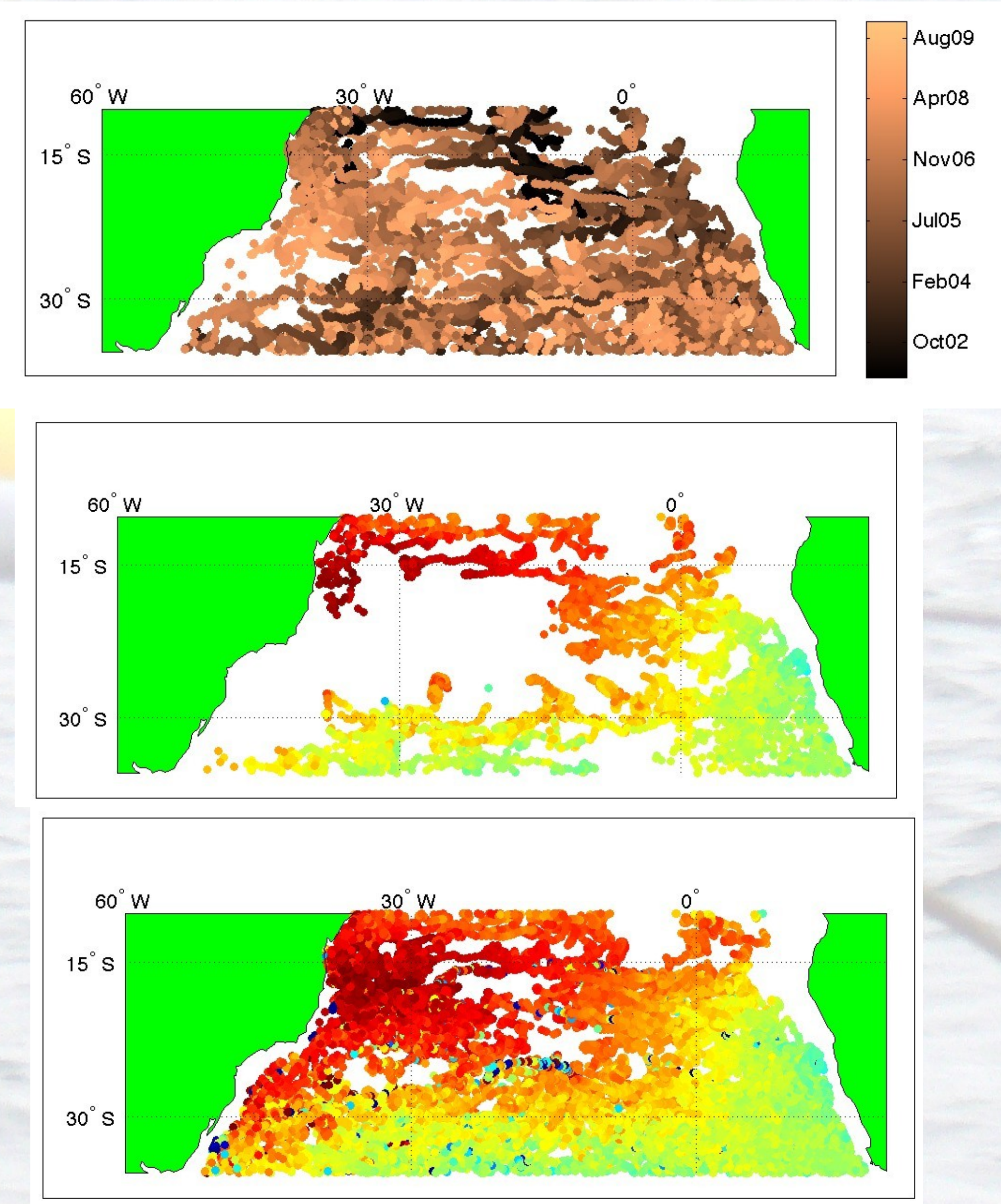
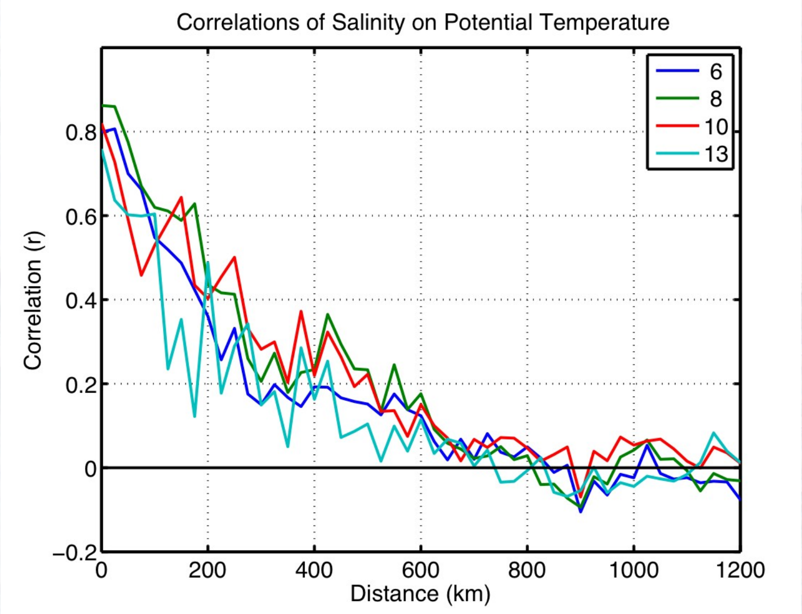
Short Term Variability in Argo Data

- Data Coverage
  - Good overall coverage in real time
  - Significant gaps in transfer to delayed mode
  - 30ºS has some of the best cross basin delayed mode coverage in the South Atlantic
  - Reduced coverage at 24ºS but 16 new floats deployed on JC032 so should improve



Method of handling Argo data: Optimal Interpolation

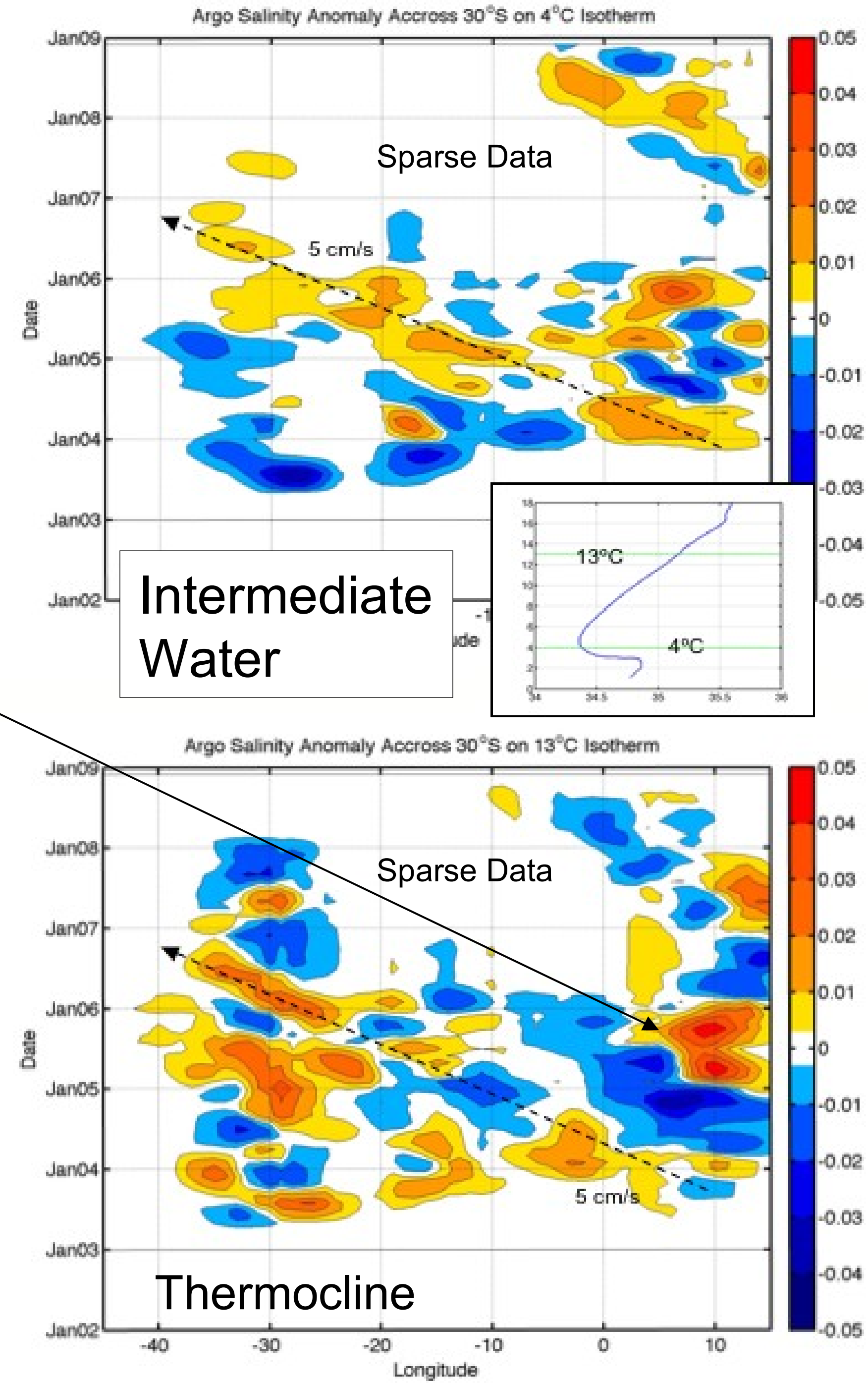
- Argo salinity data were optimally interpolated onto theta surfaces
- A background field generated from WOA05 was used
- Correlation scales were investigated for use in the OI scheme
- A decay scale of 300 km was chosen and a cutoff of 700 km



Theta Surface (ºC)	Correlation Scale (km)
6	289
8	371
10	421
13	303

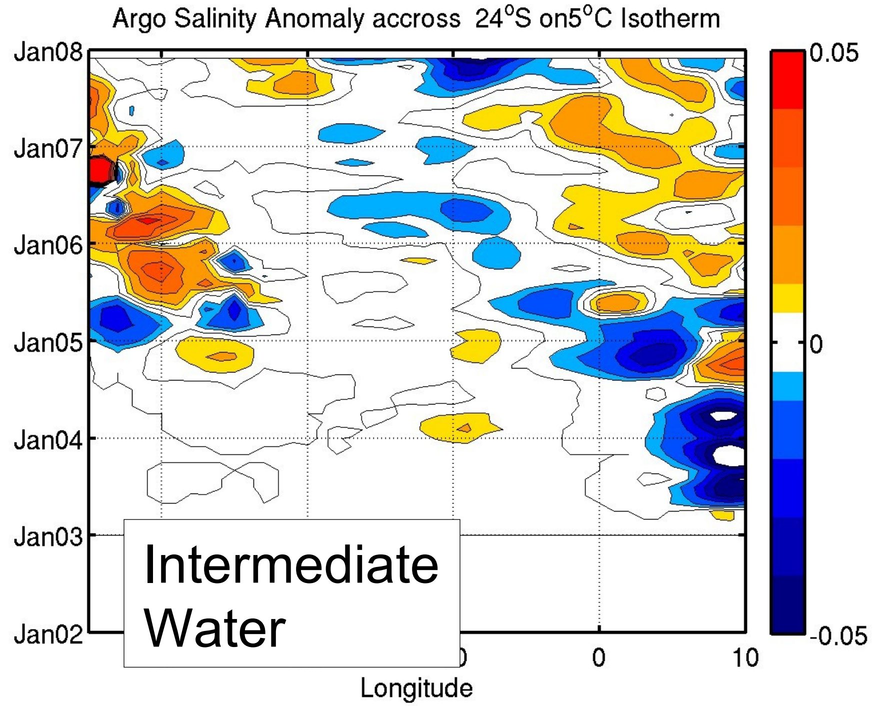
Results of Optimal Interpolation at 30ºS

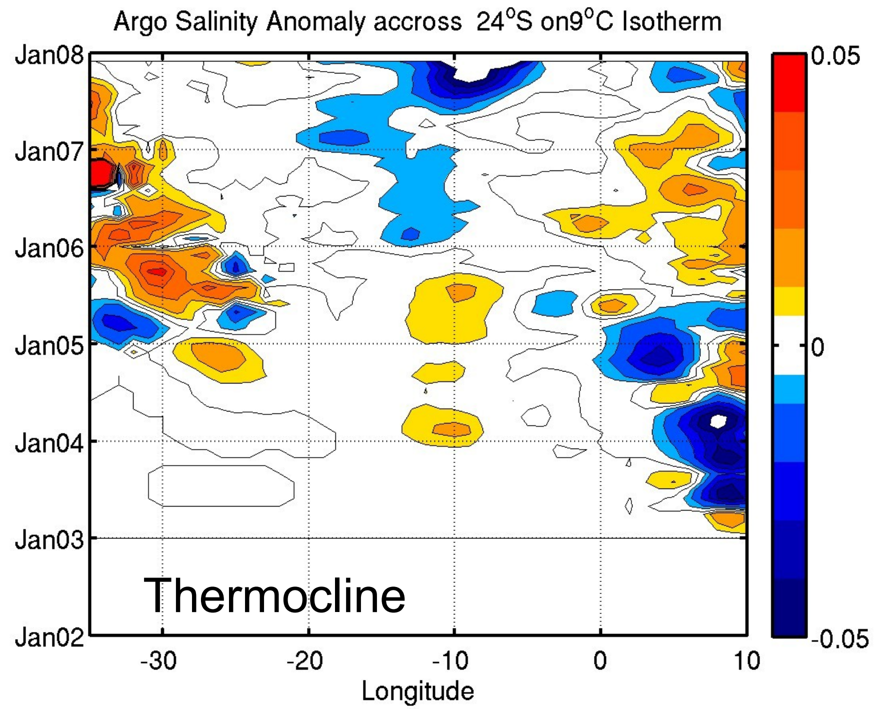
- Salinity Anomalies with large temporal amplitude are seen in the Eastern Basin – comparable with cruise changes
- No basinwide coherent signals are seen in the record
- Salinity anomalies propagate westwards with speeds of ~ 5cm/s recalling anomalies seen highlighted by Biastoch (2008) in satellite and model data



Results of Optimal Interpolation at 24ºS

- Real-time Argo data used
- Some evidence of propagating anomalies
- Increased variability at the boundaries
- No basinwide signal: Interannual variability does not encompass the changes seen in hydrographic data 2009 -1983





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Summary

- Salinification of Antarctic Origin Water at 24ºS not consistent with previously observed trends
- Changes noted at 30ºS between 1993 and 2003 are encompassed by interannual variability seen in Argo data
- Propagating features seen in salinity field at 30ºS
- The thermocline at 24ºS is fresher than previously noted change not accounted for with interannual variability

Future Work

- Look at more hydrography to investigate the temporal coherence of signals seen at 24ºS
  - Is the Antarctic origin water becoming more saline?
  - Is the thermocline the freshest it has ever been seen and what is driving this?

- Investigate the causes of the propagating features at 30ºS and the large interannual fluctuations in the eastern boundary

References

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Thank You

Any Questions?

Optimal Interpolation of Argo Data

- Argo salinity data is optimally interpolated onto potential temperature surfaces along cruise latitudes

$$S(\theta)_{obj} = S(\theta)_{bg} + w.(S(\theta) - S(\theta)_{bg})$$

Anomaly Field

$$w = Cdg.(Cdd + I.\eta^2)^{-1}$$

$$Cdd_{i,j} = < s^2 > exp\{-\frac{D^2_{i,j}}{l^2}\},$$

Correlation Length Scale

$$s^2 = \frac{1}{N}\Sigma_i(S_i - S_{bg})^2$$

Data Noise term

$$\eta^2 = \frac{1}{2N}\Sigma_i(S_i - S_n)^2$$

Determination of the Correlation Length Scale

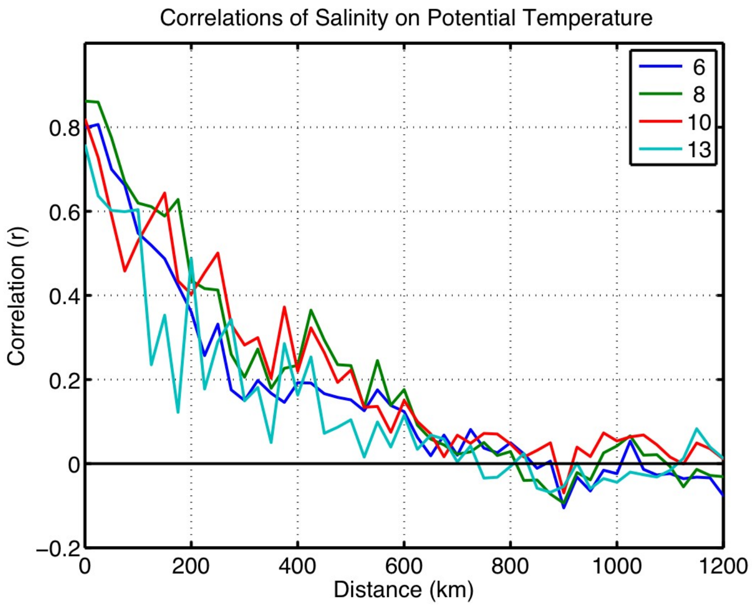
- The Correlation of Argo Salinity on Theta were determined by:
  - Salinity anomalies created relative to WOA05
  - Pairs of Profiles separated by a short time period – 20 days – were selected
  - These were separated according to distance into 25km bins
  - Anomaly pairs in each bin were correlated against one another
  - A Gaussian Curve was fitted to the outcome to determine the length scale of the form:

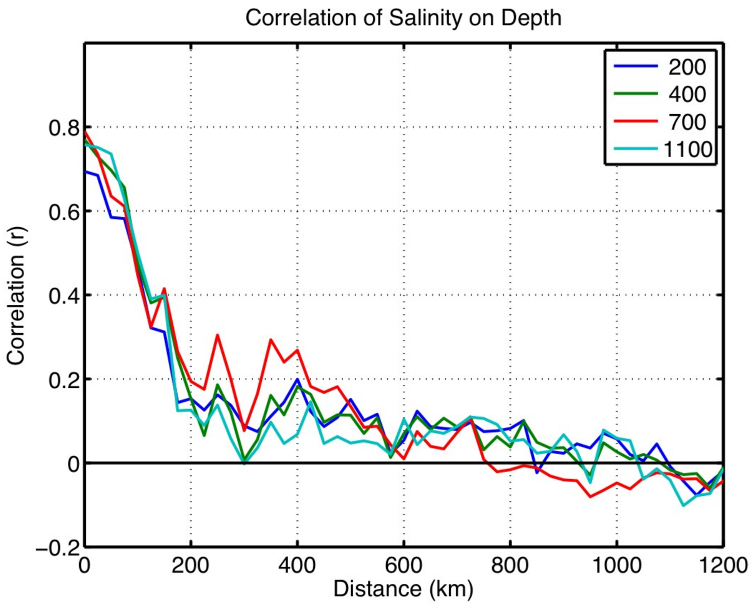
$$C(D) = exp\{-\frac{D^2}{l^2}\}.$$

where l is the l

Correlation Length Scales

Theta Surface (ºC)	Correlation Scale (km)	Depth Surface (m)	Correlation Scale (ºC)
6	289	200	139
8	371	400	121
10	421	700	132
13	303	1100	147





Meridional Anomalies?