The Southern Ocean: A Frontier for Satellite Altimetry

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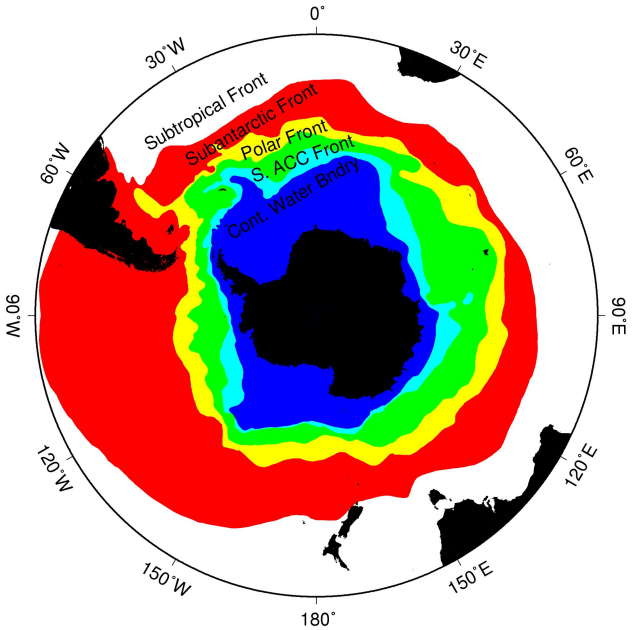
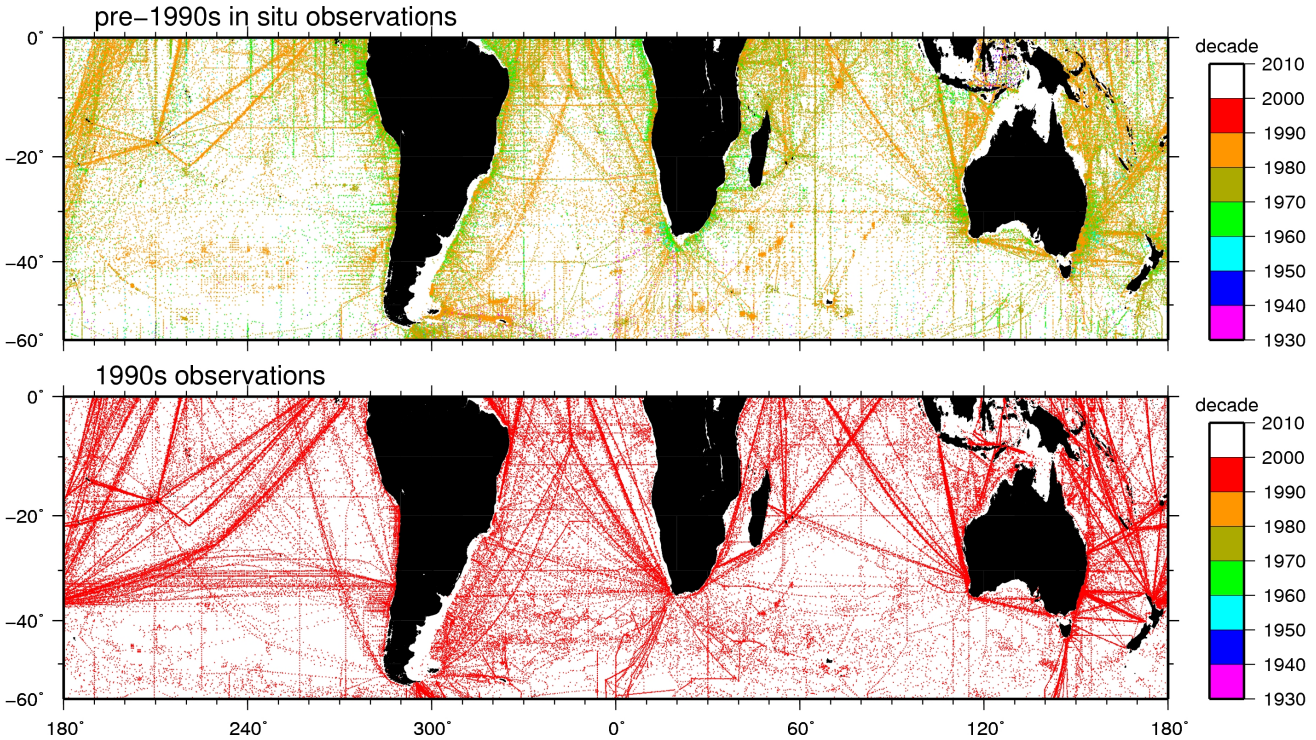
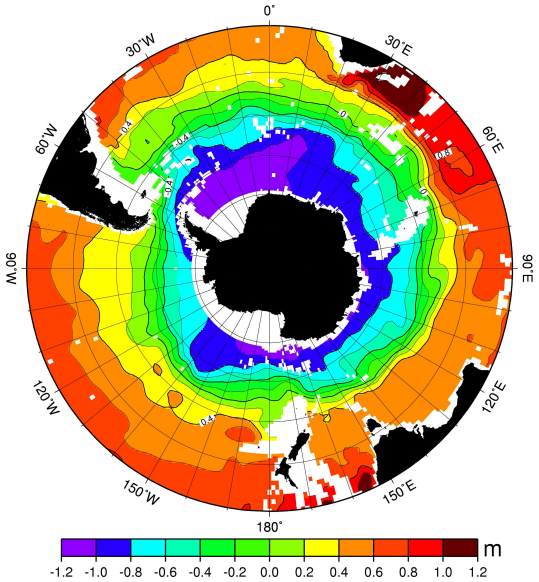


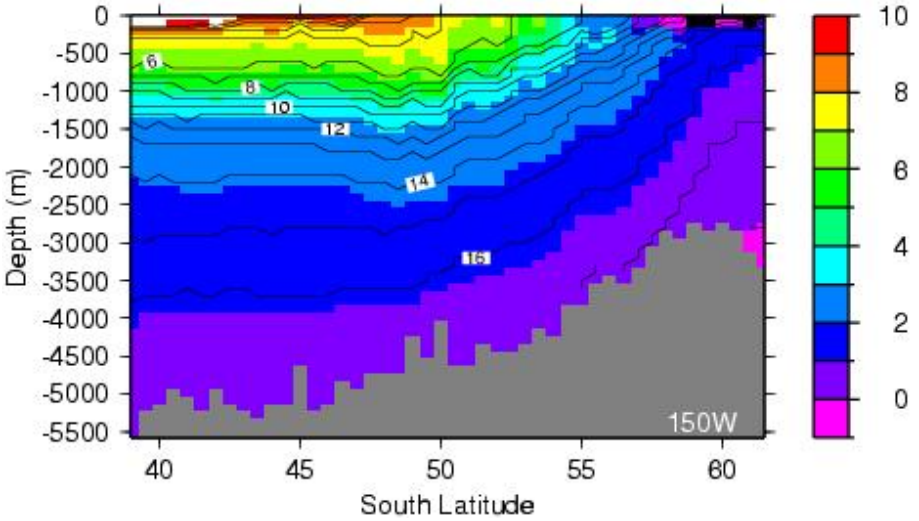
In situ observations: Sparse prior to floats



The ACC: connector and barrier

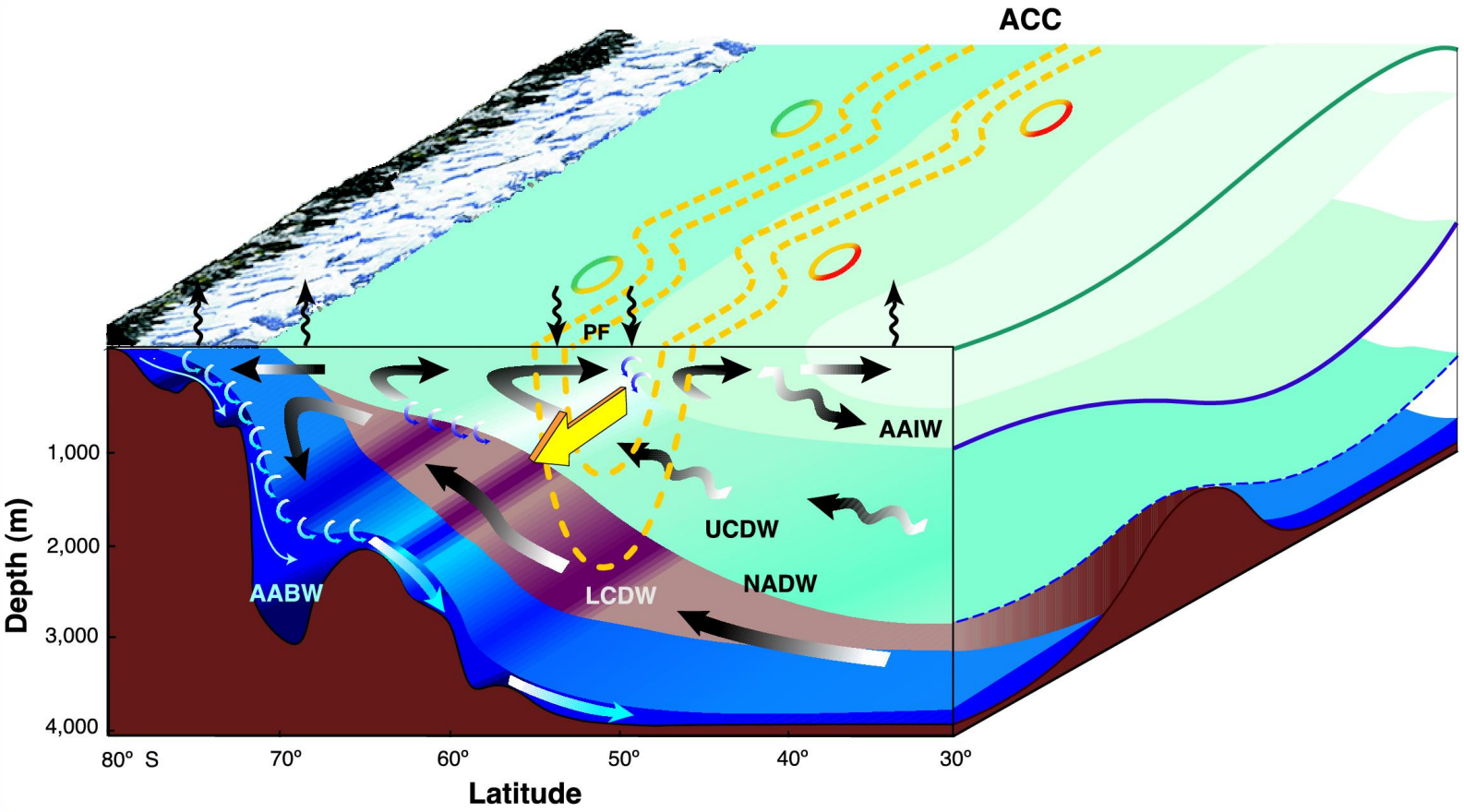


Dynamic Topography



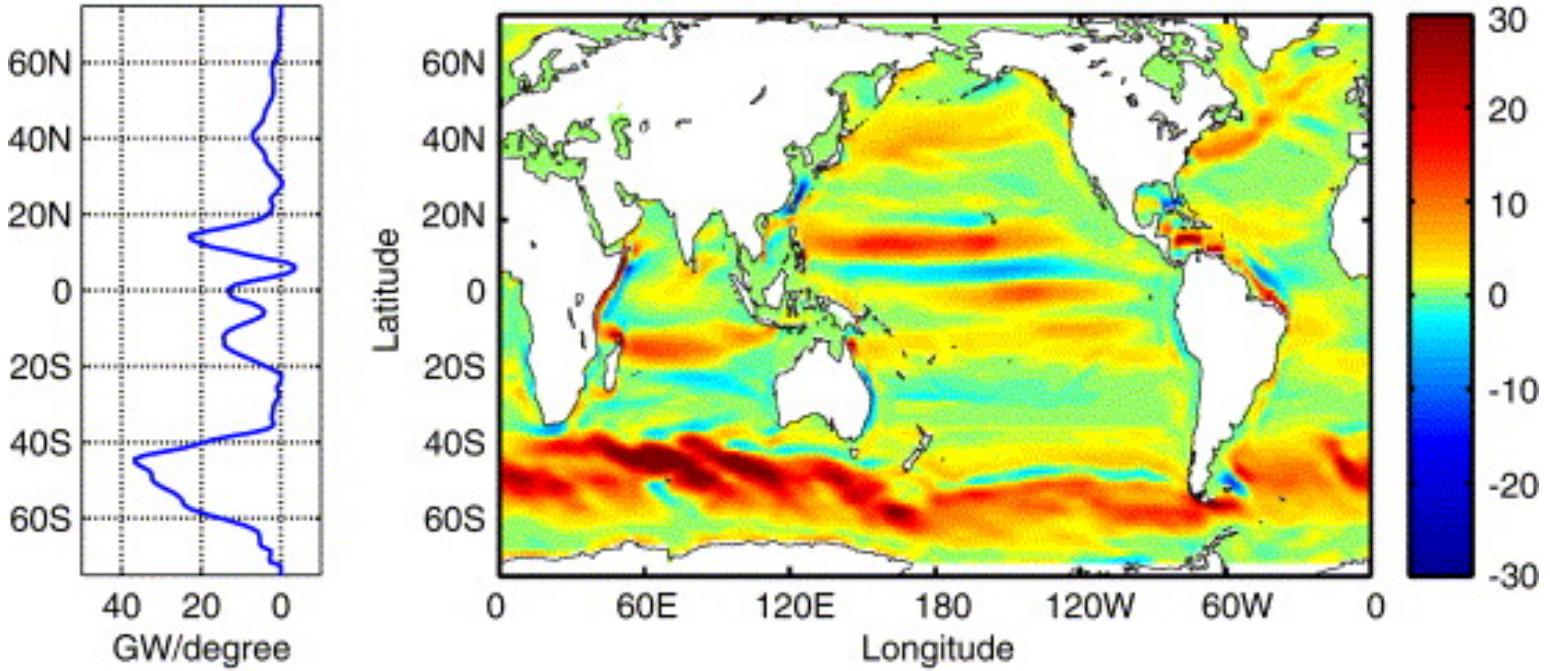
Potential Temperature and Isopycnals

Southern Ocean Overturning



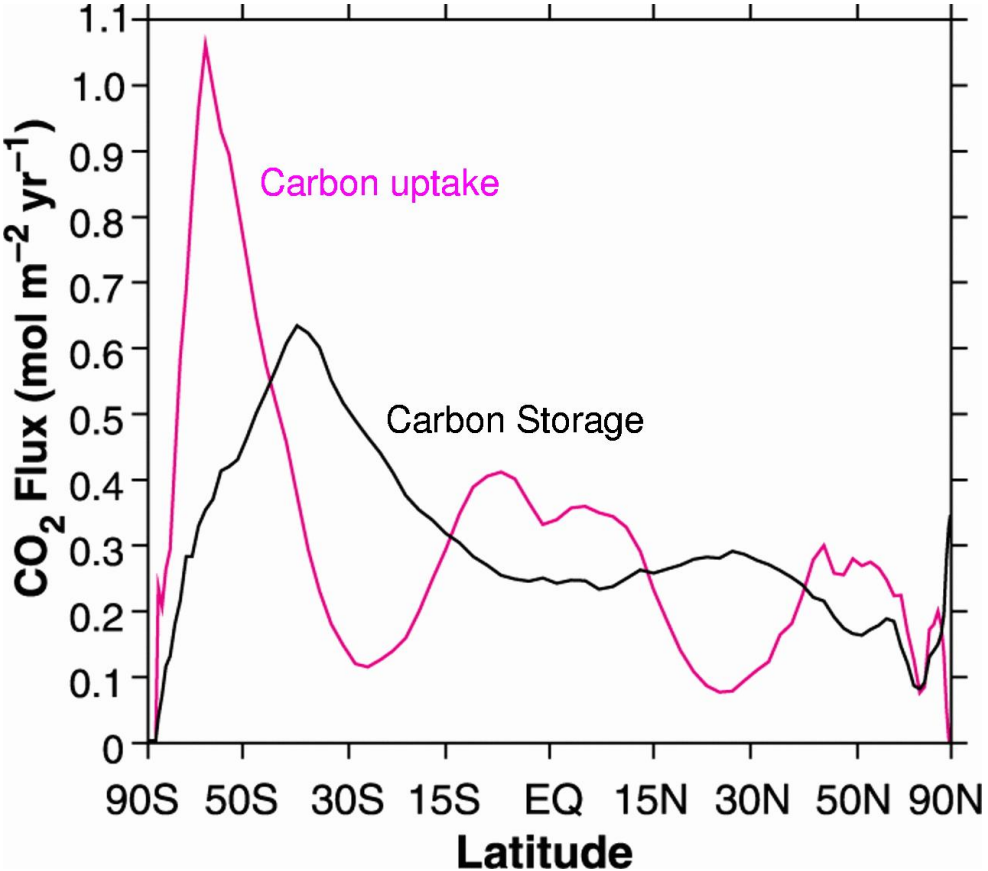
Speer et al., 2004; Olbers et al., 2004

Global Wind Energy Input: Concentrated in Southern Ocean



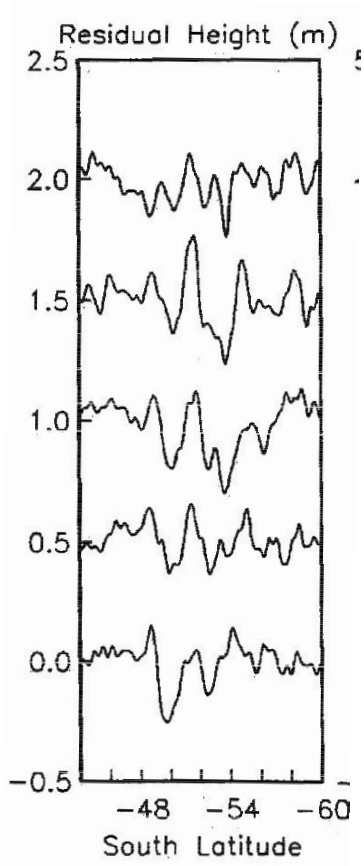
Huang et al, Deep Sea Res., 2006

Ocean Uptake of Carbon



Caldeira and Duffy, Science, 2003

Deciphering sea surface height anomalies

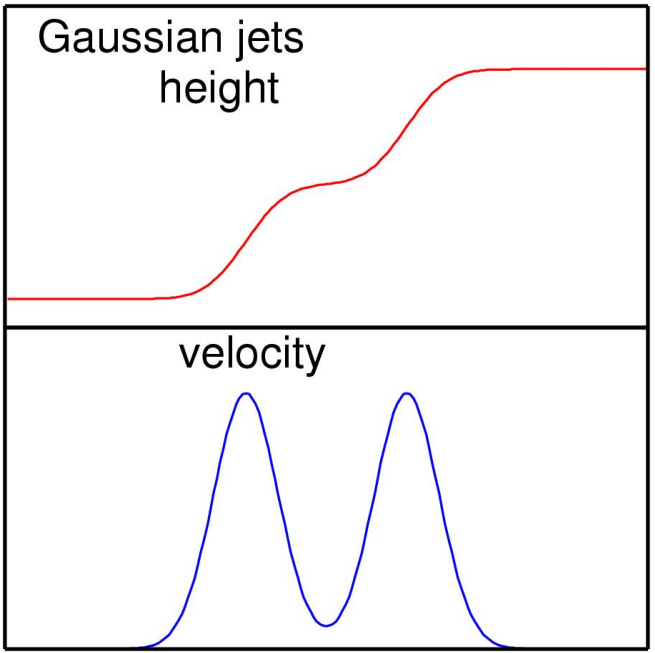


Strategies

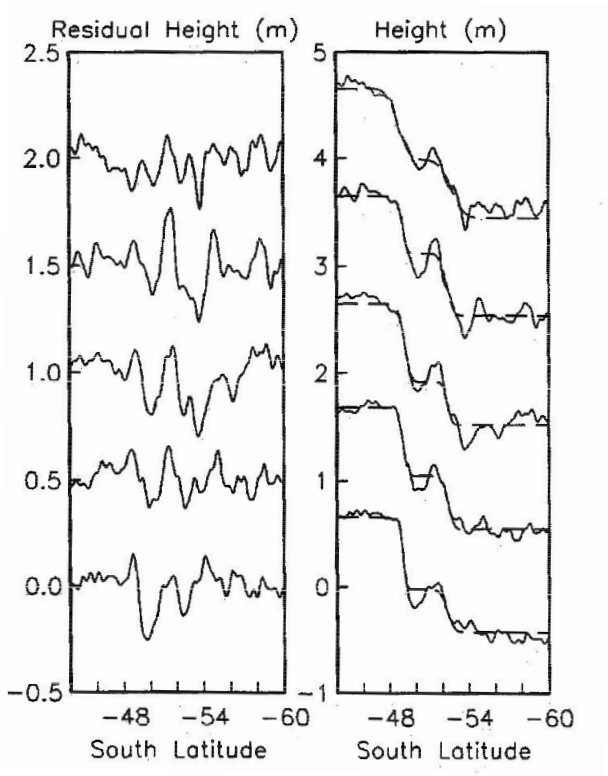
- Use an independent mean dynamic topography
- Study variability of geostrophic currents only

Geostrophic balance:

$$fv = \frac{1}{\rho}\frac{\partial p}{\partial x} = g\frac{\partial \eta}{\partial x}$$



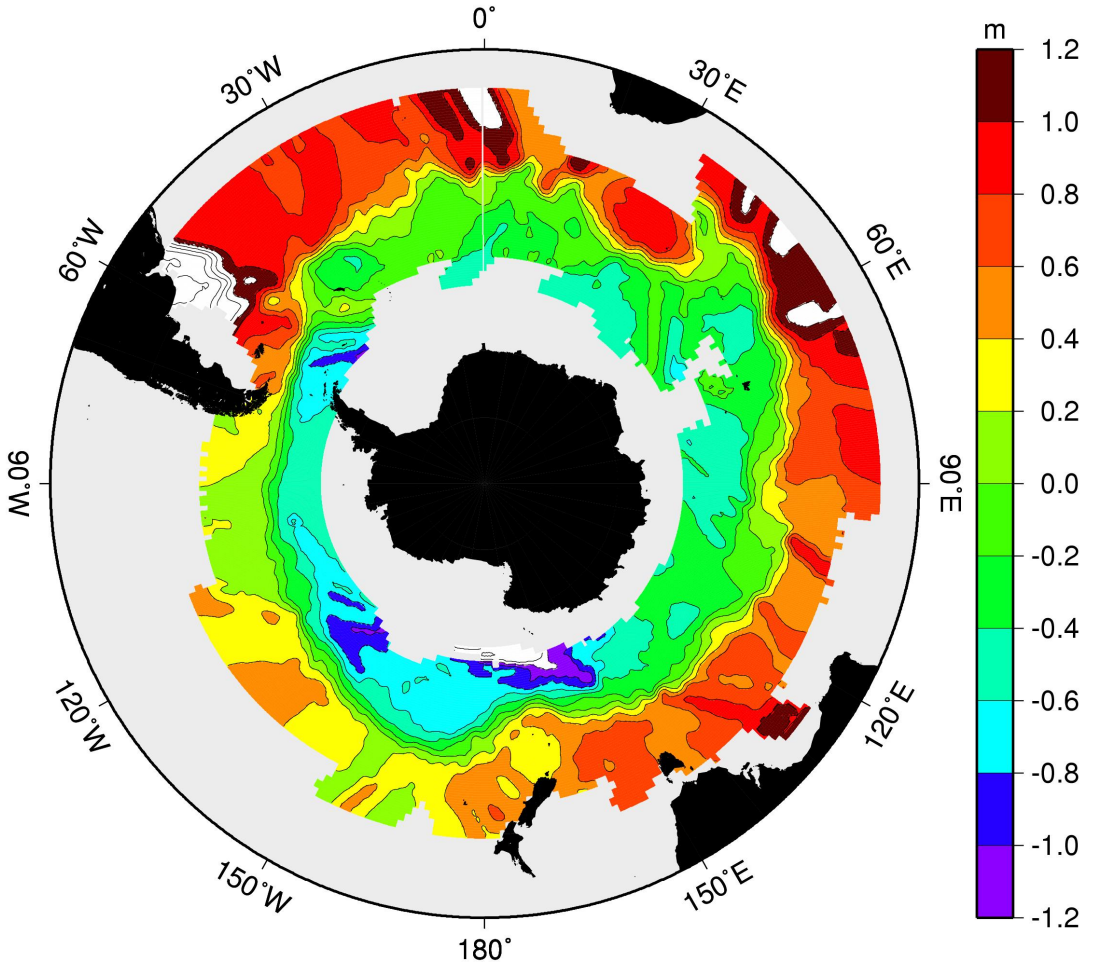
Locating the ACC: Mean plus anomaly



Gille, JGR, 1994

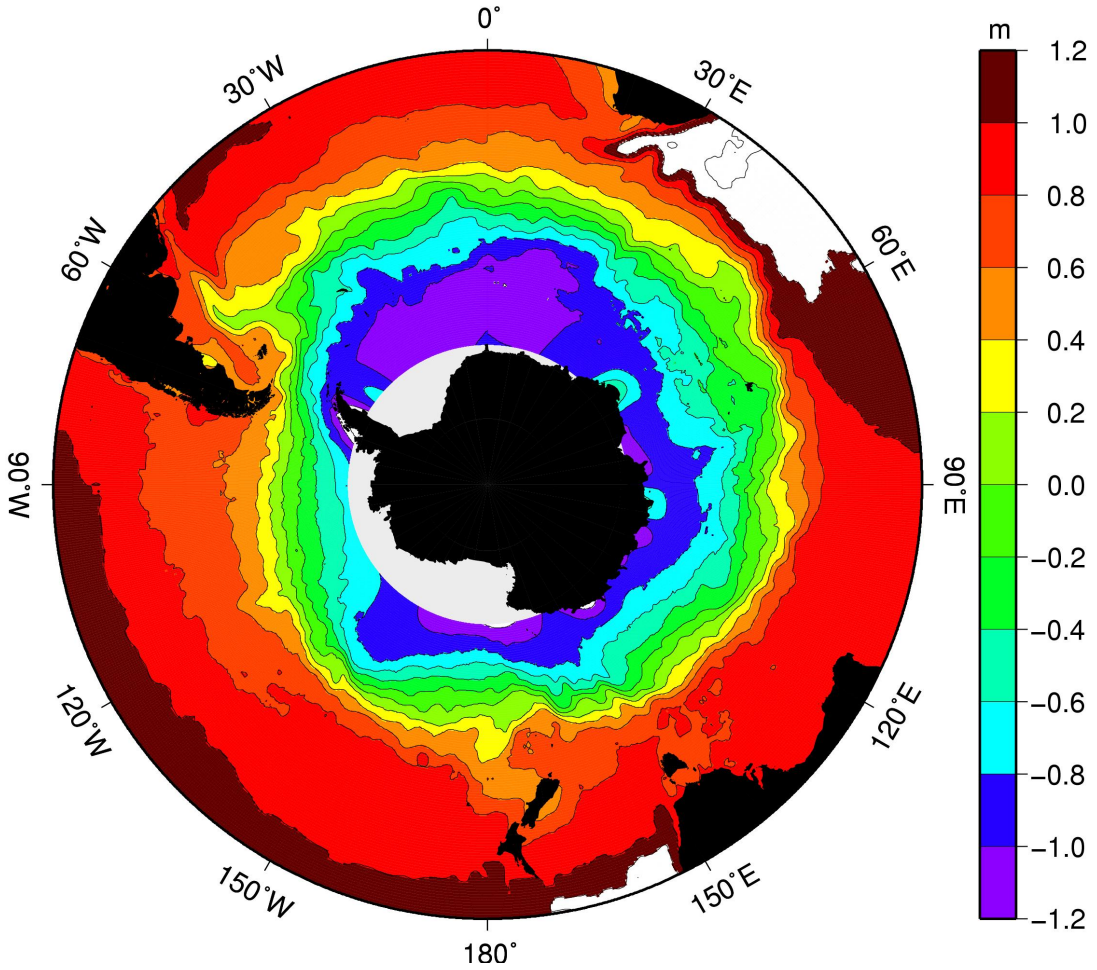
- Frontal width: 44 km
- Meandering amplitude: 75 km
- (For comparison, microwave SST suggest PF meandering amplitude: approx 120 km (Dong et al., 2006)
- TOPEX results largely in agreement with Geosat

Altimetric "Mean" Field



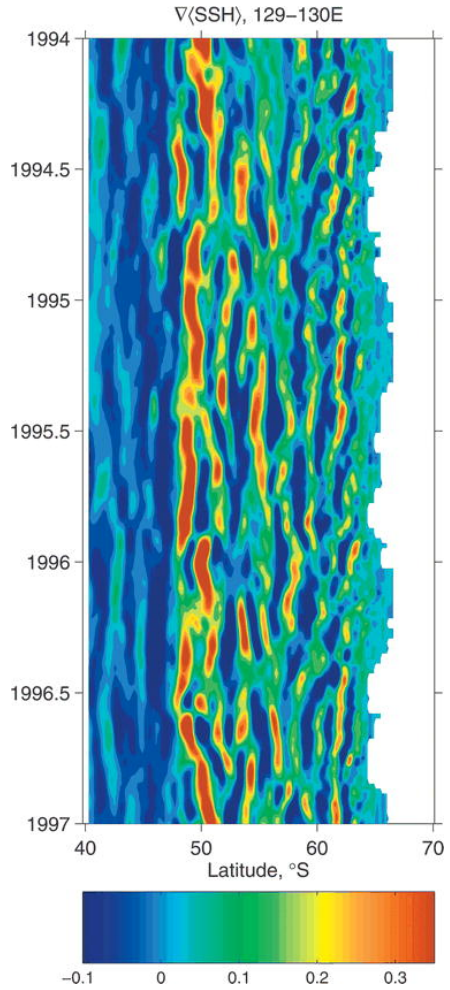
retains small-scale structure but inaccurate for large-scale.

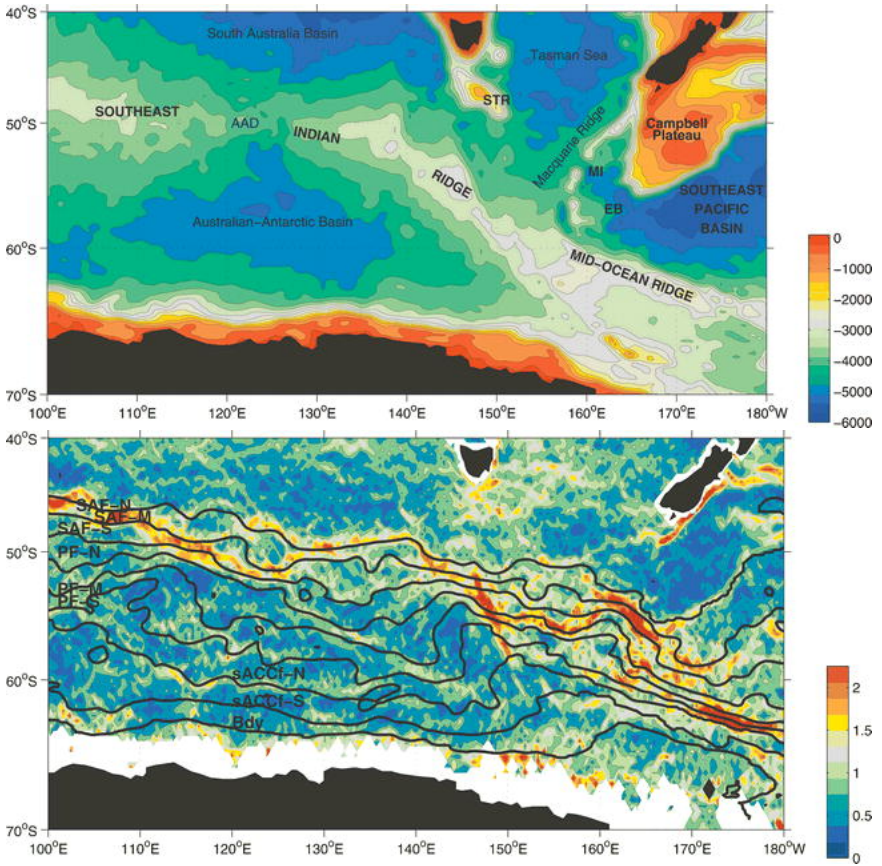
Updated Mean: GRACE, surface drifters, etc.



Niiler and Maximenko

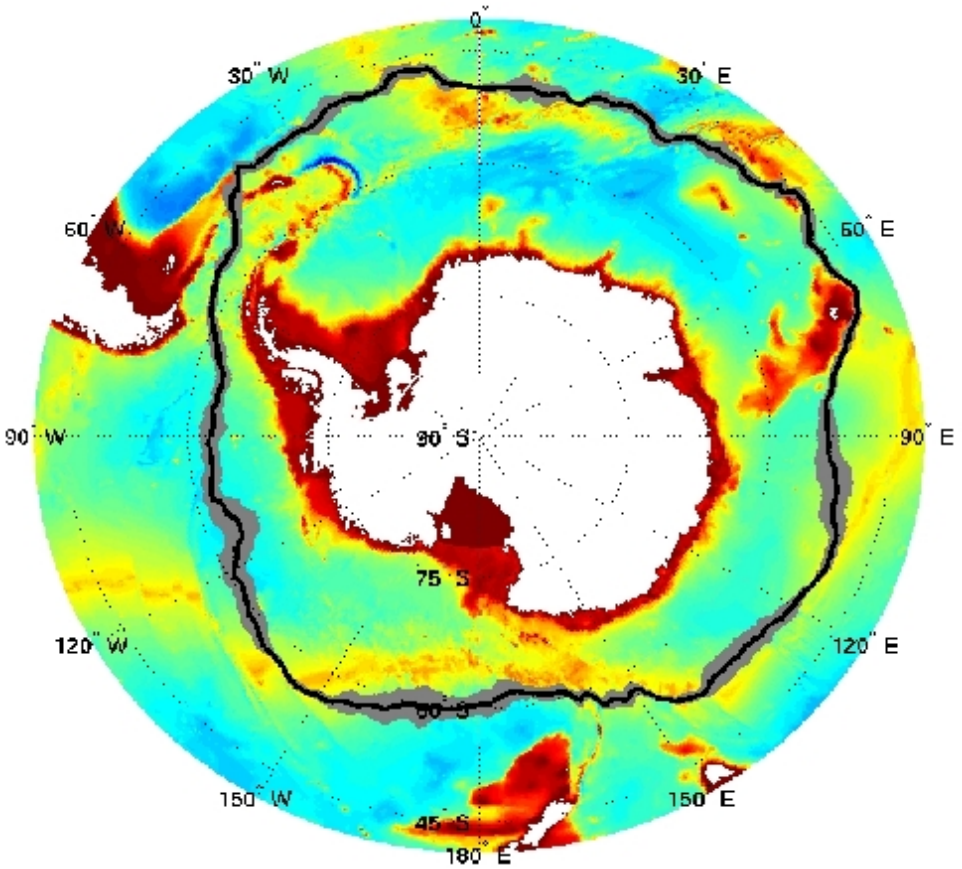
Multiple Filamented Jets





Sokolov and Rintoul, 2007

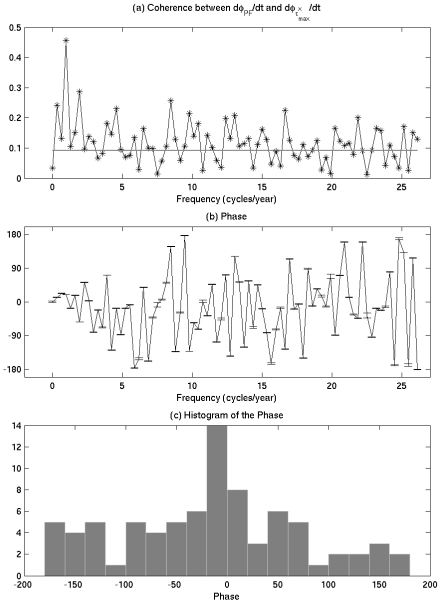
Bathymetry and the Polar Front Variability

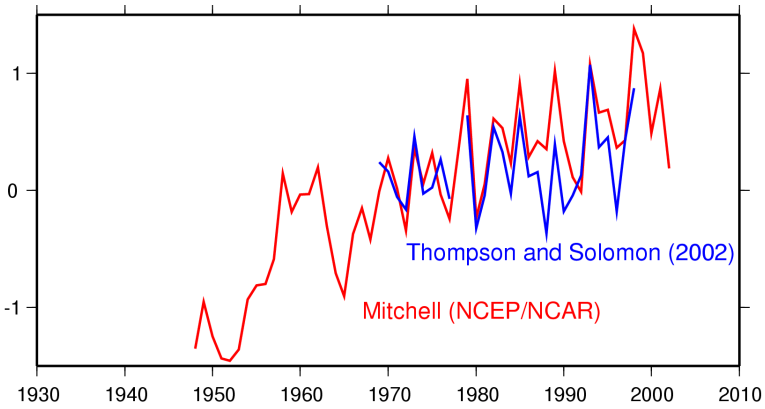


(Dong et al., JPO, 2006)

Latitudinal shift in ACC?

Southern Annular Mode intensification implies poleward shift in wind.



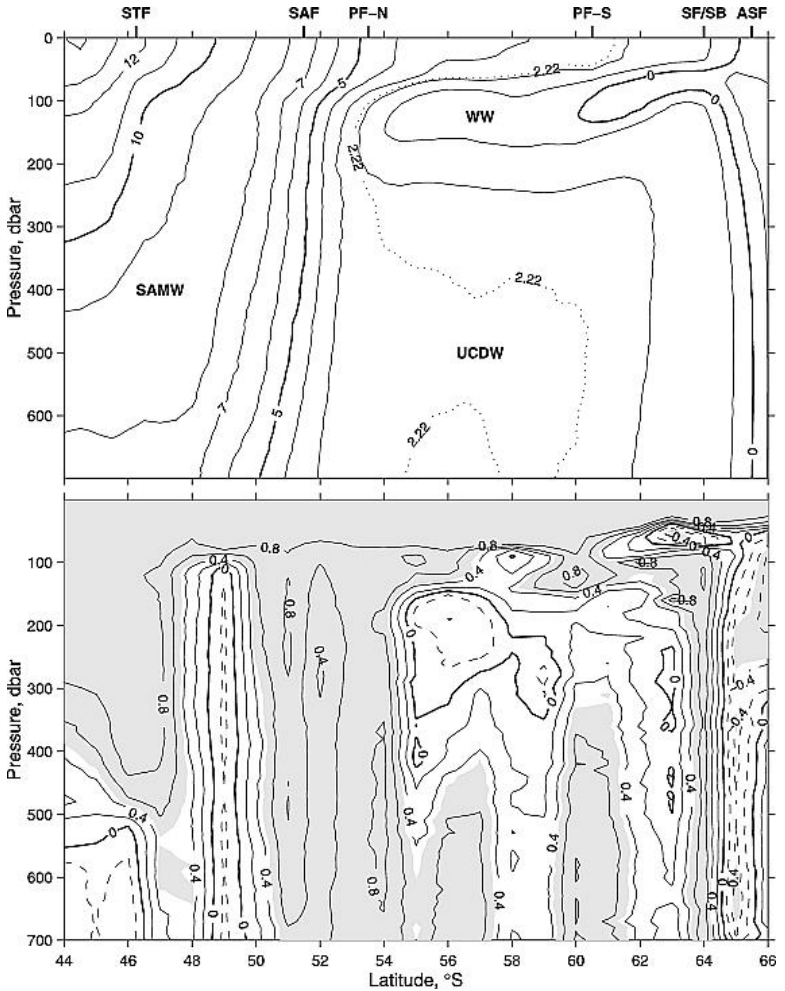


Poleward shift in wind implies poleward shift in ACC (at least on some time scales; Dong et al., JPO, 2006)

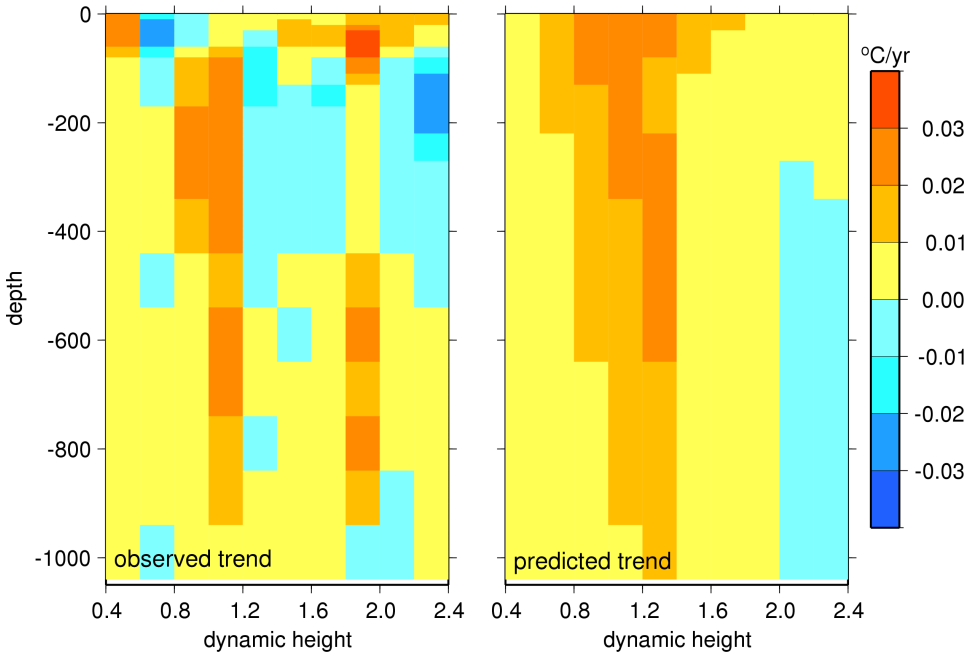
$$\phi_{PF} \propto \phi_{\tau}$$

Latitudinal shift in ACC?

ACC displacement is top-to-bottom. (Sokolov and Rintoul, 2003)



Latitudinal shift in ACC?



Sparse hydrographic record indicates ACC has warmed at all depth levels over last 50 years.

In ACC below 200 m depth, ~95% of profile trend explained as poleward migration of current at 1° latitude/35 years.
(Gille, 2008, J. Climate in press)

Summary

- Southern Ocean: historically undersampled, climatically important, experienced substantial warming over last 50+ years.
- Altimetry has exposed complex filamented nature of Antarctic Circumpolar Current.
- Regional changes in Southern Ocean consistent with migration of ACC fronts, driven by changes in latitude of wind forcing.
- Extended record from T/P, Jason, and Jason-2 should enable full unraveling of ACC frontal response to climatic shifts in wind.