

Variability in the Southern Ocean south of Africa: evidence of atmospheric induced variability

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AOML

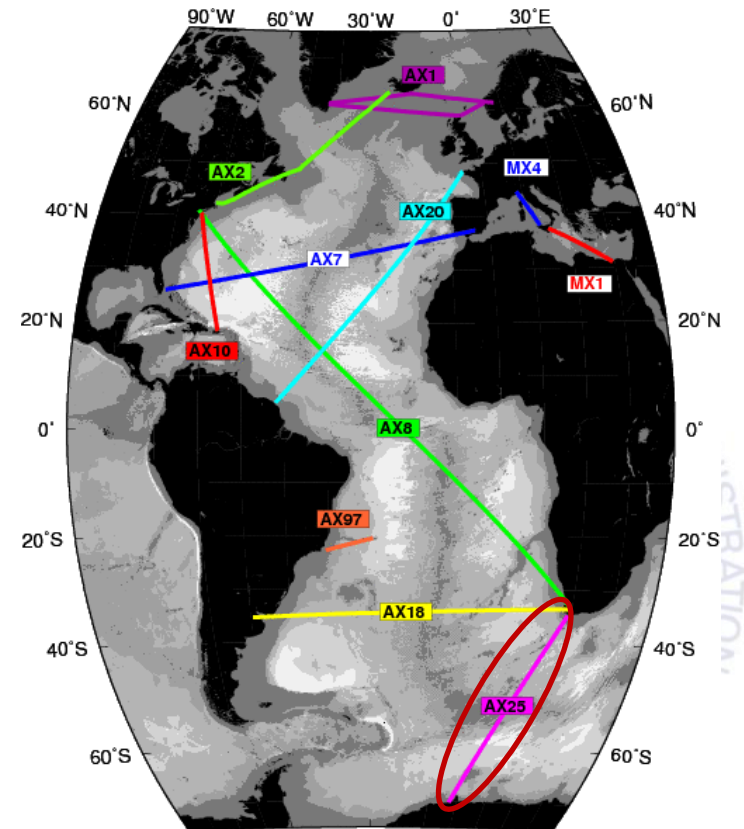
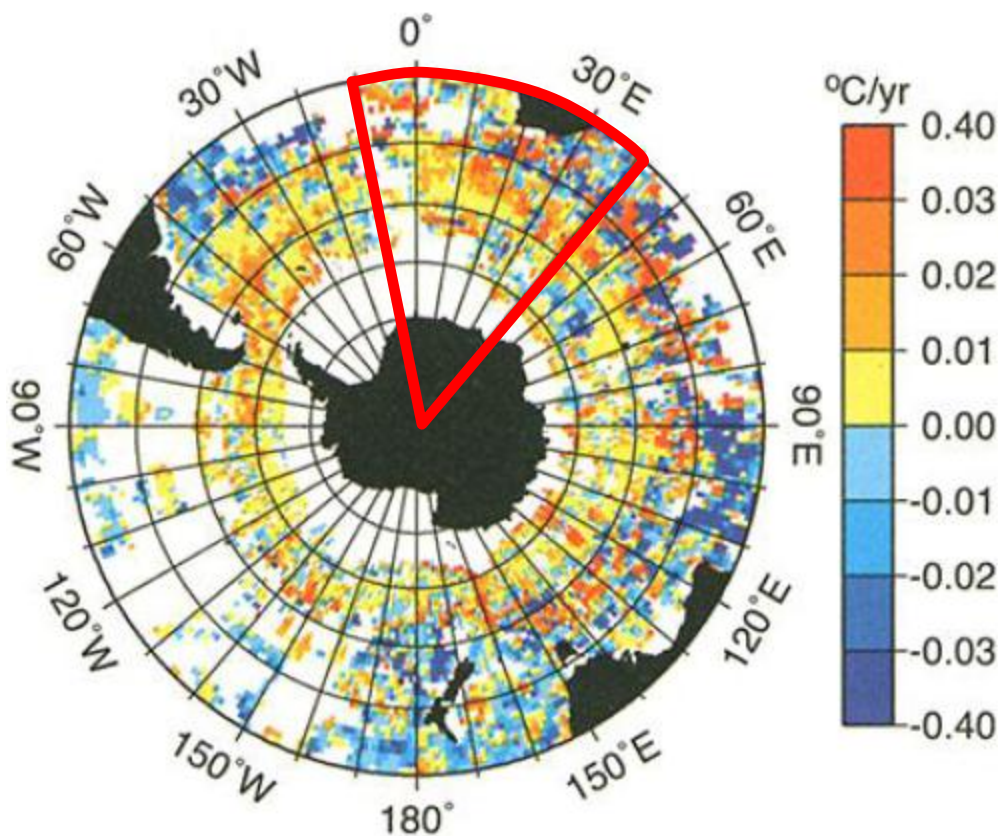


PHOD retreat, March 28-29, 2012

The goal

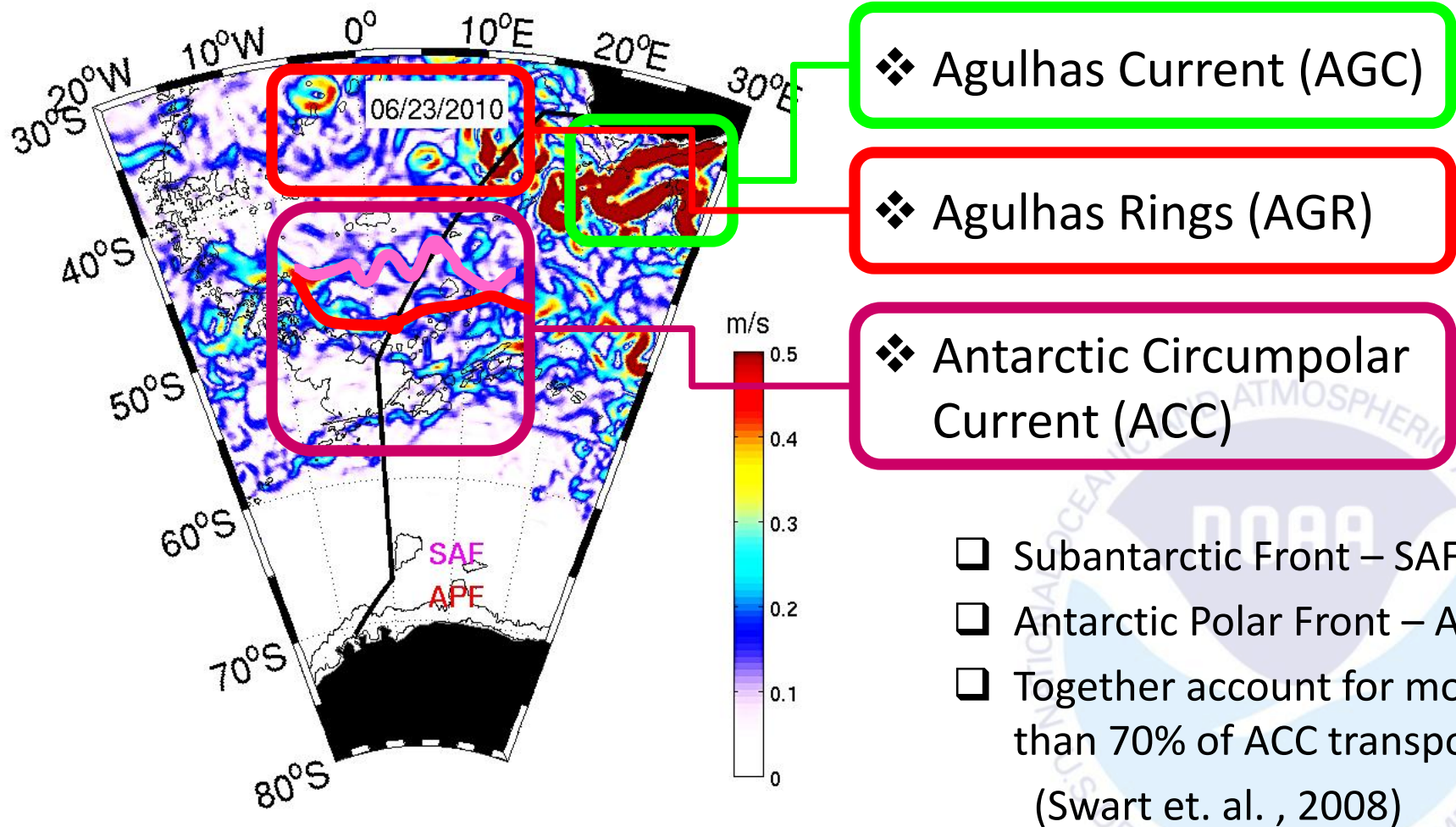
- ❖ To evaluate the variability in the Southern Ocean between South Africa and Antarctica and investigate its link with the atmospheric variability

Gille [2002]





The dynamics



Altimetry-derived geostrophic velocity

- ❑ Subantarctic Front – SAF
- ❑ Antarctic Polar Front – APF
- ❑ Together account for more than 70% of ACC transport (Swart et. al. , 2008)



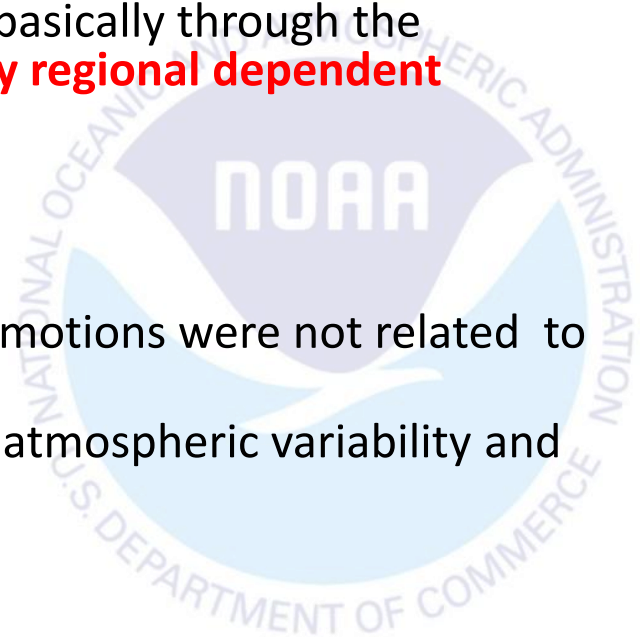
Previous work

❖ Southern Ocean

- ❑ **Gille 2002, 2008** – Indicated a consistent warming trend during last decades concentrated within the ACC
- ❑ **Sokolov 2009** – Suggested the S.O. warming as potentially due to a southward shift in the ACC
- ❑ **Sallee et. al 2008** – Observed that the frontal position variability is largely controlled by the atmospheric variability – basically through the Southern Annular Mode (SAM) – **but largely regional dependent**

❖ XBT transect AX25

- ❑ **Billany et. al 2010** – Demonstrated that frontal motions were not related to the SAM index
- ❑ Remain to be determined the link between the atmospheric variability and the oceanic

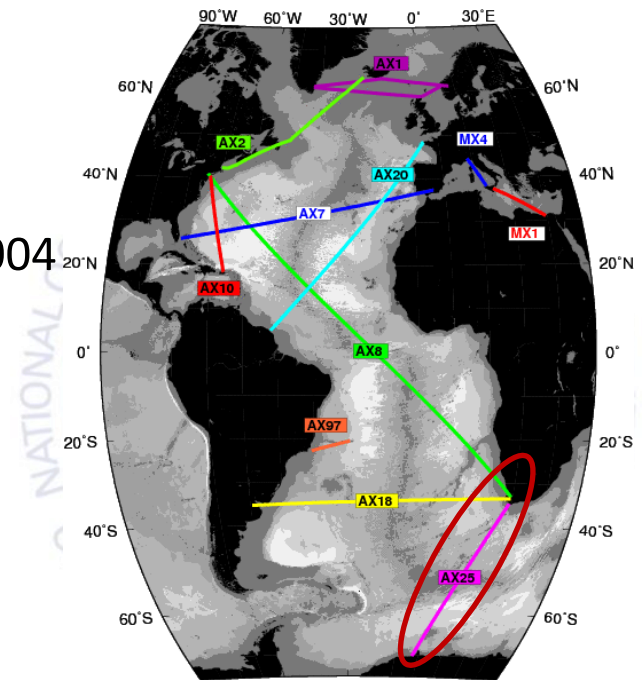


❖ Atmospheric variability

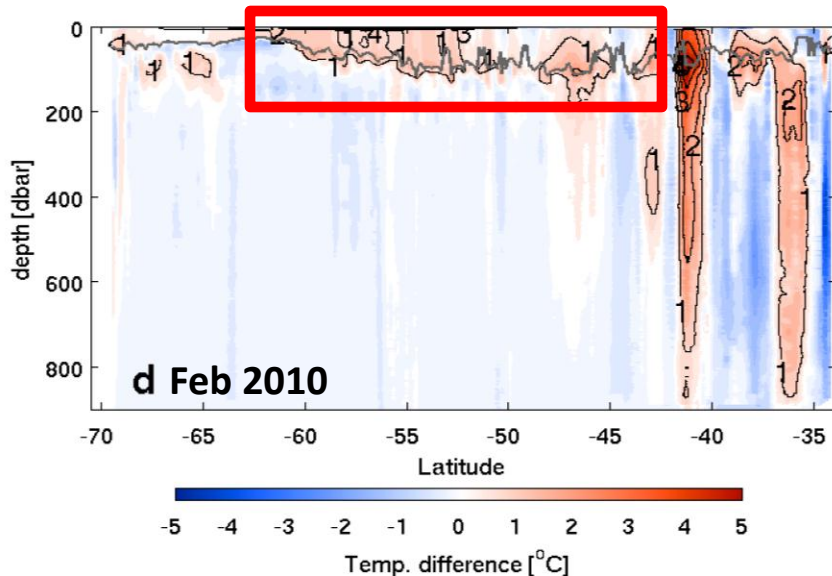
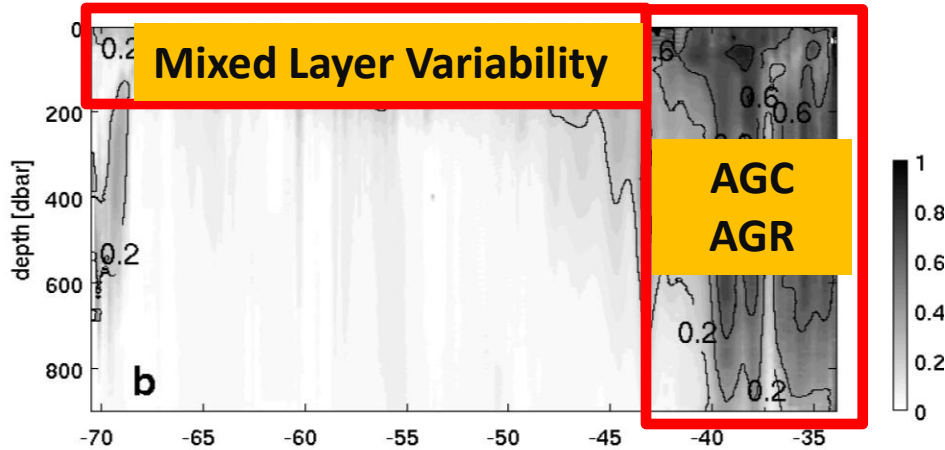
- ❑ Satellite Winds – CCMP (Atlas et. al [2011], 1993-2010)
- ❑ SAM index – NOAA-CPC (www.cpc.ncep.noaa.gov)

❖ Oceanic variability

- ❑ XBT HD along AX25 - 16 transects, starting in 2004
- ❑ Satellite SST – OISST.v2 (1993-2010)
- ❑ Satellite altimetry – AVISO (1993-2010)
 - APF and SAF variability
 - Transports
 - Frontal motions



XBT-derived thermal variability



❖ North of 45°S

❑ Agulhas Rings – up to 5°C anomalies

❖ Within the ACC

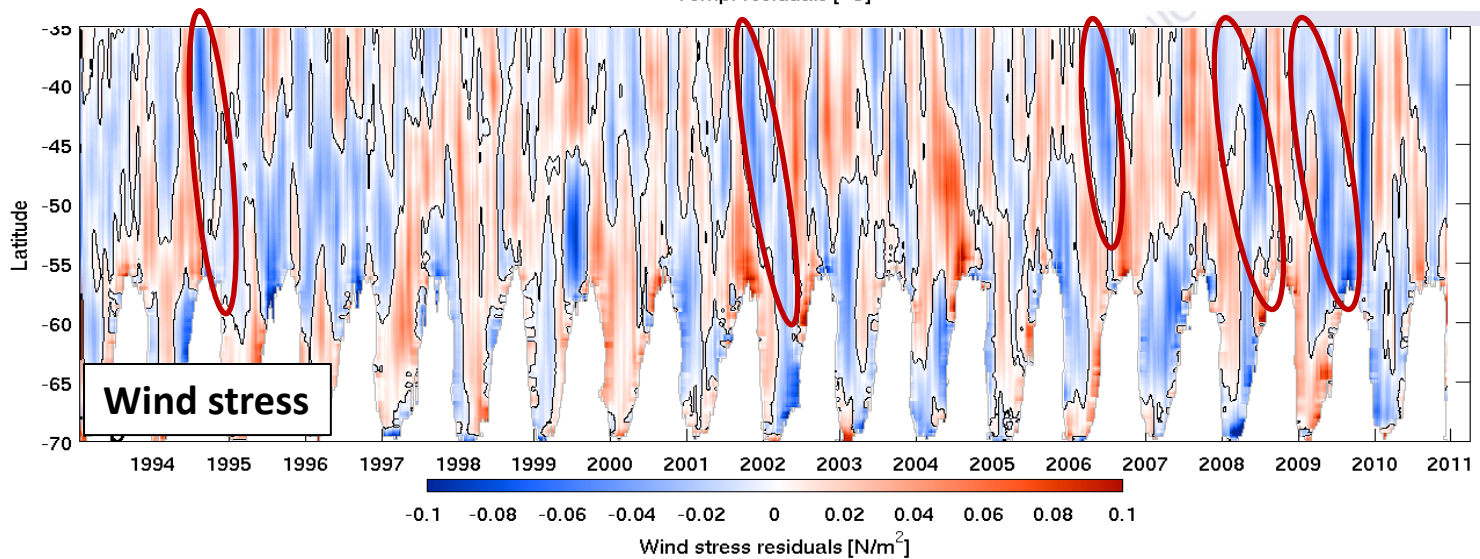
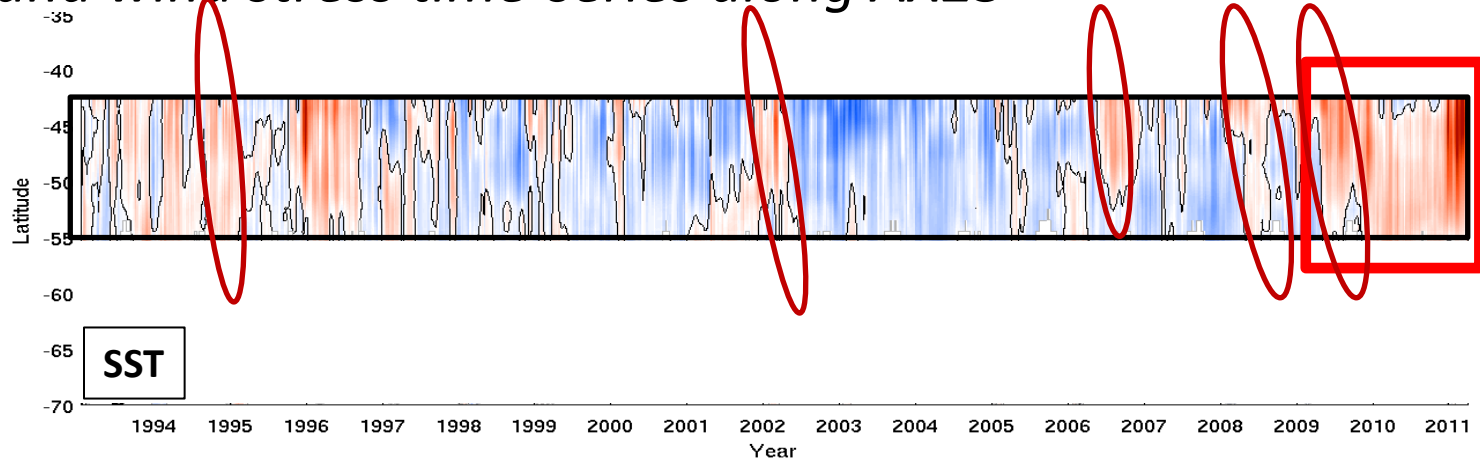
❑ Mixed layer variability – up to 2°C anomalies

❑ Warm anomalies starting in 2009

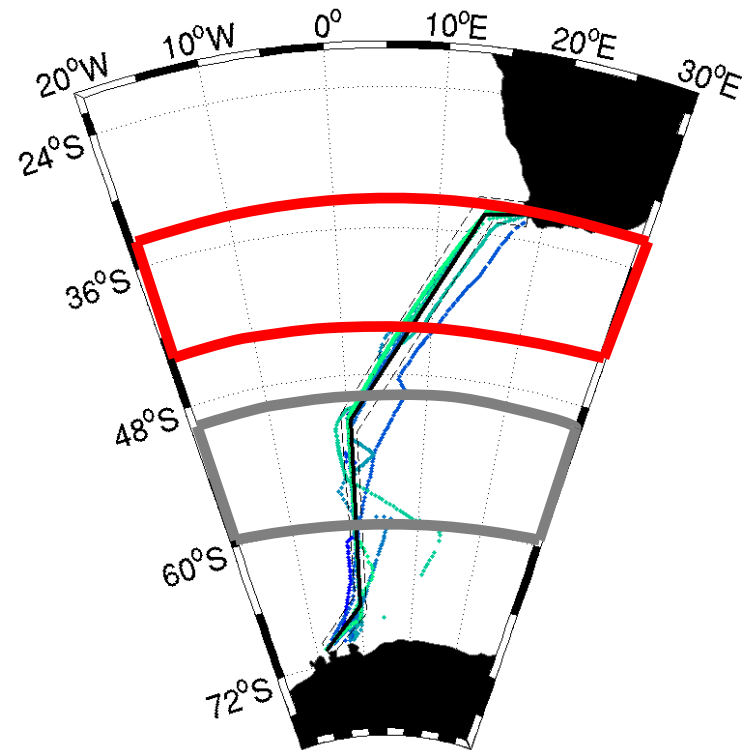
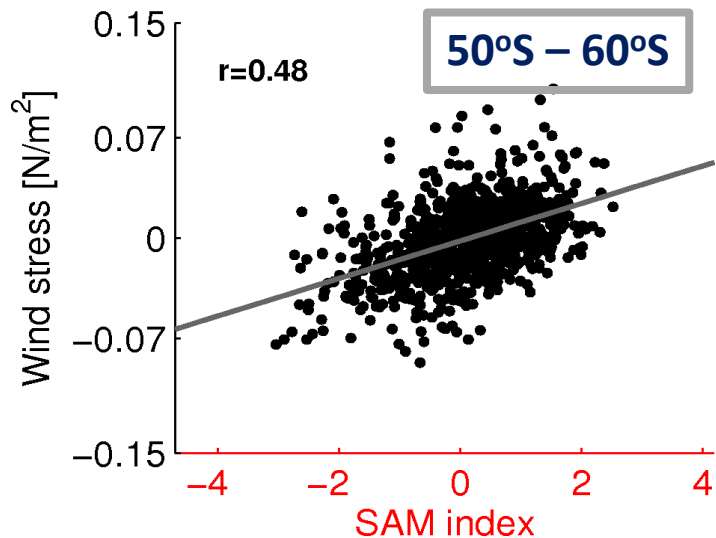
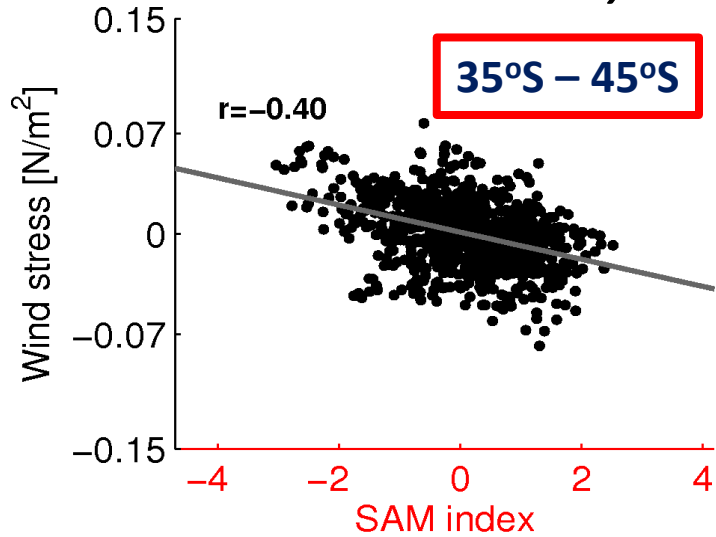
figure from Domingues et. al. [2012], to be submitted

Results

SST and wind stress time-series along AX25

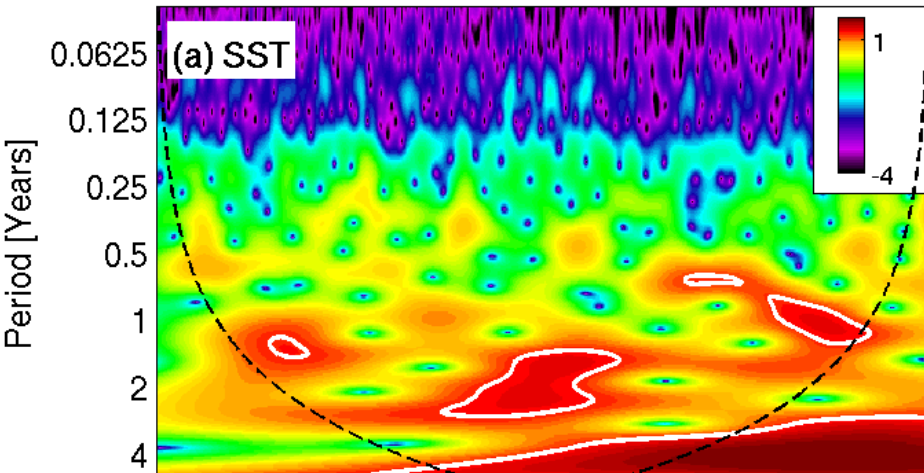


Wind stress variability VS. SAM



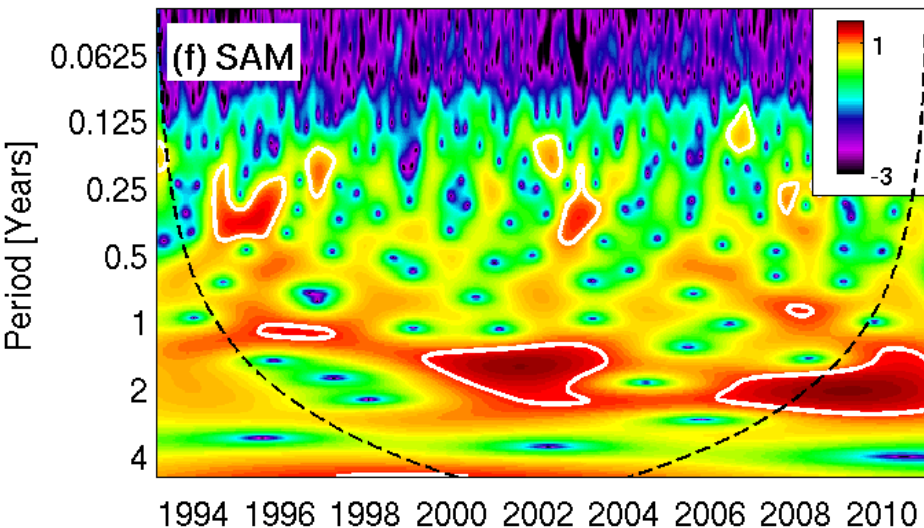
- ❑ Southward displacement of the westerlies during positive SAM
 - ❑ Ocean response to SAM through Ekman transport anomalies
- (Gupta and England 2006)

Wavelet transforms



❖ SST - residuals

- Mostly interannual variability
- Periodicity of ~ 2 years



❖ SAM index

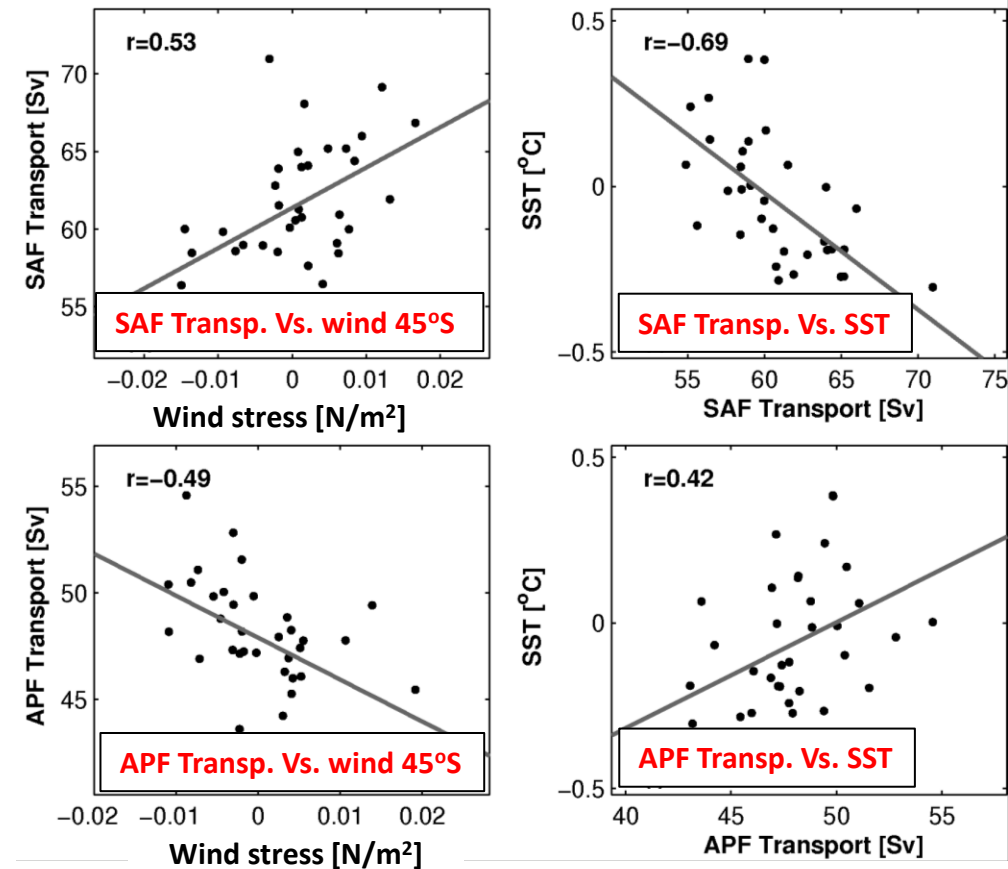
- Mostly interannual variability
- Periodicity of ~ 2 years

figures from Domingues et. al. [2012], to be submitted



Discussion

Interannual time-scales



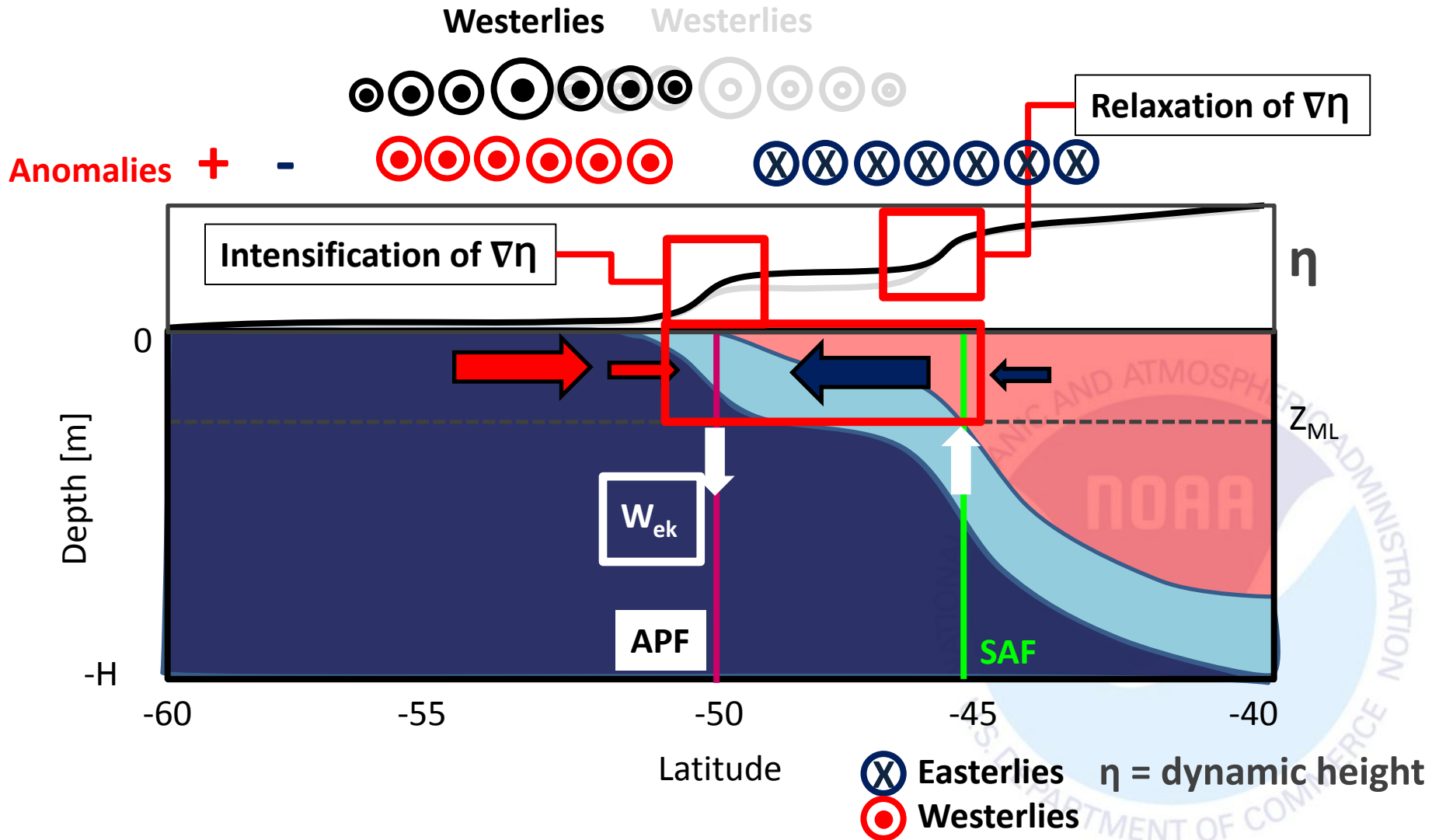
❖ Different fronts are exposed to different Ekman regimes (Sallee et. al. 2008)

- ❖ Positive SAM
- ☐ ↑ SST within ACC
 - ☐ ↓ SAF transport
 - ☐ ↑ APF transport



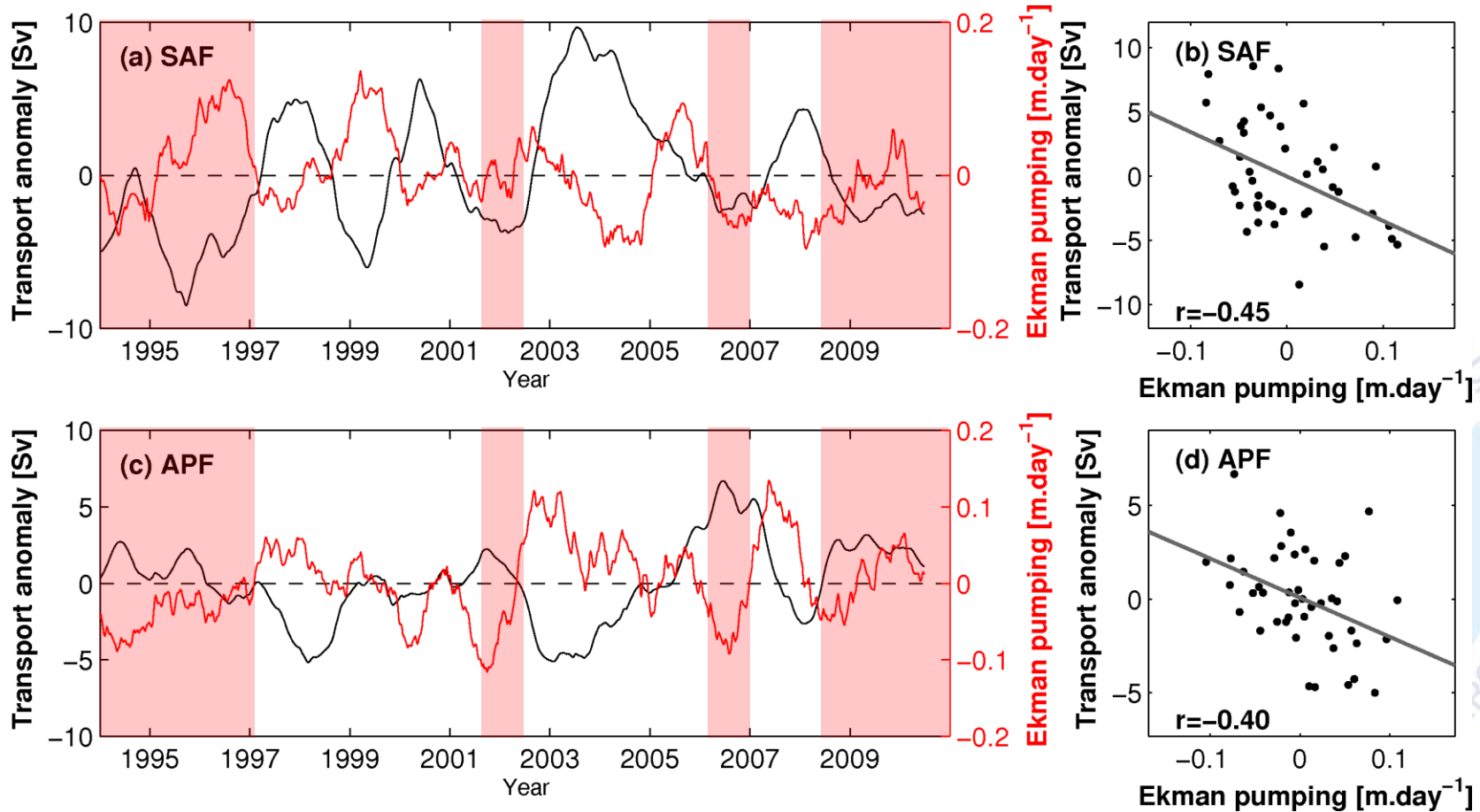
Discussion

The potential mechanism – Interannual time-scales



Ekman suction velocities

$$w_{ek} = \frac{1}{\rho} \frac{dM_y}{d_y}, \text{ and } M_y = \int_{x_1}^{x_2} \left(-\frac{\tau_x}{f} \right) dx$$





Summary

- ❖ Link between atmospheric variability and the oceanic variability south of Africa

- ❖ SAM-induced wind stress anomalies relate with:
 - **Warmer mixed layer within ACC**
 - **Lower SAF transport through relaxation of the dynamic height gradient**
 - **Higher APF transport through intensification of the dynamic height gradient**

- ❖ Consistent with observed warming within the ACC
 - ❑ SAM has a consistent positive trend over last decades

- ❖ Manuscript “Variability in the Southern Ocean between South Africa and Antarctica during 1993-2010” ready to be submitted

