Sea Level Anomalies in the Southern Ocean due to Thermohaline Variability

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Motivation

Predicted contributions to global mean sea level rise by source

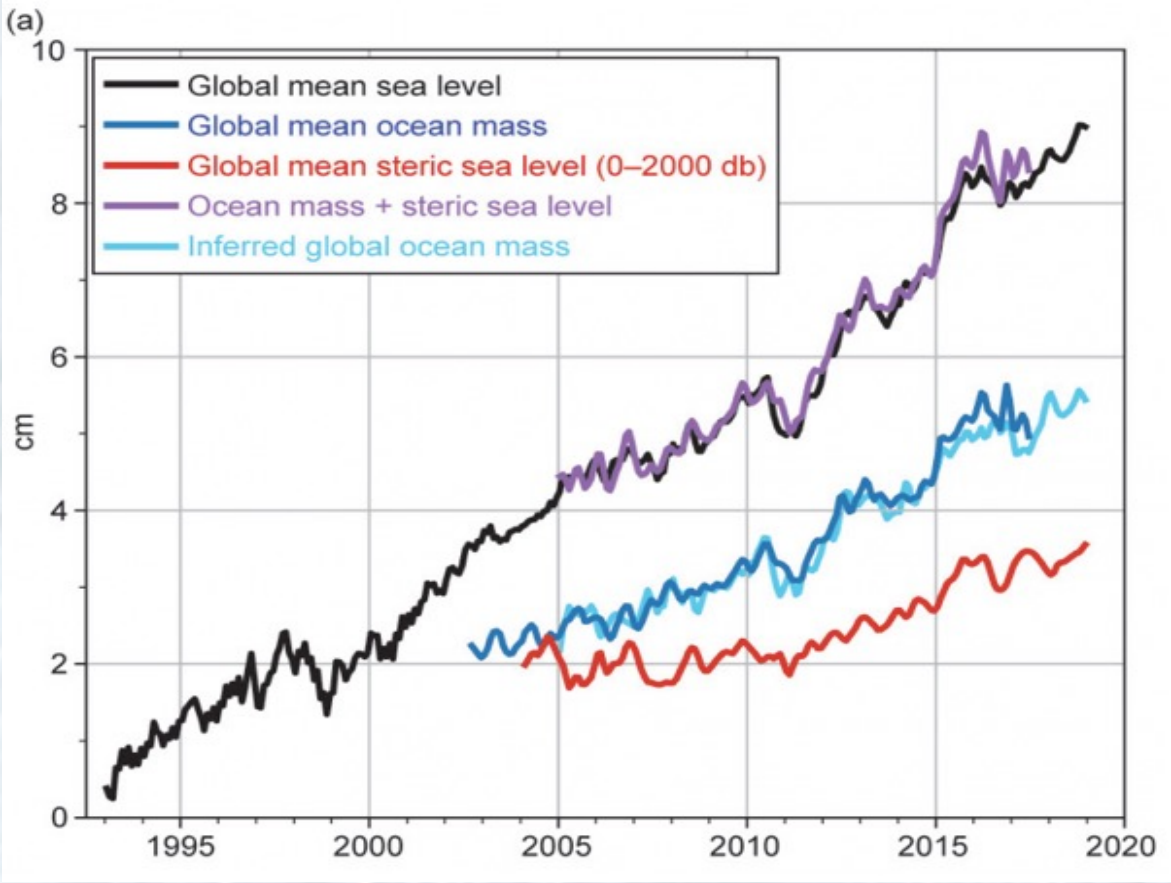


Image Source: Blunden and Arndt, 2019.

Steric Height Variations

$$\eta = -\frac{1}{\rho_0}\int_{\eta=-h}^{\eta=0} \Delta\rho(T,S)dz$$

→ Variations are caused by thermosteric and halosteric sea level changes
→ Global steric SLR mainly originates from oceanic heat uptake

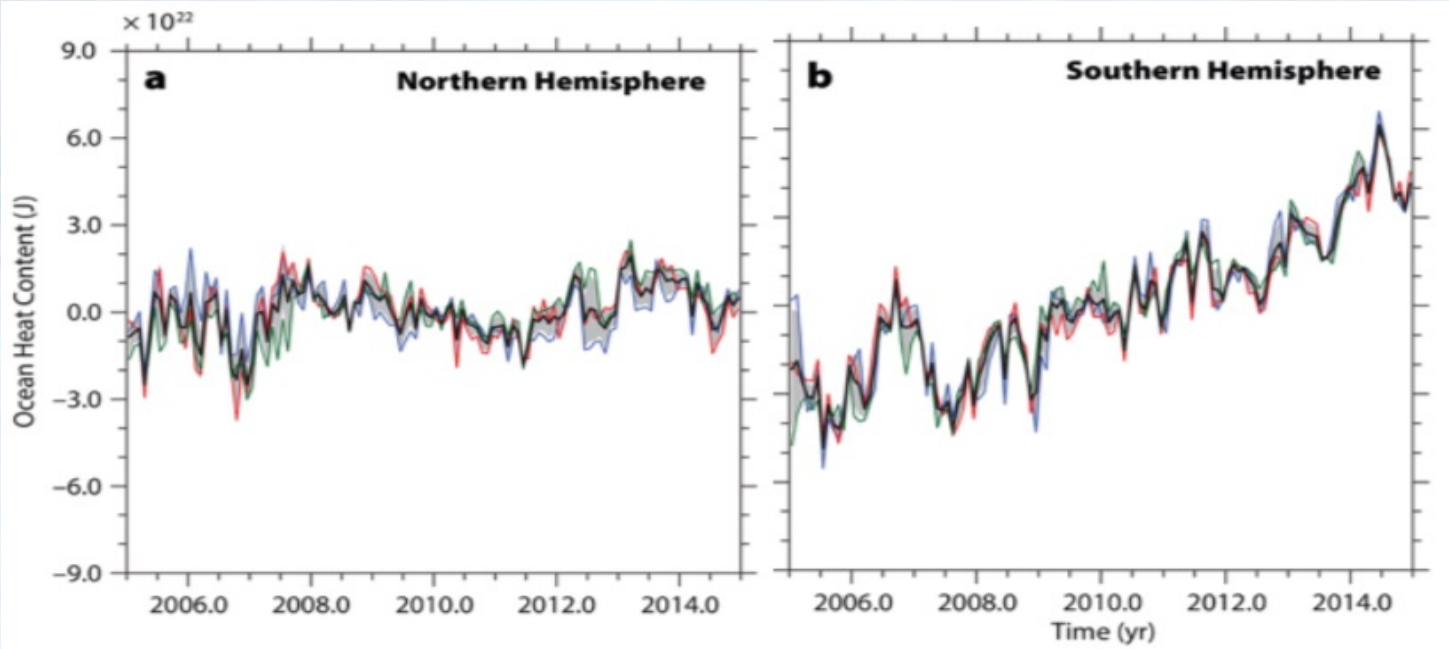
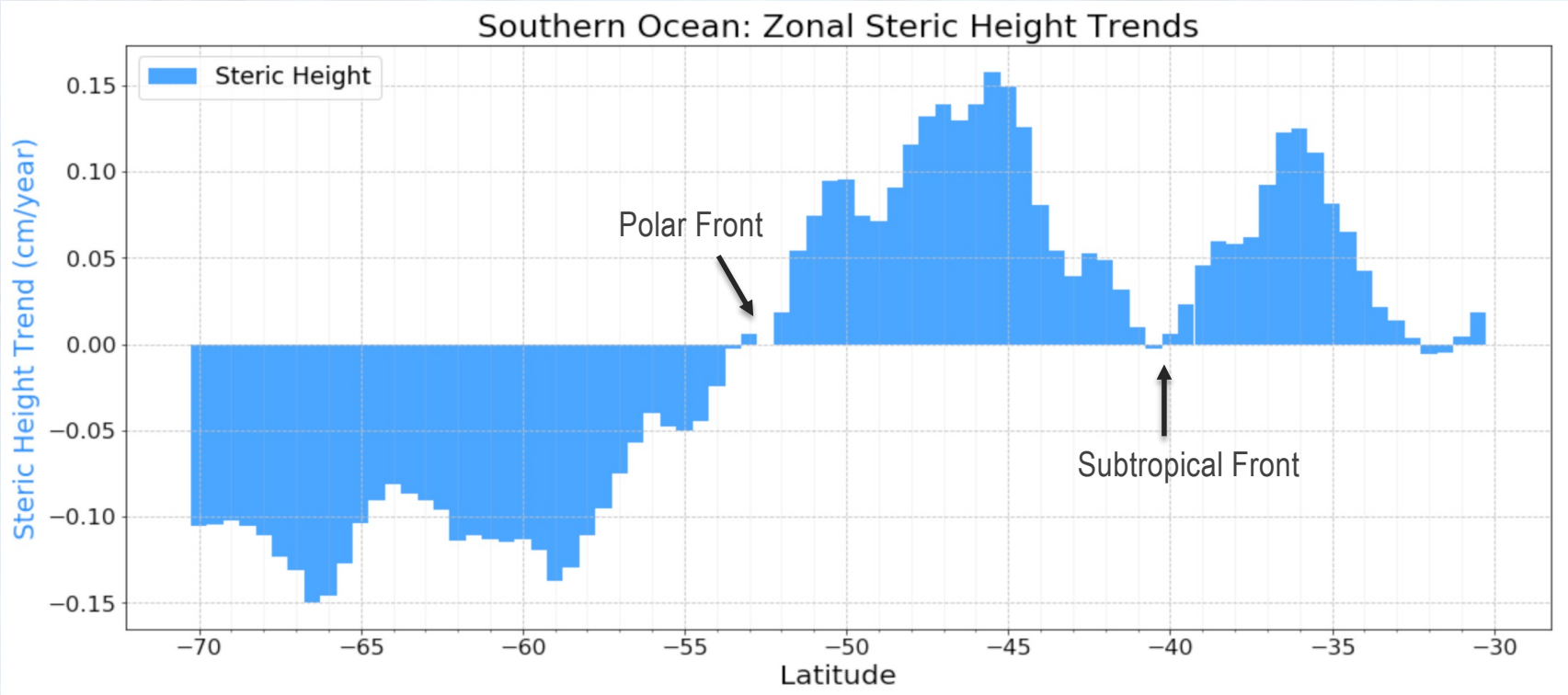


Image Source: Llovel, W., & Terray, L., 2016.

Objectives

Research Question:

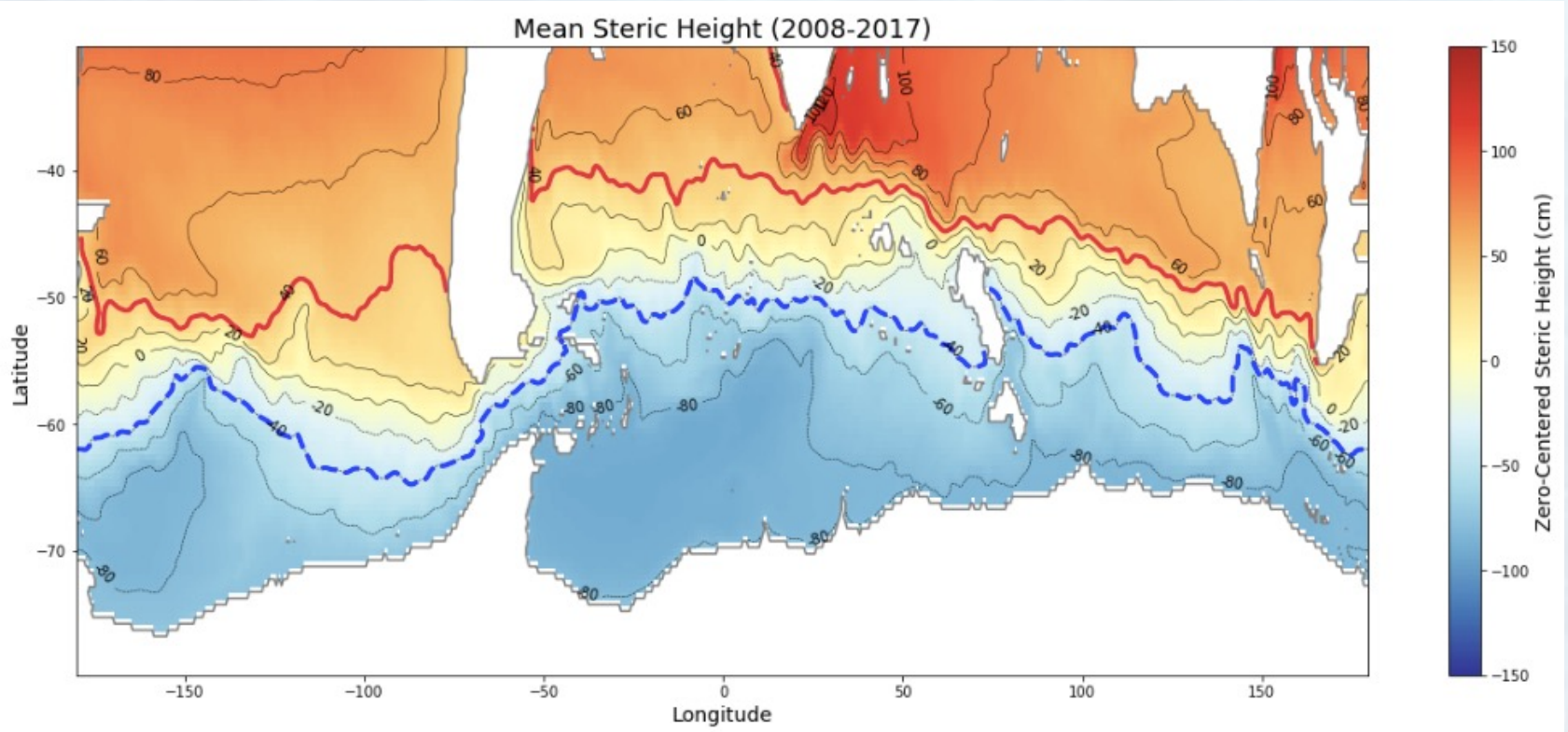
Where does temperature (T) and where does salinity (S) dominate steric sea level variability in the Southern Ocean? Why is steric height increasing north of the Polar Front (PF), and decreasing south of the PF?



Data

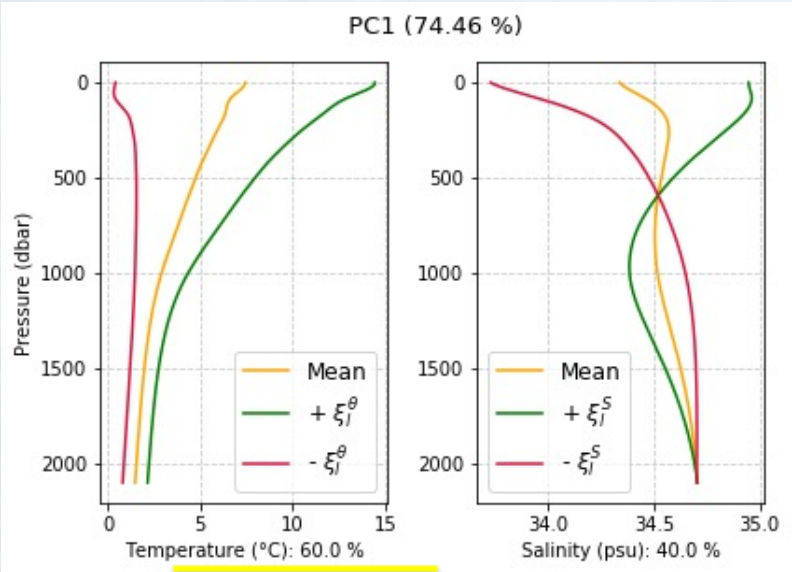
Data: GLORYS 031 Reanalysis (GREP)

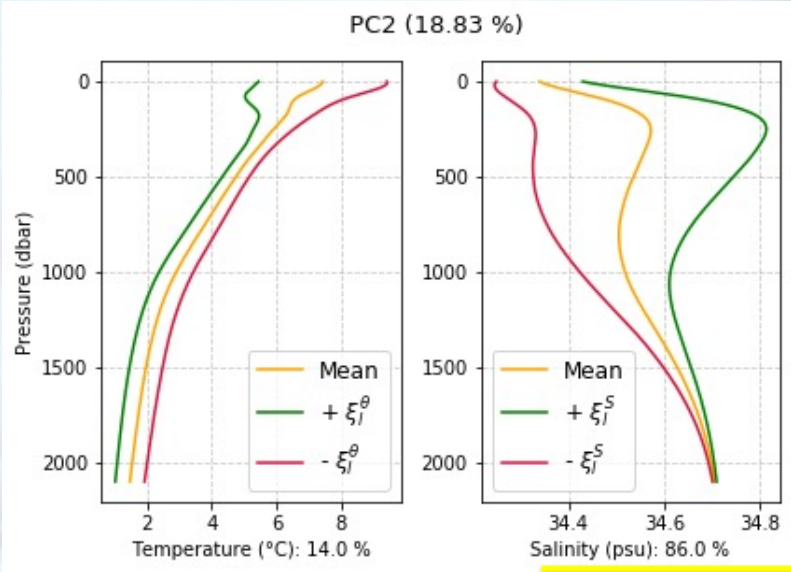
- Potential Temperature (θ) & Salinity (S) profiles until 2000 m
- Steric Height was calculated from the θ and S profiles:



Functional PCA

Definition of Modes: Effects of PC1 and PC2

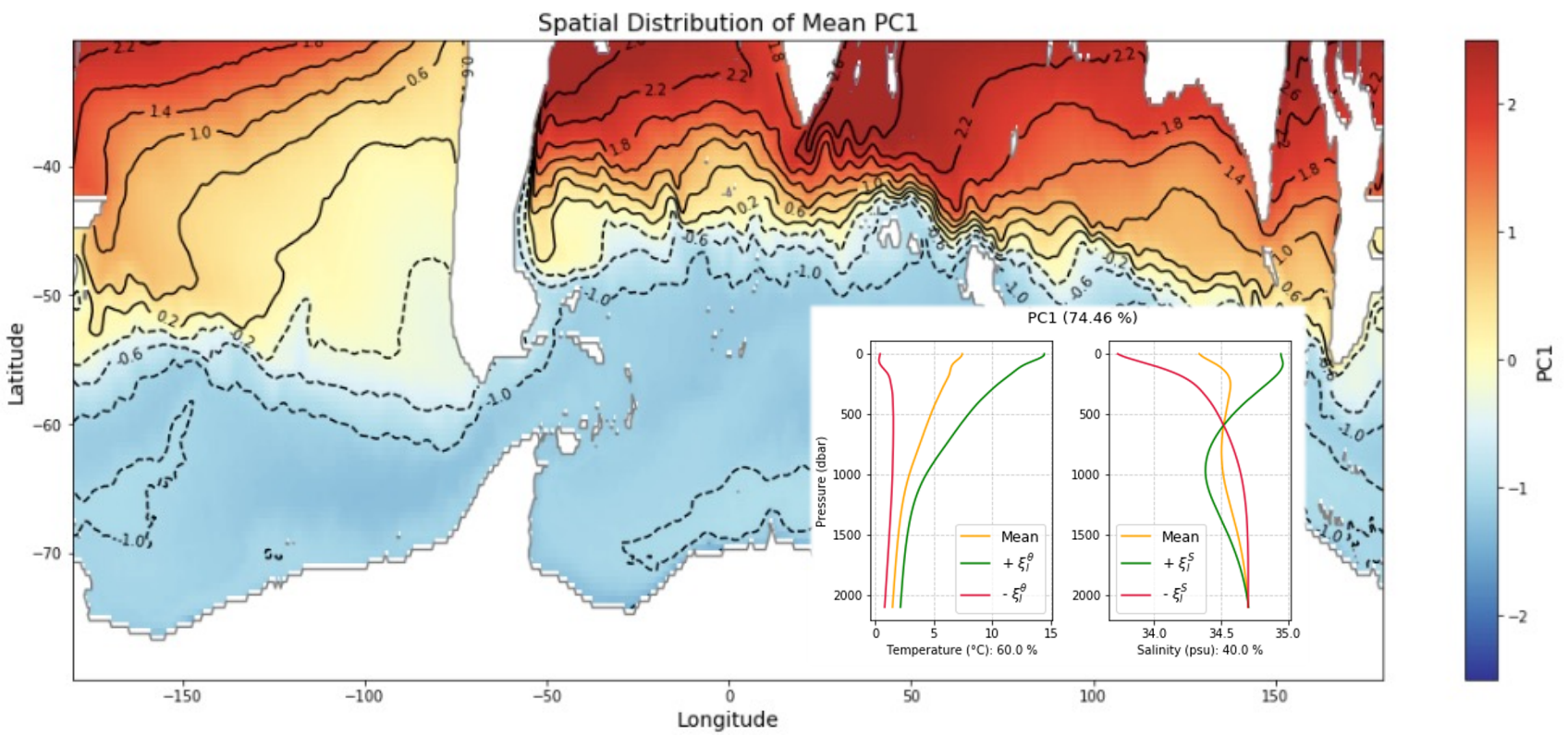




- → Temperature changes dominate PC1 variations & salinity changes dominate PC2 variations
- → Higher PC1 values indicate a warming of the water column
- → Higher PC2 values indicate a saltening of the water column

Mean Spatial Distribution

PC1

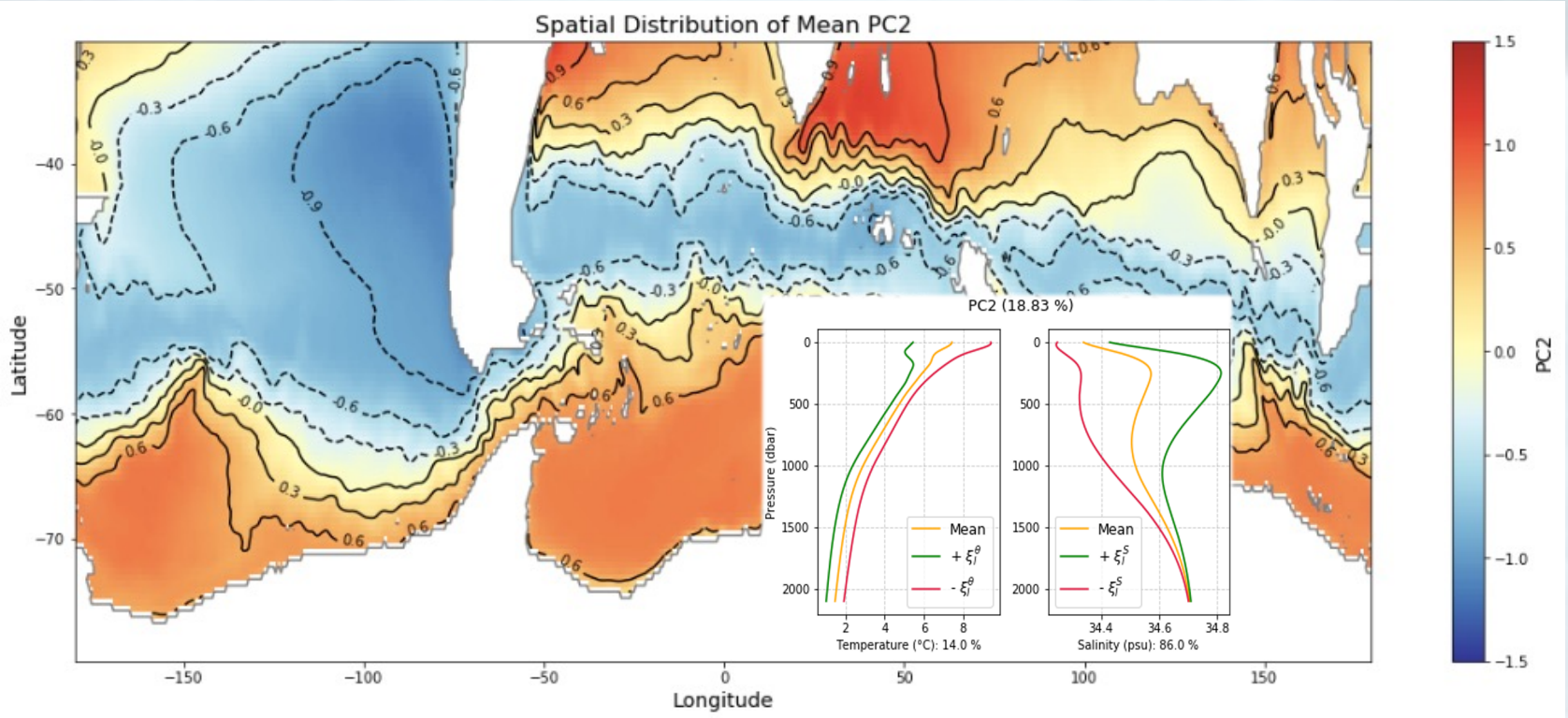


→ PC1 captures the temperature gradient from North to South

→ Higher PC1 values indicate a thermal expansion of the waters and therefore have a positive effect on steric height (slightly compensated by salinity)

Mean Spatial Distribution

PC2

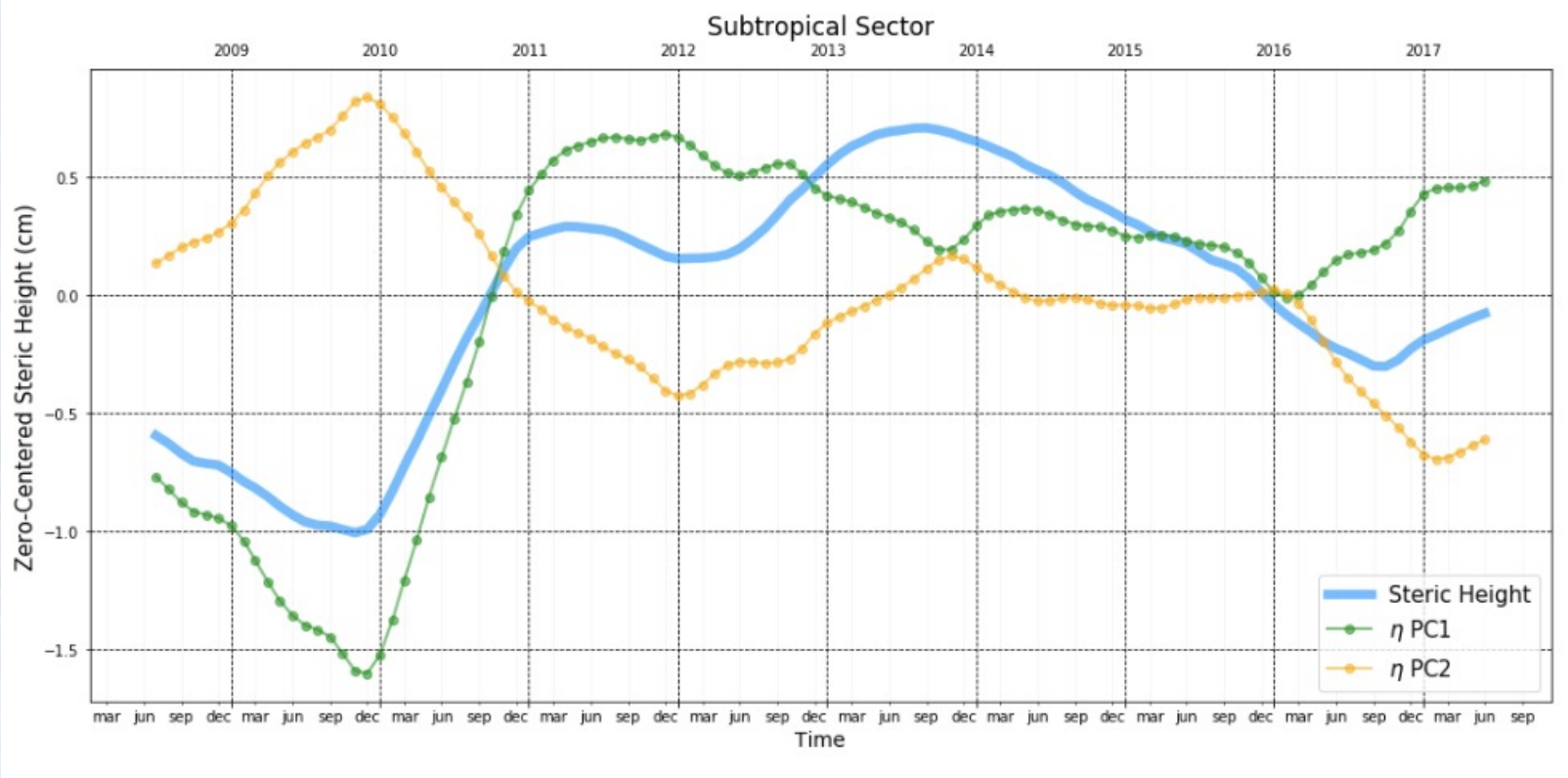


→ PC2 captures salinity in the Southern Ocean (fresh intermediate waters around the Antarctic Circumpolar Current and higher salinity north and south)

→ Higher PC2 values indicate a haline contraction and therefore have a negative effect on steric height

Time Series Analysis

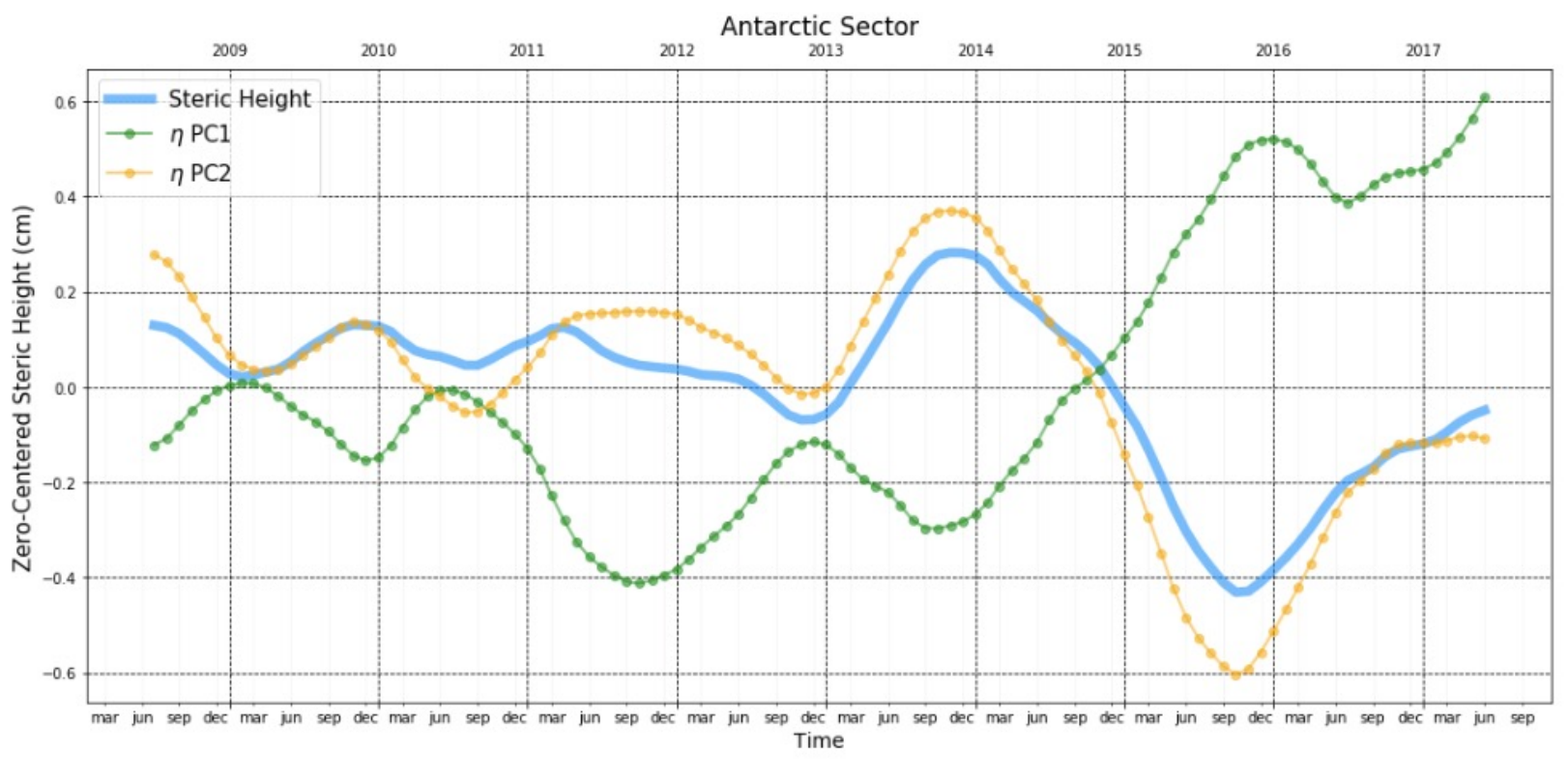
Steric Height as a Function of PC1 and PC2



→ In the subtropical sector, steric height η can be well approximated with the thermal mode PC1 (mainly temperature variations)

Time Series Analysis

Steric Height as a Function of PC1 and PC2



→ In the Antarctic sector, steric height η is better approximated with the haline mode PC2 (mainly salinity variations)

Conclusions

- → The variability of vertical thermohaline modes induces regional patterns in steric height trends in the Southern Ocean.
- → Steric height has risen north of the Polar Front and fallen south of it due to thermo- and halosteric changes.
- → Increasing temperatures have caused a significant steric SLR in the subtropical sector
- → Salinity increases since 2014 have driven negative steric height trends in the Antarctic sector of the Southern Ocean

References

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- **Data: E.U. Copernicus Marine Service Information. https://resources.marine.copernicus.eu/documents/PUM/CMEMS-GLO-PUM-001-031.pdf. 12/12/2020**