Meanders in the ACC shape the air-sea heat flux and water subduction in ACCESS-OM2

Felipe Vilela-Silva[a,c,d]; Nathan L. Bindoff[a,c,d,e]; Helen E. Phillips[a,c,d,e]; Steve R. Rintoul[b,c,d]; Max Nikurashin[a,c,d,e]

IMAS, UTas[a]; CSIRO[b] ; ARC CLEX[c] ; AAPP[d] ; ACEAS[e]. Corresponding author: Felipe, felipe.dasilva@utas.edu.au

Introduction and Methods

The ACC's standing meanders mark locations of strong poleward heat flux, strong EKE and contribute to the ACC's momentum balance (TNG14).

We use the monthly mean outputs from ACCESS-OM2-01 model (JRA55 forcing) from 1993 to 2018. We track the ACC fronts at each snapshot using the subsurface temperature that coincides with local transport maximum (as in Langlais et al., 2011).

The monthly subduction of water below the permanent thermocline

$$S = -(\vec{U} \cdot \nabla(MLD) + w) \text{ (Eq. 1)}$$

is obtained with the lateral induction of fluid through the sloping base of the winter mixed layer and the vertical velocity at the same level (Marshall et al., 1993). Water subduction occurs if S > 0. The S determines the rate that the surface waters enters in the ocean interior.

References

TNG14: Thompson, A. F. and Naveira Garabato, A. C. (2014). Equilibration of the Antarctic Circumpolar Current by standing meanders. JPO, 44(7):1811–1828.

Marshall et al. (1993). Inferring the subduction rate and period over the North Atlantic. JPO, 23(7), 1315–1329.

Langlais, C. et al. (2011). Variability and mesoscale activity of the Southern Ocean fronts: Identification of a circumpolar coordinate system. OM, 39(1-2):79–96.

SR07: Sokolov, S. and Rintoul, S. R. (2007). Multiple jets of the Antarctic Circumpolar Current south of Australia. JPO, 37(5):1394–1412.

Phillips, H. E., & Bindoff, N. L. (2014). On the nonequivalent barotropic structure of the Antarctic Circumpolar Current: An observational perspective. JGR: Oceans, 119(8), 5221–5243.

Meander Length Variability and Composites

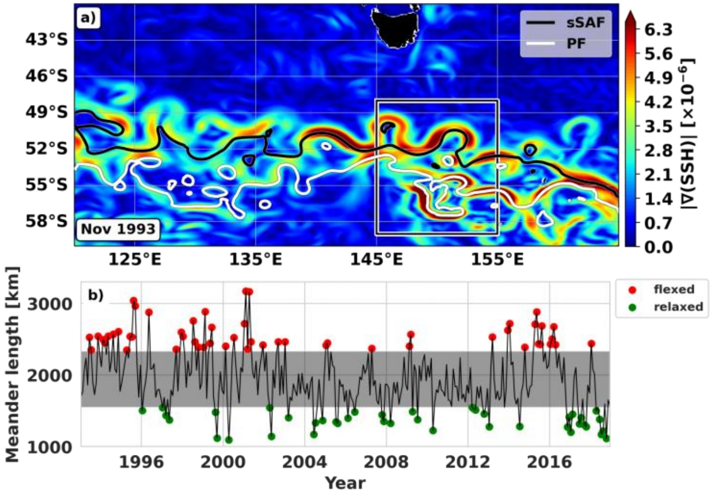

Fig. 1: The ACC fronts at the Macquarie Meander (black rectangle). a) snapshot of SSH gradient overlayed by the Polar Front (PF in white) and south Subantarctic Front (sSAF in black) in Nov 1993. b) Time series of the PF length between 145°E and 155°E . The grey shaded area delimits the values out of the flexed (red) and relaxed (green) regimes.

The frontal tracking algorithm identifies the PF and sSAF as the 2.9°C isotherm at 282 m depth and 5.3°C isotherm at 383 m depth, respectively. We follow SR07 to test the accuracy of these isotherms to represent the fronts (i.e., they lie within regions of high SSH gradient; Fig. 1a).

To examine the changes in water properties caused by the meander, we explore **composites of "flexed" and "relaxed" meander regimes.** The composites are based on the mean (1938 km) +\- 1*std (393 km) of meander length time series (Fig. 1b). The local surface net heat flux, mixed layer depth (MLD), vertical velocities at the MLD and water subduction follows the shape of the meander in both composites (the relaxed composite is shown in Fig. 2).

- The **trough of the meander hosts warming of the surface ocean** (positive heat flux) and cooling occurs at the crest (Fig. 2a). The heat loss at the crest results in buoyancy loss (or density gain) that causes the **deepening of the MLD at the crest** (Fig. 2b);
  - The changes of the MLD shape the lateral induction of fluid (Eq. 1);
- As observed in the meander at the Kerguelen Plateau (Phillips and Bindoff, 2014), **the magnitude of the vertical velocities are enhanced at the Macquarie Meander** (Fig. 2c).
- The coupling between the enhanced lateral induction and vertical velocities result in **water subduction reaching the PF waters at the Macquarie Meander** (Fig. 2d).

Conclusions

i. Standing meanders shape regions of heat gain and loss by the ocean;
ii. The air-sea net heat fluxes at meanders modulate the ML thickness;
iii. Water subduction terms increase in magnitude at meanders.
- Important role for water mass formation and vertical flux of nutrients.

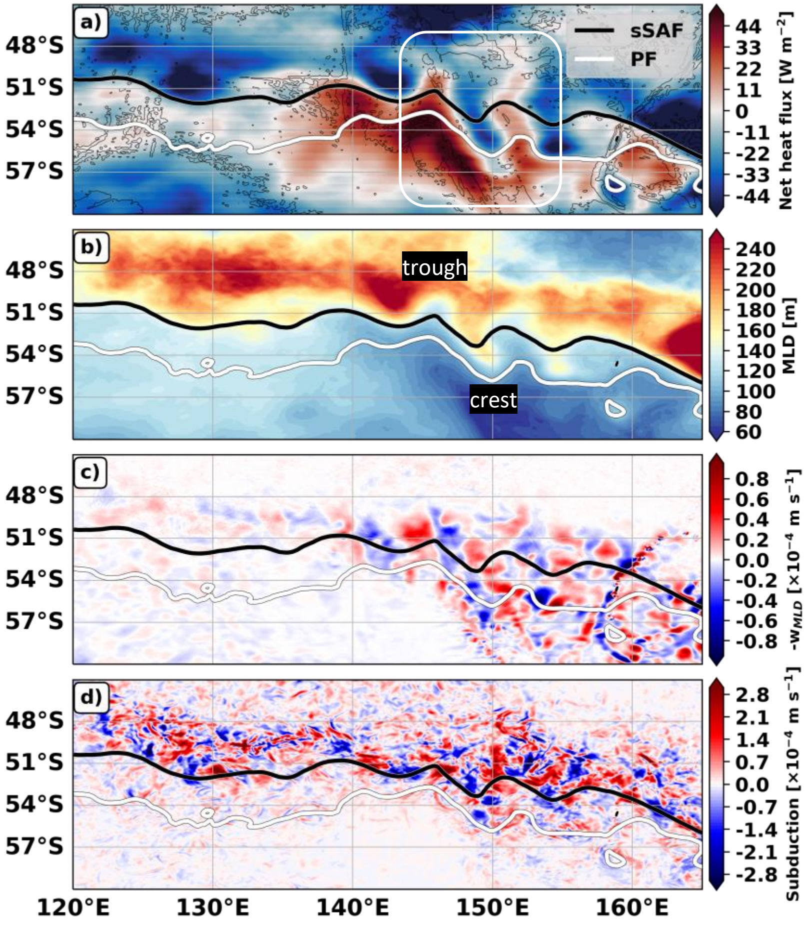

Fig. 2: The relaxed composites for a) surface net heat flux, b) MLD, c) vertical velocities at the MLD, and d) water subduction. White and black contours represent the PF and sSAF, respectively.