Using coastal altimetry to improve Meridional Overturning Circulation estimates in the South Atlantic

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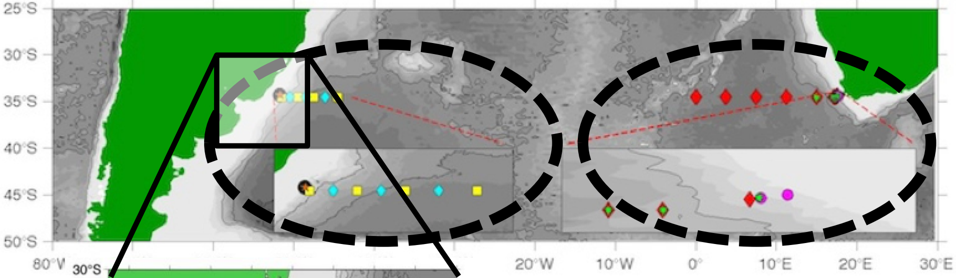
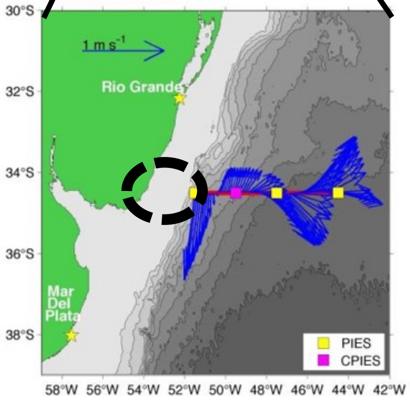
Motivation

- **South Atlantic:**
  - **Nexus** for **water masses formed remotely**
  - Only basin where **heat is transported equatorward**
  - South Atlantic MOC Basin-wide Array (SAMBA, 34.5^{o}S) since **2009**



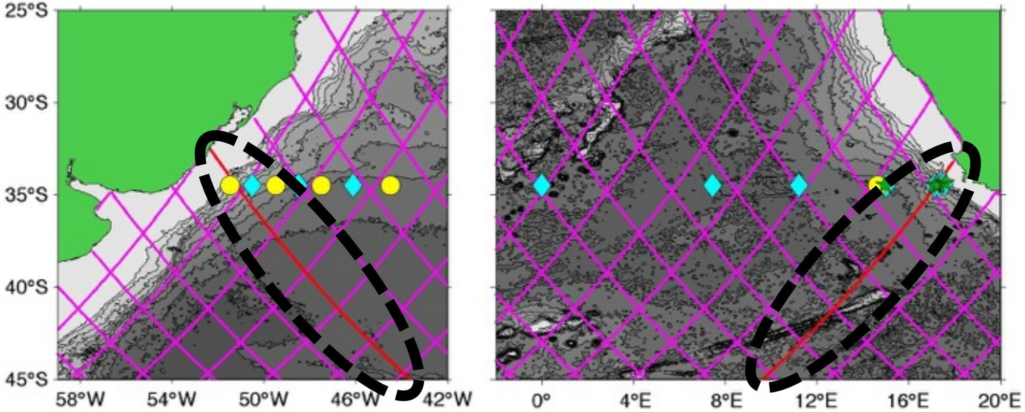
- SAMBA: mostly composed of **PIES**
- **Total MOC transport**: **14.7 Sv** , with 8.6 Sv std dev. (Meinen et al., 2018)



- **Limitations** of the SAMBA array:
  - Most inshore moorings at ~1300 m depth
  - No continuous measurements inshore
- Currently, **transport inshore** of the moorings estimated using average value from **model simulations**
- Inshore transport: variability thought to be **~3 to 4 Sv**

Methodology and data

- We proposed to use **coastal altimetry** to **fill the gap**

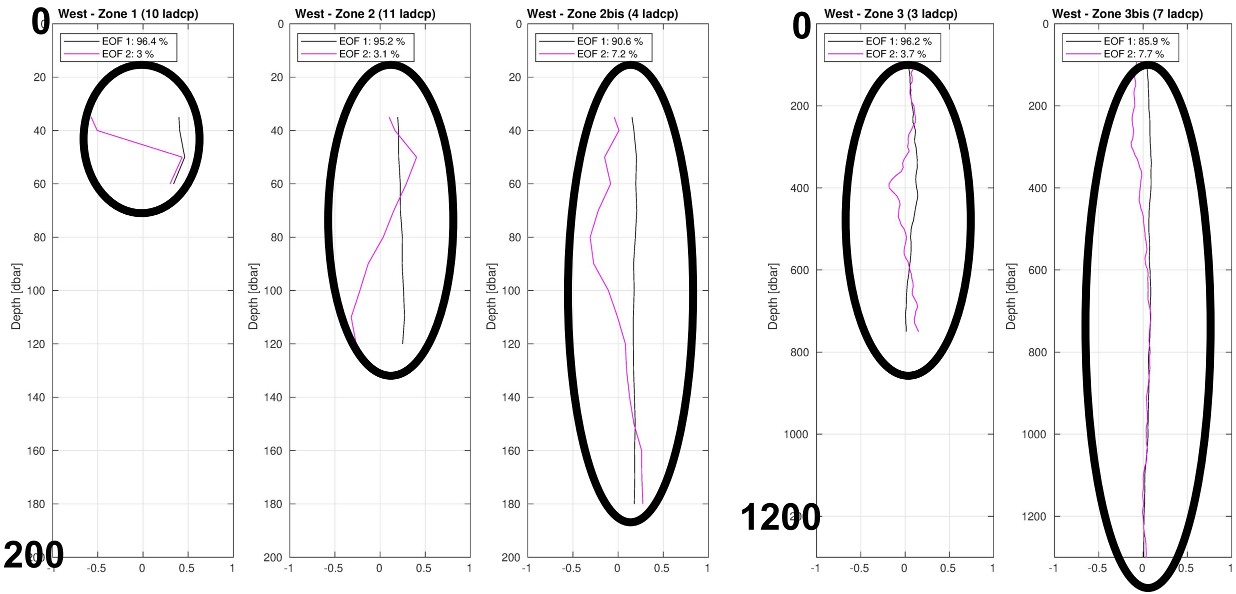


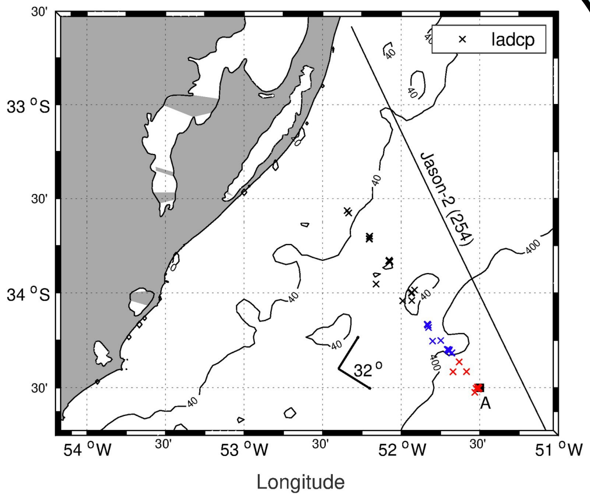
- Data from the **reference TOPEX/Poseidon-Jason tracks**
- Along-track **Sea Level Anomaly**, then **Geostrophic Current**, which is perpendicular to the satellite track

- *In situ* observations to estimate mean structure of current on shelf => Integrate Geostrophic Current vertically => **Geostrophic Transport** across the track
- Ageostrophic component: **Ekman transport** from atmospheric product
- Altimetry data: CTOH (Birol et al., 2017), ALES (Passaro et al., 2018)
- In situ data: PIES, lowered ADCP sections, moored ADCP

Along South America

- **45** Lowered ADCP profiles in-shore of SAMBA



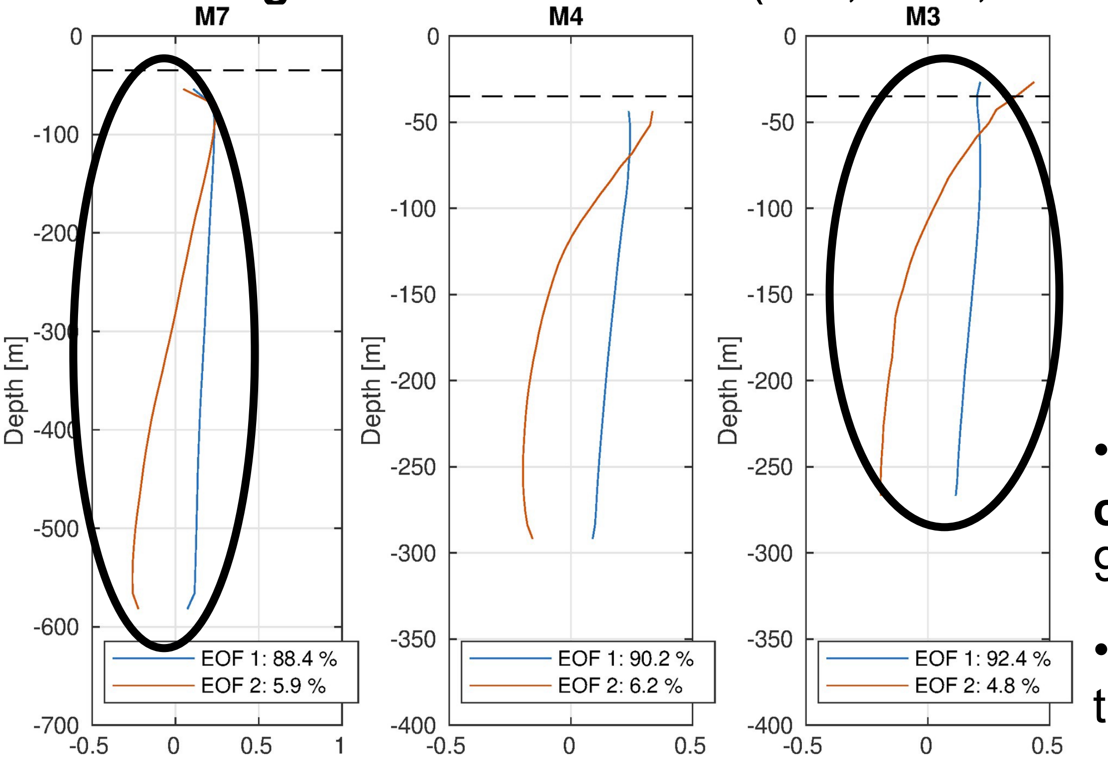


EOF of the along shore profiles in 5 zones (Black: EOF1, magenta: EOF2)

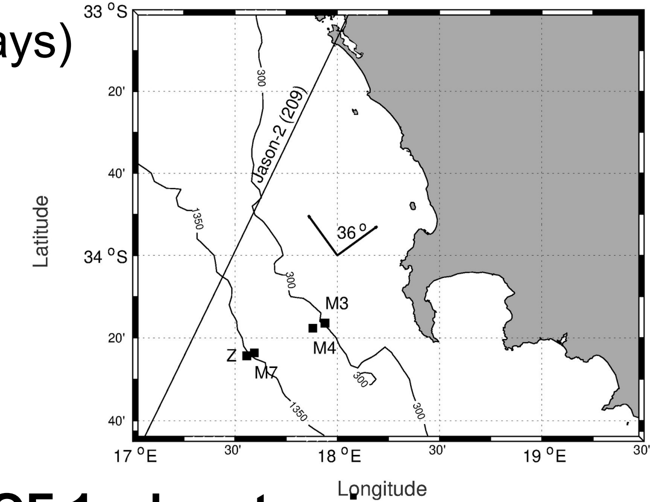
- **EOF 1 = barotropic component, dominant** (96.4%, 95.2%, 90.6%, 96.2%, 85.9%)
- Inshore of 400m: **near constant on the vertical**; consistent with Lago et al. (2019)
- Offshore of 400m: **equivalent-barotropic** (same direction, but magnitude changes with depth); here goes to **0 near the bottom**

Along South Africa

- **3 moorings** in-shore of SAMBA (153, 1192, 1476 days)



EOF decomposition of the along-shore current at each mooring



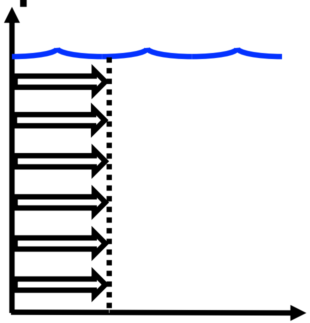
- **EOF 1 = barotropic component, dominant** (88.4%, 90.2%, 92.4%)
- **Shelf** (M3): **near constant** on the vertical
- **Shelf break** (M7): **decreases with depth**

Estimation of transport

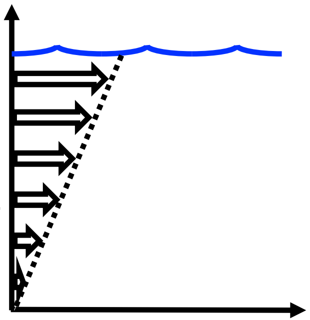
⇒ Based on the analysis of in situ data, the current can be considered as:

- **Constant on the vertical, between the coast and the 400m isobath**
- **Equivalent-barotropic down to 0 near the bottom beyond the 400m isobath**

• Between the coast and the 400 m isobath:



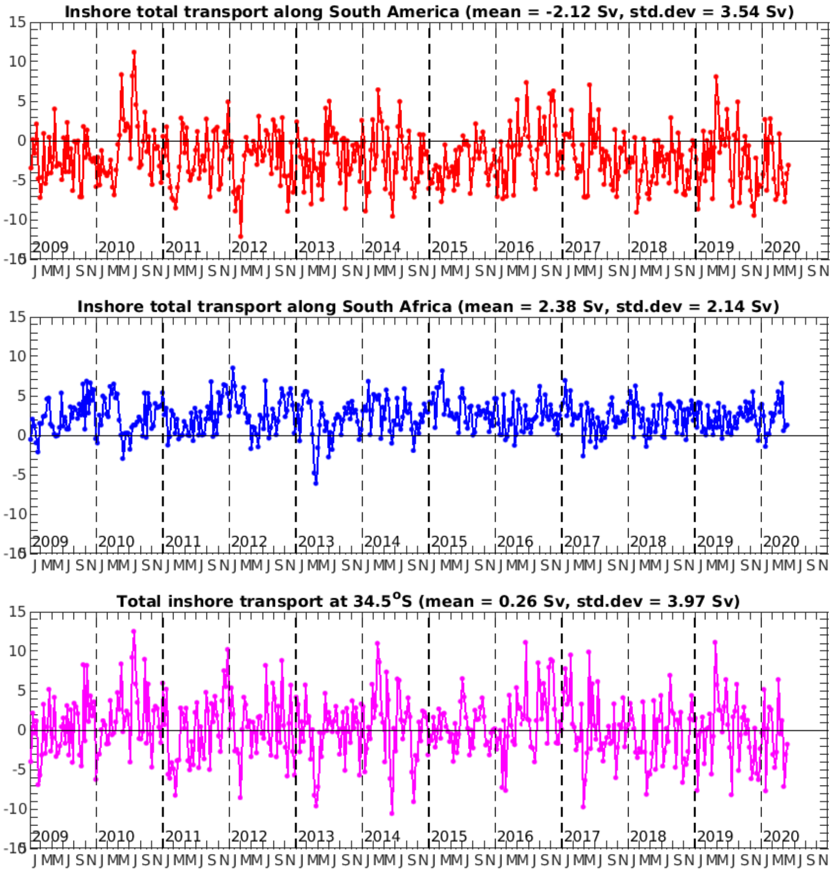
• Between the 400 m isobath and closest SAMBA mooring:



• We then **estimate the geostrophic transport** on **each side of the SAMBA array** by integrating the current:

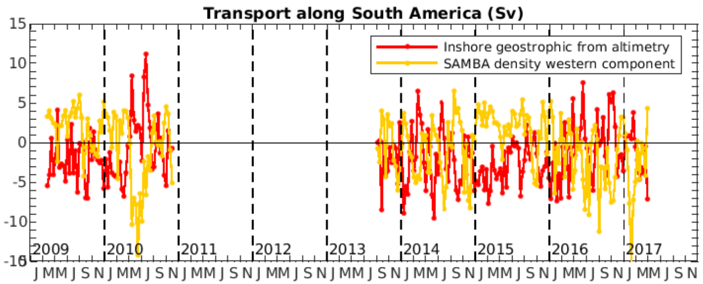
- **Vertically**, using these 2 reference profiles inshore and offshore of the 400m isobath
- **Horizontally** between the coast and the isobath of the most inshore SAMBA mooring

Estimation of transport



- **Along South America**, the **transport** is mostly **southward** (Brazil Current), with large variability and frequent reversals
- **Along South Africa**, the transport is mostly **northward** (Benguela Current), with smaller variability and few reversals
- **Mean transport estimates** on each side largely **compensate each other**
- The **total inshore transport** has **non negligible variability** (~4 Sv std dev)
- **Total inshore transport** is more **correlated** with the transport along **South America** (corr. 0.84) than along South Africa (corr. 0.46)

Estimation of transport

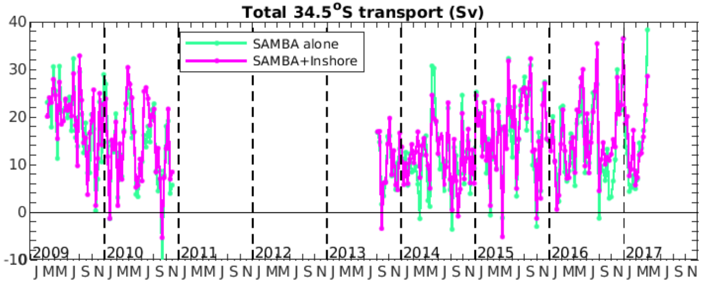


• **Along South America**, the **inshore transport** is **anticorrelated** (-0.53) with the **baroclinic component** on the **western side** of SAMBA (estimated by Meinen et al., 2018)

• This is likely associated with **changes in Brazil Current position**, which is only partially sampled by the SAMBA array

• Similarly, **along South Africa**, the **inshore transport** is also **anticorrelated** (-0.47) with the **baroclinic component** on the **eastern side** of SAMBA

• As a result, **adding the inshore transport** time series **to SAMBA** estimates leads to a **reduction in the total variability**, from 8.6 to 8.2 Sv in standard deviation



Conclusions

- We found a **way to estimate the meridional transport inshore** of the SAMBA array at 34.5°S using **coastal altimetry** and **in situ data**
- Available current observations suggest that **currents inshore of the array are mostly barotropic** (fully barotropic on the shelf and upper slope, equivalent barotropic further down the slope)
- Using these profiles, we estimated the **mean meridional transport inshore of the SAMBA array to be close to 0**
- Although the **inshore transport** has **significant variability**, it is partially **anticorrelated with the baroclinic components** estimated **from SAMBA**, so that **their inclusion leads to a reduction in total transport variability**
- The **altimetry-derived inshore estimates** allow to **better account for** the **boundary components** of the 34.5°S transport