AN ASSESSMENT OF THE BRAZIL CURRENT STRUCTURE AND VARIABILITY BASED ON OCEAN PREDICTION SYSTEMS AND IN SITU MEASUREMENTS ALONG THE NOAA HIGH-DENSITY XBT TRANSECT

Samantha B. O. Cruz[1], Mauro Cirano[1], Maurício M. Mata[2], Marlos Goes[3,4], Gustavo Goni[3], Afonso M. Paiva[1], Ivenis I. C. Pita[1].

[1]Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil; [2]Federal University of Rio Grande (FURG), Rio Grande, Brazil; [3]National Oceanic and Atmospheric Administration/Atlantic Oceanographic and Meteorological Laboratory (NOAA/AOML), Miami, USA; [4]Cooperative Institute for Marine and Atmospheric Studies (CIMAS), University of Miami, Miami, USA

Introduction

The Brazil Current (BC) is the Western Boundary Current that closes the South Atlantic Subtropical Gyre. As the BC flows southward along the Brazilian continental margin, it shows a very distinct vertical structure and mesoscale activity. Between 20° S and 28°S, the BC can be described as a warm and saline southward flow that ranges from the surface to depths of 400–550 m, increasing its transport by approximately 1.6 Sv per degree of latitude, from 19°S to 32°S. Most of the previous studies at BC were typically limited in terms of temporal coverage, and lack of spatial cross-flow resolution. This gap can now be filled with the NOAA AX97 High Density XBT transect at ~22°S (Fig. 1), with bimonthly sampling since 2004, which is one of the longest sustained monitoring system of the BC. The main goal of this work is to assess the structure, location and variability of the BC in eddy resolving Ocean Forecasting and Analysis Systems (OFAS) in comparison with the AX97 data.

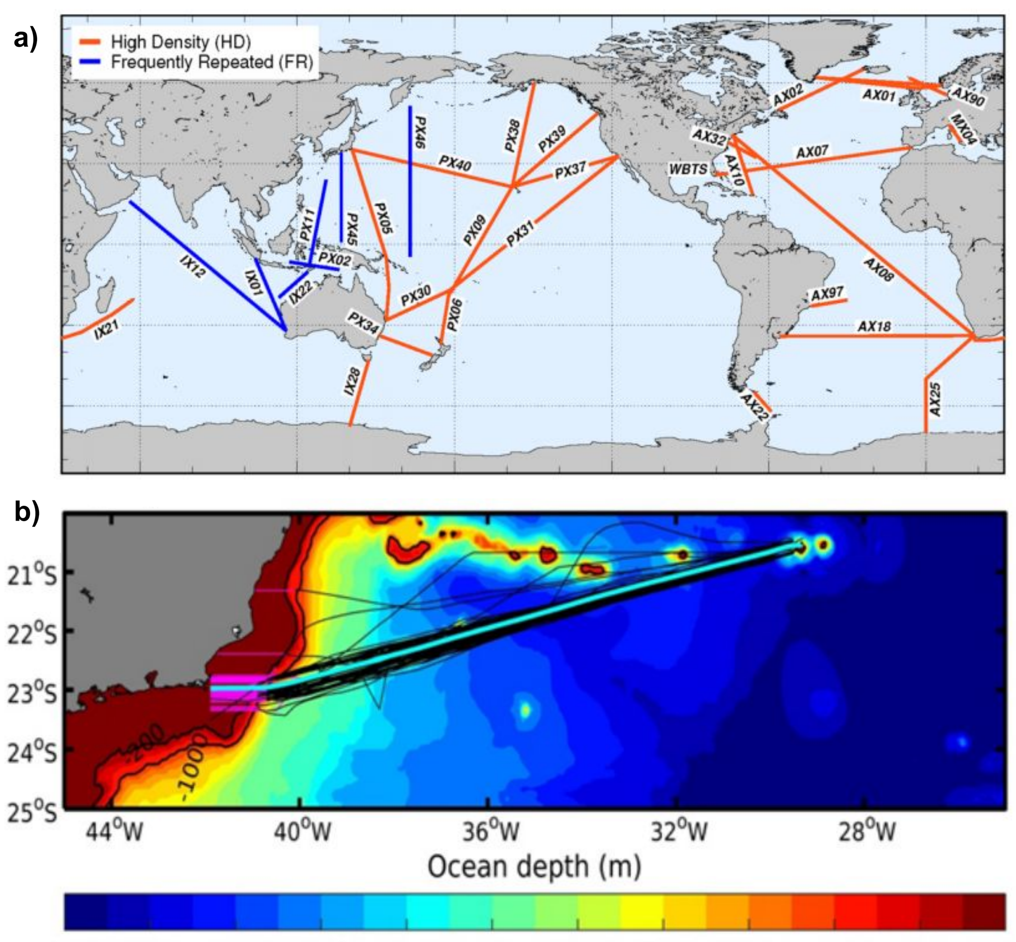


Figure 1: (a) Map of XBTs transects over the world (b) Zoom over the AX97 region showing the AX97 sections overlaid on the contours of the local bathymetry (m).

Ocean Forecasting and Analysis Systems - OFAS

OFAS are increasingly being used for ocean, weather and ecosystems forecast along the Brazilian coast. Given the importance of the BC variability for these applications, it is paramount to assess how realistic these models are in the region. OFAS, however, face several challenges to represent the BC at this latitude, because of the strong interaction of the flow with bathymetric features, coastal upwelling, eddy variability and recirculation gyres. In this work, the XBT data are compared against two OFAS datasets: i) the **HYCOM/NCODA** GLBu0.08 reanalysis experiments 19.0 and 19.1, from October 2nd 1992 to December 31th 2012 and GLBu0.08 analysis experiments 90.9, 91.0, 91.1 and 91.2, from January 1st 2013 to November 20th 2018 and ii) **Mercator** GLORYS12V1 physics reanalysis 001_030 from January 1st 1993 to December 26th 2017.

Brazil Current geostrophic velocity

To estimate geostrophic velocities along the AX97 XBT transect, the relative dynamic height is calculated from the temperature profiles and updated salinity estimates, assuming a reference level at z = 500 m, which is approximately the interface between the Central and Intermediate waters near the σ_θ = 26.8 kg/m³ isopycnal surface. The absolute dynamic height (DH(z)) is calculated by imposing at the reference depth the respective Argo-based monthly climatology value of absolute dynamic topography (e.g., Yu et al., 2006). Finally, absolute geostrophic velocities from the AX97 data are derived from DH(z) using the thermal wind relation. Fig. 2 shows the comparison between the mean velocity of BC derived from XBT data and based on **HYCOM/NCODA** and **Mercator** at the same geographic area, with the associated standard deviation for each case.

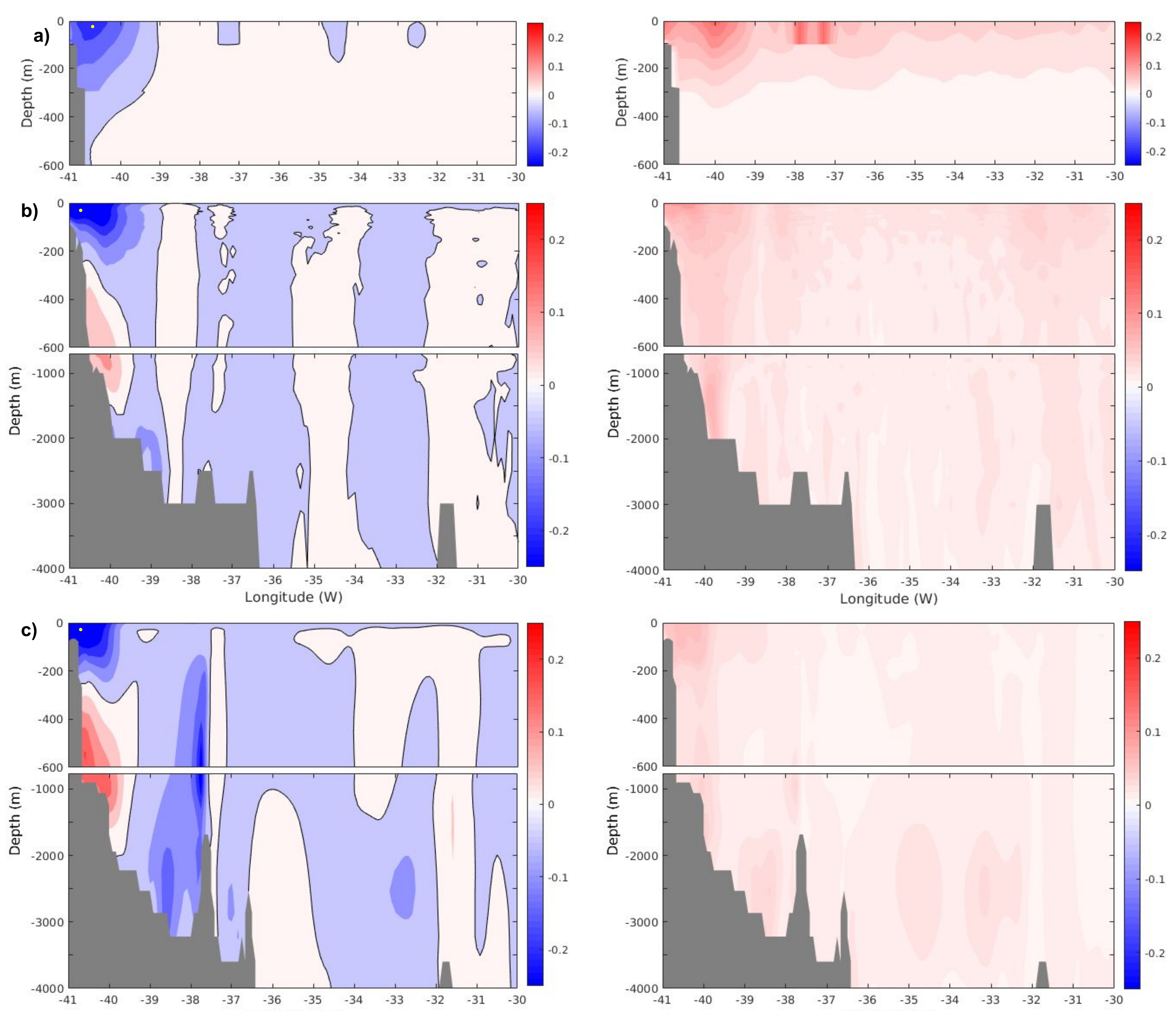


Figure 2: Mean velocity (left) and associated variability (right) for the a) NOAA AX97 High Density XBT transect; b) **HYCOM/NCODA**; c) **Mercator**. The yellow points indicate the location of the maximum mean velocity of the BC.

Brazil Current volume transport

Using the methodology descripted in Goes et al (2019), the BC volume transport was estimated for the AX97 transect and the two OFAS. The absolute geostrophic BC transport estimated for the AX97 XBT data is calculated by integrating the cross-section velocities in the top 500 m from 41°W and the location of the minimum cumulative transport between 41°W and 36°W. After the eastern limit of the BC is found, the transport is calculated between these two locations taking into account only the southward velocities, which represent the BC flow. The same methodology was adopted for **HYCOM/NCODA** and **Mercator**.

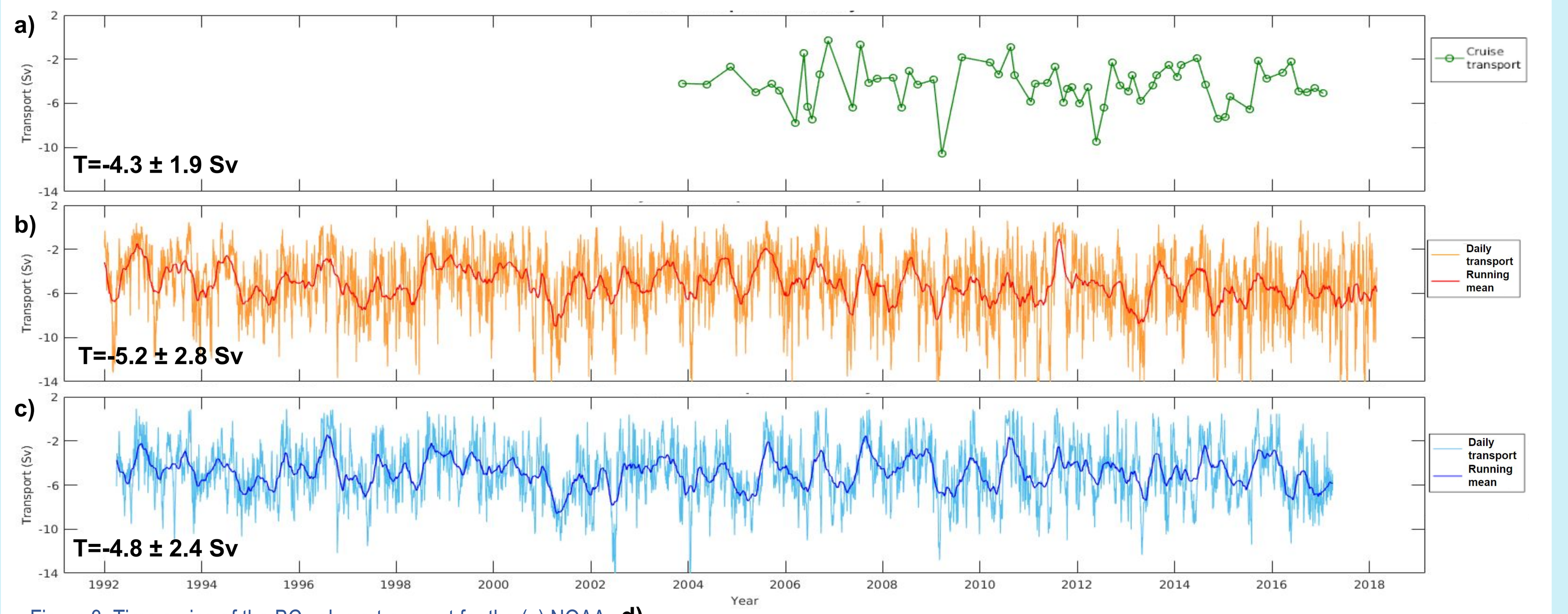
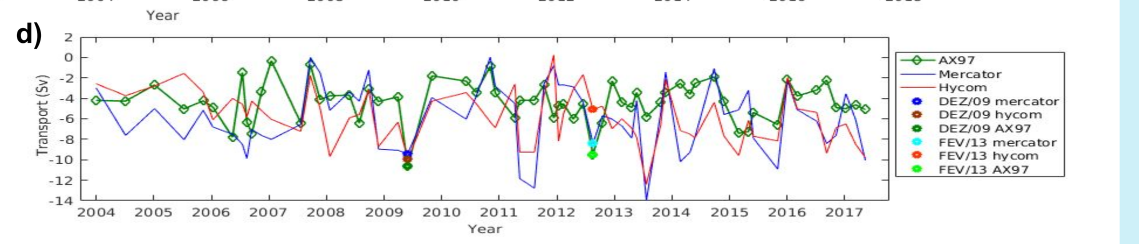


Figure 3: Time series of the BC volume transport for the (a) NOAA AX97 High Density XBT transect; (b) **HYCOM/NCODA**; and (c) **Mercator**. The darker color in (b) and (c) represents a 90 day running mean. (d) Same as a, but with HYCOM/NCODA and Mercator volume transport overlayed and calculated only using the AX97 cruise dates. The dates of two case studies are indicated.



Case studies

Analysing some specific cases we can compare the results derived from a given AX97 cruise with the outputs obtained from the OFAS for the same period. For that purpose, we have chosen the cruises of December 2009 and February 2013 which are indicated in Fig. 3. The associated velocity during these two case studies are presented in Fig. 4.

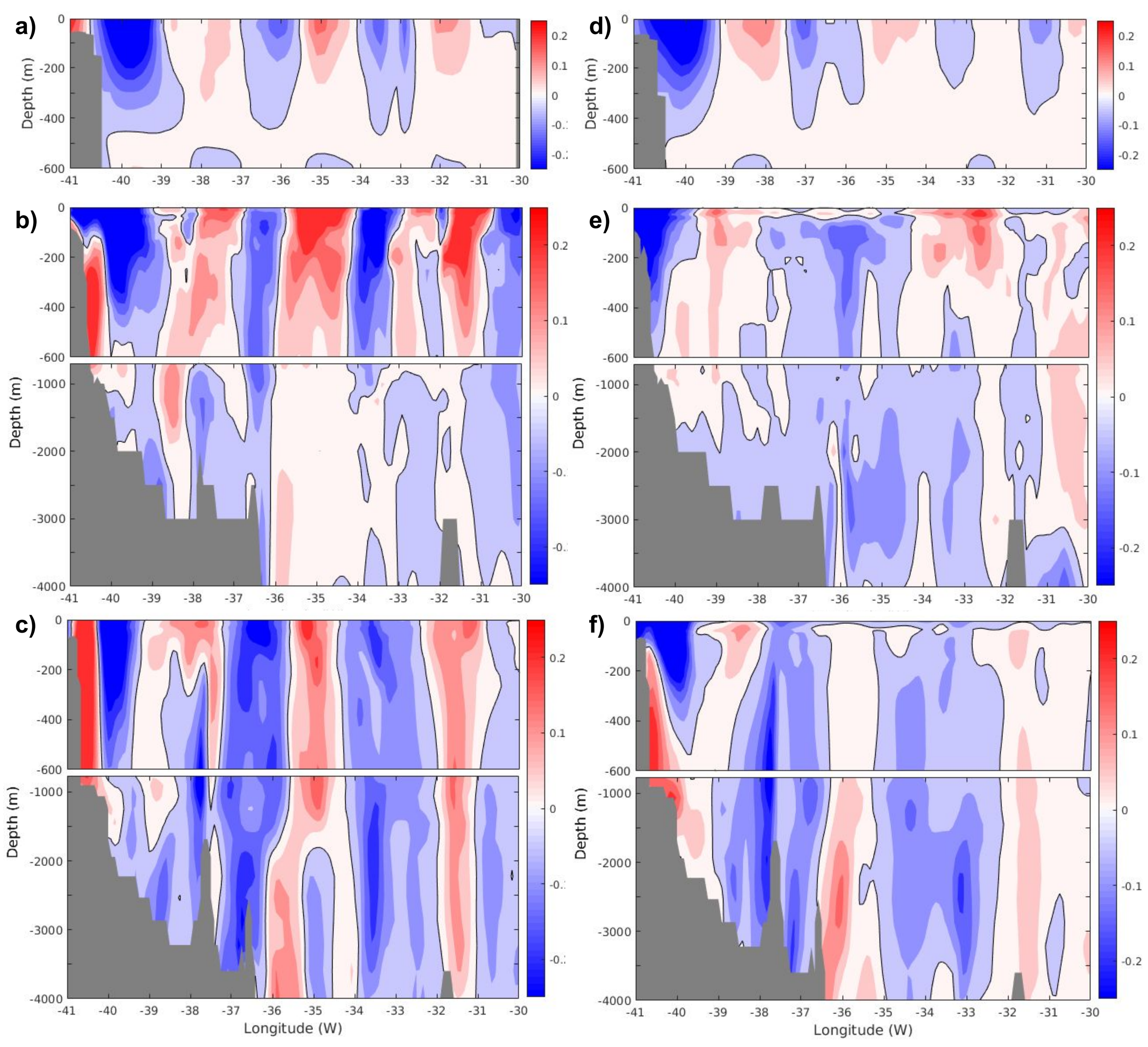


Figure 4: Velocity distribution during the December 2009 cruise period for the a) NOAA AX97 High Density XBT transect. b) HYCOM/NCODA, c)Mercator and d-f) The same, but for the February 2013 cruise period.

Results and conclusion

After analysing the BC main structure and assessing the OFAS against the observations along the NOAA AX97 XBT transect we concluded that the two OFAS presented a higher mean transport and also a higher variability of the BC when compared with the observations. In addition, higher maximum mean core velocities in the southward direction were also captured by the OFAS. When the OFAS BC transport are assessed only during the cruise dates no significant changes are observed, which is an excellent indication that the AX97 sampling period is enough to capture the BC mean transport and associated variability.

	AX97	HYCOM	MERCATOR
Total serie transport (Sv)	-	-5.2 ± 2.8	-4.8 ± 2.4
Maximum velocity (m/s)	-	-0.37 ± 0.11	-0.44 ± 0.06
Cruise dates transport (Sv)	-4.3 ± 1.9	-4.7 ± 2.9	-4.9 ± 3.3
Cruise dates maximum velocity (m/s)	-0.18 ± 0.12	-0.33 ± 0.29	-0.41 ± 0.26

Table 1: Mean transport and standard deviation of the BC for the NOAA AX97 transect, HYCOM/NCODA and Mercator considering the whole time series and only the cruise dates. The maximum mean core velocity in southward direction and its associated variability is also indicated in both cases.

Future perspectives

Our goal is to use the framework of GODAE Oceanview to assess and evaluate all available forecasts and reanalysis for the AX97 region. These studies are important to infer OFAS inconsistencies and to improve the observational sampling, both issues are part of a long-term strategy to improve the knowledge about ocean dynamics and impacts in the BC region.

Relevant references

Goes, M., Cirano, M., Mata, M.M., Majumder, S. (2019). Long-term monitoring of the Brazil Current transport at 22°S from XBT and altimetry data: seasonal, interannual and extreme variability. Journal of Geophysical Research - Oceans (accepted)

Goni et al. (2019). More than 50 years of successful continuous temperature section measurements by the Global Expendable Bathythermograph Network, its integrability, societal benefits, and future. Frontiers in Marine Science. (under revision)

Lima, M.O., Cirano, M., Mata, M.M., Goes, M., Goni, G., and Baringer, M. O. (2016). An assessment of the Brazil Current baroclinic structure and variability near 22° S in Distinct Ocean Forecasting and Analysis Systems, Ocean Dynamics. Ocean Dynamics, 66: 893-916

Yu, P., Morey, S .L., and O'Brien, J. J. (2006). Development of New Techniques for Assimilating Satellite Altimetry Data into Ocean Models. Available at: http://www.coaps.fsu.edu/~morey/GoM/08_Yu_Peng_WGNE_2006.pdf. (Doctoral thesis)

NOAA NSF CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico | Fundação Universidade Federal do Rio Grande | UFRJ | MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES MCTIC | BRASIL GOVERNO FEDERAL | The Global Ocean Observing System GOOS | MARINHA DO BRASIL