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A Comparative Analysis of Ocean Reanalysis in the South Atlantic

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Introduction

The Atlantic Ocean plays a crucial role in the formation of deep and bottom waters, which are integral to the Atlantic Meridional Overturning Circulation (AMOC).

The AMOC transports heat northwards across the Atlantic, making the South Atlantic Ocean unique compared to other ocean basins.

Due to its role in global heat and salt redistribution, the variability in AMOC is believed to impact the climate.

This variability may originate or be regulated in the South Atlantic through water mass mixing and exchanges between ocean basins, highlighting the importance of studying this region.

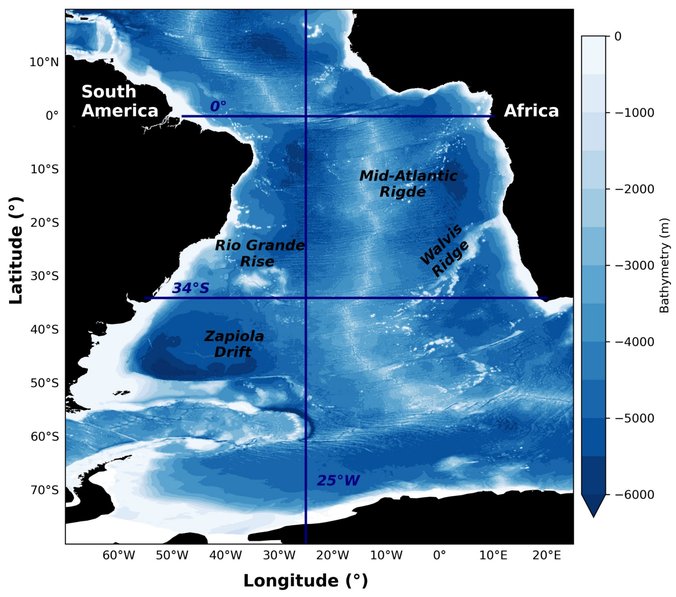

Figure 1. Bathymetry and study area (GEBCO 2024 Grid). The blue lines indicate the analyzed zonal sections (0° and 34°S) and the meridional section (25°W).

This study aims to evaluate five ocean reanalysis datasets in the South Atlantic Ocean to investigate their representation of key oceanographic features and the vertical structure of the ocean.

Methodology

Table 1 - Reanalyses used in the comparative analyses and their main characteristics.

Center	Mercator Ocean	Mercator Ocean	CSIRO	NLR	FIO
Country	France	France	Australia	United States	China
Product name	GLORYS4v4	GLORS12v1C	BRAN2020	GOFS3.1	FIOCOM1.0
Name in this study	GLORYS4	GLORS12	BRAN	GOFS	FIOCOM
Horizontal resolution	1/4°	1/12°	1/10°	1/12°	1/10°
Vertical resolution in levels (m)	75	50	51	41	57
Ocean Model	NEMO	NEMO	MOM5	HYCOM	MOM5
Atmospheric forcing	ERA-Interim / ERA5	ERA-Interim / ERA5	JRA-55	CFSR/ CFSv2/ NAVGEM	ERA-Interim / ERA5

The reanalyses are from different distribution centers as Mercator Ocean, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Naval Research Laboratory (NRL), and First Institute of China (FIO).

Oceanographic databases from the Copernicus Marine Environment Monitoring Service (CMEMS) were used to evaluate the reanalyses: OSTIA for Sea Surface Temperature (SST), MULTIOBS for Sea Surface Salinity (SSS), SSALTO/DUACS for Sea Surface Height (SSH) and ARMOR3D for Mixed Layer Depth (MLD).

BIAS, RMSE and MAE were calculated for surface analysis. Additionally, temperature and salinity climatology from WOA23 were used for in-depth comparisons in three transect regions: the equator, 25°W, and 34°S. Accumulated and transport related to water masses were also calculated for 34°S.

Water masses were divided into four layers (South Atlantic Central Water (SACW), Antarctic Intermediate Water (AAIW), North Atlantic Deep Water (NADW), and Antarctic Bottom Water (AABW)) according to Hernández-Guerra et al. (2019). The comparisons for transport analyses used AXMOC database (Pita et al., 2024).

Results and Conclusions

- All reanalyses presented difficulties in accurately representing high variability areas such as the Brazil-Malvinas Confluence and Agulhas Retroflection, especially in SST and SSH (not shown).
- For SSS, the reanalyses struggled to represent this variable near large river systems since SSS satellite data are not assimilated.
- The MLD (not shown) tended to be overestimated in high latitudes, likely due to overestimation of westerlies in atmospheric forcing.
- The reanalyses showed temperature and salinity values closely aligned with WOA23 for three sections analysed (not shown).
- The transport of AABW was underestimated in most reanalyses, likely due to low resolution in the deep ocean. For other water masses, all reanalyses tended to overestimate water masses transport in the upper ocean (SACW and AAIW) and also in the NADW levels compared to AXMOC database.

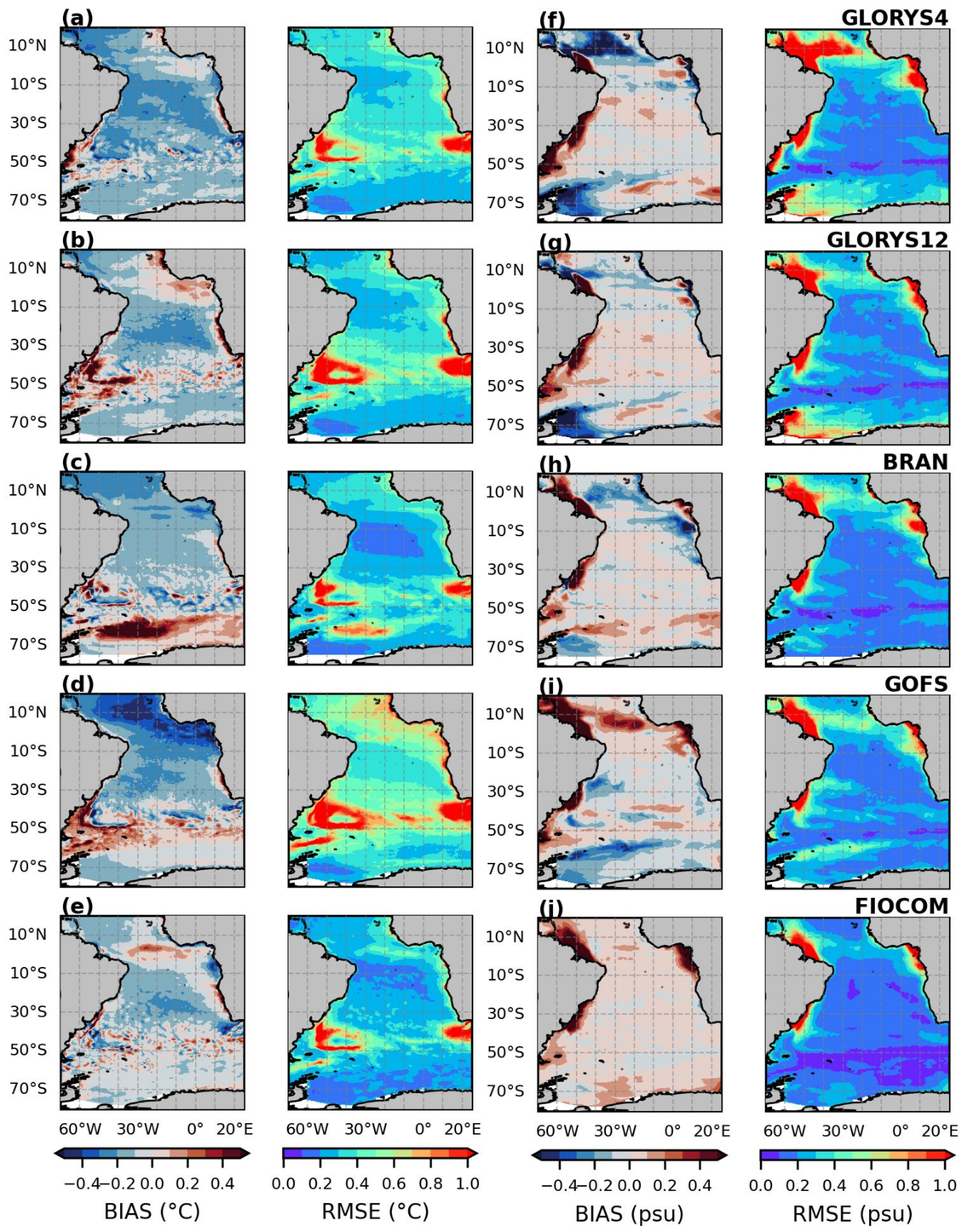

Figure 2. Mean BIAS on the first and third columns, and RMSE on the second and fourth columns calculated over the study area. The results for SST (panels a–e) are displayed in the left columns, while those for SSS (panels f–j) are in the right columns.

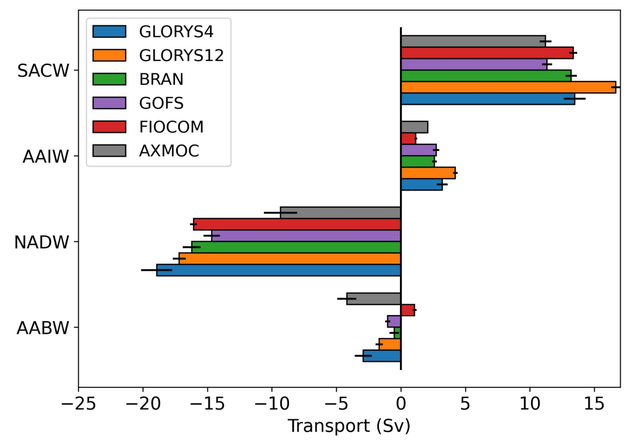

Figure 3. Water masses total volume transport estimated from each ocean reanalysis and AXMOC database.

References

Hernández-Guerra, A., Talley, L., Pelegrí, J., Vélez-Belchí, P., Baringer, M., Macdonald, A.M., Mcdonagh, E.: The upper, deep, abyssal and overturning circulation in the Atlantic Ocean at 30°s in 2003 and 2011. Progress in Oceanography 176, 102136 (2019). https://doi.org/10.1016/j.pocean.2019.102136

Pita, I., Goes, M., Volkov, D.L., Dong, S., Schmid, C.: South atlantic meridional overturning circulation and its respective heat and freshwater transports from sustained observations near 34.5°s. Frontiers in Marine Science Volume 11 - 2024 (2024) https://doi.org/10.3389/fmars.2024.1474133.