IN SITU OBSERVATIONS OF THE SPATIOTEMPORAL VARIABILITY OF HYDRODYNAMICS ON THE AMAZON CONTINENTAL SHELF

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1. INTRODUCTION

The Amazon Continental Shelf (ACS) exhibits highly energetic hydrodynamics modulated by trade winds, tides, fluvial discharge, and mesoscale activity of the North Brazil Current (NBC). This study aims to characterize the spatial-temporal variability of hydrodynamics on the ACS based on in situ data.

2. DATA SET AND METHODS

This study is based on: i) 6 coastal sea level stations provided by IBGE, BNDO and SiMCosta, ii) velocity measurements from 201 drifters of NOAA Global Drifter Program (Fig. 1), iii) 3 moorings of the AMANDES III project, and iv) 127 CTD profiles from AMANDES and REVIZEE projects.

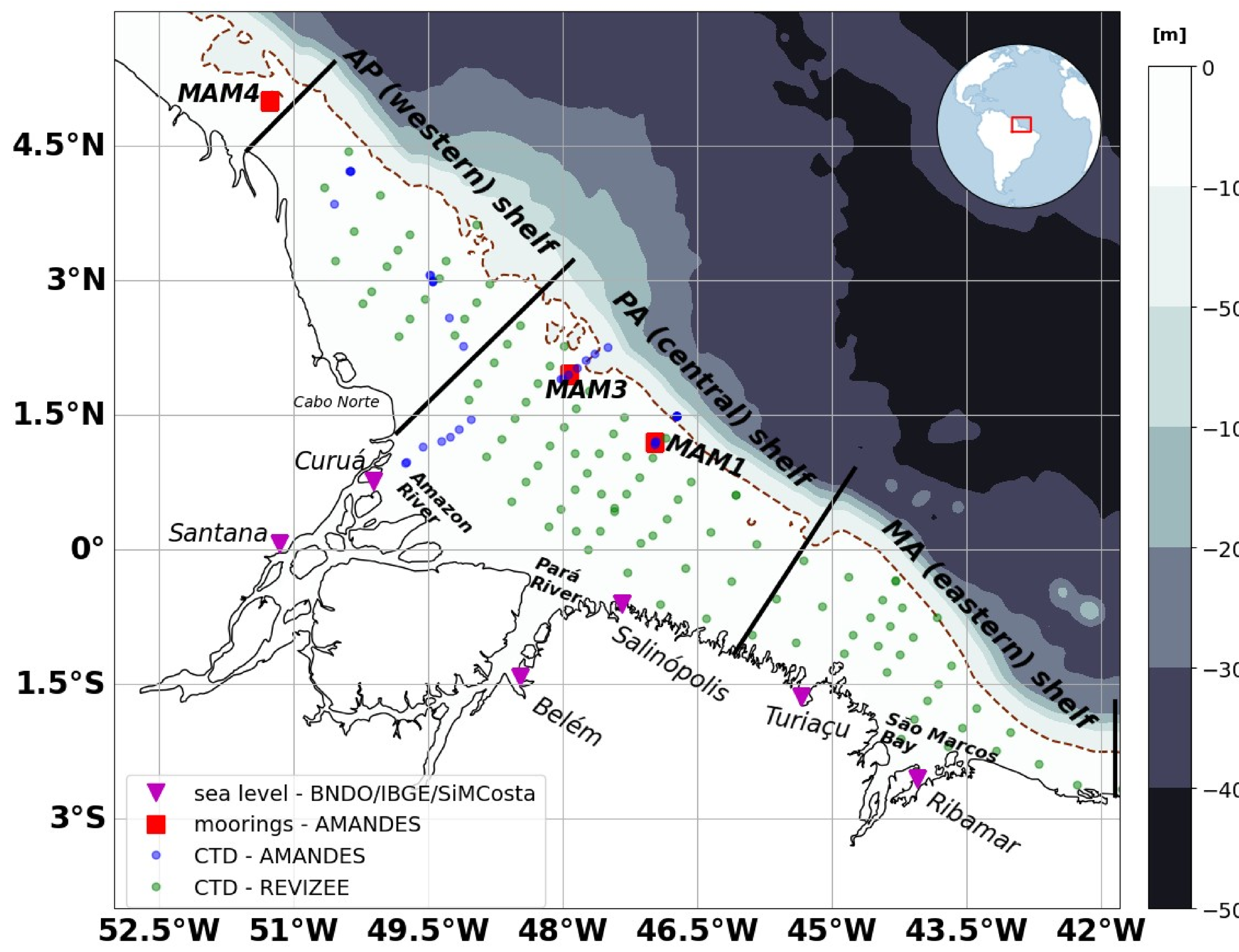

Figure 1. Bathymetry of the Amazon Continental Shelf (ACS) (shaded), including the Maranhão shelf [MA], Pará shelf [PA] and Amapá shelf [AP]. The dotted line indicates the 100 m isobath. The black line indicates the boundaries between the ACS sectors. The magenta dot indicates the coastal stations of the IBGE/BNDO/SiMCosta sea level measurements. The red square and blue dot indicate the moorings and CTD profiles from the AMANDES project. The green dot indicates the CTD profiles from the REVIZEE project. The inset indicates the area of analysis.

A harmonic tidal analysis was performed on the sea level and velocity time series. The relative importance of turbulence and stratification on the ACS was assessed using the Richardson number calculated from time series of temperature, salinity and velocity recorded by the MAM1, MAM3 and MAM4.

3. RESULTS AND DISCUSSION

Tides play a crucial role in the variability of the Amazon coastal sea level, accounting for at least 95% of the total variance at all stations. They show a spatial pattern in tidal heights (Fig. 2), with meso and macro-tidal conditions prevailing in the west and east, respectively. Tidal currents dominate the cross-shelf component on the PA shelf and decrease on the AP shelf, while residual currents are more important for the alongshelf component (Fig. 3).

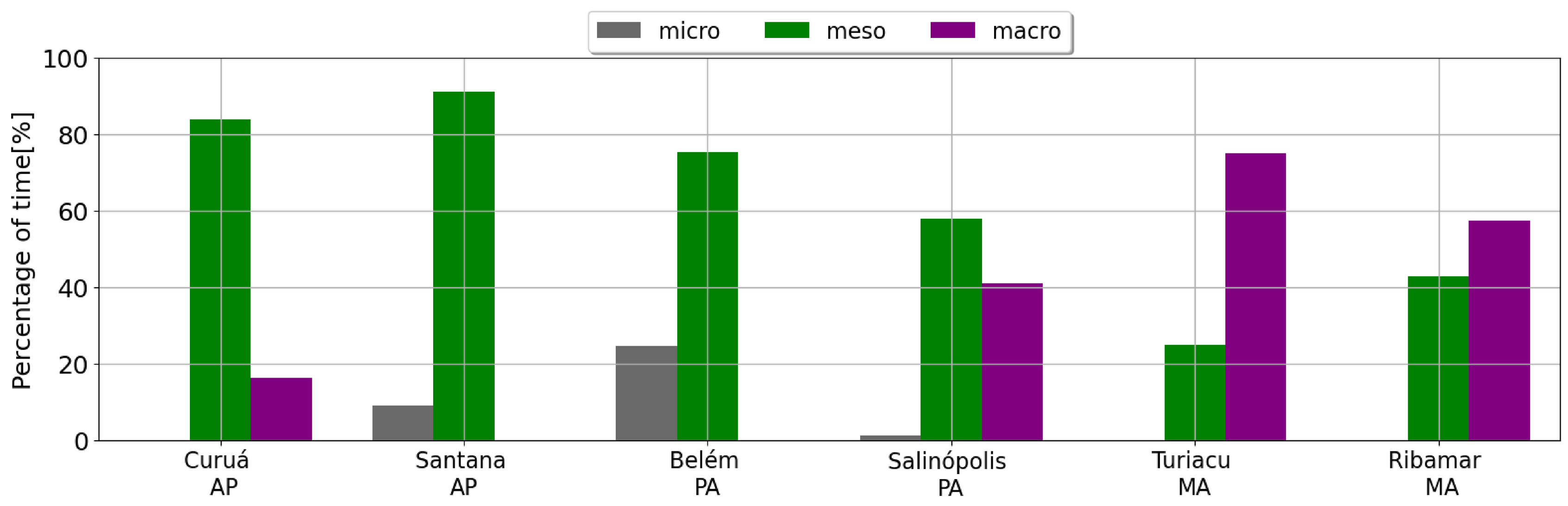

Figure 2. Percentage of time where tidal range (H) exhibits macro (H ≥ 4 m), meso (2m <H < 4 m), and micro (H ≤ 2 m) tidal conditions at Curuá (AP (western) shelf), Santana (AP (western) shelf), Belém (PA (central) shelf), Salinópolis (PA (central) shelf), Turiaçu (MA (eastern) shelf) and Ribamar (MA (eastern) shelf).

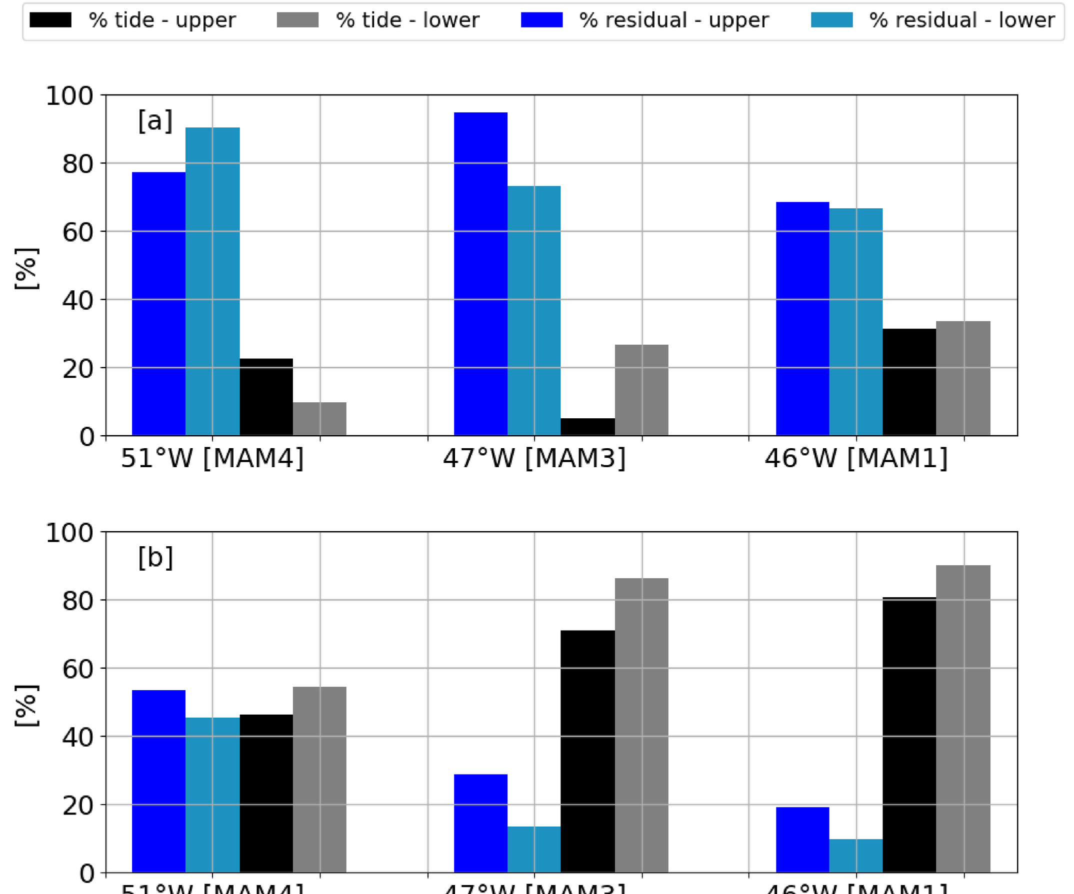

Figure 3. Percentage contribution of tidal (black and gray) and residual (blue and light blue) currents to the temporal variability of the alongshelf [a] and cross-shelf components [b] of the velocity at moorings MAM1, MAM3 and MAM4 at the top and bottom of the water column.

Figure 4 shows a rotary spectrum of raw alongshelf and cross-shelf velocities in the upper (lower) water column from moorings MAM1, MAM3, and MAM4. All spectrums display a prominent energy peak at 0.5-day periods in both layers, associated with semidiurnal tides.

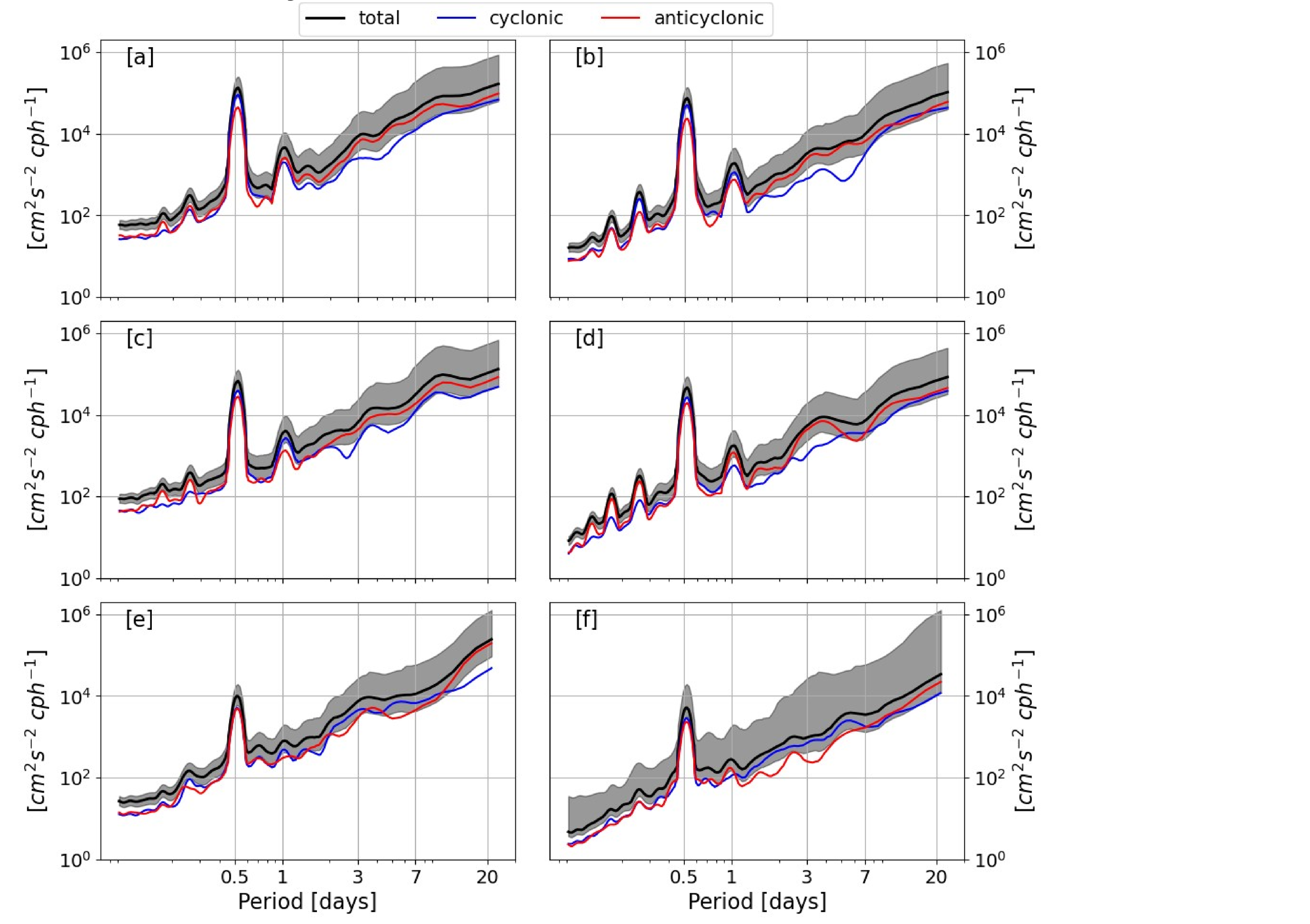

Figure 4. Rotary spectrum of the raw alongshelf and cross-shelf velocity at the top [a,c,e] and bottom [b,d,f] at MAM1 [a,b], MAM3 [c,d] and MAM4 [e,f] (see Fig. 1 and Table 2). The black, blue and red lines represent the total, cyclonic and anticyclonic spectrum, respectively. The shading represents the 99% confidence interval.

The influence of tides on the temporal variability of the Richardson number is more pronounced at MAM1 and MAM3 (PA shelf) (Fig. 5). At MAM4 (AP shelf), an increase in stratification and vertical shear of the horizontal velocity occurs due to the combined influence of the northwestward spreading of the Amazon plume and velocity modulations associated with the NBC.

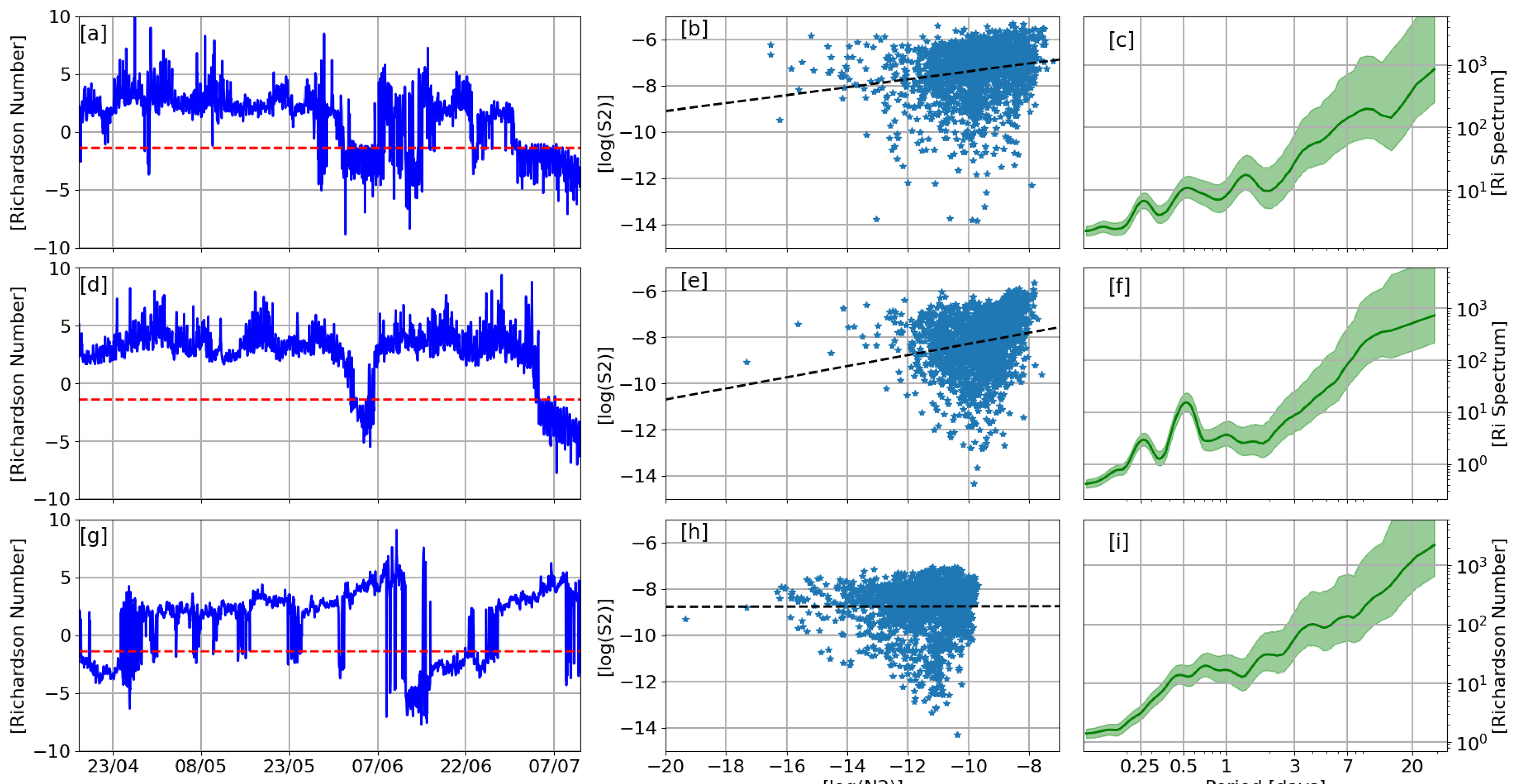

Figure 5. Comparison between stratification and turbulence at MAM1 [a-c] , MAM3 [d-f], and MAM4 [g-i] based on the Richardson Number. Panels [a, d, g] display the temporal series of the Richardson number, where the dotted red line indicates Ri = 0.25 in logarithmic scale (-1.38). Panels [b, e, h] present the scatter of stratification and turbulence parameters. The dotted black line indicates log(N2) = log(S2). Panels [c, f, i] show the spectrum of the temporal series of the Richardson number. The green shading represents the 99% confidence interval. The geographical locations of the stations are shown in Fig. 1.

The TS diagrams (Fig. 6) illustrate the occurrence of coastal water influenced by the discharge on the inner shelf, mixing water on the middle shelf, and oceanic water near the shelf-break (depths greater than 60 m).

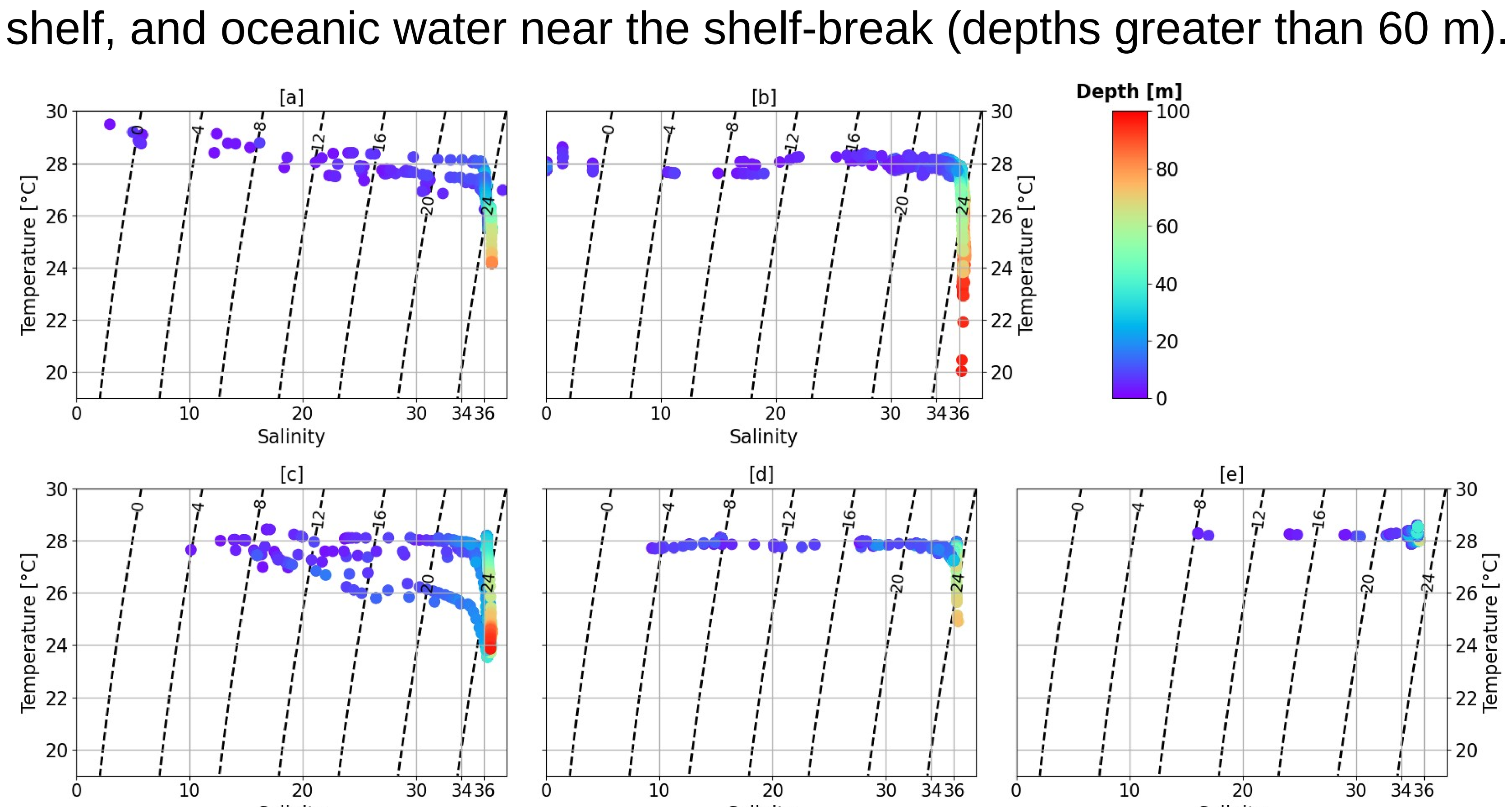

Figure 6. Temperature-salinity (TS) diagrams based on 23 CTD profiles collected by the AMANDES project between April 11 and 13, 2008 [a,b], and 104 CTD profiles conducted by the REVIZEE project campaign between March 15th, 1995 and May 13th, 1995 [c,d,e]. Panels [a, b] represent profiles collected on the AP (western) and PA (central) shelves, while panels [c,d,e] represent profiles collected on the AP (western), PA (central) and MA (eastern) shelves, respectively. The black dotted line indicates the σθ isopycnals. The geographical locations of the stations are shown in Fig. 1.

4. CONCLUSION

This study is part of a project that aims to characterize the spatio-temporal variability of the hydrodynamics of the ACS. This project has financial support from National Council for Scientific and Technological Development (CNPq, process 406506/2022-1).

References
Freitas, P. P. de, Cirano, M., Teixeira, C. E. P., Melres, S. J. R., Sousa, A. K. C. dos S., Gomes, V. J. C., Guerrero-Martin, C. A., & Koch-Larrouy, A. (2025). Spatial and temporal variability of hydrodynamics on the Amazon Continental Shelf: An observational approach. Continental Shelf Research, 105491. https://doi.org/10.1016/j.csr.2025.105491