In situ Observations of the Spatiotemporal Variability of Hydrodynamics on the Amazon Continental Shelf

Pedro Paulo de Freitas[1*];Mauro Cirano[3] ; Carlos Eduardo Peres Teixeira[4]; Sávio Jeliel Roque Melres[2]; Antony Kadu Carvalho dos Santos de Sousa[2]; Vando Costa Gomes[2]; Camilo Andrés Guerrero-Martin[2]; Ariane Koch-Larrouy[5]

[1] Center for Marine Studies, Federal University of Paraná (UFPR), Brazil; * freitaspedro@ufpr.br

[2] Faculty of Engineering, Federal University of Pará (UFPA), Brazil;

[3] Institute of Geosciences, Federal University of Rio de Janeiro (UFRJ), Brazil;

[4] Labomar, Federal University of Ceará (UFC), Brazil;

[5] Université de Toulouse, LEGOS (CNRS/IRD/UPS/CNES), France.

Abstract

The Amazon Continental Shelf (ACS) exhibits highly energetic hydrodynamics influenced by trade winds, tides, fluvial discharge, and mesoscale activity associated with the North Brazil Current. Spanning approximately 2.600 km from 2°S to 4°N, the ACS encompasses the northern Brazilian continental shelf off the states of Amapá, Pará, and Maranhão. This study characterizes the spatial-temporal variability of hydrodynamics on the ACS using in situ data of six coastal sea level stations (IBGE, BNDO, and SiMCosta), velocity measurements from 201 drifters of NOAA Global Drifter Program, three moorings of the AMANDES III project, and 127 CTD profiles from AMANDES and REVIZEE projects.

A harmonic tidal analysis was conducted on the sea level time series to assess the tidal variations and determine the residual sea level by subtracting the tidal signal from the raw series. Spectral analysis (FFT) was applied to both the raw and residual (tidally removed) sea level series. Additionally, rotational spectral analysis was used to examine the energy distribution in surface currents based on drifter velocity data. The relative importance of turbulence and stratification on the ACS was evaluated using the Richardson number, calculated temperature, salinity, and velocity time series recorded by the MAM1, MAM3 and MAM4 moorings located on the Pará and Amapá shelves.

Tides play a dominant role in the variability of the Amazon coastal sea level, explaining at least 95% of the total variance across at all stations. A spatial pattern in tidal heights is observed, with meso- and macro-tidal conditions prevailing in the western and eastern, respectively. The influence of tides on the temporal variability of the Richardson number is more pronounced at MAM1 and MAM3 (Para shelf). At MAM4 (Amapá shelf), an increase in stratification (N^2) and vertical shear of the horizontal velocity (S^2) is driven by the combined effect of the northwestward spreading of the Amazon River plume - modulated by winds - and velocity field variations associated with the North Brazil Current (NBC). TS diagrams reveal the presence of coastal water influenced by the discharge on the inner shelf, mixed water on the middle shelf, and oceanic water near the shelf-break (depths > 60 m).

To further investigate additional forcing mechanisms affecting the ACS hydrodynamics and cross-shelf exchanges, a high-resolution hydrodynamical model (ROMS) is being implemented in the region. . This study is part of a broader project aimed at characterizing the spatio-temporal variability of ACS hydrodynamics, supported by the National Council for Scientific and Technological Development (CNPq, process 406506/2022-1).