PATHWAYS OF OCEANIC WATER INTRUSION INTO THE AMAZON CONTINENTAL SHELF

Pedro Paulo de Freitas[1], Mauro Cirano[2], Carlos Eduardo Peres Teixeira[3] Martinho Marta-Almeida[4]

1 – Federal University of Pará (UFPA), Salinópolis, Pará, Brazil
2 – Institute of Geosciences, Federal University of Rio de Janeiro (UFRJ), Brazil
3 – Federal University of Ceará (UFC), Labomar, Brazil
4 – Centro Oceanográfico de A Coruña, Instituto Español de Oceanografia (IEO-CSIC), A Coruña, Spain
e-mail: pedropaulof@ufpa.br

1. INTRODUCTION

The Amazon Continental Shelf (ACS) is a shallow region (<100 m), with a maximum width of 330 km, which encloses the northern portion of the Brazilian continental shelf and is delimited between 2°S and 4°N. The ACS is located on a continental margin of great potential for the development of strategic economic activities and has great ecological and climatic importance on a global scale.

The aim of the present study is to characterize the existence of preferential ocean water intrusion pathways into the ACS along 3 sectors: Maranhão (MA shelf), Pará (PA shelf) and Amapá (AP shelf).

2. DATA SET AND METHODS

This study is based on: i) 306 surface drifter trajectories along 1344 km of the ACS provided by the Global Drifter Program (GDP), ii) 20 years of high resolution numerical reanalysis results (GLORYS12V1) provided by the Copernicus Marine Environment Monitoring Service (CMEMS) and iii) simulations with the Lagrangian model Parcels v2.2.0.

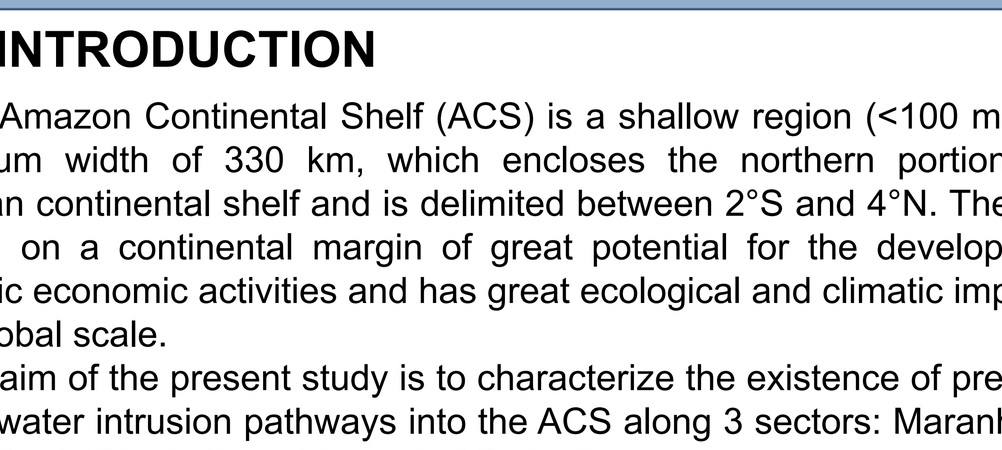

Figure 1. Bathymetry of the Amazon (shaded) including Maranhão shelf [MA], Pará shelf [PA] and Amapá shelf [AP]. The magenta line indicates the boundaries between the Amazon continental shelf sectors. The two black dots (39°W; 2°S and 39°W; 1°S) indicate the positions at which particles were released in the Lagrangian model (OceanParcels) on the isobaths of 3000 and 3600 m, respectively. The inset indicates the search area for drifters and the analysis area of 20 years of high resolution numerical reanalysis results (GLORYS12V1) provided by the Copernicus Marine Environment Monitoring Service (CMEMS).

Two experiments were carried out with the Parcels toolbox in order to illustrate the representability of the circulation in the study area by the GLORYS12V1 and the trajectories generated by the Lagrangian modeling.

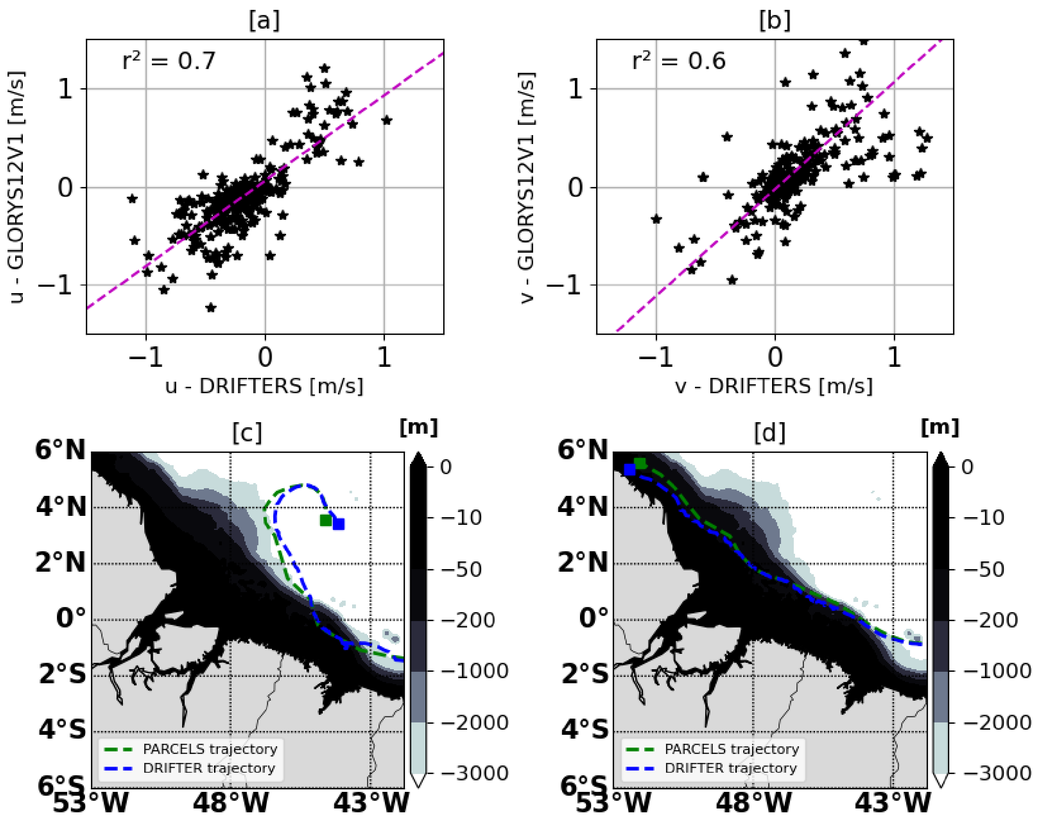

Figure 2. [a] e [b] Scatters of the velocity components u and v, respectively, measured by GDP drifters that presented trajectory into the Amazon Continental Shelf in the period between 2001 and 2020 and the surface velocity simulated by the model GLORYS12V1 on the same trajectories as the drifters. The magenta line in panels [a] and [b] indicates a least squares fitting between the data and model series. [c] e [d] illustrate comparisons between the trajectory of a GDP drifter (blue line) and the trajectory simulated by Parcels using the surface velocity fields of the model GLORYS12V1 during the period between 2008/06/01 - 2008/06/20 and between 2011/12/17 - 2012/01/11, respectively.

Based on the scientific literature about the morphology of the ACS and the average position of the North Brazil Current (NBC), this study adopted as a criterion for intrusion into the ACS the detection of drifters and/or particles crossing the 50 m isobath and standing in equal or shallow depths for at least 1 day.

3 RESULTS AND DISCUSSION

Figure 3 illustrates the points where trajectories of drifters crossing the 50 m isobath were observed and shows that the MA shelf is the sector where most observations of intrusion occurred, followed by the PA shelf. From a total of 306 drifters selected in the study area, 260 entered into the ACS, and of these, 78% entered into the MA shelf sector and 22% into the PA shelf sector.

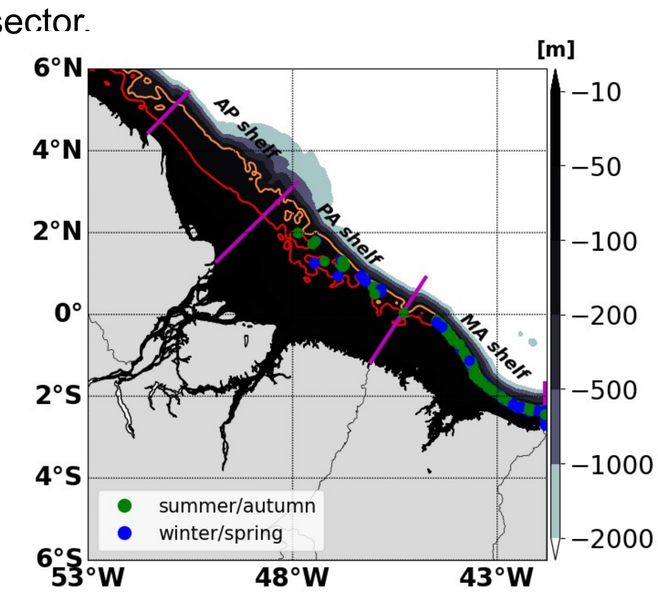

Figure 3. Geographical location of intrusion points of drifters on the Amazon Continental Shelf (ACS), where green (blue) represents (austral summer/autumn) (austral winter/spring), indicating the season in the intrusion occurred. The shaded region indicates the bathymetry of the ACS, with the 50 m isobath highlighted in red, indicating the approximate middle portion of the continental shelf. The 100 m isobath is highlighted in orange, indicating the approximate position of the shelf break. The magenta lines indicate the boundaries between the sectors of the ACS.

The preferential sector for intrusion of simulated particles into the ACS is the MA shelf with 67%, followed by the PA shelf with 32%. The AP shelf sector shows low intrusion, corresponding to less than 1%. The intrusion rate into the ACS is highest during the austral summer/autumn in all sectors, being around 55% in the MA shelf and PA shelf and 100% in the AP shelf. The seasonality of the trade winds and North Brazil Current are the forcing mechanisms of the variability in the oceanic water intrusion into the ACS.

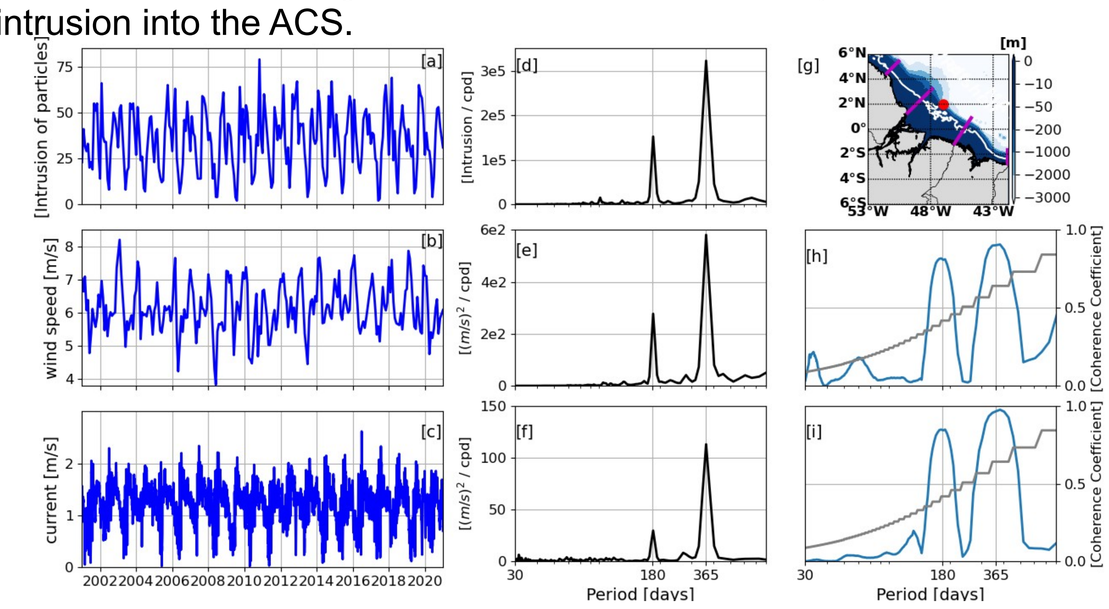

Figure 4. [a] Time series of the daily number of particle intrusions into the ACS observed over the 20 years of the Lagrangian experiment (2001-2020). [b] Time series of daily wind intensity at 10 m above the surface at 47°W and 2°N from the ECMWF ERA-Interim reanalysis (2001-2020). [c] Time series of daily surface velocity at 47°W and 2°N (800 m isobath) from the GLORYS12V1 model. Panels [d], [e], and [f] show the spectrum of the intrusion series of particles, wind intensity, and current intensity, respectively. Panel [g] Illustrate the location of the point (47°W and 2°N) from which the wind intensity and surface velocity series were extracted. Cross-spectrum between [h] the particle intrusion series into the ACS and the wind intensity and [i] the particle intrusion series into the ACS and the intensity of the surface current. The gray line in panels [h] and [i] indicates the 99% confidence interval.

Rotatory spectral analysis of the velocity series collected by the drifters shows that the principal semidiurnal lunar constituent M2 modulates the drifter trajectories on the ACS.

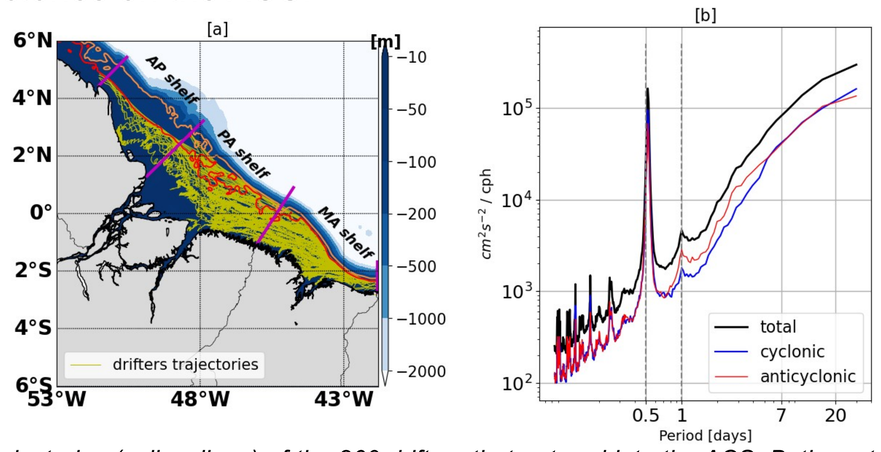

Figure 5. [a] Trajectories (yellow lines) of the 260 drifters that entered into the ACS. Bathymetry of the ACS is shaded, including the Maranhão Shelf [MA], the Pará Shelf [PA], and the Amapá Shelf [AP]. The magenta line indicates the boundaries between the sectors of the ACS. The right panel [b] shows the average rotary spectrum analysis of the u and v velocity components measured by the drifters..

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
Brink, K. H. (2016). Cross-Shelf Exchange. Annual Review of Marine Science, 8(1), 59–78. doi:10.1146/annurev-marine-010814 15717.