Ocean Forecasting and Analysis Systems (OFAS) as a Tool to Investigate Coastal Trapped Waves Along the Brazilian Continental Margin

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Introduction

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- Their wavelength scale is around 10^3 km;
- Temporal scales in the order of some days to few weeks;
- Amplitudes of 10^0 to 10^2 cm;
- Propagate with the coast in its left (right) in the southern (northern) hemisphere.

Introduction

These waves have already been studied along the Brazilian continental margin until 11°S through *in situ* measurements and high resolution models.

This study is associated with the BRICS program "Paradigm", which has the intercomparison of the different OFAS as one of its goals.

Introduction

Objective:

Investigate the representation of CTW on the Brazilian Continental Margin through seven different OFAS and use them to investigate physical processes of these waves in the region.

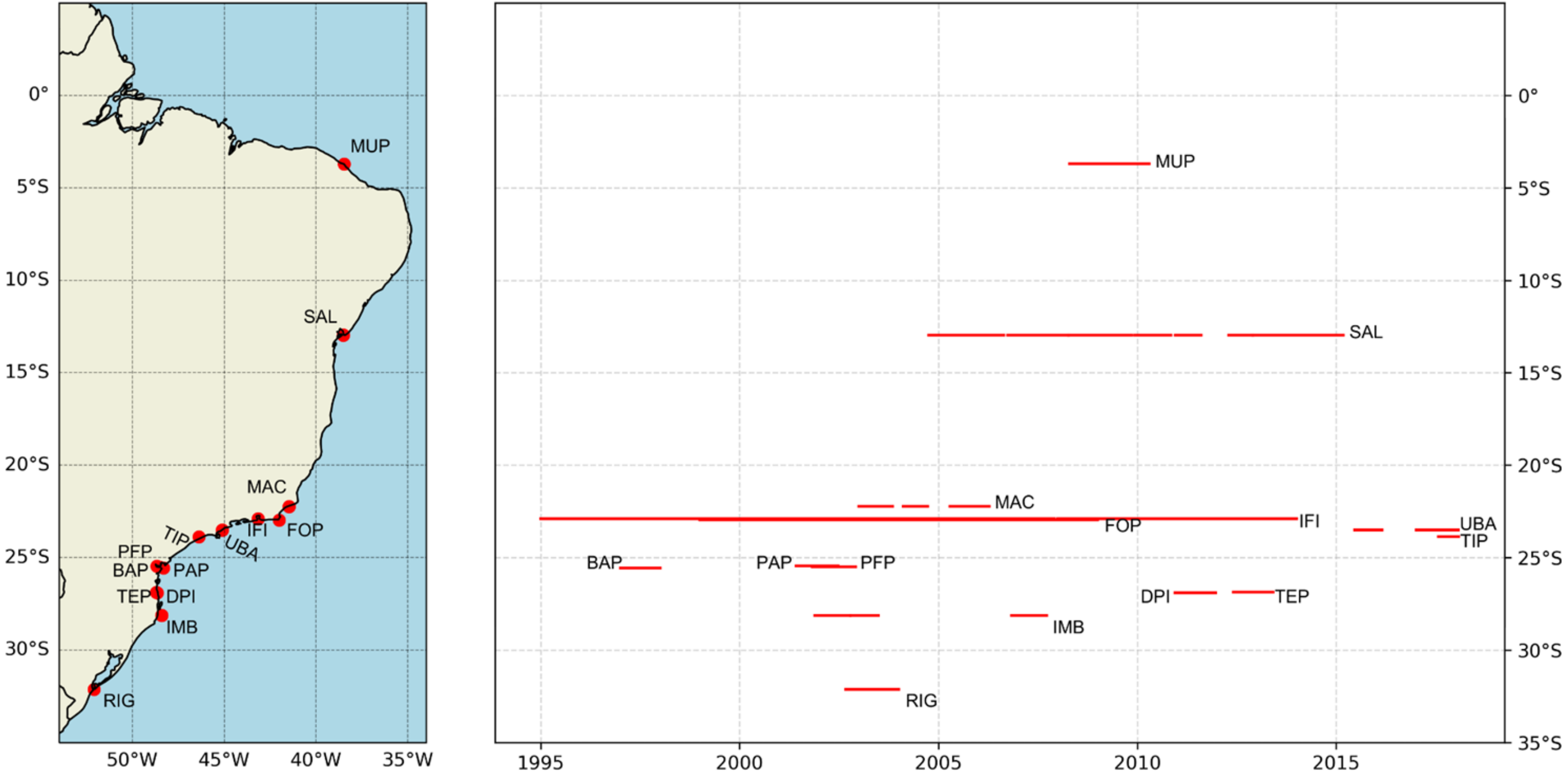


Figure 1: Spatial (left panel) and temporal (right panel) coverages of the measured SSH data used in this study. The latitudes and acronyms for the locations on the map are MUP - Mucuripe's Port (-3.7°), SAL - Salvador (-13°), MAC - Macaé (-22.2°), IFI - Ilha Fiscal (-22.9°), FOP - Forno's Port (-23°), TIP - TIPLAM (-23.9°), PFP - Ponta do Félix Portuary Terminal (-25.4°), PAP - Paranaguá Port (-25.4°), BAP - Barra of Paranaguá Port (-25.5°), TEP - TEPORTI (-26.9°), DPI - Delegacy of Itajaí's Ports (-26.9°), IMB - Imbituba (-28.9°), RIG - Rio Grande (-32.1°).

Data and Methods

Table 1: Main configurations of OFAS evaluated in this study.

Center	CSIRO	CMCC	UK Met Office	Mercator Ocean	Mercator Ocean	ECMWF	NRL
Country	Australia	Italy	UK	France	France	Europe	USA
Name	BRAN2020	C-GLORSv5	GLOSEA5	GLORYS12V1C	GLORYS2V4	ORAS5	GOFS 3.1
Name in this study	BRAN	CGLO	FOAM	GLOR12	GLOR4	ORAS	GOFS
Ocean Model	MOM5	NEMO	NEMO	NEMO	NEMO	NEMO	HYCOM
Atmospheric Forcing	JRA-55	ERA INTERIM	ERA INTERIM/Met Office NWP atmospheric analysis	ERA INTERIM/ ERA 5	ERA INTERIM/ ERA 5	ERA-40/ERA INTERIM/ECMWF OPS	CFSR, CFSv2, and NAVGEM
Number of Vertical Levels	51	75	75	50	75	75	41
Nominal Horizontal Resolution	1/10 º	1/4 º	1/4 º	1/12 º	1/4 º	1/4 º	1/12 º
Scheme of data assimilation	EnKF-C/EnOI	OceanVar (3DVAR Scheme)	NEMOVAR	Kalman Filter of Reduced Order and 3DVAR	Kalman Filter of Reduced Order	NEMOVAR	NCODA 3DVAR
Reference	Chamberlain et al. [2021]	Storto and Masina [2016]	MacLachlan et al. [2014]	LELLOUCHE et al., [2021]	Garric et al., [2017]	Zuo et al. [2019]	Metzger et al. (2014)

Data and Methods

1. Hovmöller diagrams of SSH along the 50 m isobath, analyzed at 1° latitude intervals across the BCM.
2. Wavelet Transforms at strategically selected key locations within the study region to resolve temporal and spectral characteristics of CTWs.
3. Cross-sectional analyses at seven transects distributed along the BCM to examine spatial variability.

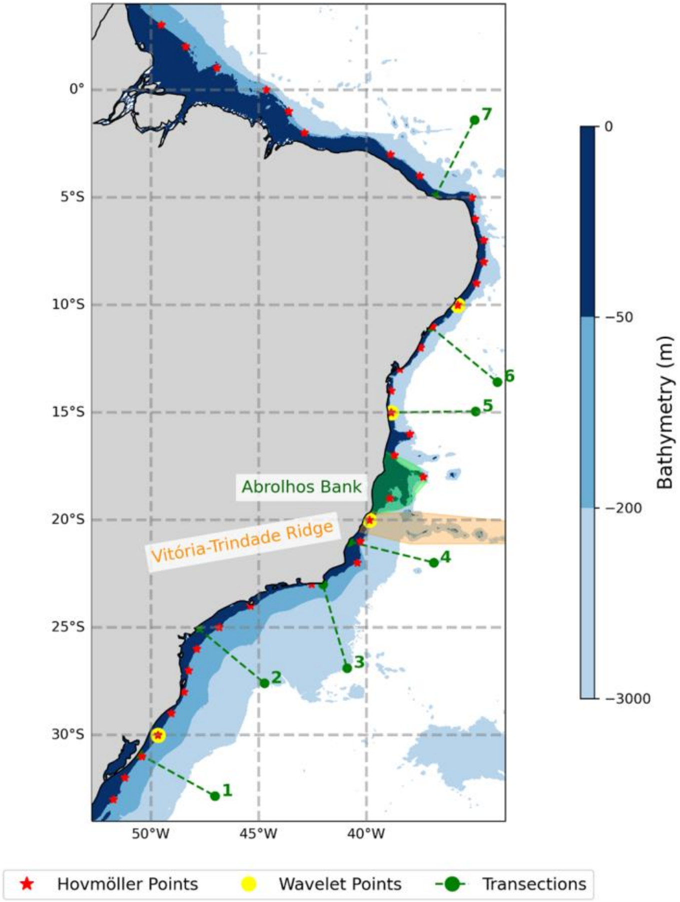


Figure 2: Geographic distribution of locations used for Hovmöller plots (red stars), Wavelet transforms (yellow circles), and velocity sections (green dashed lines). The main bathymetric features for CTW propagation in the BCM, Vitória-Trindade Ridge (VTR, orange dashed line) and Abrolhos Bank (AB, green contour) are also shown.

Table 2: Skill Scores for all OFAS in every measurement location. Grey scale indicates the performance of the OFAS in each point, bold values indicate the greatest Skill Score in a given location.

Point	Acronym	Latitude	BRAN	CGLO	FOAM	GLOR4	GLOR12	GOFS	ORAS	Lat. Mean
Rio Grande	RIG	-32.1º	**0.88**	0.86	0.87	0.82	0.83	0.69	0.79	0.82
Imbituba	IMB	-28.1º	0.45	**0.81**	0.21	0.37	0.40	0.41	0.09	0.39
Delegacy of Itajaí's Ports	DPI	-26.9º	**0.79**	0.60	0.69	0.68	0.76	0.66	**0.79**	0.71
TEPORTI	TEP	-26.9º	**0.82**	0.64	0.78	0.76	0.76	0.67	0.80	0.75
Barra of Paranaguá	BAP	-25.6º	0.79	0.73	**0.81**	0.79	0.80	0.67	**0.81**	0.77
Paranaguá Port	PAP	-25.5º	**0.85**	0.71	0.77	0.78	0.78	0.70	0.80	0.77
Ponta do Félix Portuary Terminal	PFP	-25.4º	**0.88**	0.77	0.82	0.83	0.81	0.74	0.83	0.81
TIPLAM	TIP	-23.9º	**0.82**	0.66	0.74	0.75	0.75	0.70	0.79	0.74
Ubatuba	UBA	-23.5º	0.85	0.77	0.22	0.85	0.83	0.69	**0.87**	0.73
Forno's Port	FOP	-23.0º	0.76	0.68	**0.78**	0.77	0.76	0.62	0.77	0.73
Ilha Fiscal	IFI	-22.9º	0.77	0.56	0.71	0.69	**0.80**	0.76	0.70	0.71
Macaé	MAC	-22.2º	**0.86**	0.66	0.78	0.77	0.81	0.72	0.78	0.77
Salvador	SAL	-13.0º	0.72	0.63	0.57	0.66	0.64	**0.75**	0.53	0.64
Mucuripe's Port	MUP	-3.7º	0.54	0.51	**0.60**	0.37	0.40	0.58	0.48	0.50
SPAO Mean			**0.77**	0.69	0.67	0.71	0.72	0.67	0.70	0.70

Results

Are the waves observed in the north the same waves observed in the south?

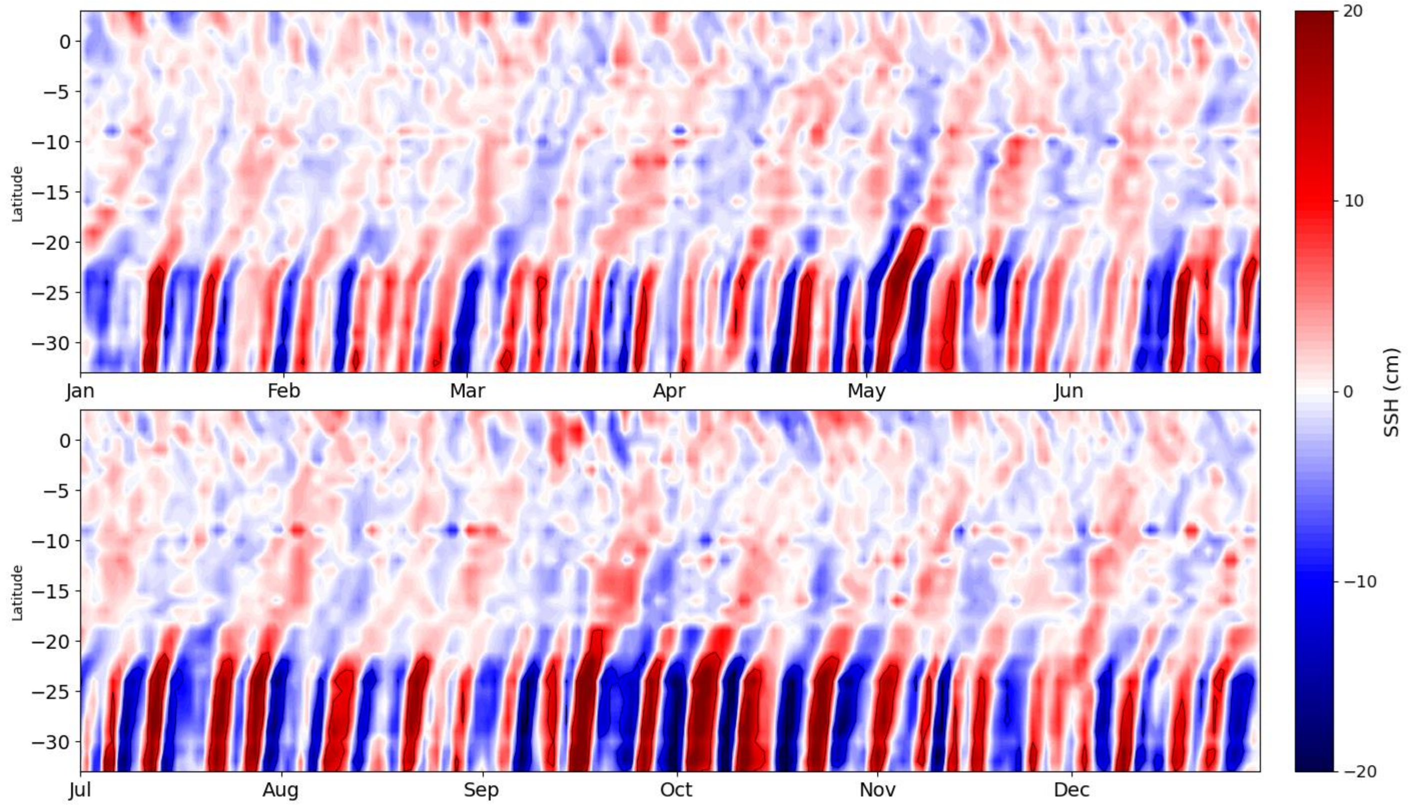
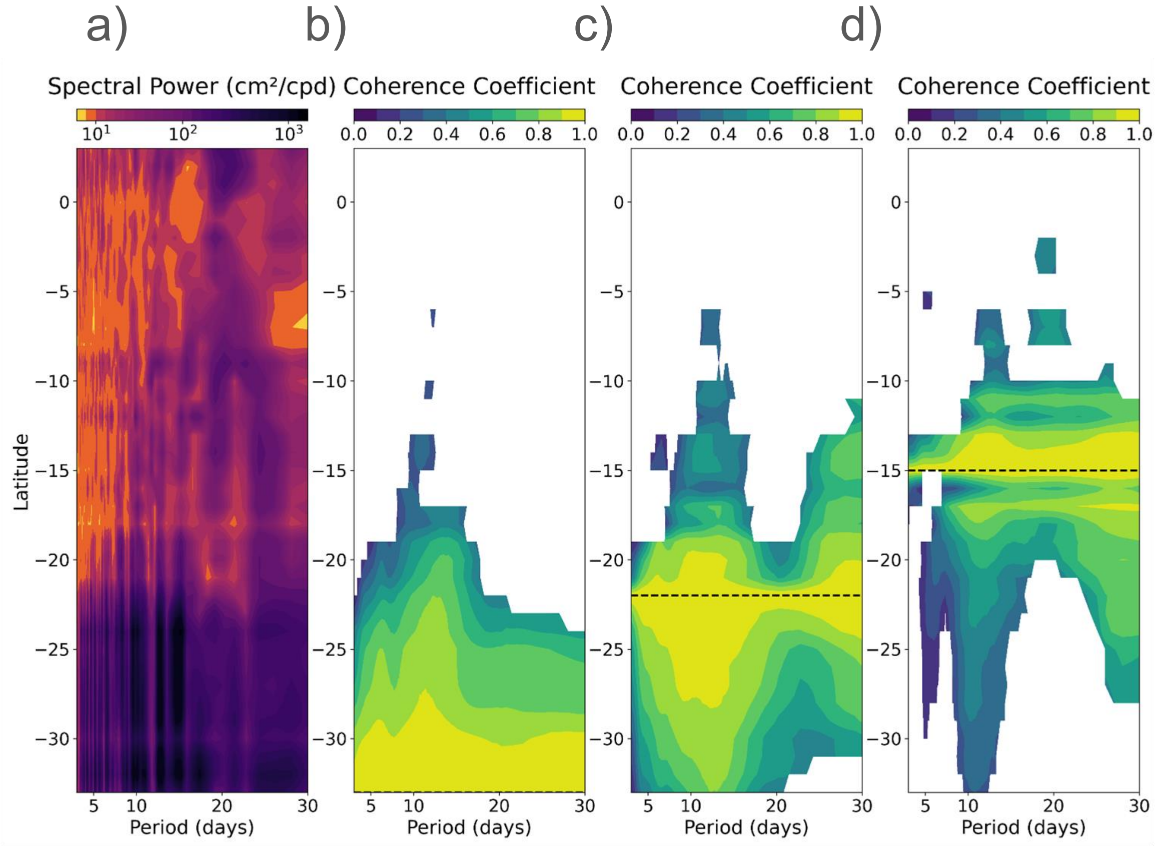


Figure 3: Hovmoller diagram of band-pass filtered (Butterworth filter) SSH from BRAN for the year of 2001 along the 50 m isobath of the BCM. Black contours denote amplitude thresholds at 10 cm intervals.



- Higher frequency energy is deprecated north of the VTR;
- The waves at the NE BCM have statistically significant coherence with the CTW at the SE BCM.

Figure 4: (a) Spectral Analysis (FFT) of the SSH at the 50 m isobath based on the BRAN SPAO; (b) associated cross-spectrum coherence coefficients between the 33°S point and the other locations with a 99% confidence interval; (c) same as (b), but for the 22°S point; (d) same as (b), but for the 15°S point.

Results

How does the CTW behave seasonally?

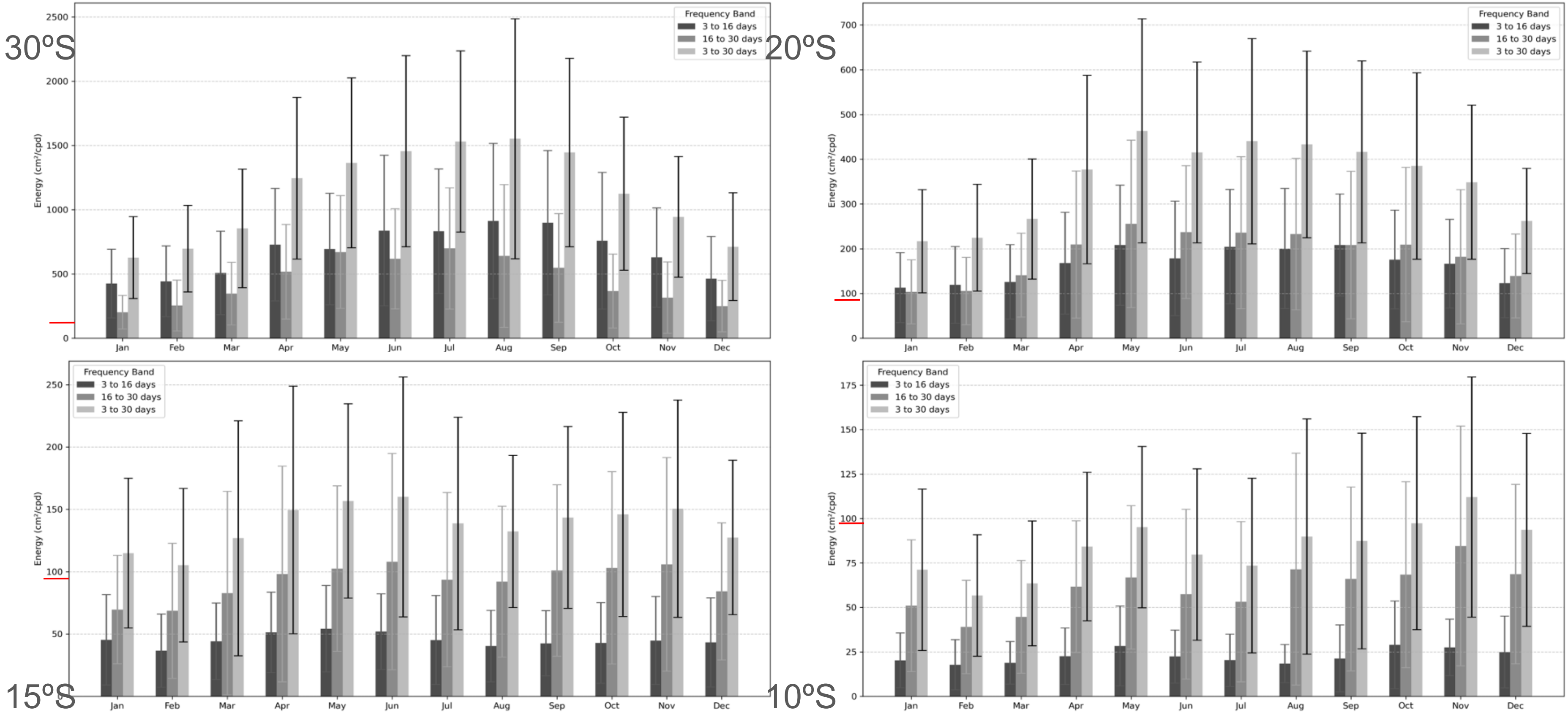


Figure 5: The mean SSH energy per month at each location (see Figure 2) and its standard deviation. The data was extracted from BRAN at the 50 m bathymetry point and divided into three frequency bands: 3 to 16 days, 16 to 30 days, and 3 to 30 days.

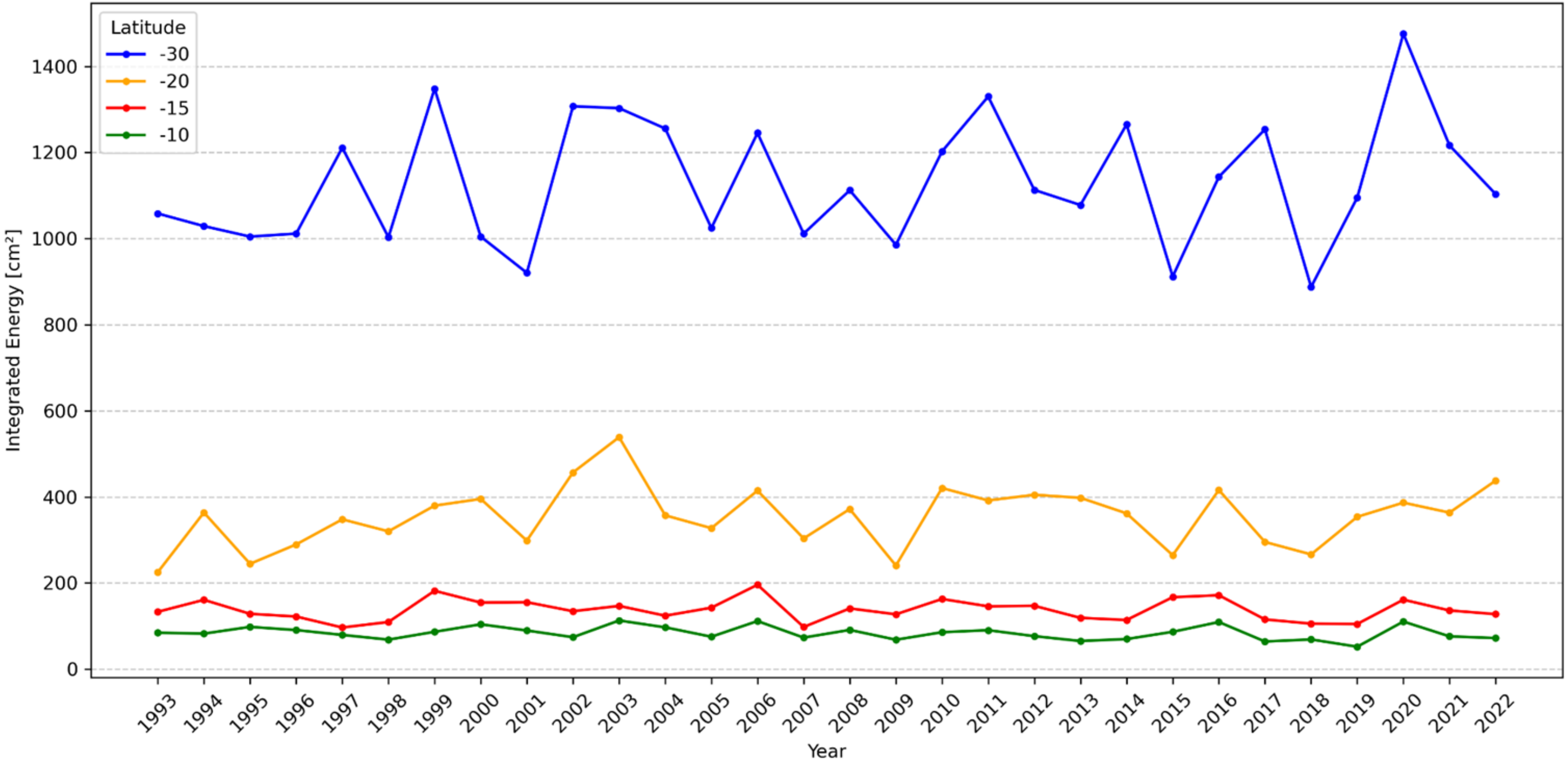


Figure 6: Mean integrated energy in the 3 to 30 days band from BRAN's SSH values for each latitude of this study at the isobath of 50 m.

Results

How does the CTW influence the along-shore current field?

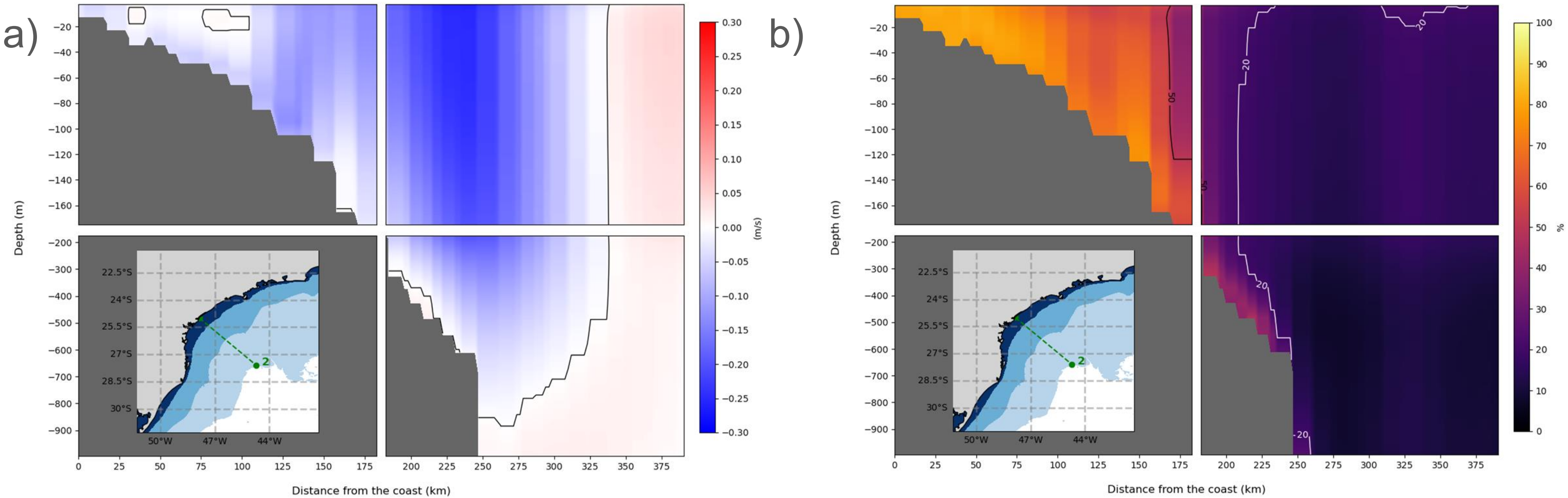
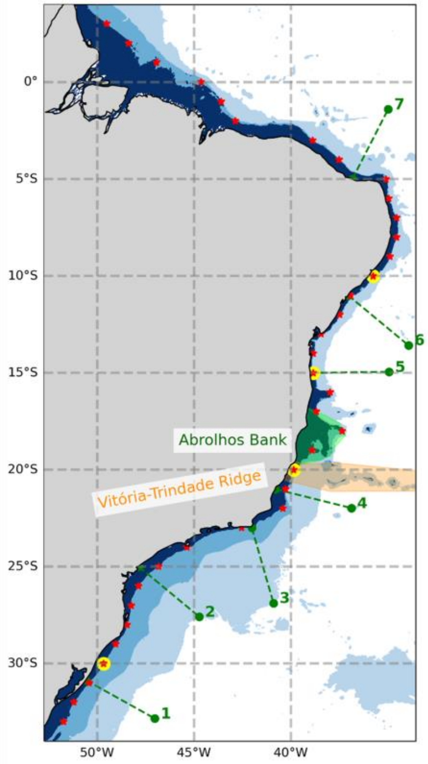


Figure 7: Mean BRAN raw along-shore velocity (a) and Percentage of variance explanation between the BRAN Filtered and raw along-shore velocity (b) along the section 2. The period is from 1993 to 2022.

Main Conclusions



- Every OFAS was able to represent the CTW along the BCM, but with better results south of the AB;
- The AB acts as a "natural filter", and only waves with a certain frequency are able to propagate through;
- There is an observable seasonality along the southern bit, with higher waves during winter, however, north of the VTR, this pattern is no longer observed, and other regimes arise;
- The CTW have a great impact on the continental shelf hydrodynamics, representing around 80% of the variance of the mean along-shore flow in some cases.

Credits

- Slides by SlidesCarnival
- Icons by flaticon.com

Thanks!

Questions or Suggestions?

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