Coastal circulation over the Gulf of Cadiz continental shelf. Local vs remote effects.

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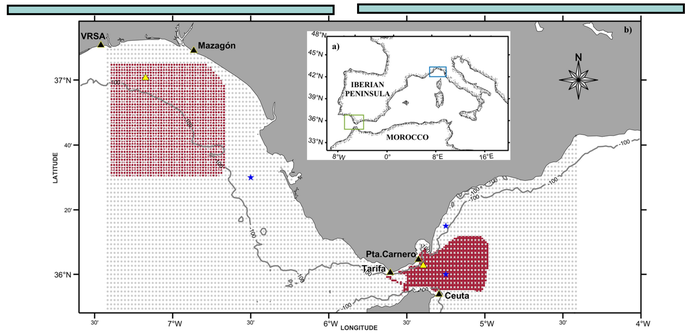
INTRODUCTION

Studies about the coastal circulation over the northern continental shelf of the Gulf of Cadiz (GoC), based on current velocity observations, were published on relatively recent dates (e.g., Relvas and Barton, 2002). Since then, a considerable number of articles have been written dealing with this subject up to the present date (e.g., Oliveira et al., 2022). One of the most studied features in these studies are the so-called Coastal Counter Currents (CCCs) in the coastal shelf. These features are located roughly between the 100 m isobath and the coastline, and they are directed toward west. Nevertheless, despite the considerable number of articles devoted to the analysis of this phenomenon, the actual along-coast extension and origin of these CCCs remain unclear.

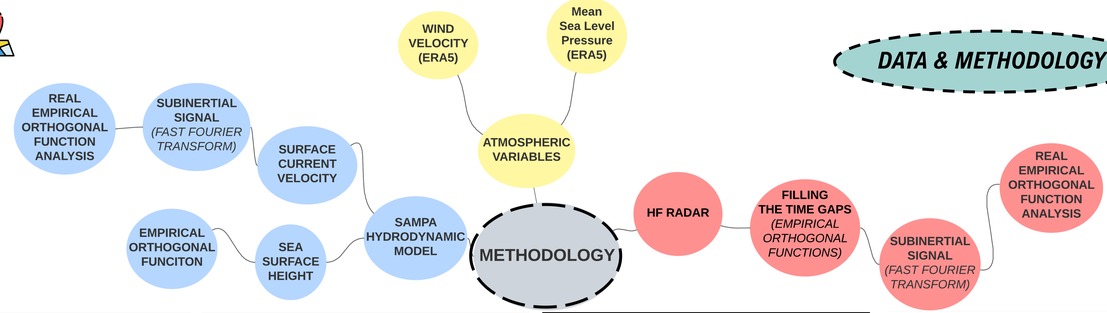
To study the origin of the main spatio-temporal patterns of the low-frequency variability (containing oscillation periods longer than 30 hours) of the currents over the continental shelf of the GoC and their connection with the Strait of Gibraltar (SoG) and the westernmost part of the Alboran Sea. For this purpose, two complementary data sources have been used (i) the HFR-derived surface currents recorded by the GoC and SoG antenna systems, and a high-resolution numerical SAMPA model.

GEOGRAPHICAL AREA

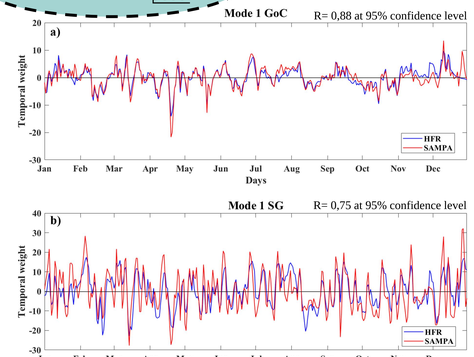


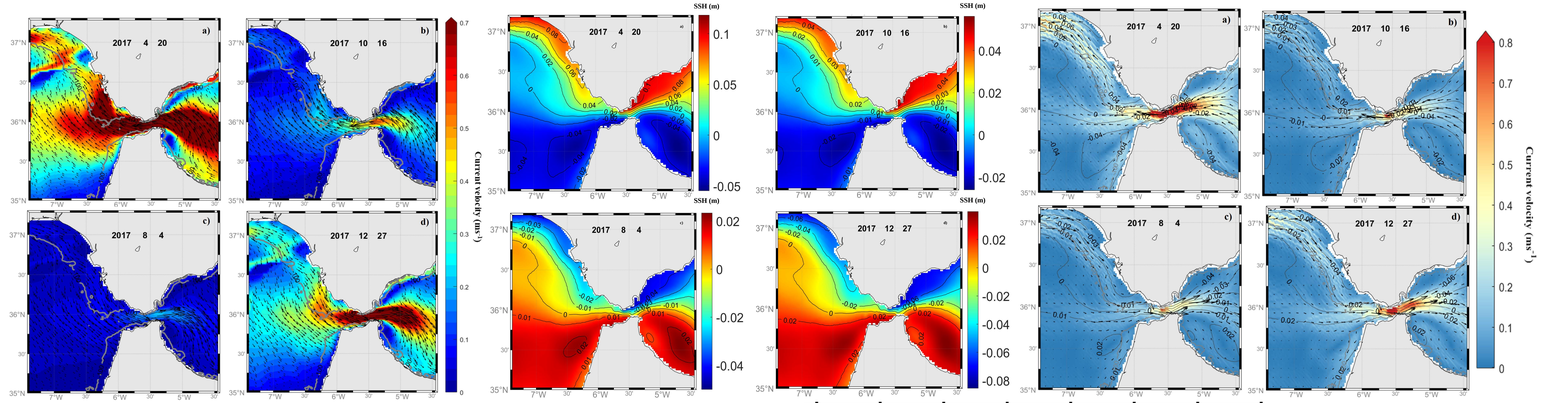
- ADCP
- RADAR HF ANTENNAS
- WIND SAMPLES
- HF RADAR MESH
- SAMPA HYDRODYNAMIC MODEL MESH

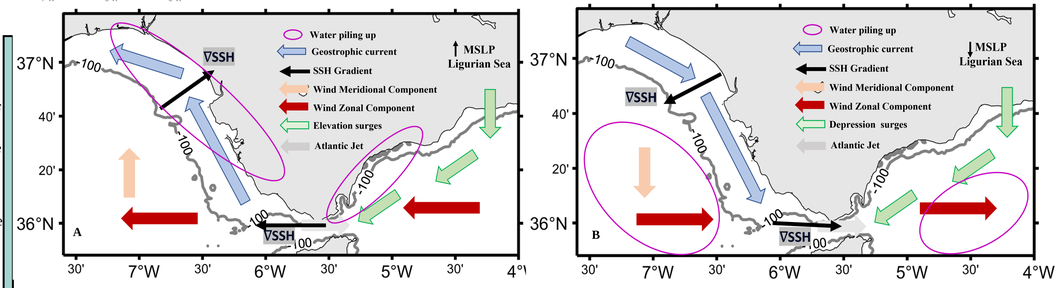
DATA & METHODOLOGY



RESULTS







	Subinertial current (m s⁻¹)	v10m Alborán (m s⁻¹)	v10m GoC (m s⁻¹)	u10m Alborán (m s⁻¹)	u10m GoC (m s⁻¹)	MSLP Liguria (mbar)	
W	-0.58 (0.00)	0.12 (0.27)	0.28 (0.01)	-0.53 (0.00)	-0.46 (0.00)	1	MSLP Liguria (mbar)
SP	-0.69 (0.00)	-0.04 (0.74)	0.33 (0.00)	-0.66 (0.00)	-0.61 (0.00)	1	
SU	-0.48 (0.00)	-0.43 (0.00)	0.32 (0.00)	-0.34 (0.001)	-0.32 (0.00)	1	
A	-0.73 (0.00)	0.07 (0.5)	0.4 (0.00)	-0.68 (0.00)	-0.63 (0.00)	1	
W	0.81 (0.00)	0.08 (0.46)	-0.08 (0.46)	0.90 (0.00)	1		u10m GoC (m s⁻¹)
SP	0.90 (0.00)	-0.09 (0.42)	-0.57 (0.00)	0.93 (0.00)	1		
SU	0.86 (0.00)	0.57 (0.00)	-0.65 (0.00)	0.87 (0.00)	1		
A	0.87 (0.00)	0.45 (0.00)	-0.23 (0.01)	0.92 (0.00)	1		
W	0.88 (0.00)	-0.18 (0.10)	-0.31 (0.00)	1		u10m Alborán (m s⁻¹)	
SP	0.89 (0.00)	-0.07 (0.48)	-0.54 (0.00)	1			
SU	0.90 (0.00)	0.61 (0.00)	-0.64 (0.00)	1			
A	0.88 (0.0)	0.24 (0.02)	-0.38 (0.00)	1			
W	-0.22 (0.04)	0.66 (0.00)	1			v10m GoC (m s⁻¹)	
SP	-0.56 (0.00)	0.32 (0.00)	1				
SU	-0.57 (0.00)	-0.43 (0.00)	1				
A	-0.10 (0.00)	0.33 (0.00)	1				
W	-0.16 (0.18)	1				v10m Alborán (m s⁻¹)	
SP	-0.24 (0.03)	1					
SU	0.63 (0.00)	1					
A	0.28 (0.00)	1					

CONCLUSIONS

- The analysis of daily currents in the GoC, SoG, and Westernmost Alboran Sea using HFR and SAMPA models revealed an EOF Mode 1 that captured important coastal current patterns such as CCCs and eastward current intensification episodes.
- Applying a real EOF decomposition on the SAMPA time series provided the extension to a spatial dominion that comprised the GoC, SoG and Westernmost Alboran Sea areas.
- The main CCC and eastward current intensification events are connected along the three areas. These intense and extensive current intensification processes seem to be triggered by a synchronized action of local winds over the GoC and additional remote effects which are coming from (i) the wind forcing over the Alboran Sea and the easternmost side of the SoG and (ii) the MSLP forcing over the Ligurian Sea.

A) Easterly winds will produce, CCCs in both the Alboran Sea and the GoC. In addition, in the SoG there will be a piling up of water associated with the Atlantic inflow blocking that will in turn create an eastward-directed along-shore SSH gradient in easternmost GoC the corresponding across-shore gradient directed towards the coast and the associated geostrophic current which will be directed, westwards. In addition, according to Bolado-Penagos et al. (2021), the inverted barometer response of the SSH to a MSLP rising over the Ligurian Sea creates elevation surges, which induce a current intensification in the same direction as the propagation speed, should strengthen the Atlantic inflow blocking and the corresponding along-shore SSH gradients. Relying on the significant negative correlation between the meridional component of the wind and Mode 1 currents, in summer and spring, we can deduce that a northward wind corresponds to a westward intensification of the Mode 1 currents. A greater northward wind favors the piling up of water against the coast leading to a greater intensity of the adjusted geostrophic current. B) the inverted barometer response of SSH to the MSLP dropping over the Ligurian Sea creates a depression surge, which induces a current intensification in the opposite direction to the propagation speed. The arrival of this surge at the SoG enhances the intensity of the Atlantic inflow. As in case A, all these processes would occur at the same time in the different coastal zones of the studied area, resulting in the spatial connectivity of the response in the entire domain.

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Relvas, P., Barton, E. D., 2002. Mesoscale patterns in the Cape Sao Vicente (Iberian Peninsula) upwelling region. J. Geophys. Res., Oceans, 107 (C10), 3164. https://doi.org/10.1029/2000JC000456.

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