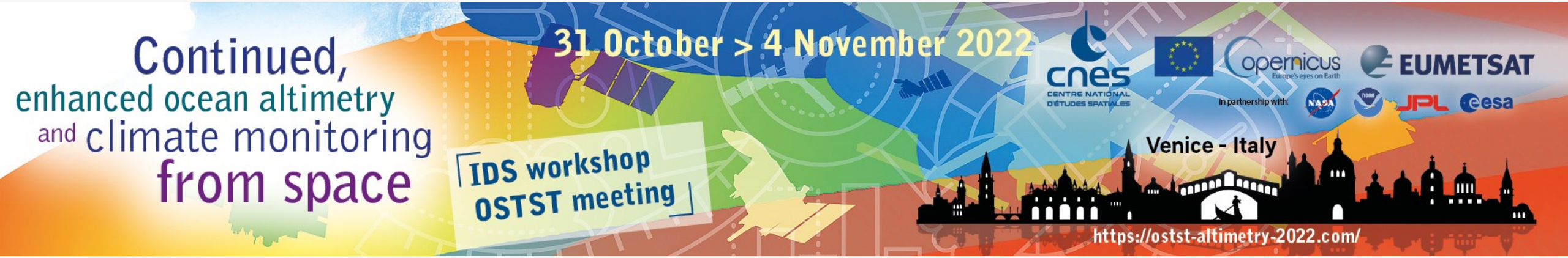
# Coastal circulation in the Gulf of Cádiz using multi-mission altimetry data

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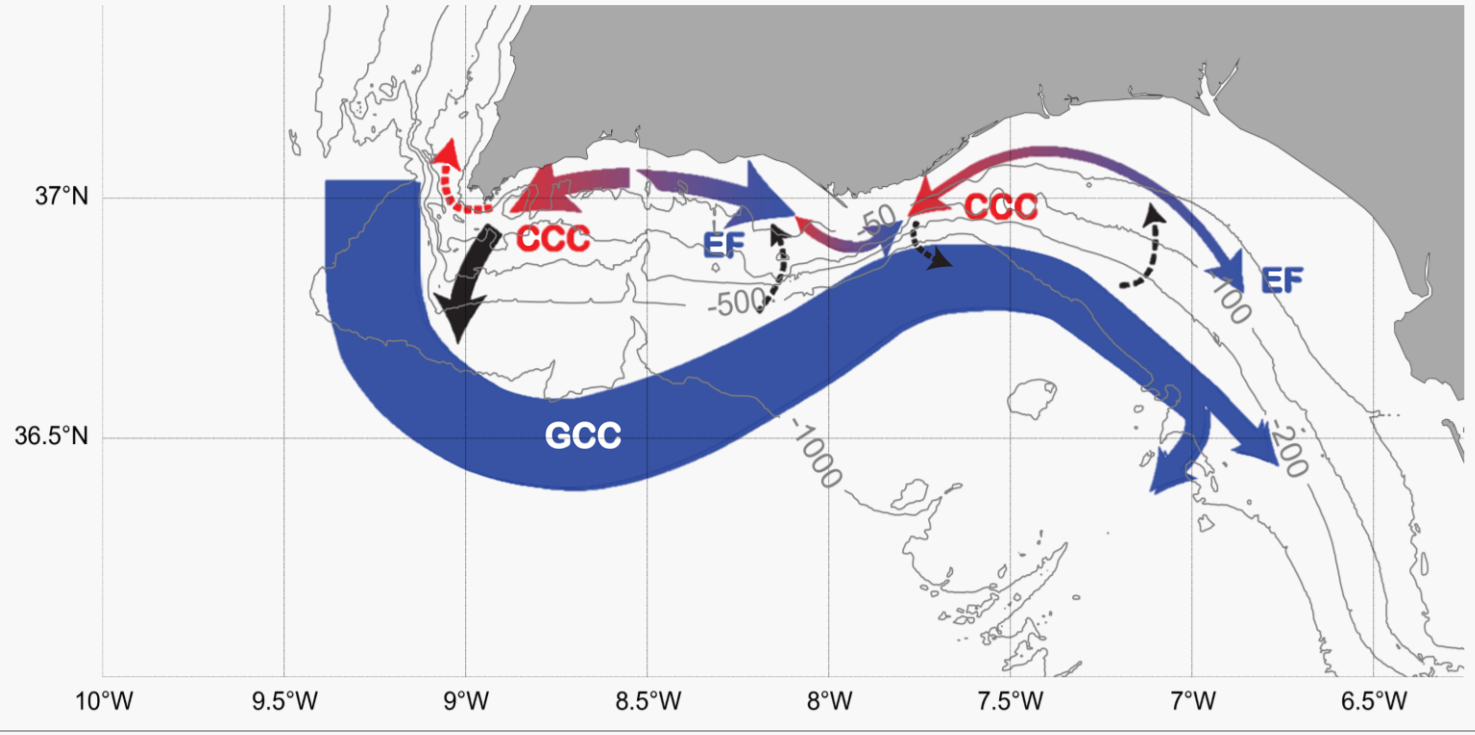
Facultad de Ciencias del Mar y Ambientales

Università degli Studi di Ferrara

# Study area

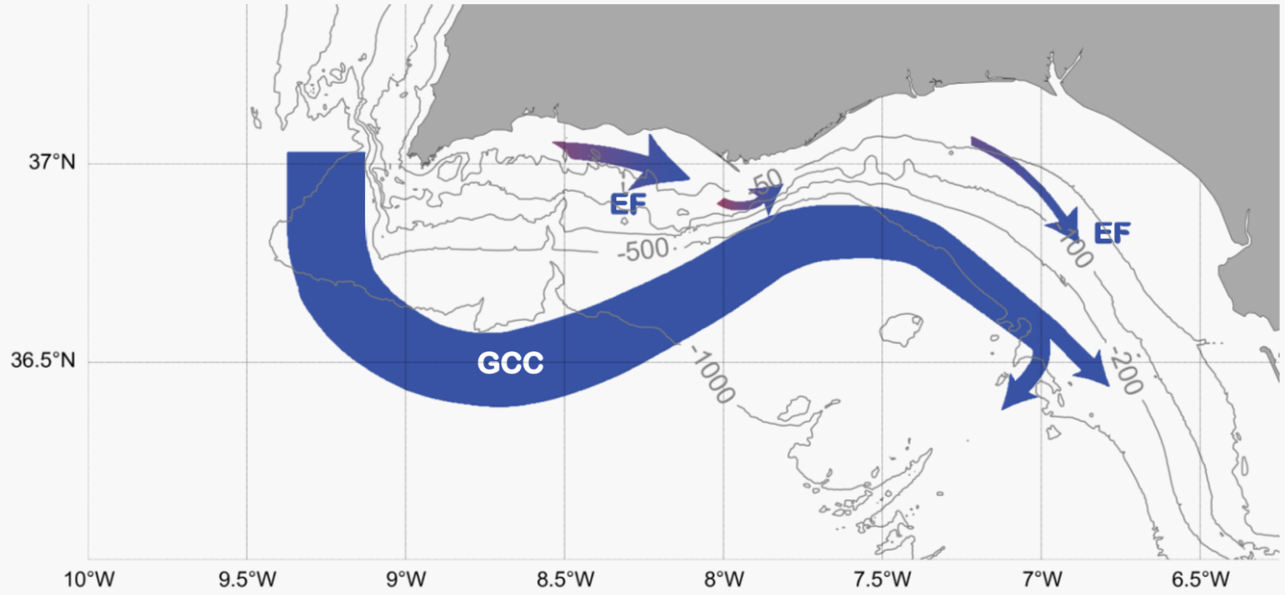


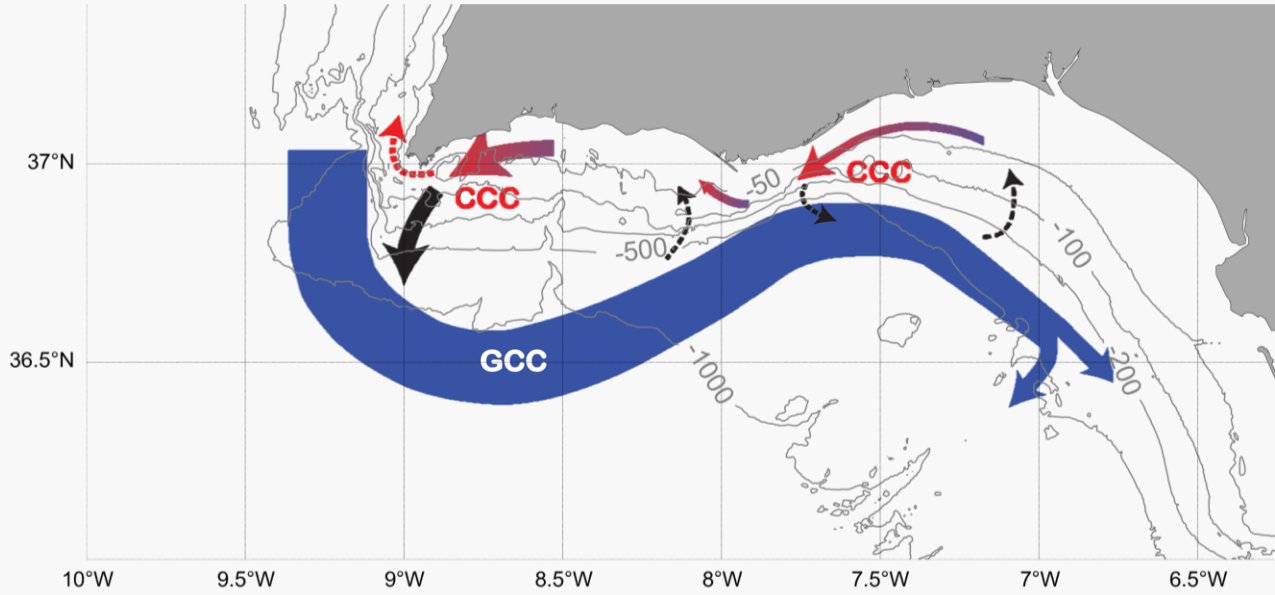

Gulf of Cádiz Current (GCC)

Eastward Flow (EF)

Westward Flow, Coastal Countercurrent (CCC)

# Study area



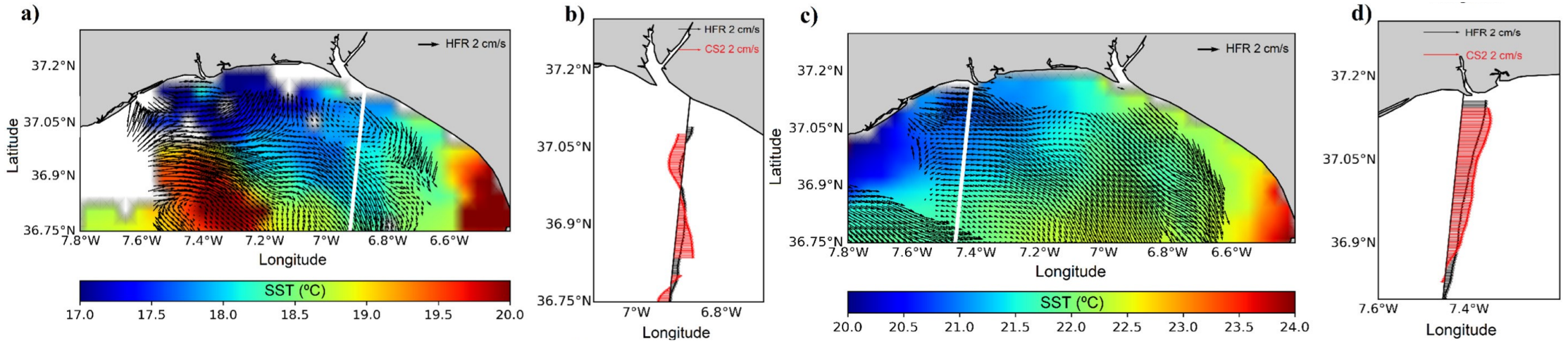

Eastward Flow mode:
Predominant under NW wind conditions (upwelling-favourable).

CCC mode:
Predominant during the relaxation (or reverse) of upwelling-favourable winds, enhanced by easterlies.

# Previous studies

**Assessment of near-shore currents from CryoSat-2 satellite in the Gulf of Cádiz using HF radar-derived current observations** (https://doi.org/10.1016/j.rse.2021.112310)

Good capacity of altimetry-derived surface velocities for detecting small scale gradients and structures over an area of high variability and complex dynamic.



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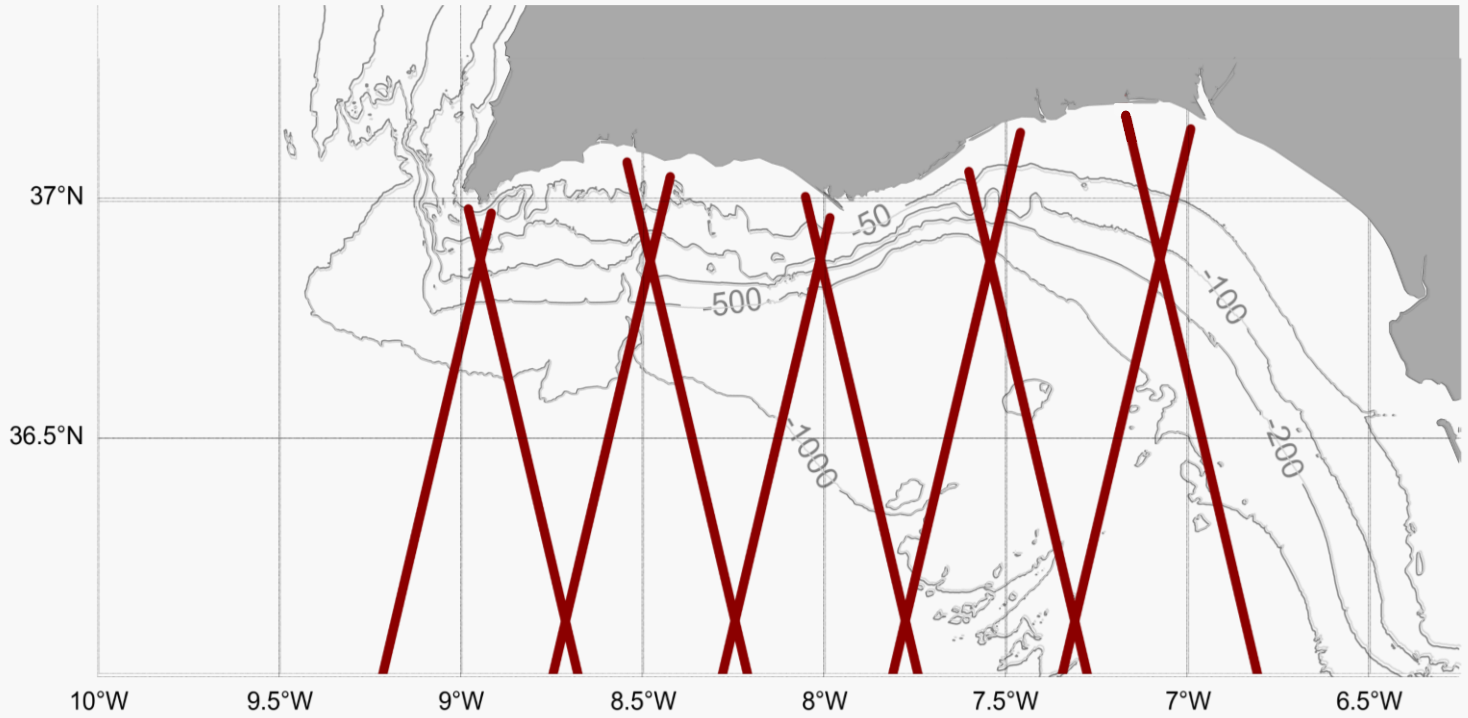
- Only normal to the coast tracks were selected
- Altimetry edition not independent from HFr data: filter cut-off length for altimetry data based on HFr detected variability

# Data and Edition Strategy

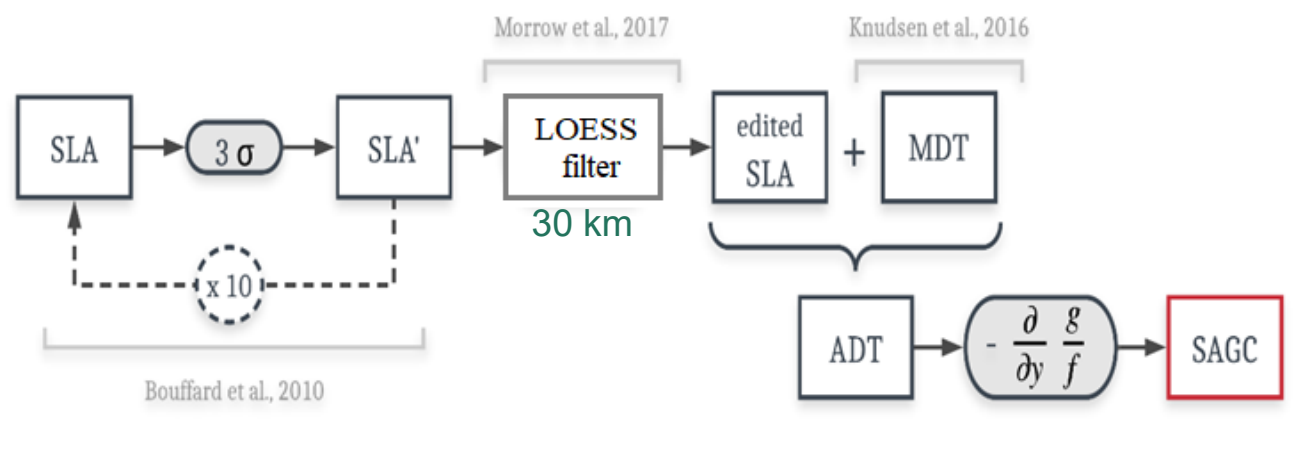



Sentinel-3A/B level 2 80Hz data provided by the ESA Earth Console Parallel Processing Service (P-PRO) SAR versatile altimetric toolkit for ocean research and exploitation (SARvatore) service.

Pre-defined processing setup for coastal zones.

SAR Altimetry MOde Studies and Applications (SAMOSA++) model (Dinardo et al., 2020)

# Data and Edition Strategy




| Range corrections | Geophysical corrections | |
|---|---|---|
| **Atmospheric Corrections** | **Tidal Corrections** | **Ocean Surface Corrections** |
| Dry Tropospheric | Ocean Tide (TPXO8-atlas model) | Dynamic Atmospheric Correction |
| Wet Tropospheric | Long-Period Equilibrium Tide | Sea State Bias (5% Significant Wave Height) |
| Ionospheric | Ocean Loading Tide | |
| | Solid Earth Tide | |
| | Geocentric Polar Tide | |

* 30 km most suitable filter cut-off distance for the Gulf of Cadiz after extensive evaluation against high frequency radar

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# Along-shore geostrophic component

**Geostrophic approximation in shallow waters → Bottom-friction has to be taken into account**

$$U_{g+fc} = \frac{-g}{\left(f + \frac{r^2}{f}\right)} \cdot \frac{\partial ADT}{\partial y}, where\ r = \frac{0{,}35 \cdot C_d}{d}$$

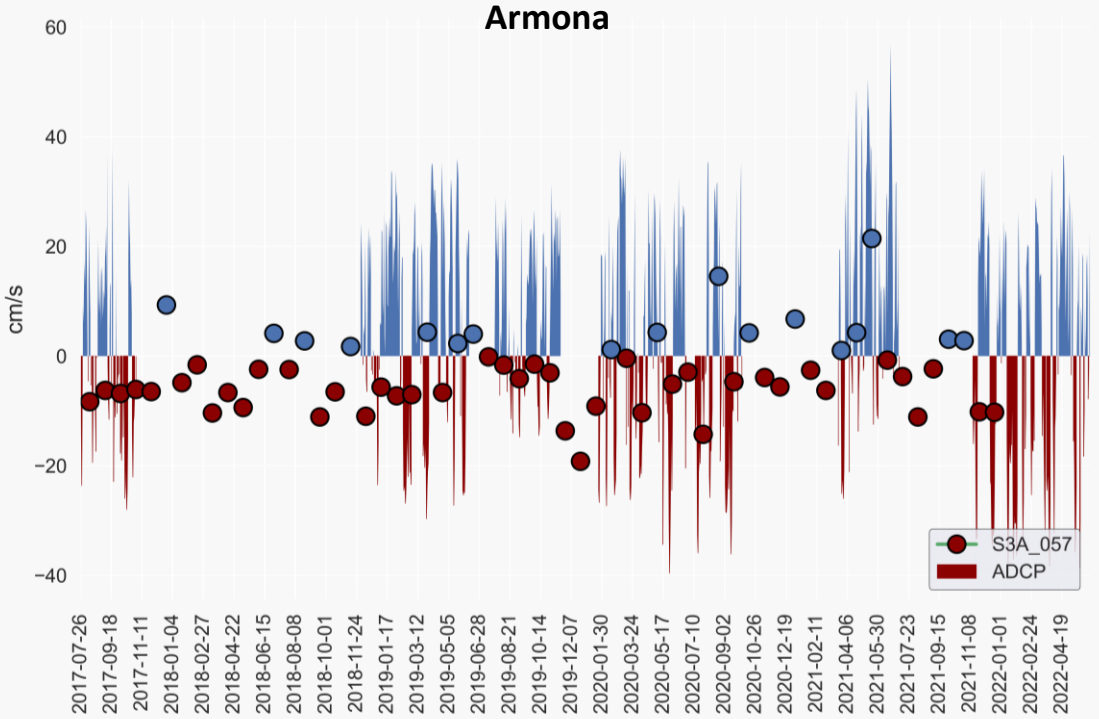
$U_{g+fc} = Zonal\ geostrophic\ component\ with\ friction\ correction$

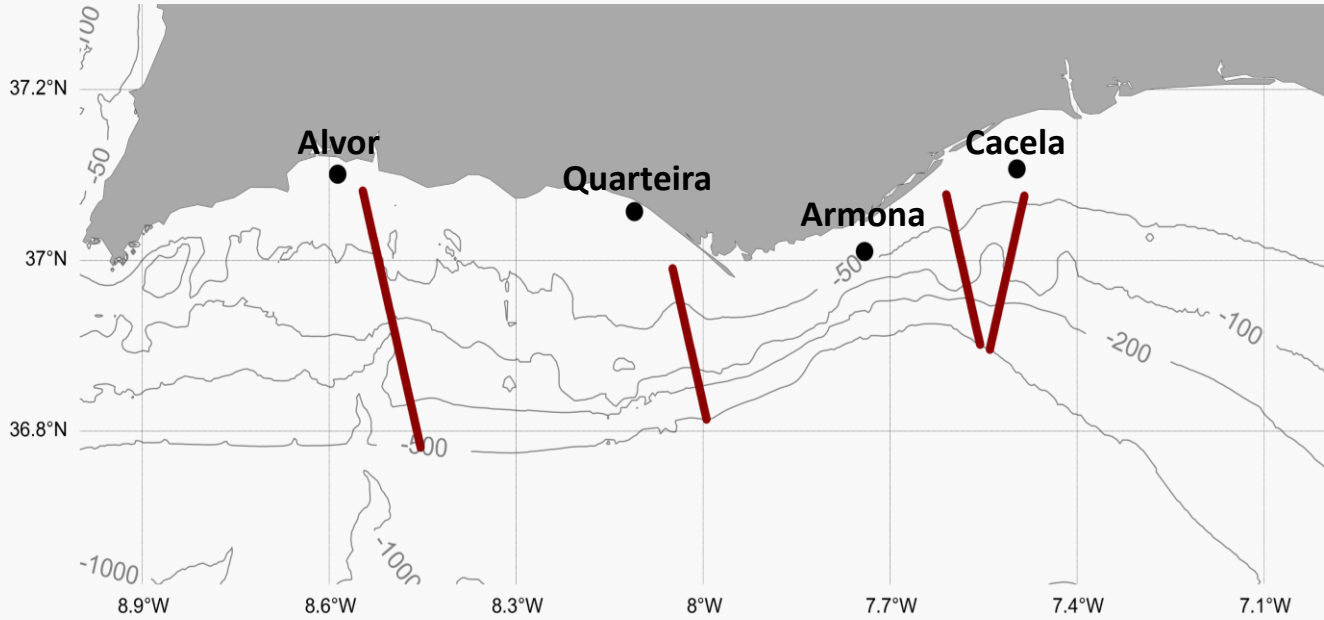
$C_d =$ bottom drag coefficient $(2 \cdot 10^{-3})$

$d = depth$

Find the complete development of the correction in:
Assessment of near-shore currents from CryoSat-2 satellite in the Gulf of Cádiz using HF radar-derived current observations (https://doi.org/10.1016/j.rse.2021.112310)

# Detecting coastal circulation reversals

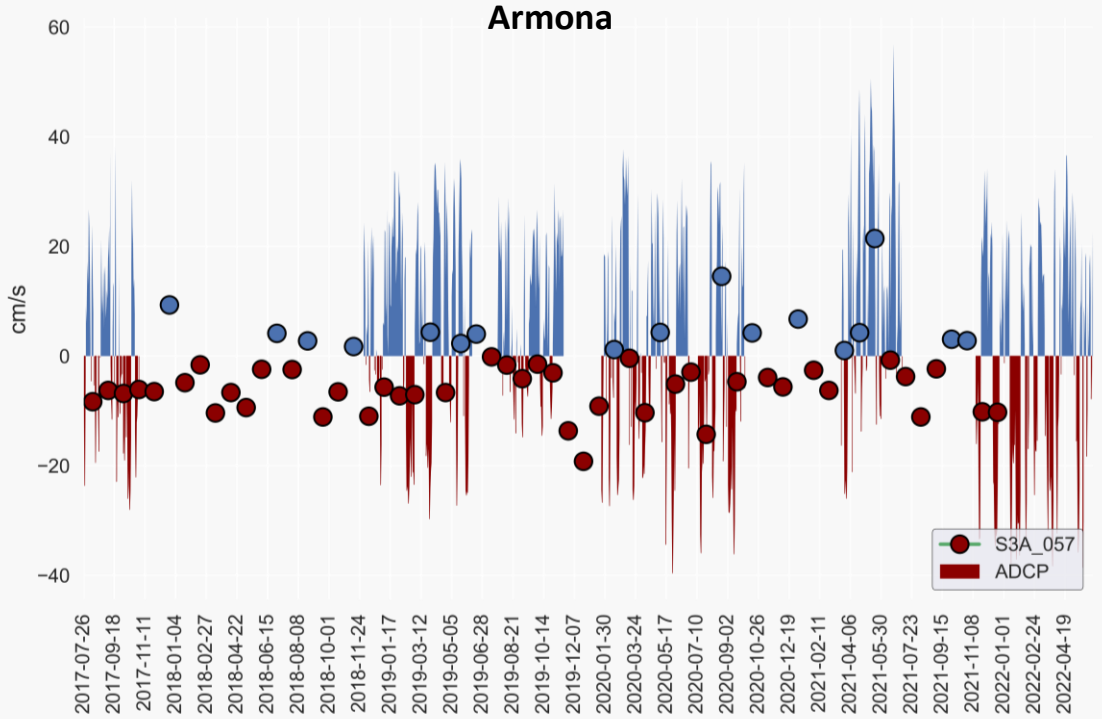


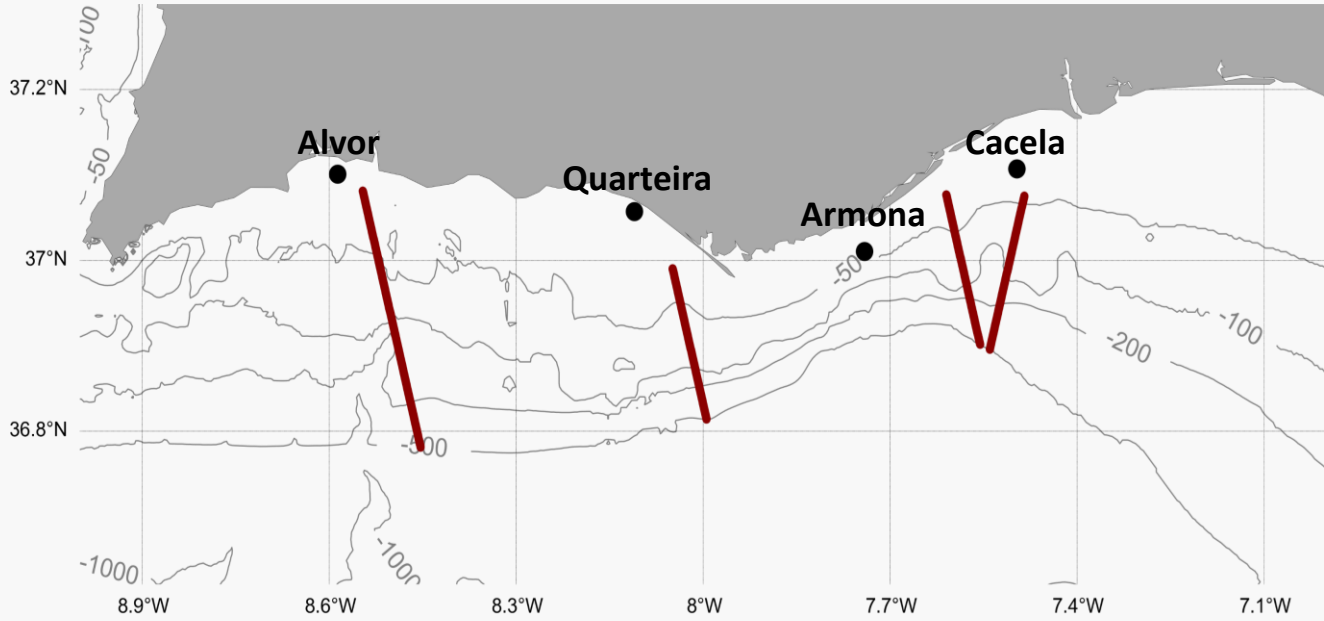




## Coastal ADCP vs S3A/B $U_{geos}$

- 72h average ADCP velocities previous to the corresponding satellite pass
- Average along-track S3A/B $U_{geos}$ over the continental shelf (up to 500 m depth)

# Detecting coastal circulation reversals

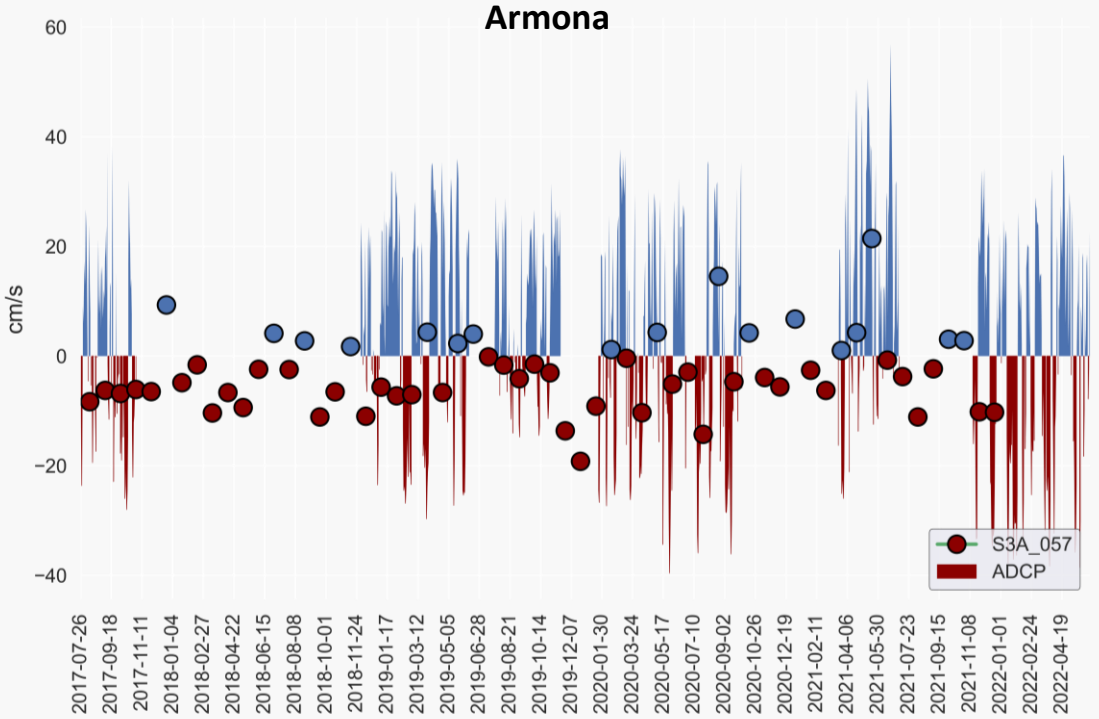


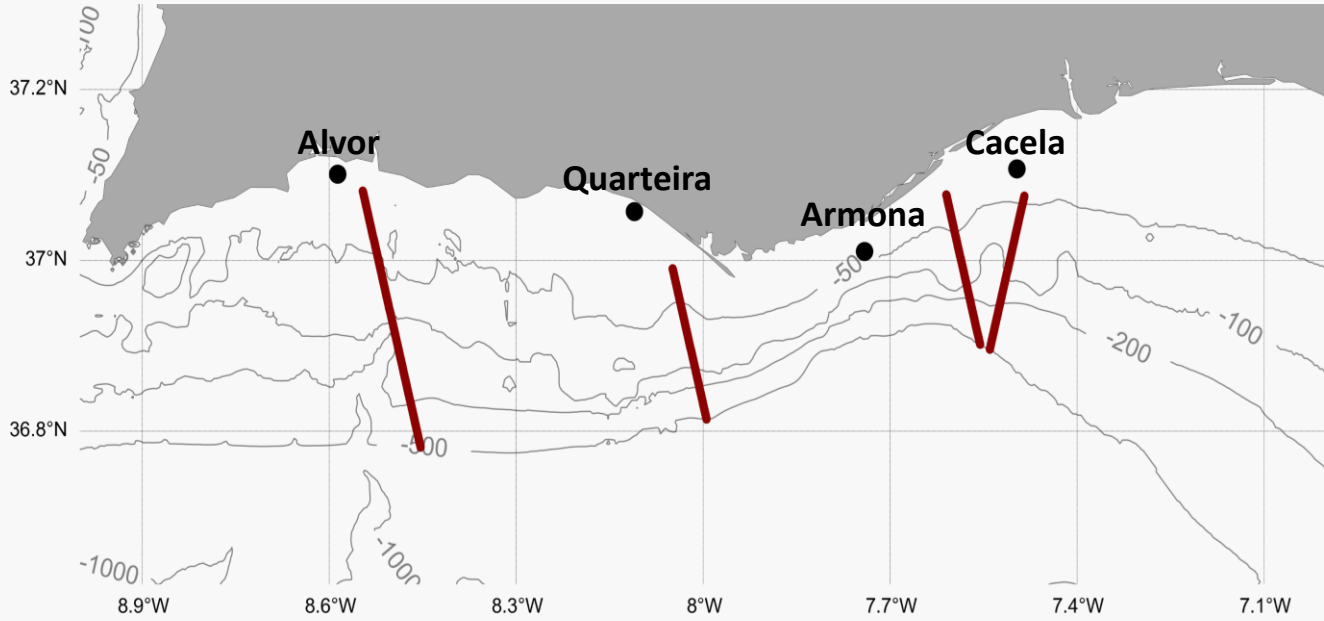




| Two-tailed Fisher Test | | Altimetry | |
|---|---|---|---|
| | | Eastward flow (+) | Westward flow (-) |
| ADCP | Eastward flow (+) | 17 | 13 |
| | Westward flow (-) | 1 | 14 |

**A significant relationship exists, p-value = 0.0012637**

# Detecting coastal circulation reversals




A significant relationship exists between **altimetry-derived zonal geostrophic flow** and **ADCP detected zonal coastal along-shore flow**

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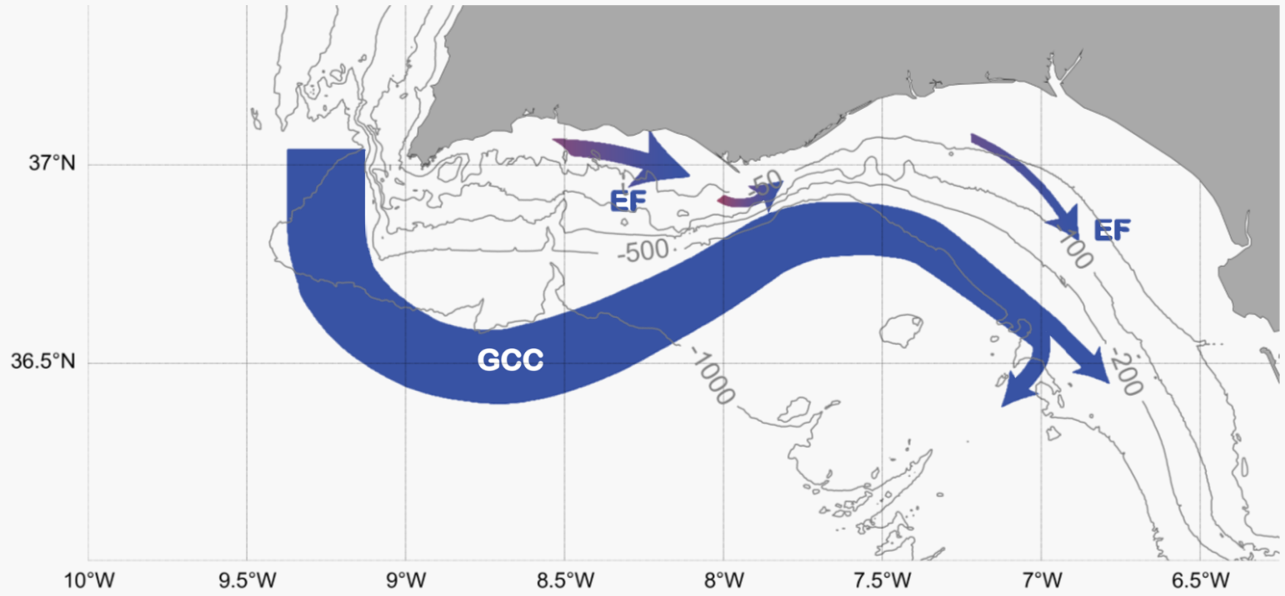
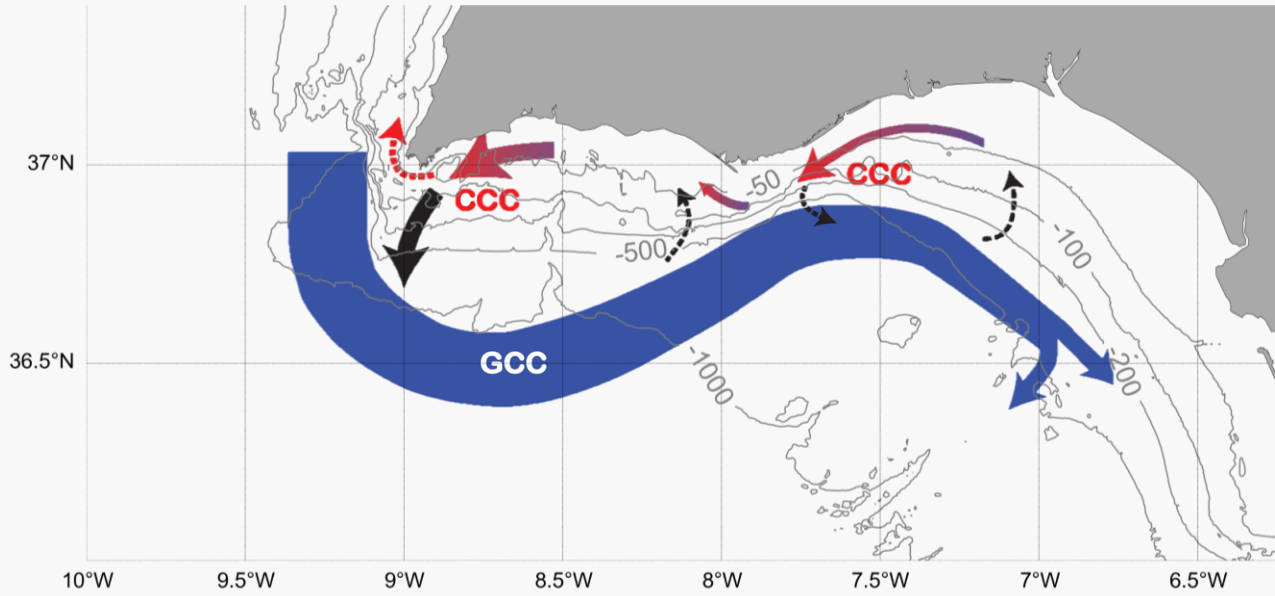
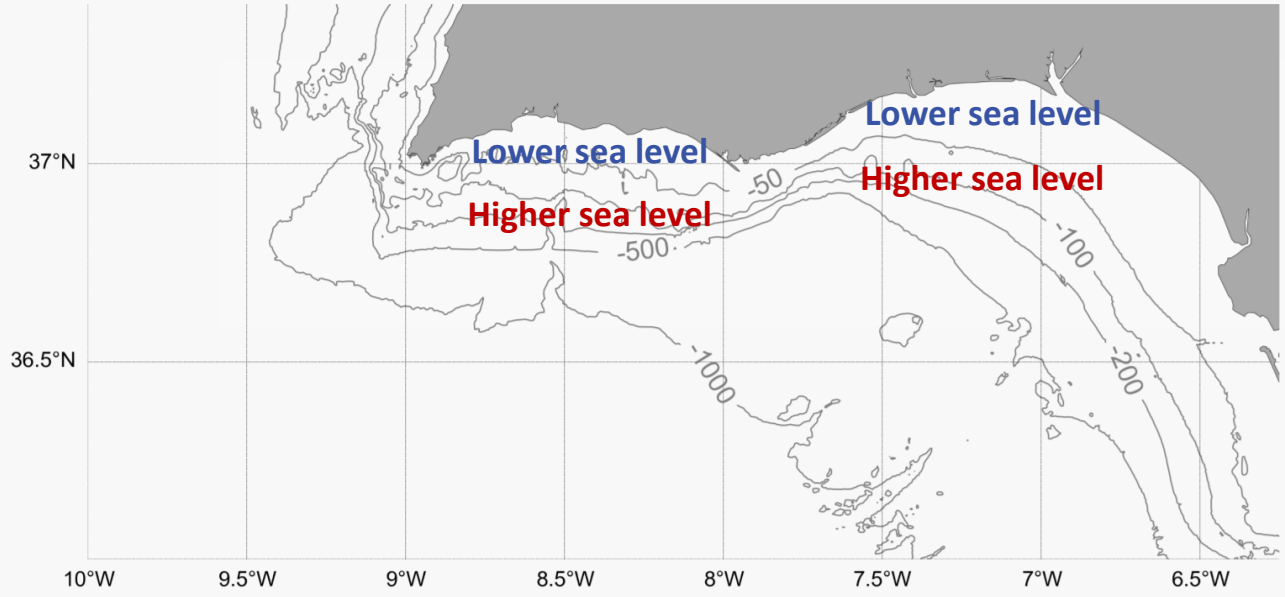
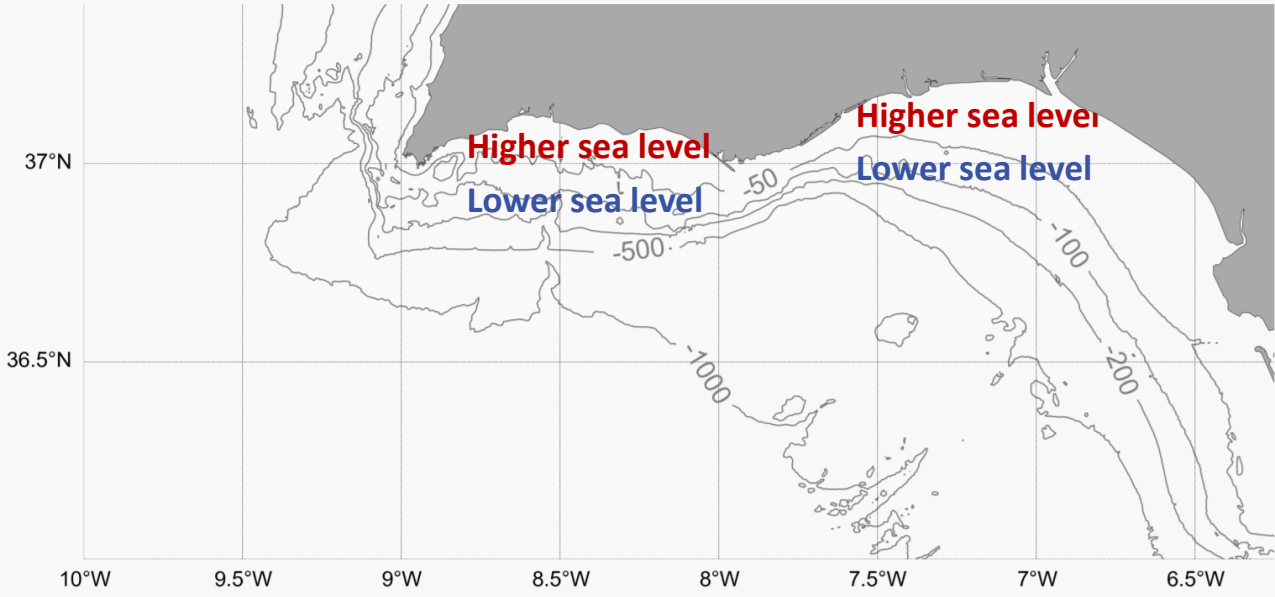
A significant relationship exists between **ADT cross-shore gradient** and coastal **along-shore flow direction**

# Detecting coastal circulation reversals

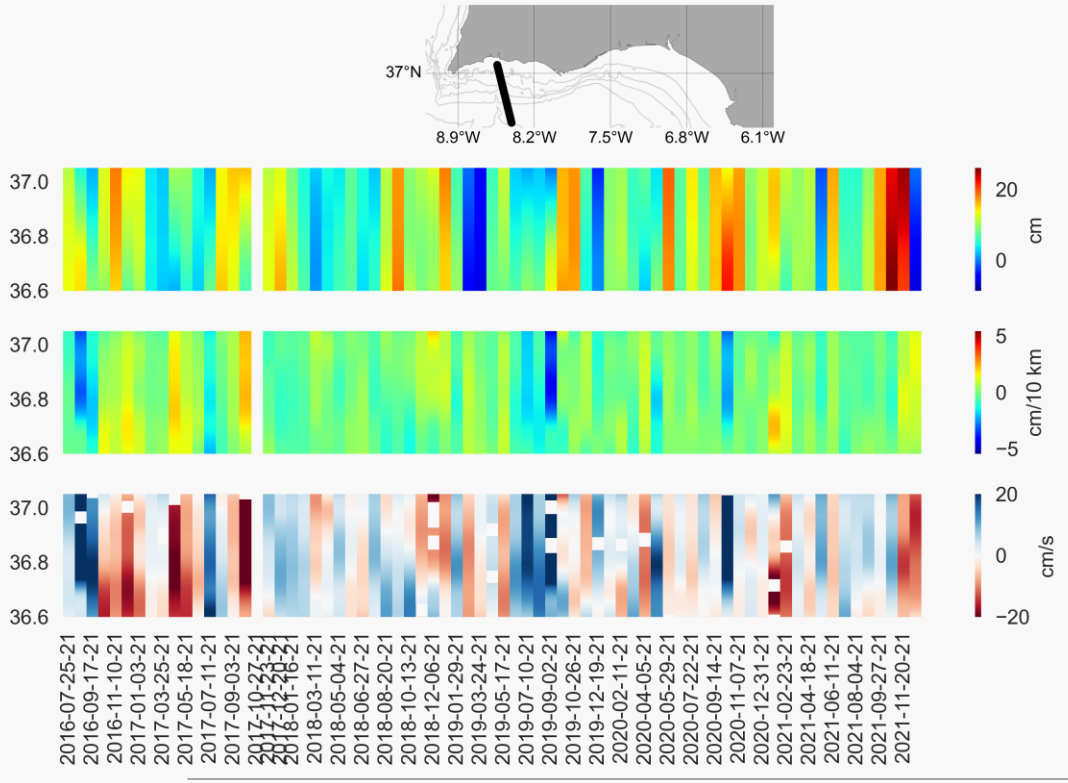


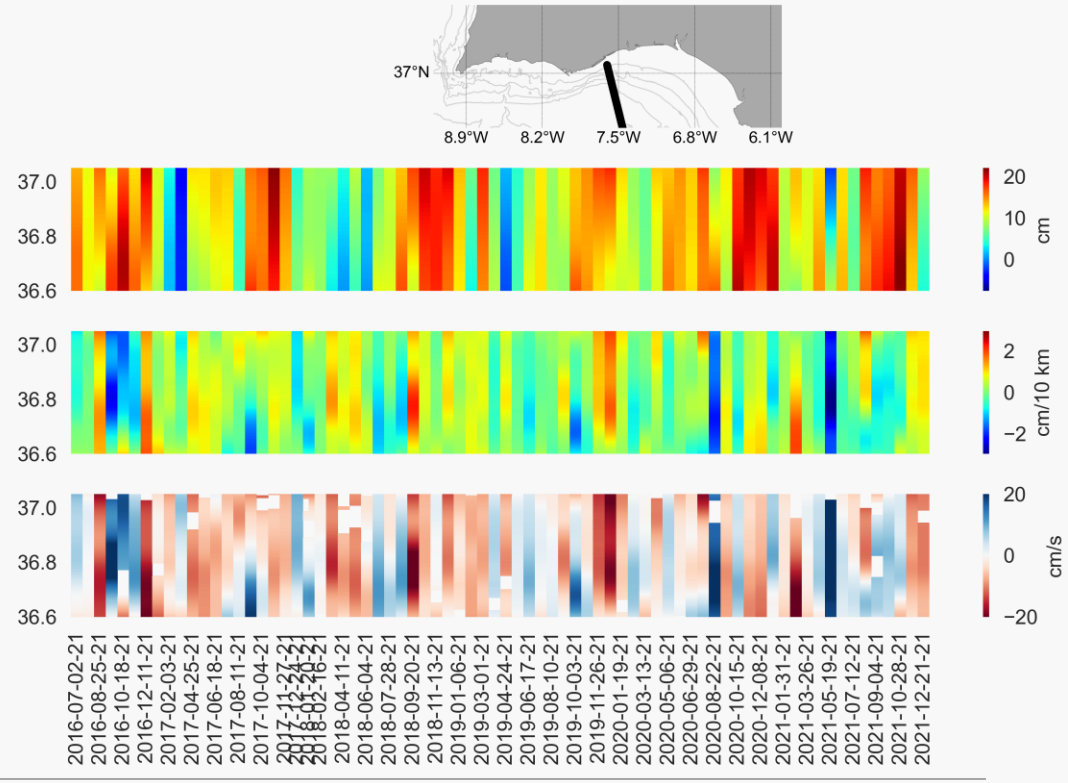



# Temporal coastal circulation variability




**Coastal circulation along-track temporal analysis:**

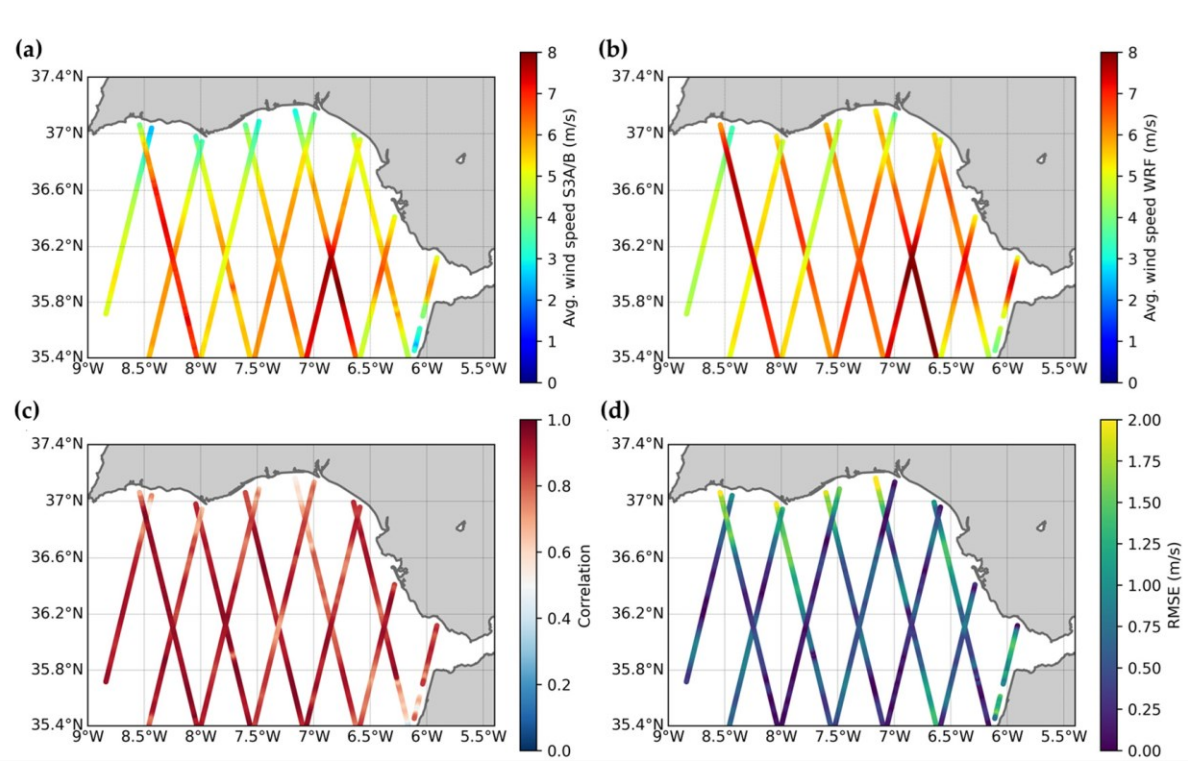
- Seasonal variability

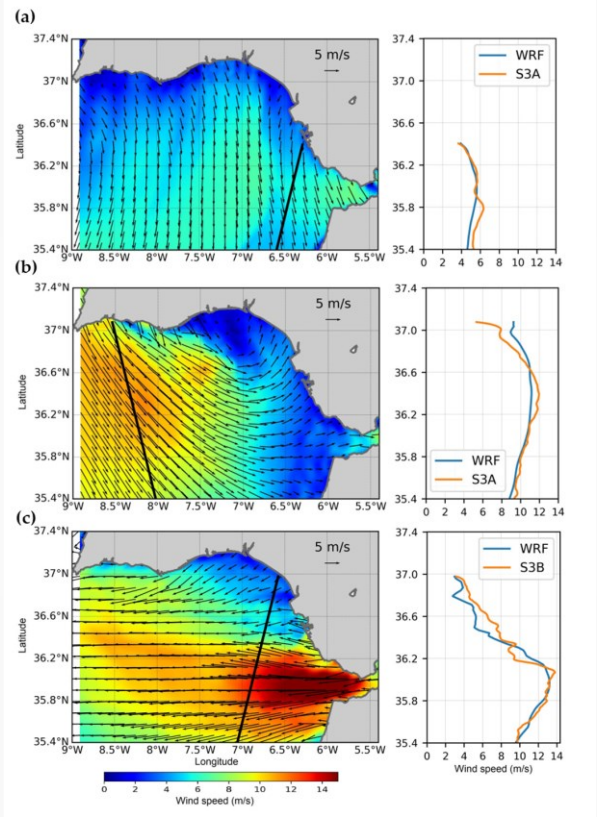
- Along-shore flow reversal variability

# Current research

Wind effect over the coastal circulation:

- Validation of the Weather Research and Forecasting (WRF) model over the Gulf of Cádiz using in-situ and altimetry data.
- High-resolution wind model to generate further knowledge of the Surface circulation over the area in synergy with altimetry derived-circulation.



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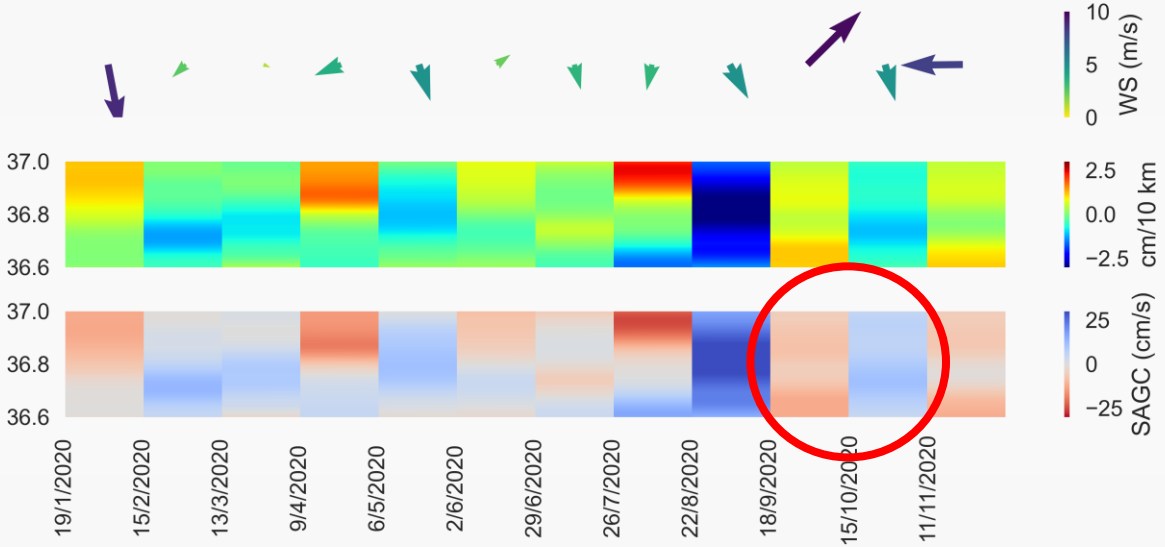
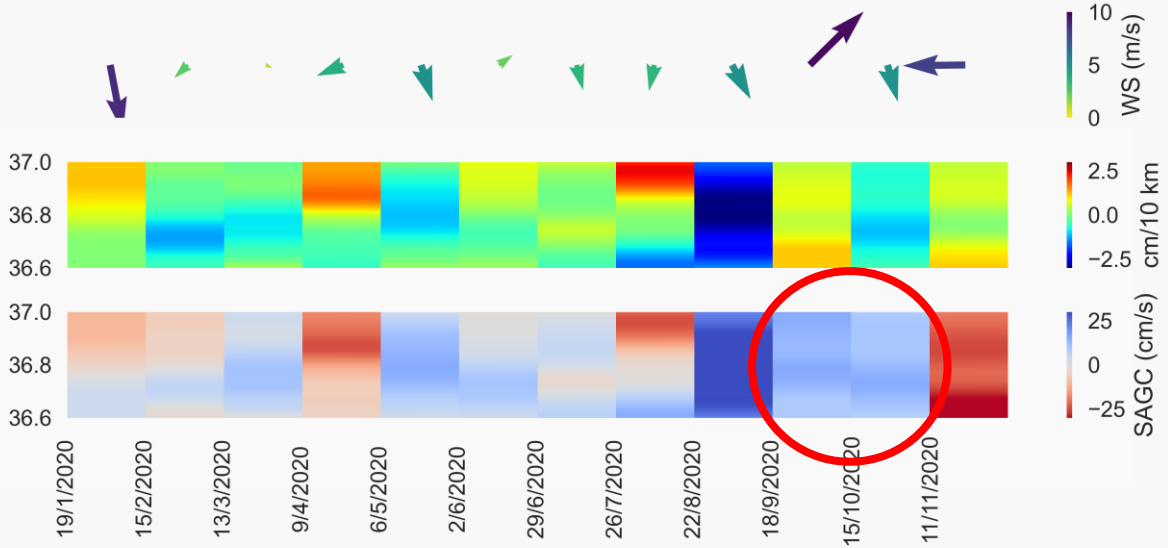



+ Wind component



# Final remarks

From the former results, it can be stated that…

· Current coastal altimetry data can be used to detect **along-shore coastal flow reversals** in the Gulf of Cádiz area, independently from any other observing system, as it has been statistically proved.

· Altimetry-derived geostrophic along-shore flow is estimated based on the **cross-shore ADT gradient** and the **geostrophic approximation**.

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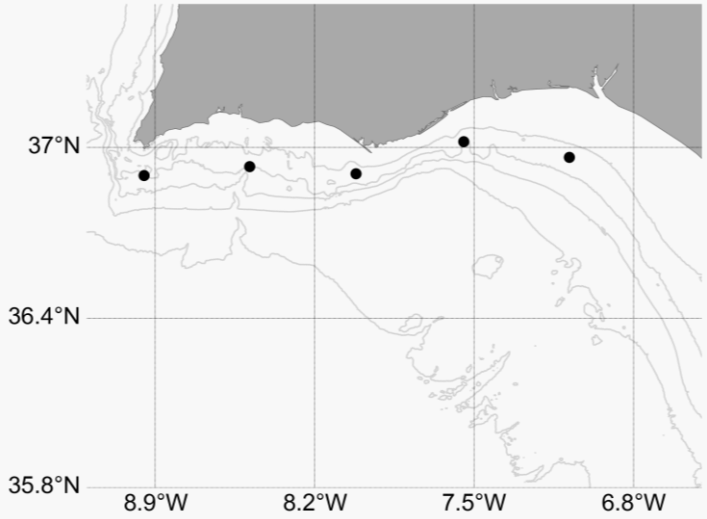
---

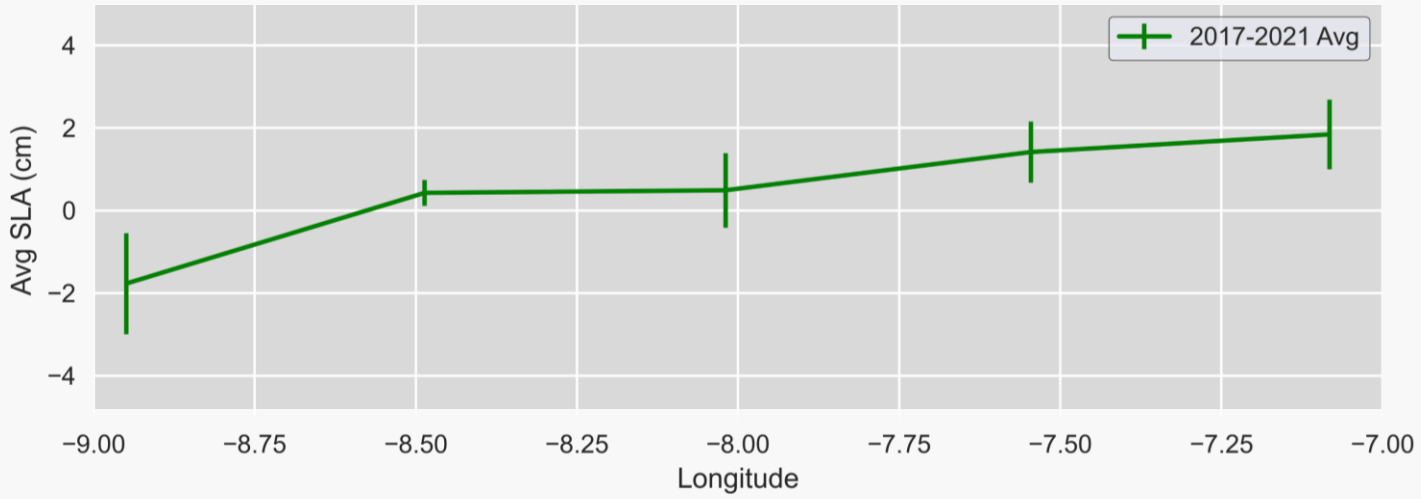
However, is it really a geostrophic flow?

The fact that a **statistical relationship** exists between the along-shore flow and the cross-shore ADT gradient **does not imply causation**.

# Final remarks

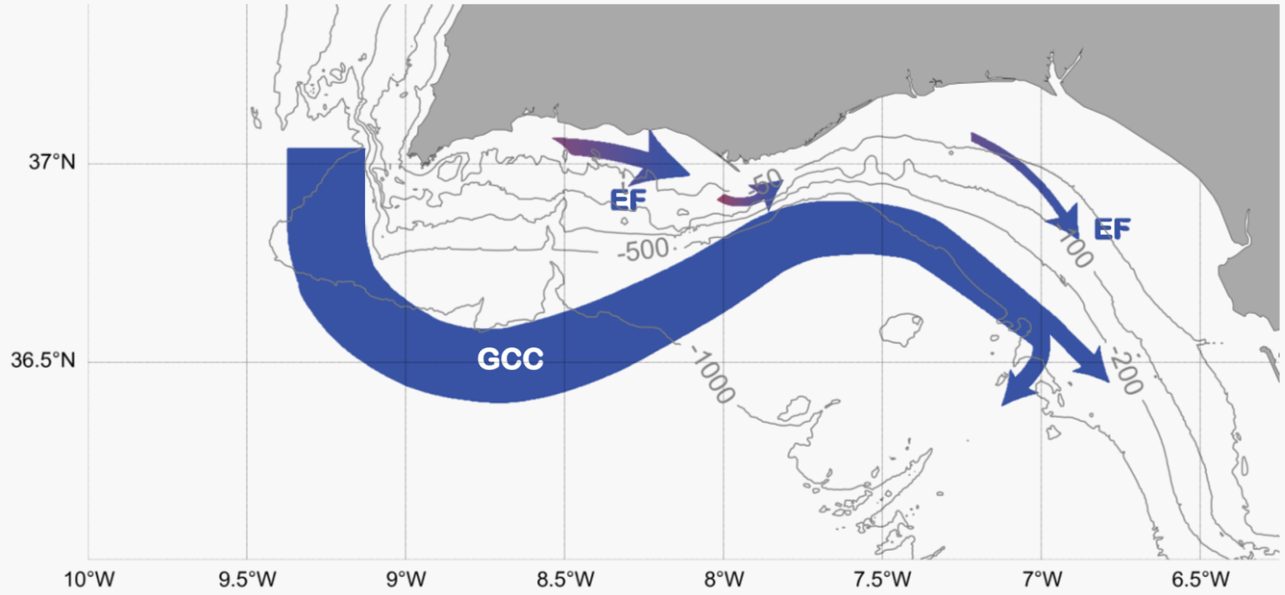
**Wind-induced along-shore pressure gradient**

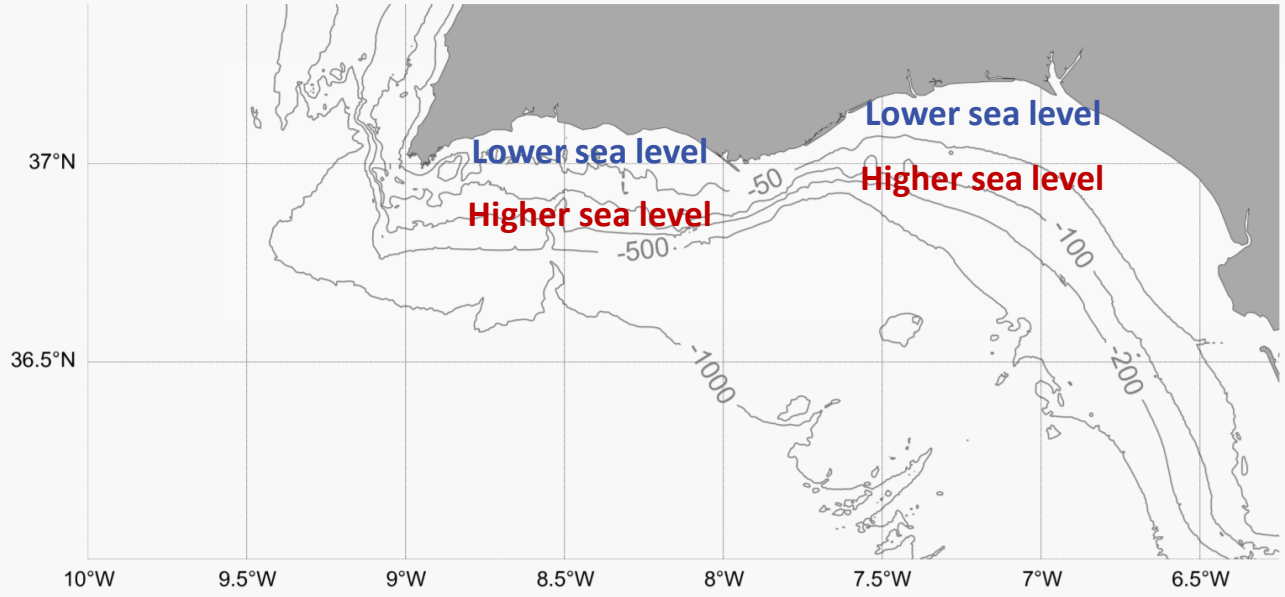



Could it be responsible for the westward coastal circulation (coastal countercurrent, CCC) during the relaxation of upwelling-favourable winds?

# Detecting coastal circulation reversals




Eastward circulation driven by upwelling-favorable winds

↓

Lower sea-level closer to the coast

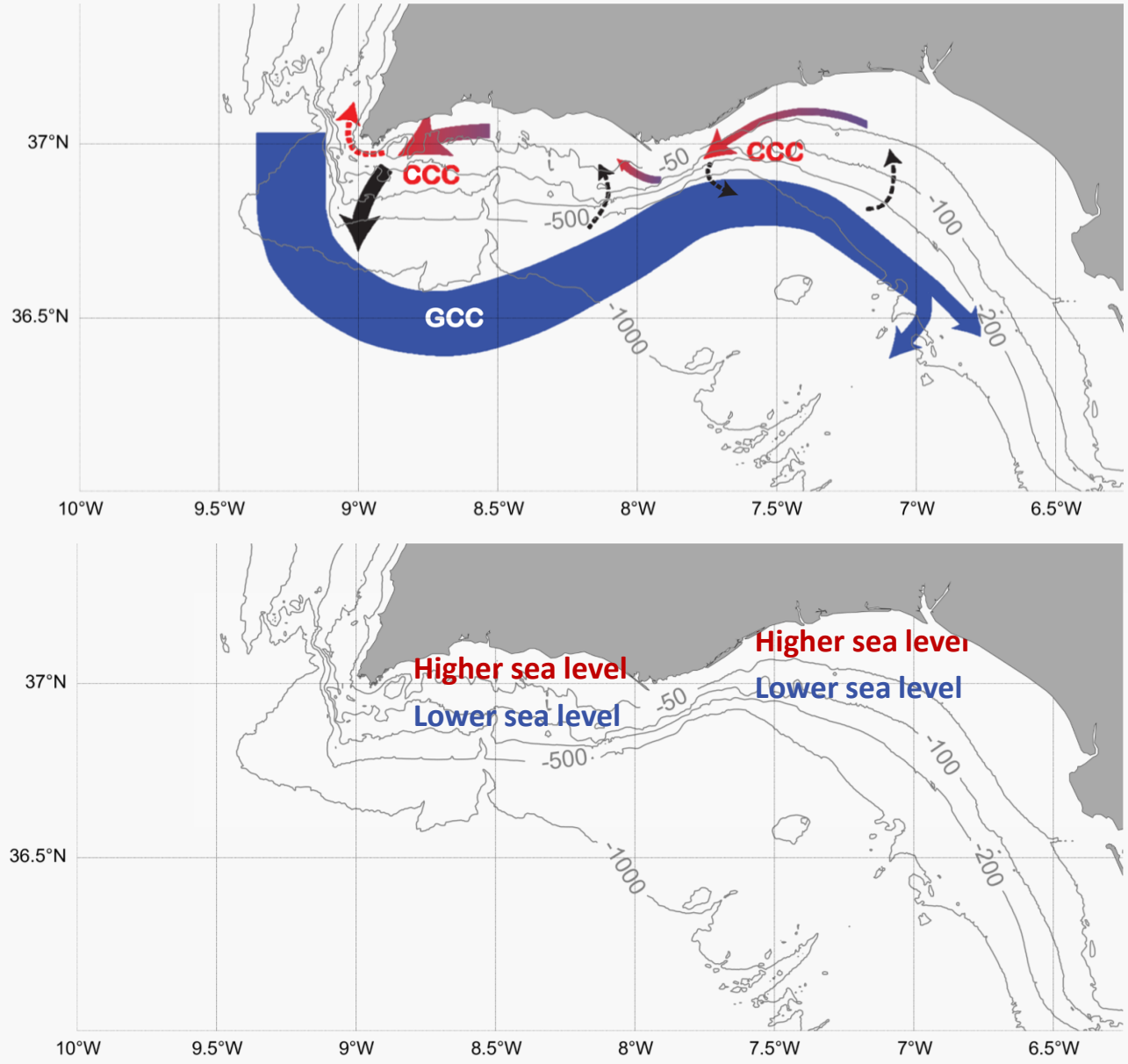
↓

Negative cross-shore ADT gradient

↓

Geostrophic eastward flow

# Detecting coastal circulation reversals




Westward circulation driven by sea-level along-shore gradient unbalance enhanced by easterlies

↓

Higher sea-level closer to the coast

↓

Positive cross-shore ADT gradient

↓

Geostrophic westward flow

# Final remarks

From the former results, it can be stated that…

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· Altimetry-derived geostrophic along-shore flow is estimated based on the **cross-shore ADT gradient** and the **geostrophic approximation**.

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However, is it really a geostrophic flow?

Currently analysing the magnitude of the potential flows resulting from the different sea-level gradients existing in the area (along-shore, cross-shore), as well as the wind component.

# Final remarks

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· Current coastal altimetry data can be used to detect **along-shore coastal flow reversals** in the Gulf of Cádiz area, independently from any other observing system, as it has been statistically proved.

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· Statistically valid results need to be contrasted with the geophysical features of the study area before being taken for granted.

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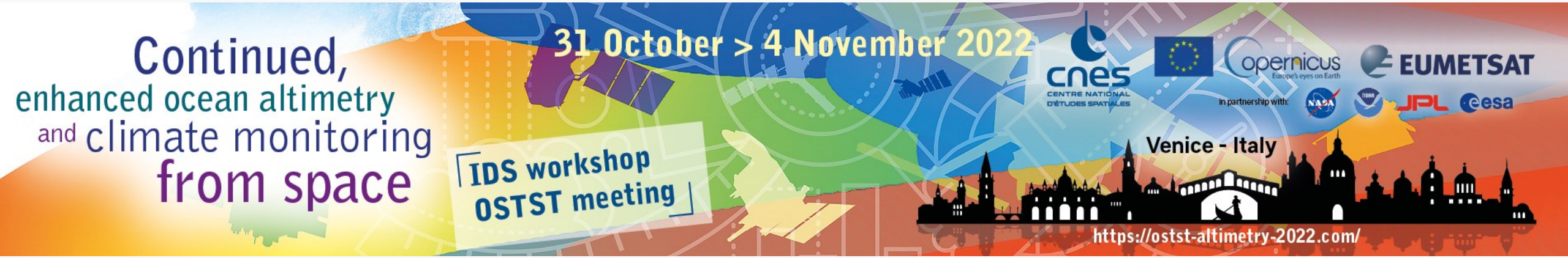


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