IDEAS-QA4EO Cal/Val workshop #4: Water Cal/Val

CryoSat-2/SWOT fine-scale oceanographic features

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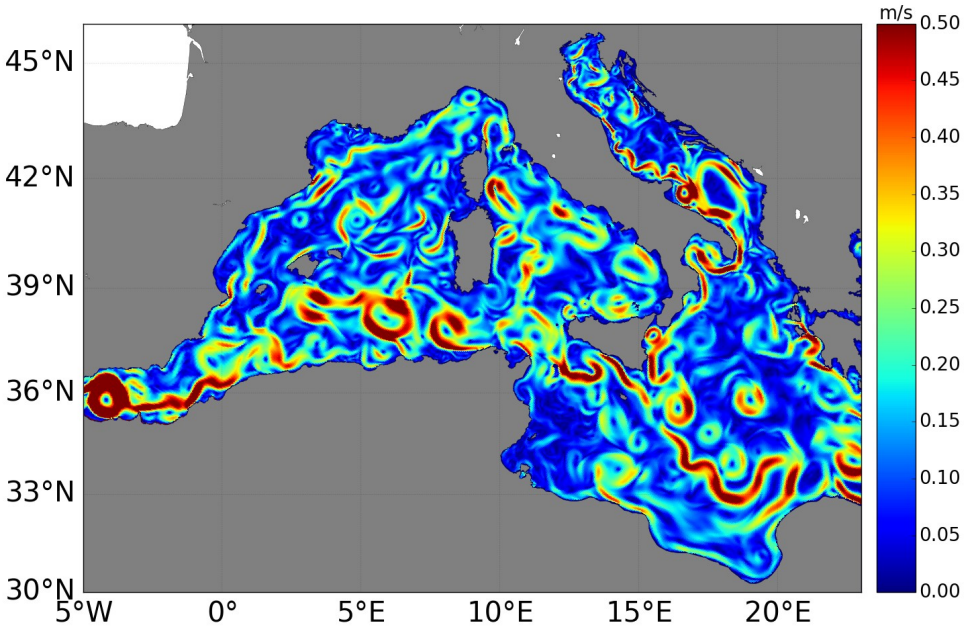
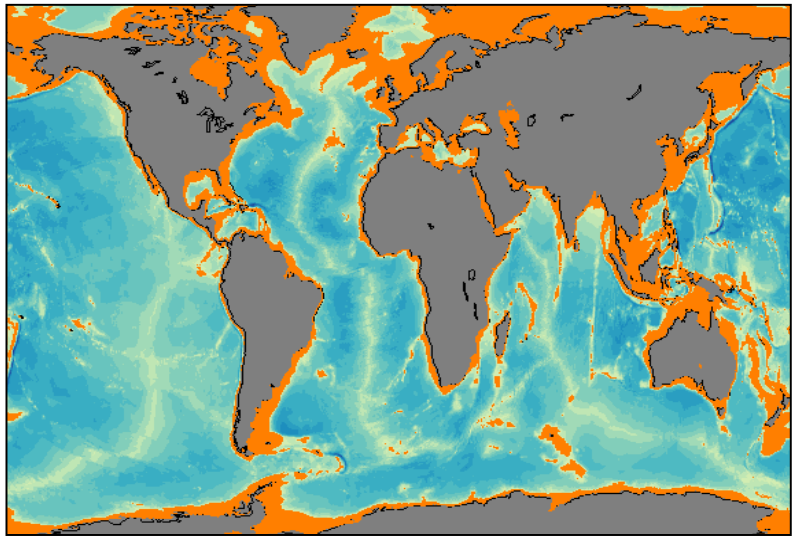
Introduction

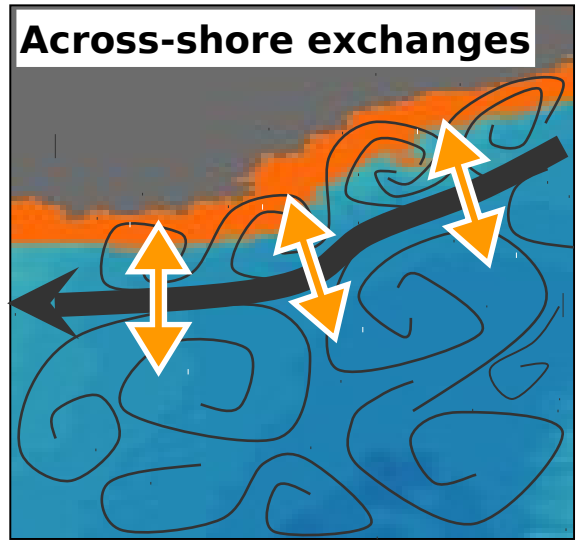
Context: observing fine-scale features

Why do we observe fine-scale features ?

1. A key role on the across-shore transport and mixing of natural and anthropogenic elements
2. Critical importance to monitor and forecast the varibility of regional dynamics
3. Actor of the exchanges with the open ocean



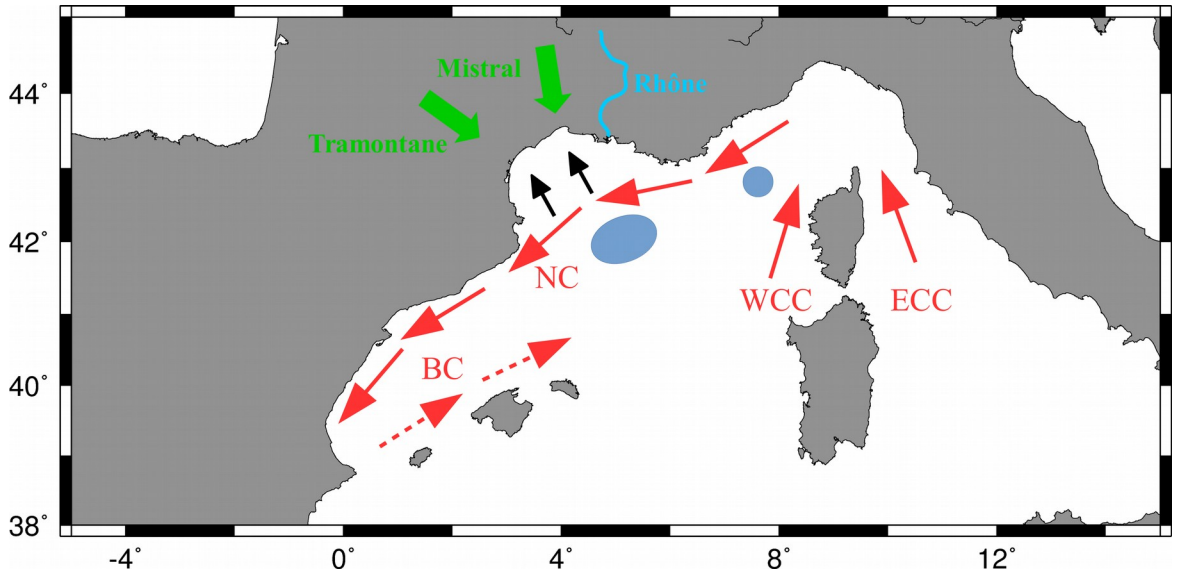




Context: observing fine-scale features

A focus on the North-Western Mediterranean Sea

- A region which is characterized by complex coastal and mesoscale dynamics with a lot of in situ instruments
- Considered as a test area for the observability of its dynamics by satellite altimetry
- A coastal slope current: the **Northern Current** which is the coastal branch of the cyclonic circulation of the northwestern Mediterranean Sea.



Main winds in the region

Main currents of the region

BC = Balearic Current

NC = Northern Current

WCC = Western corsica Current

ECC = Eastern Corsica current

Coastal intrusions

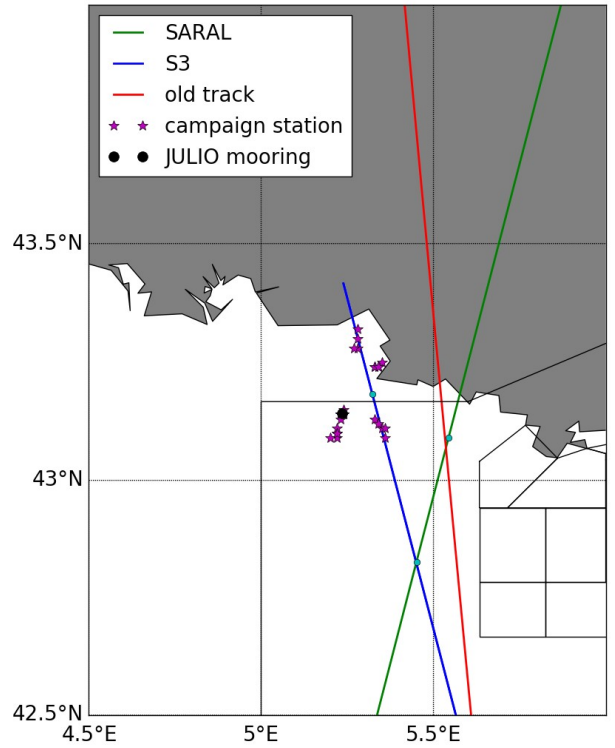
Convection cells

Context: observing fine-scale features

A focus on the North-Western Mediterranean Sea ... and on the NC intrusions

The NC dynamics at the finescale is complex and it can episodically penetrate on the Gulf of Lion shelf, strongly impacting the local biogeochemistry.

Several altimetry tracks pass over the area and especially the SWOT mission during the fast sampling phase



Objectives

- To monitor the NC intrusions over the Gulf of Lion
- To test the potential of different missions and especially CryoSat-2 to observe coastal and fine-scale structures
- To better assess the physical content and limitations of each observing systems
- To study the submesoscale / mesoscale dynamics characterisations with a focus on the vertical velocity

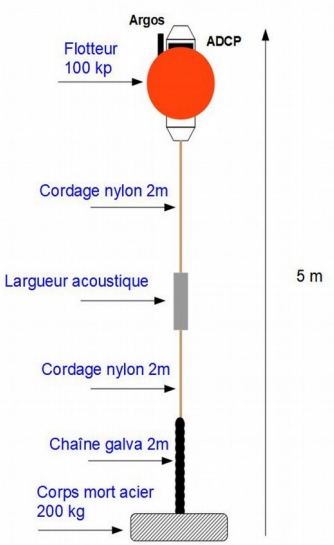
Tools and methods

Tools and methodology

In situ data

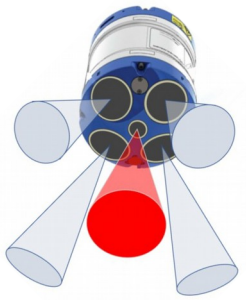
Judicious Location for Intrusion Observation (JULIO) mooring

- located on the 100-m isobath
- current velocities throughout the water column every 30 minutes
- https://people.mio.osupytheas.fr/~petrenko/julio.htm



OSCAHR & FUMSECK campaigns

- ADCP (Acoustic Doppler Current Profiler)
- MVP (Moving Vessel Profiler)
- VVP (Vertical Velocity Profiler)

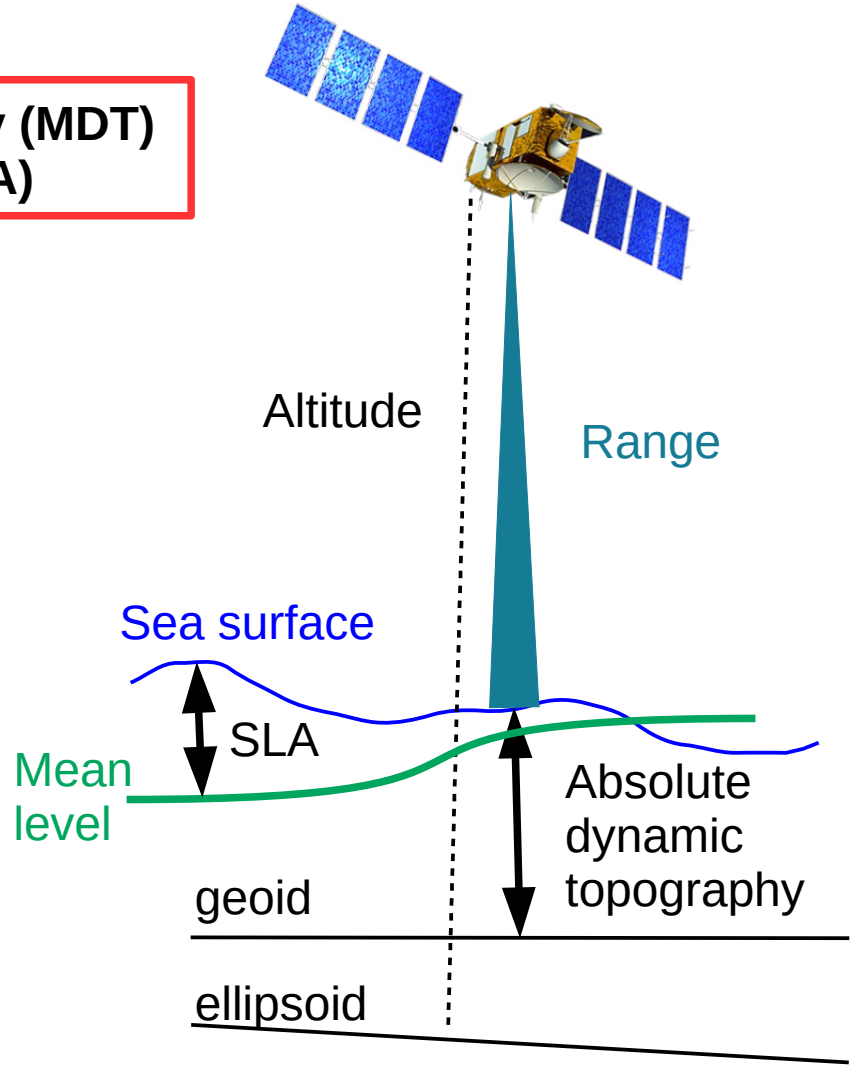


Tools and methodology

Altimetry data

Absolute Dynamic Topography (ADT) = Mean Dynamic Topography (MDT) + Sea Leval Anomalies (SLA)

- The altimeter is a radar at vertical incidence.
- The signal returning to the satellite is from quasi-specular reflection.
- Measures the distance between the satellite and the surface (**range**) converted to surface **heights**.
- Determines the position of the satellite (**precise orbit**)



Altimetry-derived current

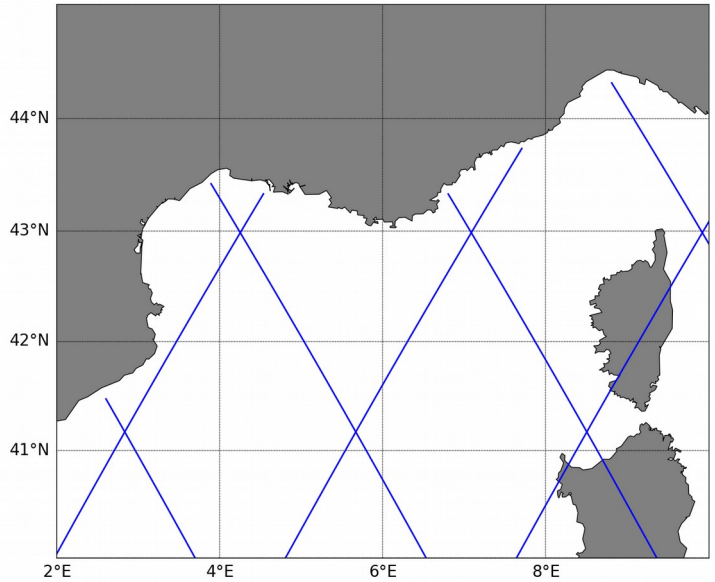
$$\vec{v} = \frac{g}{f}\frac{\partial ADT}{\partial \vec{x}}$$

g gravity, *f* Coriolis parameter

Tools and methodology

Altimetry data

Jason 3



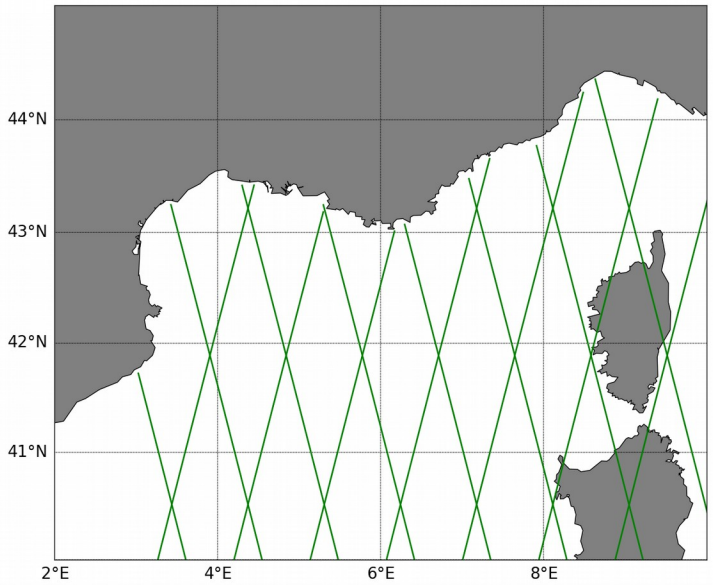
1992+

Ku-Band

Circular footprint ~ 15 km

10 days repetitivity

Sentinel-3



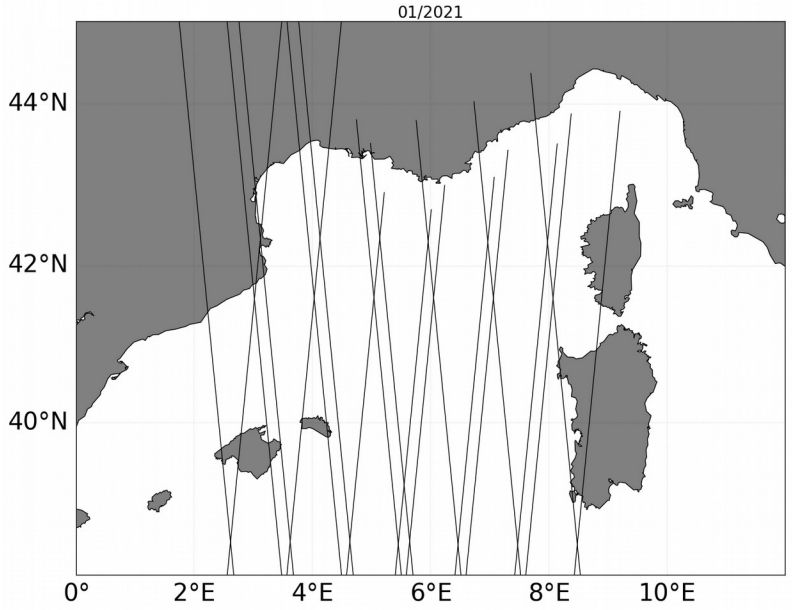
2016+

SAR altimetry

Rectangular footprint ~ 15 km x 350 m

27 days repetitivity

CryoSat-2



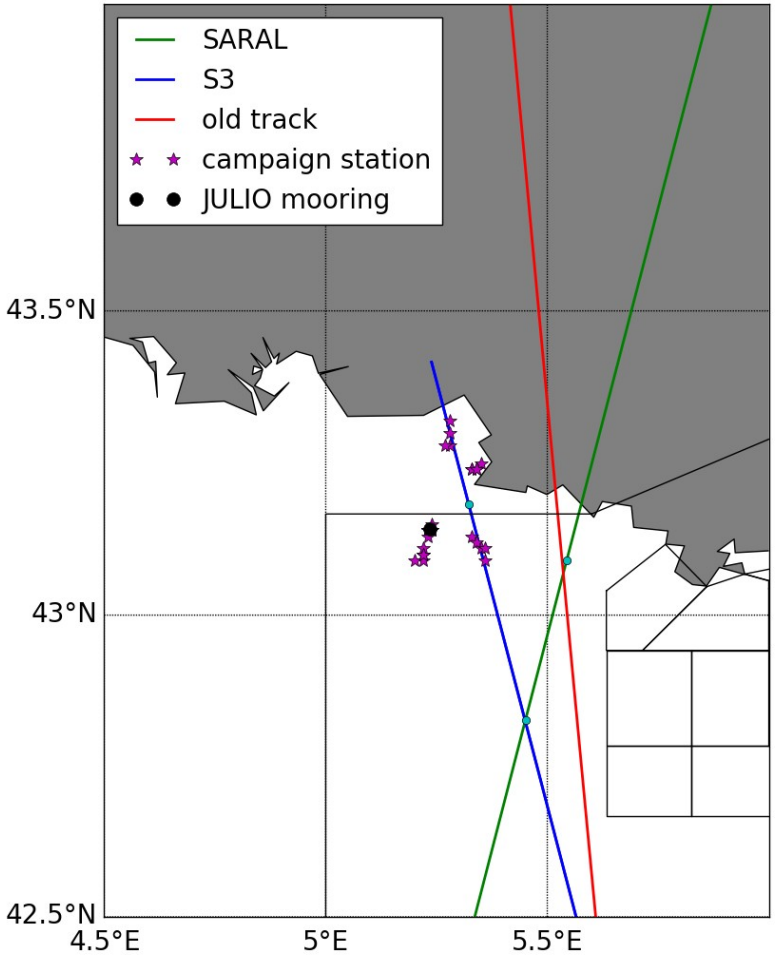
2010+

SAR altimetry

Rectangular footprint ~ 15 km x 350 m

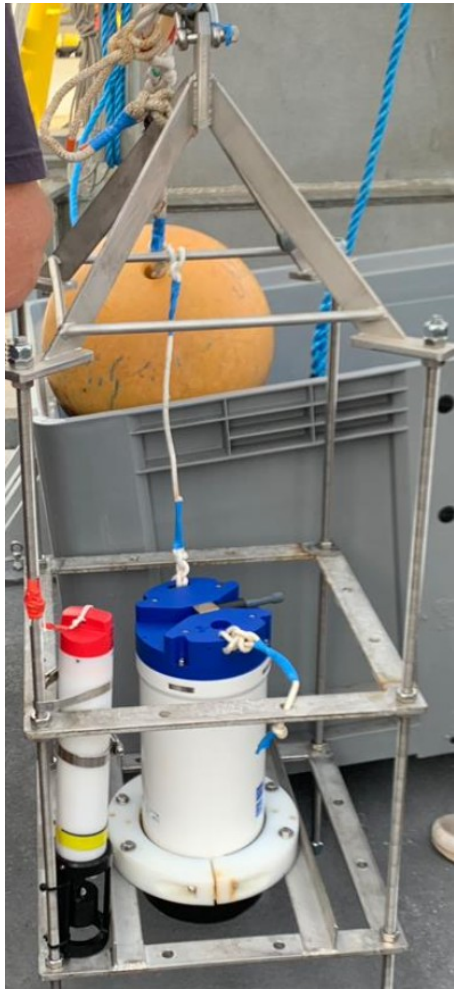
Results

Results: vertical velocity analysis

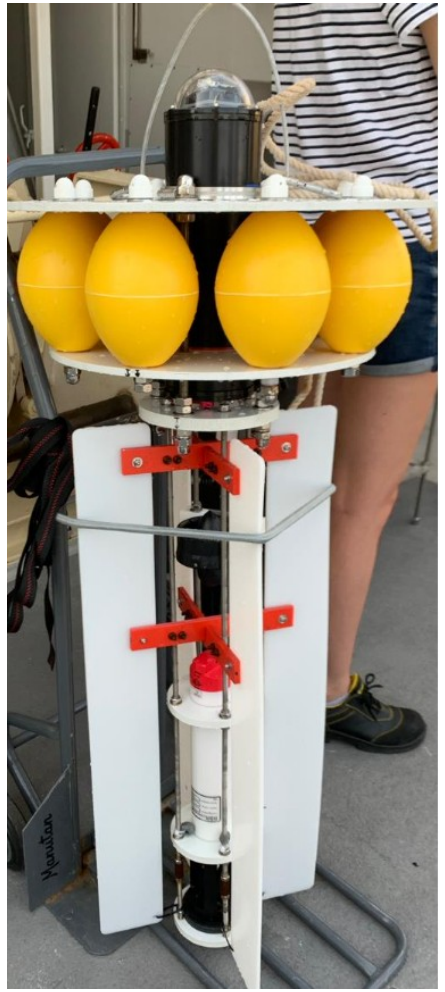


- JULIO mooring position
- FF ADCP casts
- VVP deployment

FF-Sentinel

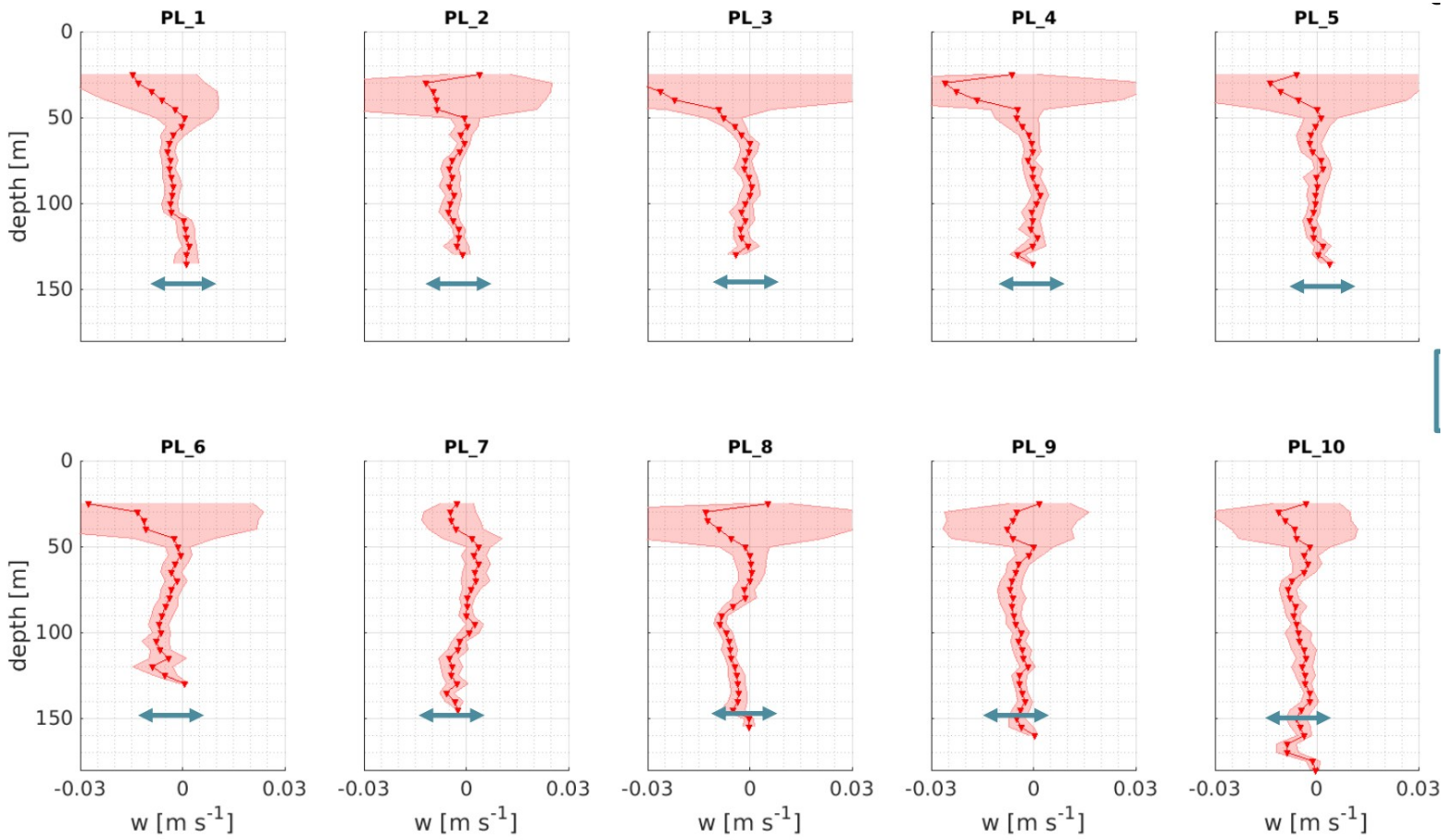


VVP



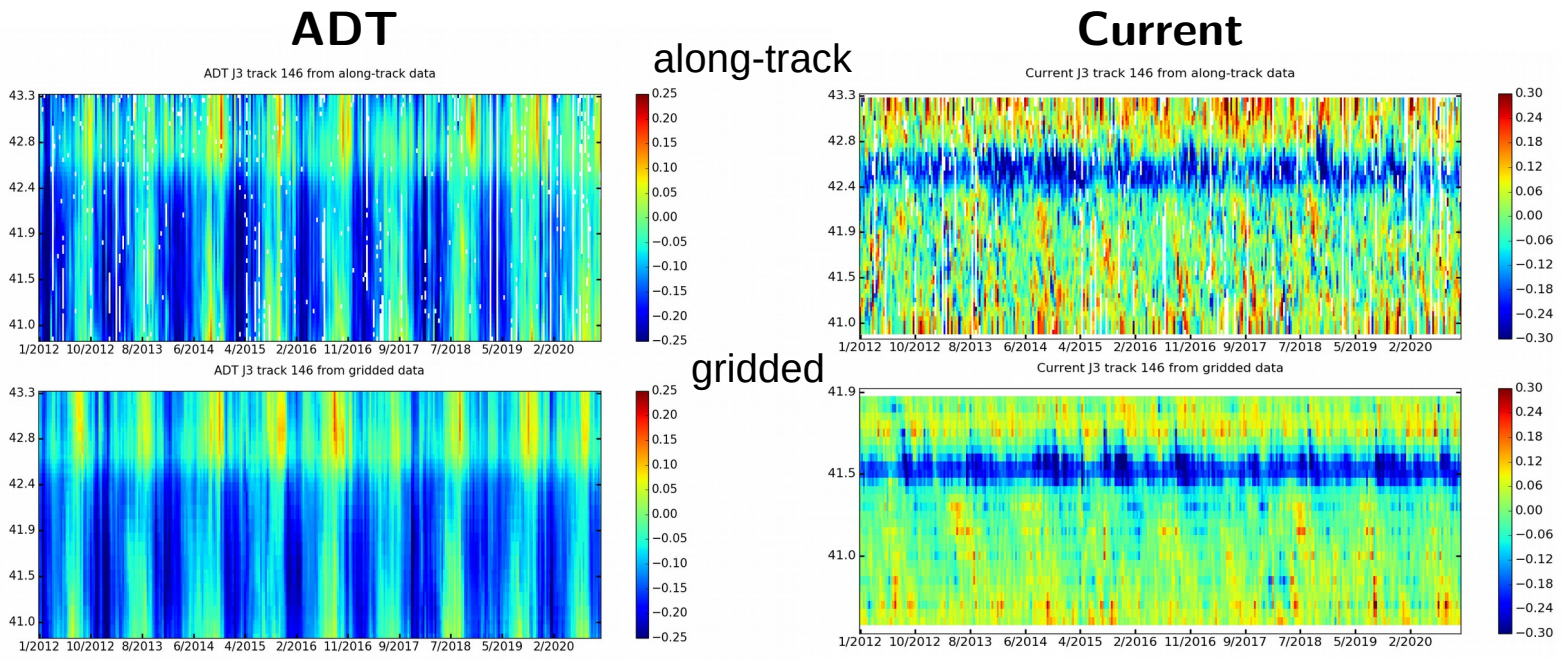
Results: vertical velocity analysis

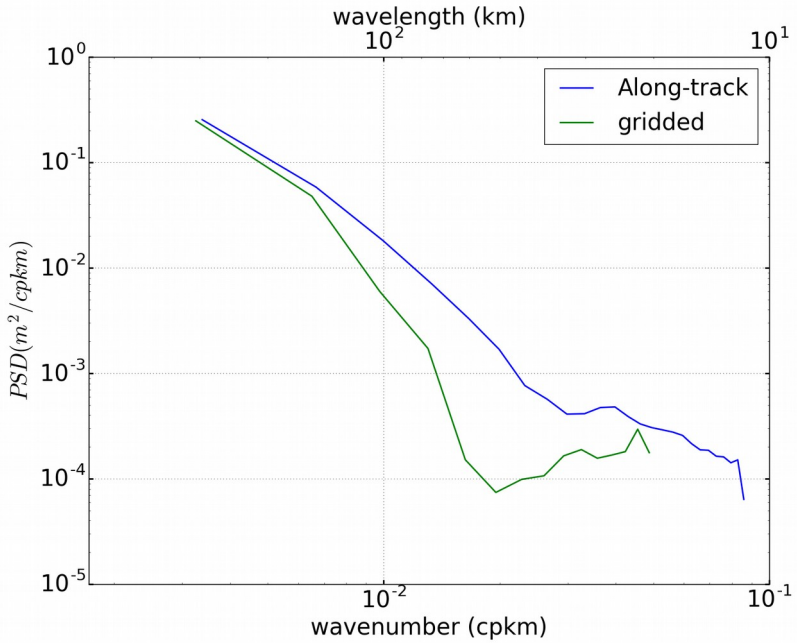
Preliminary results on vertical velocities measured with the new Sentinel ADCP deployed in Free Fall mode at the deepest station



- Last version of VVP which allows to reduce oscillations
- Large STD in the first 50 m probably due to waves
- Strong signal of vertical velocities in the VVP data allows to test different dynamical situations.

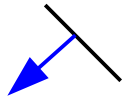
Results: intercomparisons between satellite missions

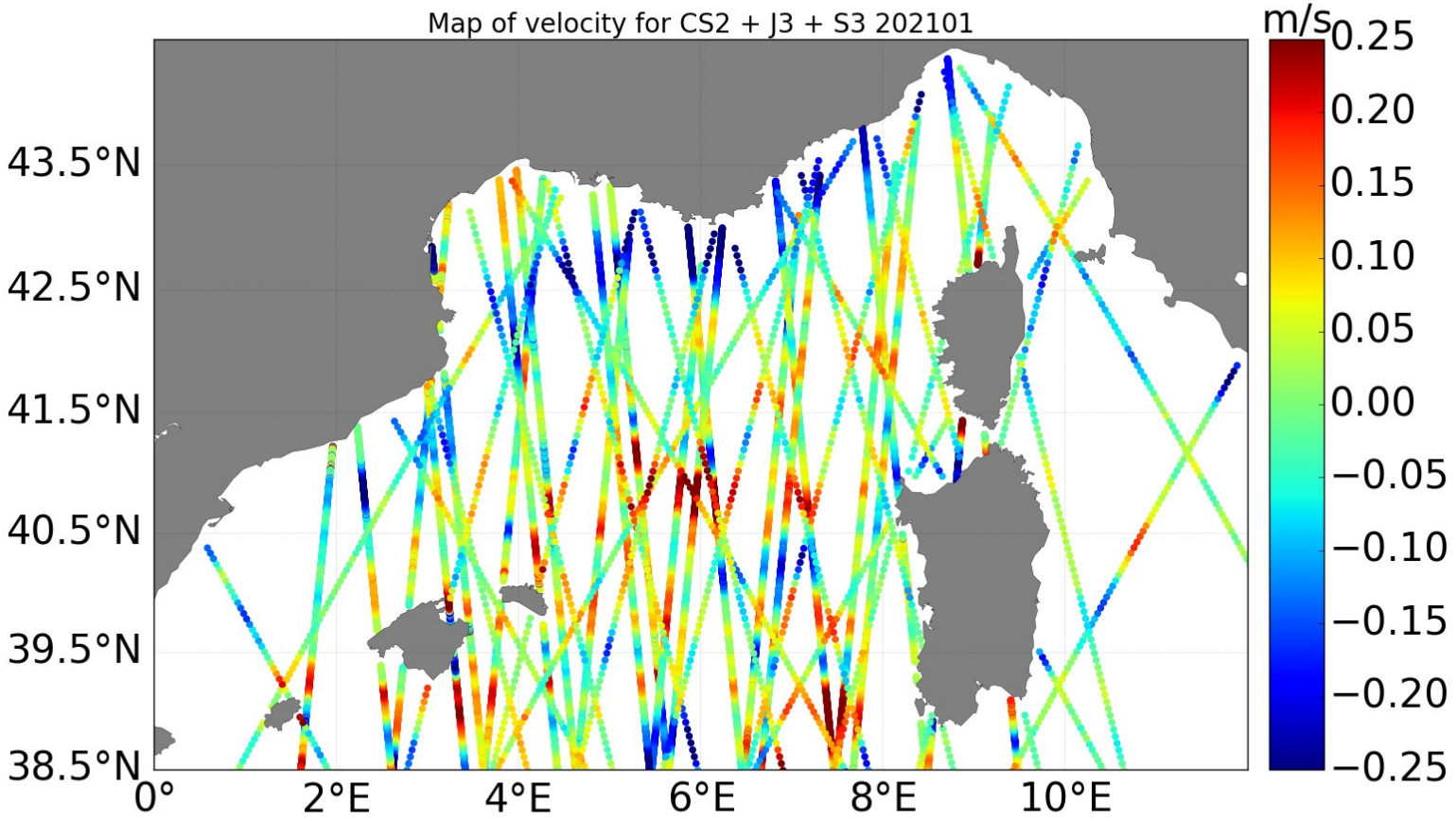




- Use of along-track altimetry rather than gridded products
- More variability in the NC localisation and a better representation of fine-scale structures
- The spectra show more signal at mesoscale fot the along-track product than for the gridded product
- Challenge of using along-track altimetry near the coasts

Results: intercomparisons between satellite missions

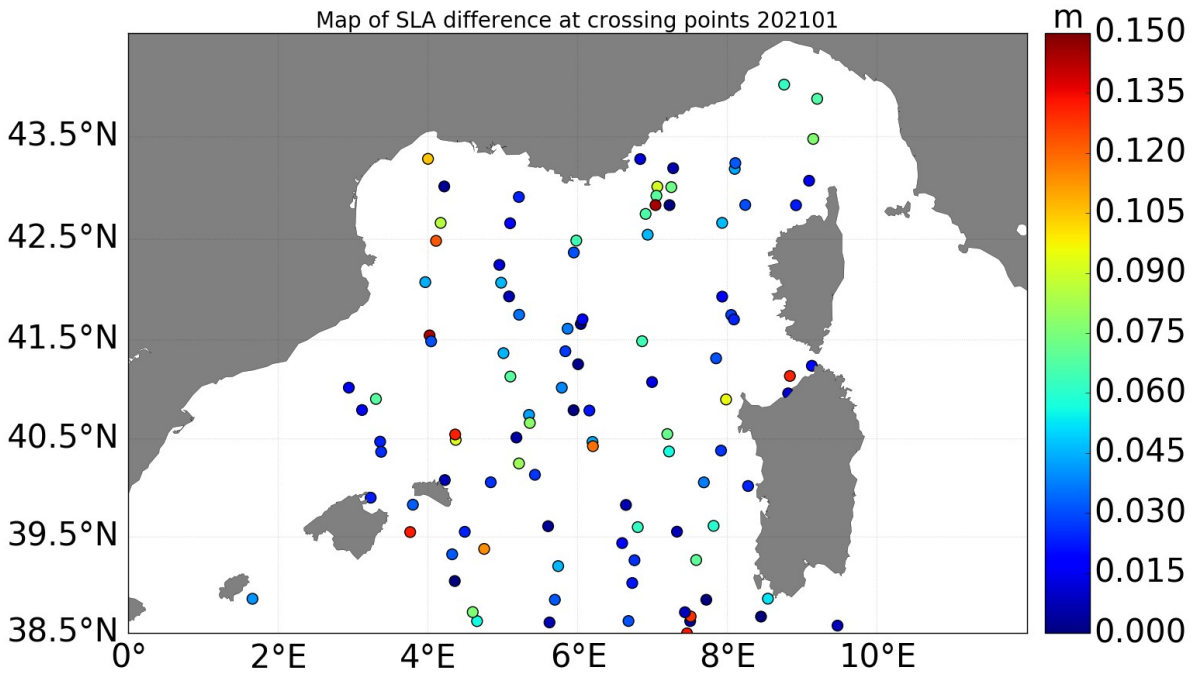
Currents perpendicular to the tracks  et 



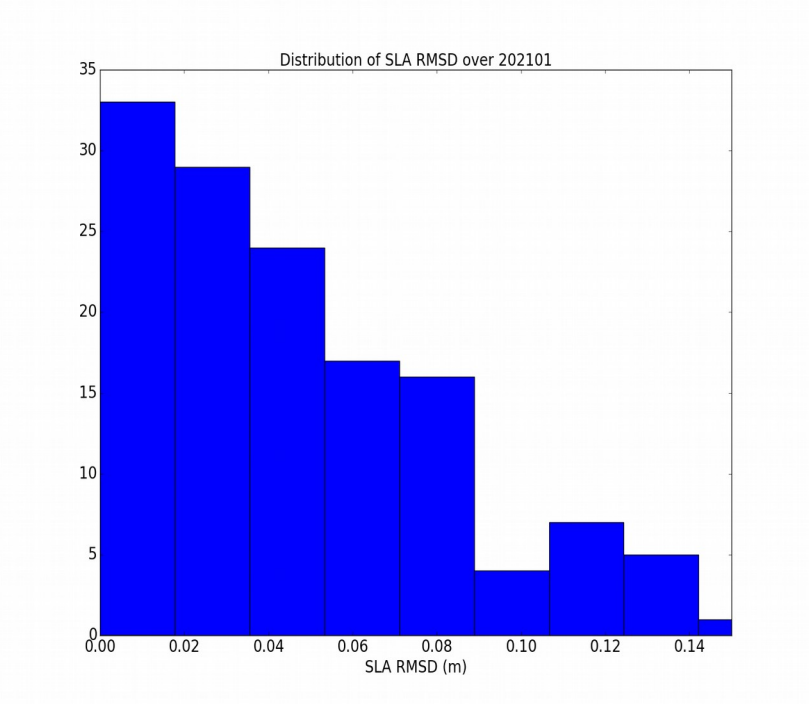
- Good agreement between the 3 missions (Jason 3, Sentinel-3, CryoSat-2)
- Reproduction of the regional circulation thanks to multi mission synergie
- Reliability of the CryoSat-2 coastal product to observe coastal structures

Results: intercomparisons between satellite missions

Difference of SLA at crossing points



Distribution of SLA difference at crossing points

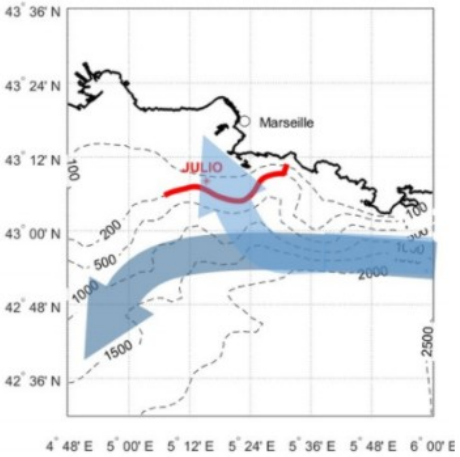


- Mainly small SLA difference in the histograms
- Current investigation for the factors of important SLA difference: satellite, Δt, distance to the coast

Results: application of AI methods

A Random Forest Algorithm (RFA) has been :
- trained with the Symphonie model data, then
- applied to satellite data and finally
- validated by JULIO in situ data

The algorithm identifies 93% of current intrusions. [Casella et al., 2020]



Projection of Symphonie data on altimetry tracks

Building classification and regression trees

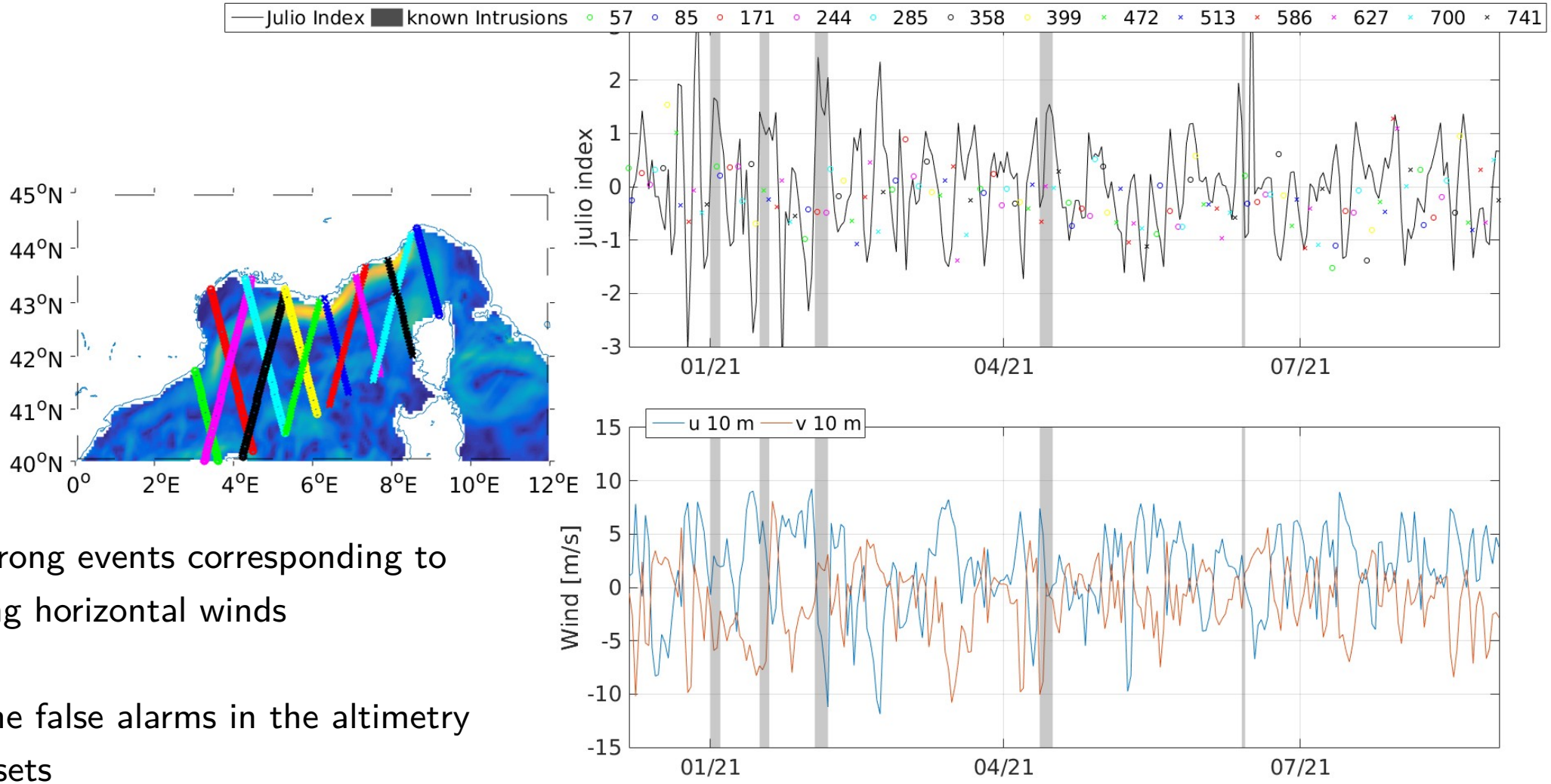
Use of JULIO data to compute a JULIO index indicating the strong intrusions of the NC

Algorithm based on random forest, an ensemble learning algorithm

Training of the algorithm using simulated SLA and horizontal winds

Test of the algorithm using SLA from Jason 3 and Sentinel-3

Results: application of AI methods



- 5 strong events corresponding to strong horizontal winds
- Some false alarms in the altimetry datasets

Conclusions and perspectives

Conclusions and perspectives

- Good agreement between the missions with different technologies
- On going adaptation of the algorithm to CryoSat-2
- Future application to Sentinel-6 data which are expected to provide better quality data in coastal areas thanks to open-burst SAR acquisitions
- SWOT mission which will pass over the JULIO mooring with a one day cycle during the fast sampling phase

Thank you for your attention