

# *SeaExplorer Underwater Glider: a new tool to measure depth-resolved water currents profiles*

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# General context

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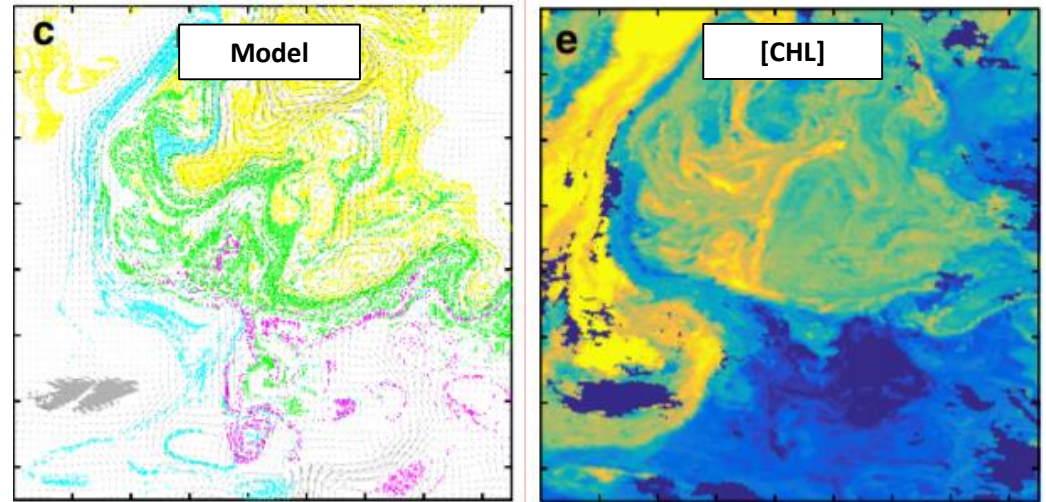
What drove us to equip the glider with an ADP?

# General context

- Scientific needs

Dynamical processes play a crucial role in the ocean

- Transport/mixing/dispersion
- Heat fluxes
- Offshore activities



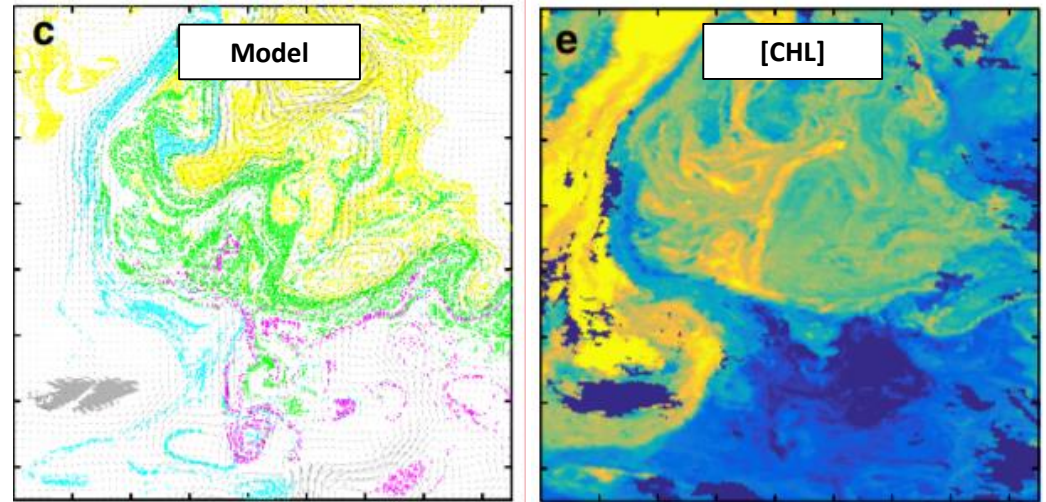
*From Lévy et al., 2018 (Nature communication)*

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## Lack of high-resolution observations

Glider-ADP data can contribute to a better characterization of mesoscale and sub-mesoscale processes

# General context

- The R&D project

- Started in 2015 and still ongoing
- Funded mainly by TOTAL-SA
- In collaboration with French academic laboratories (*CNRS, IRD*) and Nortek



- >15 weeks at sea
- > 1000 profiles

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# Theoretical and technical aspects

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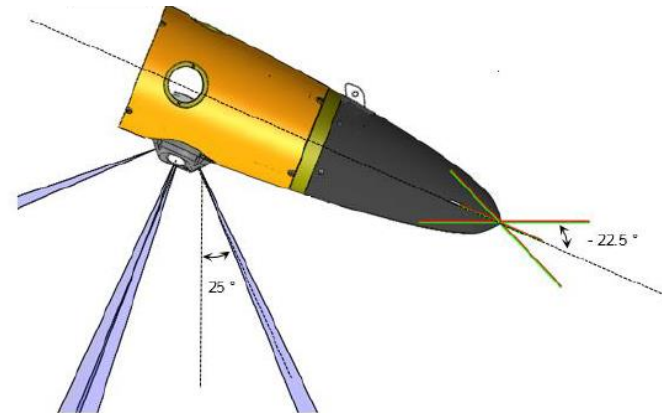
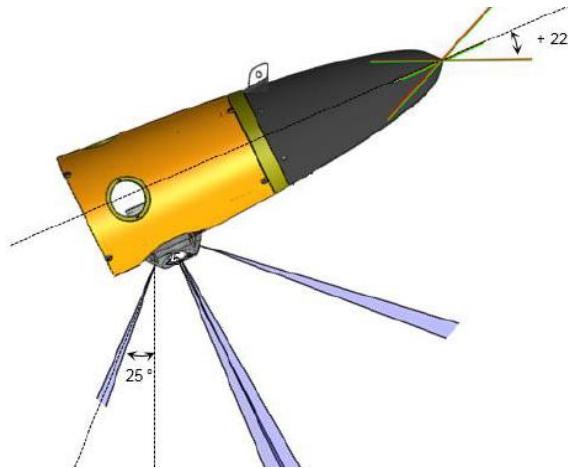
The Nortek AD2CP – 1 Mega Hertz



# Theoretical and technical aspects

- Instrument's characteristics

- Emits ultrasonic waves (1 MHz) backscattered by particles in suspension
- Use the Doppler effect to measure the ocean current velocity
- 4 beams
- Lateral transducers, angle =  $25^\circ$  (Janus configuration)
- Transversal transducers, angle =  $47.5^\circ$



# Theoretical and technical aspects

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- Main tunable parameters

Name	Abbreviation	Description
<b>Blanking distance</b>	<i>BD</i>	<i>Distance from the sensor not considered in the data processing to avoid data noise from transducer ringing</i>
<b>Cells size</b>	<i>CS</i>	<i>Discrete interval for which returns are recorded by the ADCP (~ vertical resolution of the ADCP)</i>
<b>Number of cells</b>	<i>NC</i>	<i>Number of cells for an individual profile</i>
<b>Number of pings</b>	<i>NPING</i>	<i>Number of pings averaged in each cell</i>
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Guarantee a certain degree of freedom  
Allow to adapt the sampling strategy to mission objectives

# Theoretical and technical aspects

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The challenge to obtain absolute water currents with gliders

# Theoretical and technical aspects

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Raw velocity measurements are relative to transducers and thus differ from absolute water velocities by including vehicle displacement:

$$U_{\text{adcp}}(z, t) = U_{\text{ocean}}(z, t) - U_{\text{glider}}(z, t)$$

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**Specific case:** for gliders operating in shallow waters with downward-looking ADPs, bottom track can be used to reference ADP data with the bottom.

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**Specific case:** for gliders operating in shallow waters with downward-looking ADPs, bottom track can be used to reference ADP data with the bottom.

**General case:** Use of a dedicated algorithm (the shear algorithm), initially developed for LADCP profiling and adapted for the SeaExplorer glider.

# Theoretical and technical aspects

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- Data evaluation

- Field validation missions have shown good agreement between glider and shipboard measurements (RMSE =  $0.015 \text{ m}\cdot\text{s}^{-1}$ )
- Comparison with bottom-track data and DR-mean current confirms we obtain good results with the shear algorithm (RMSE =  $0.020 \text{ m}\cdot\text{s}^{-1}$ ).



# Cases study

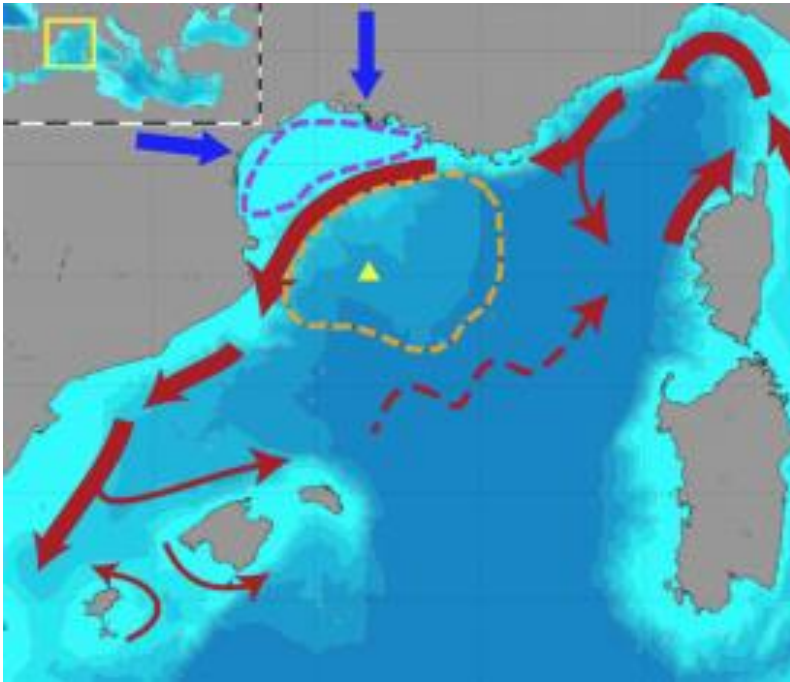
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Large ocean currents

# Cases study

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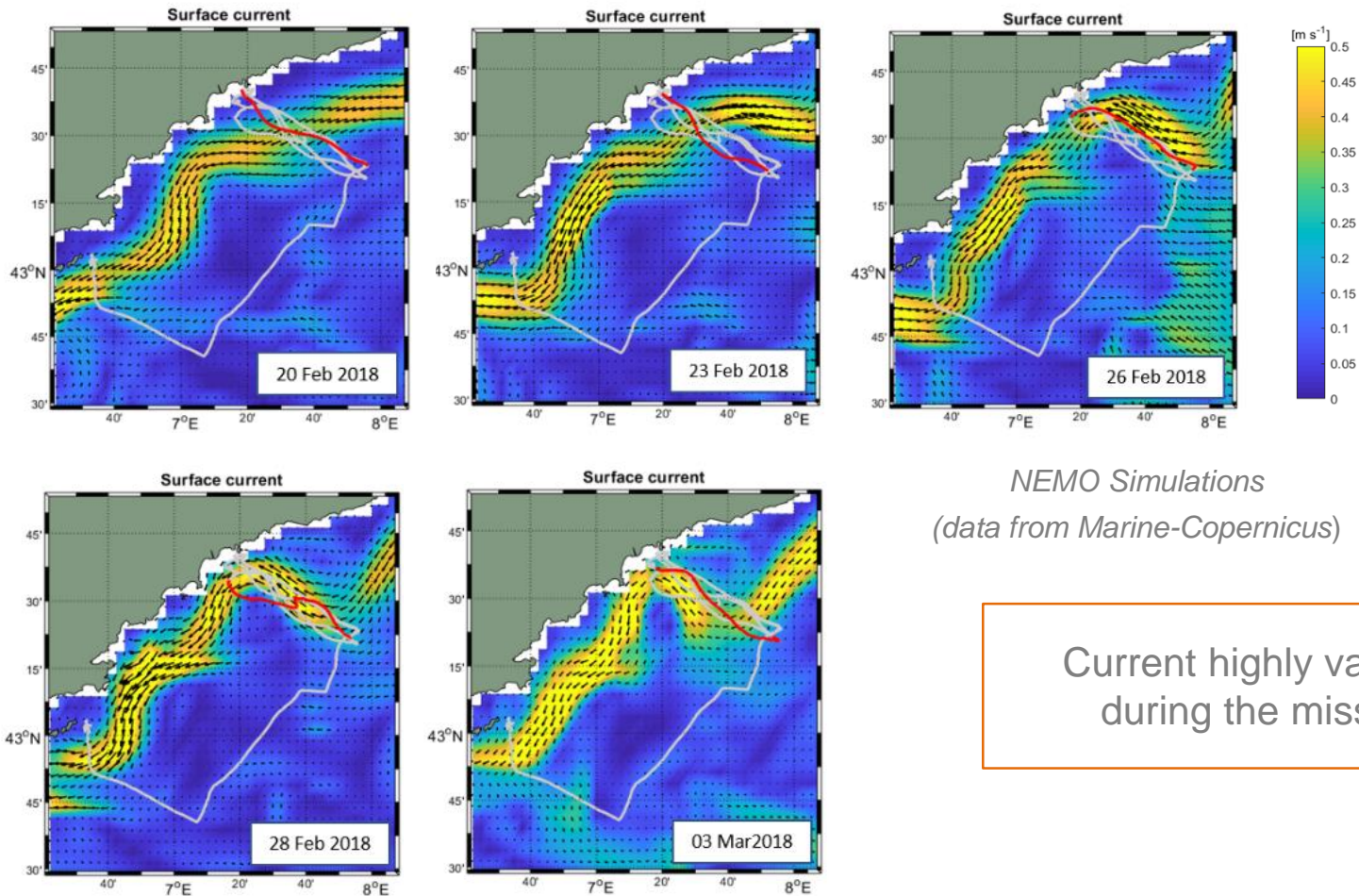
- Northwestern Mediterranean Sea



- Part of the Mediterranean observing system
- Deep convection area
- North Current

# Cases study

- Northwestern Mediterranean Sea

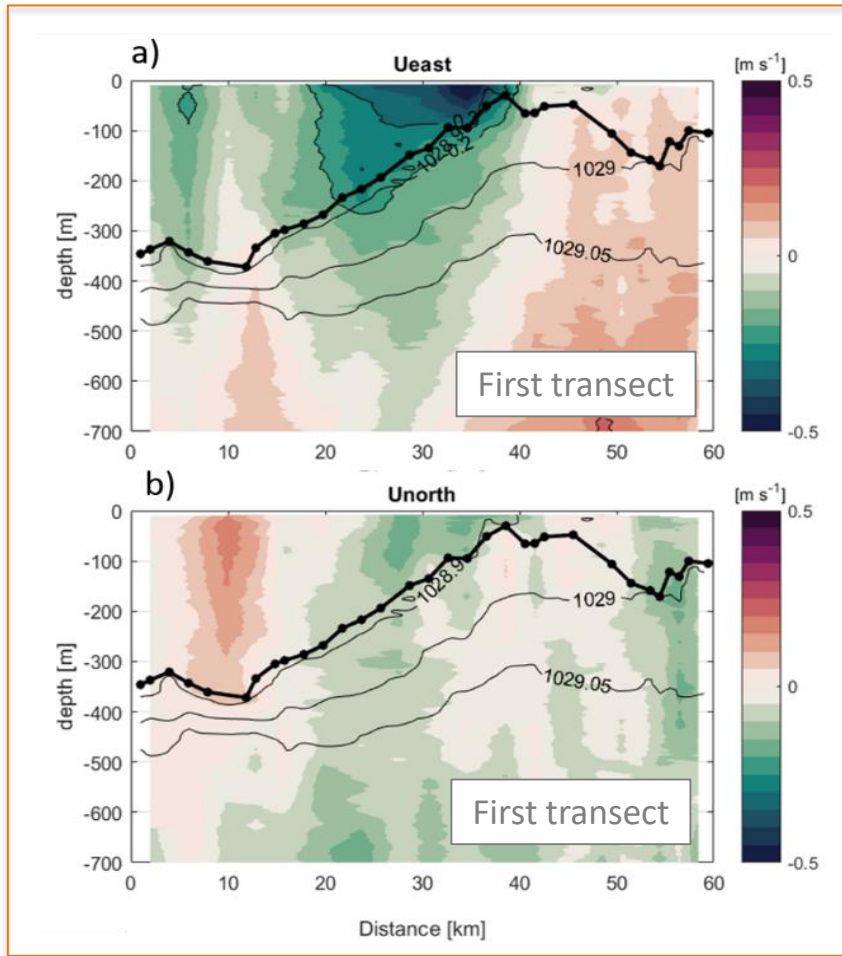


*NEMO Simulations  
(data from Marine-Copernicus)*

Current highly variable  
during the mission

# Cases study

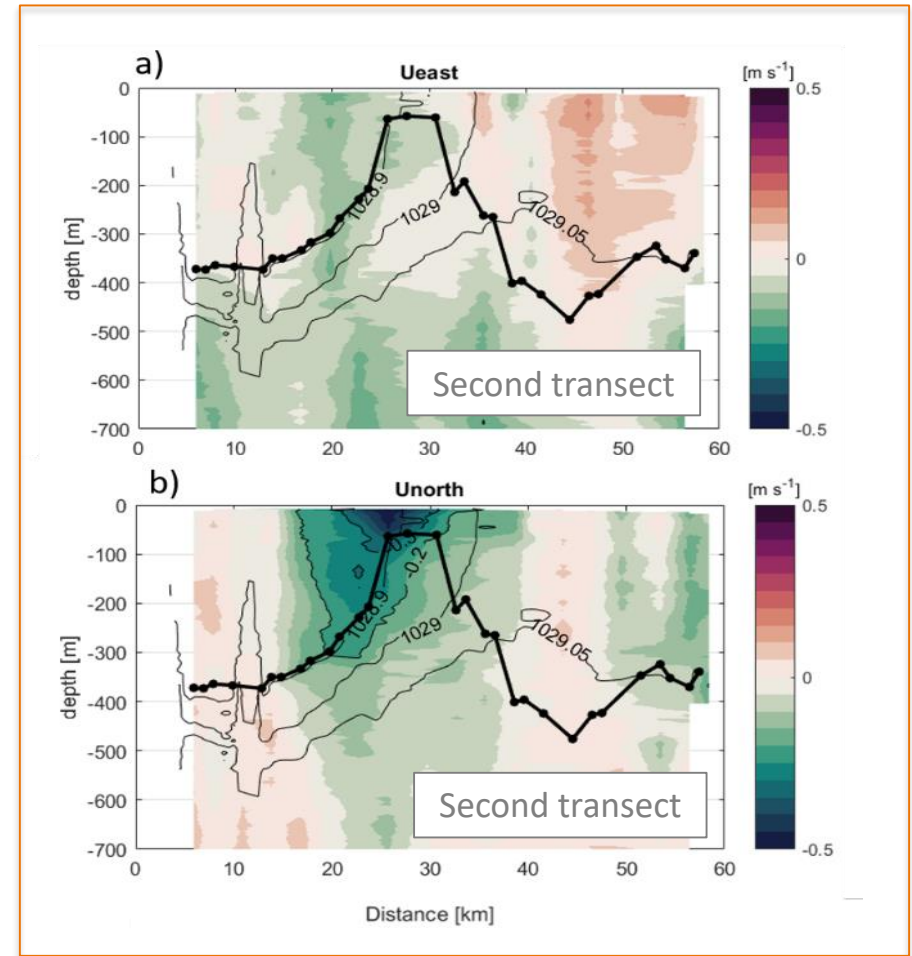
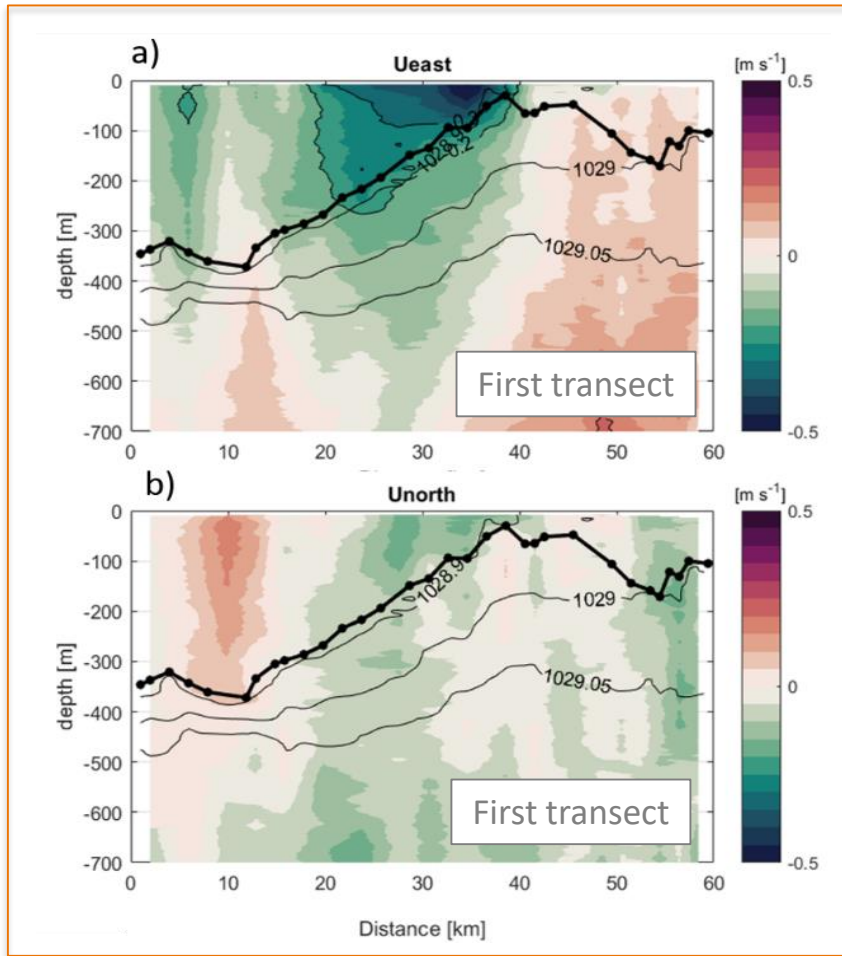
- Current profiles



Maximum velocity =  $60 \text{ cm.s}^{-1}$  westward  
Current located at 20-35 km  
Vertical extend 300m-depth

# Cases study

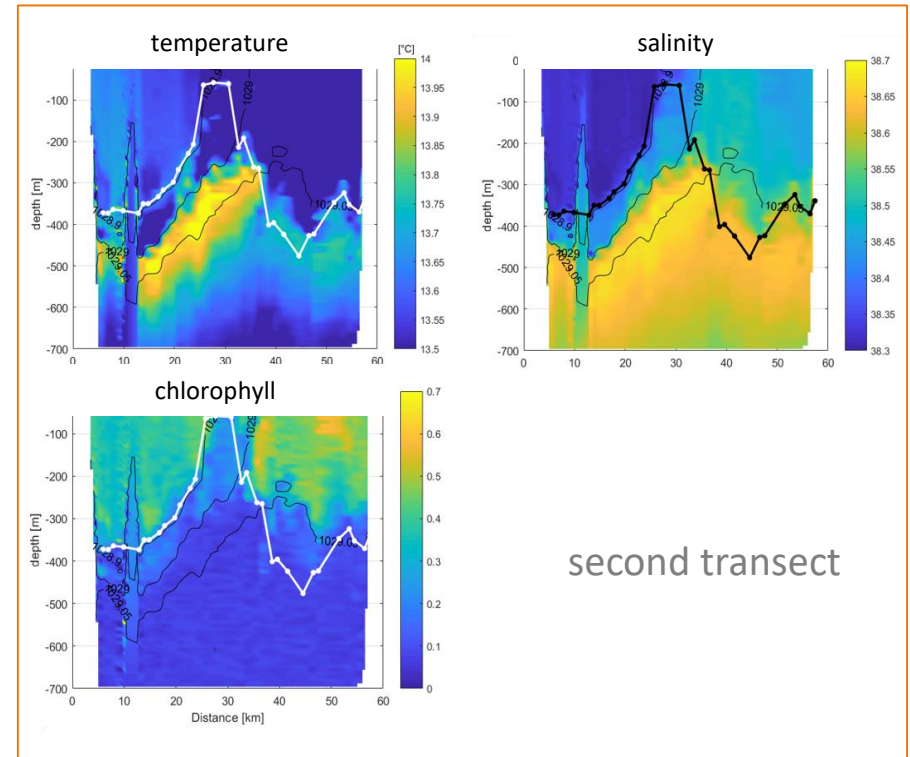
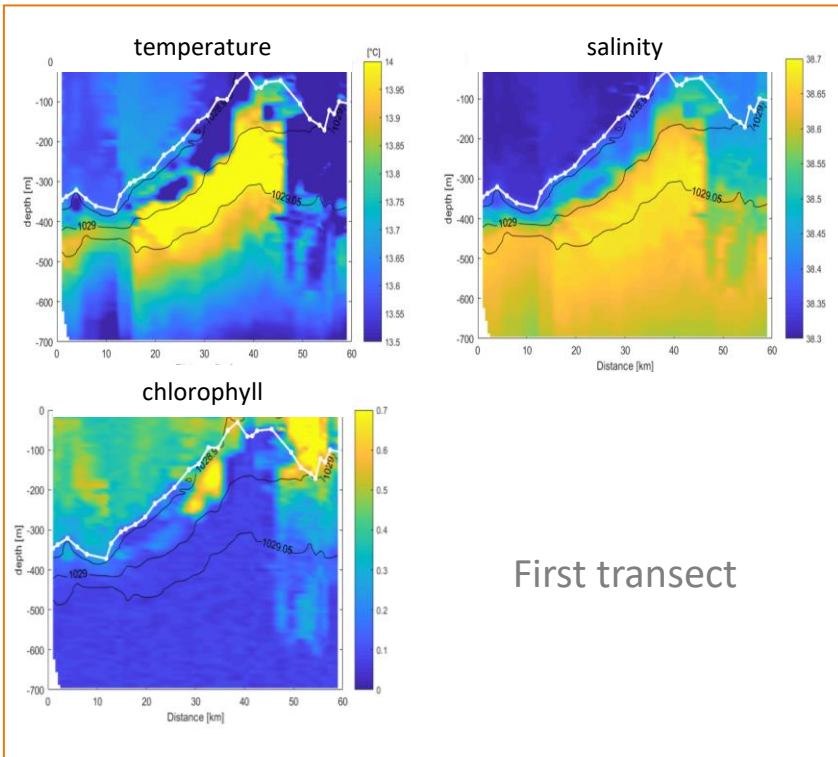
- Current profiles





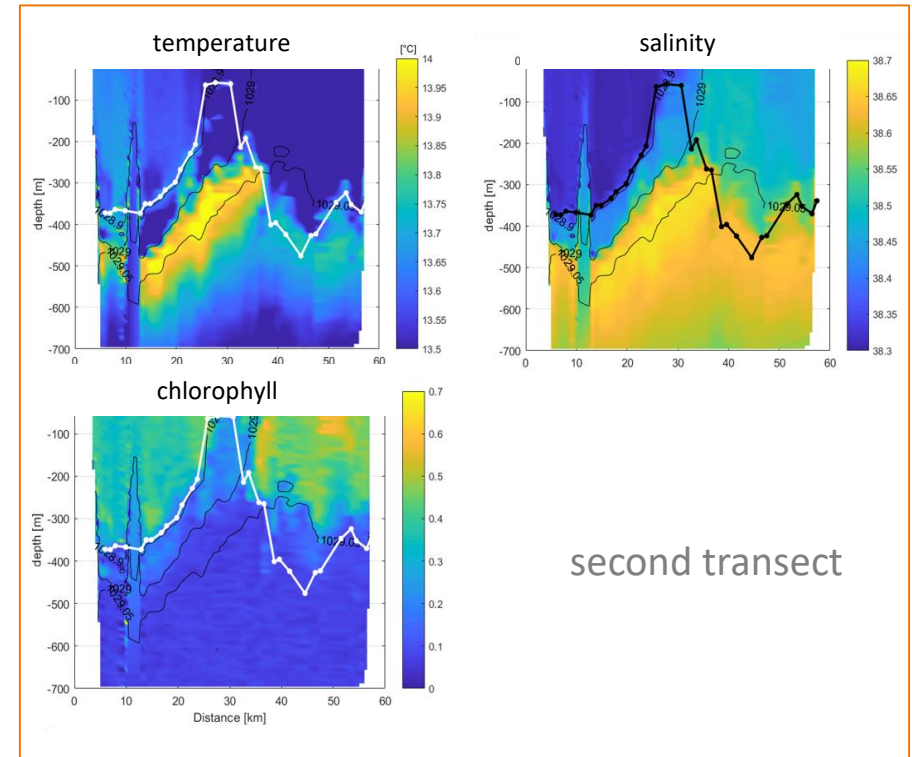
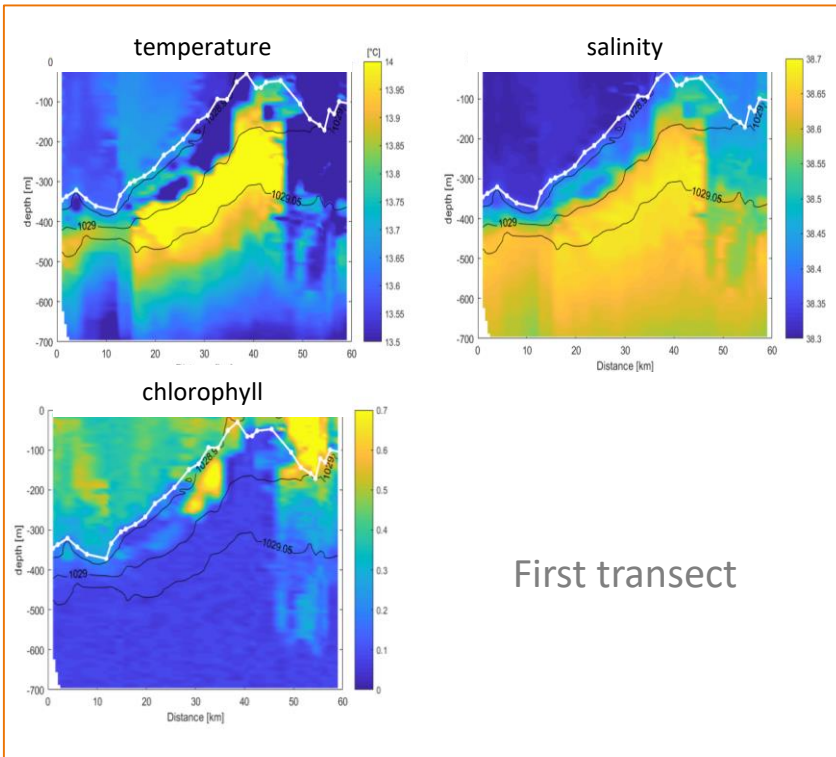
# Cases study

- Comparison with other parameters



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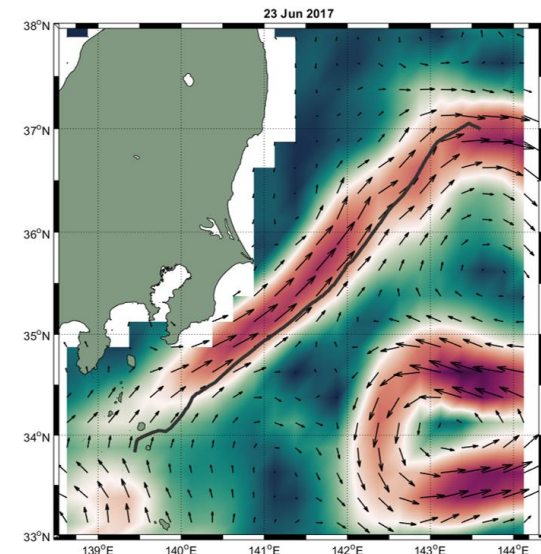
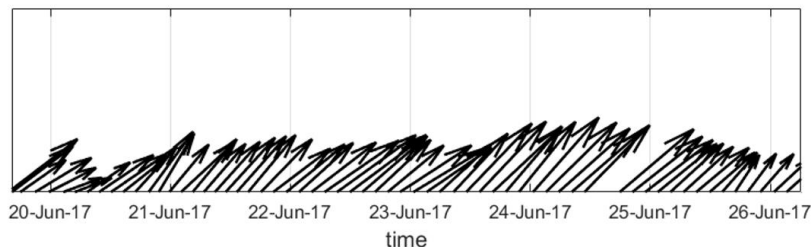
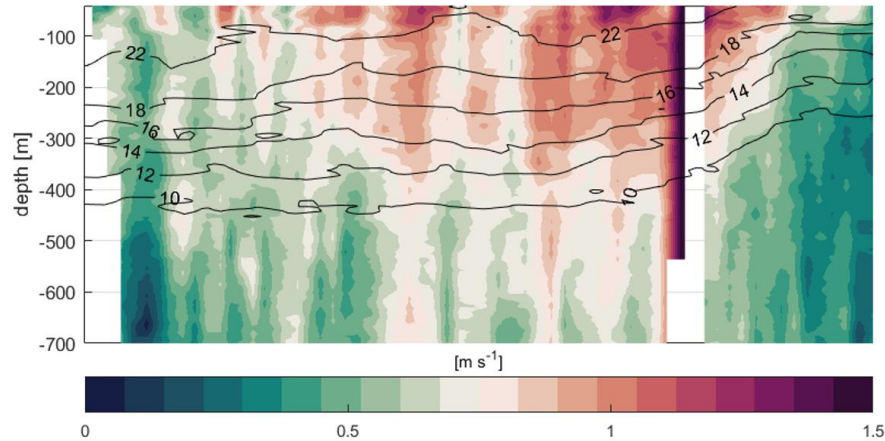


- First time water currents data were acquired simultaneously with bio-optical parameters
- High-frequency description of physical-biogeochemical interactions

# Cases study

- Kuroshio current

A glider was deployed at the border of the Kuroshio current offshore Japan, one of the most energetic current of the world. Current higher than  $1.5 \text{ m s}^{-1}$  were measured in surface and strong velocities ( $> 1 \text{ m s}^{-1}$ ) were measured until 400m-depth.



*Yasuda et al., in prep*



# Cases study

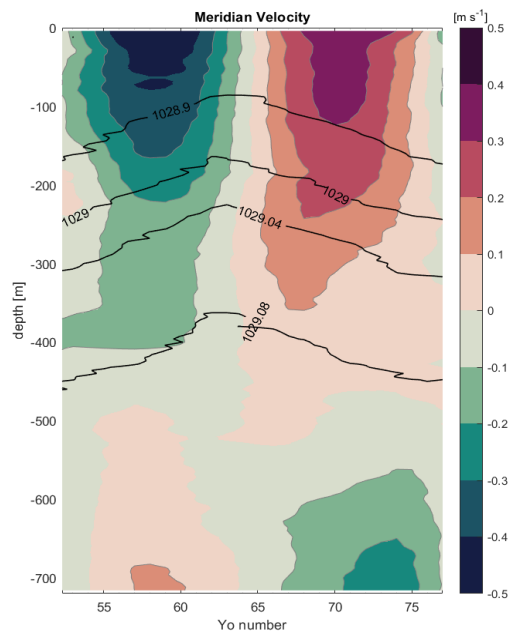
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Sub-mesoscale dynamics

# Cases study

- Cyclonic-like structure

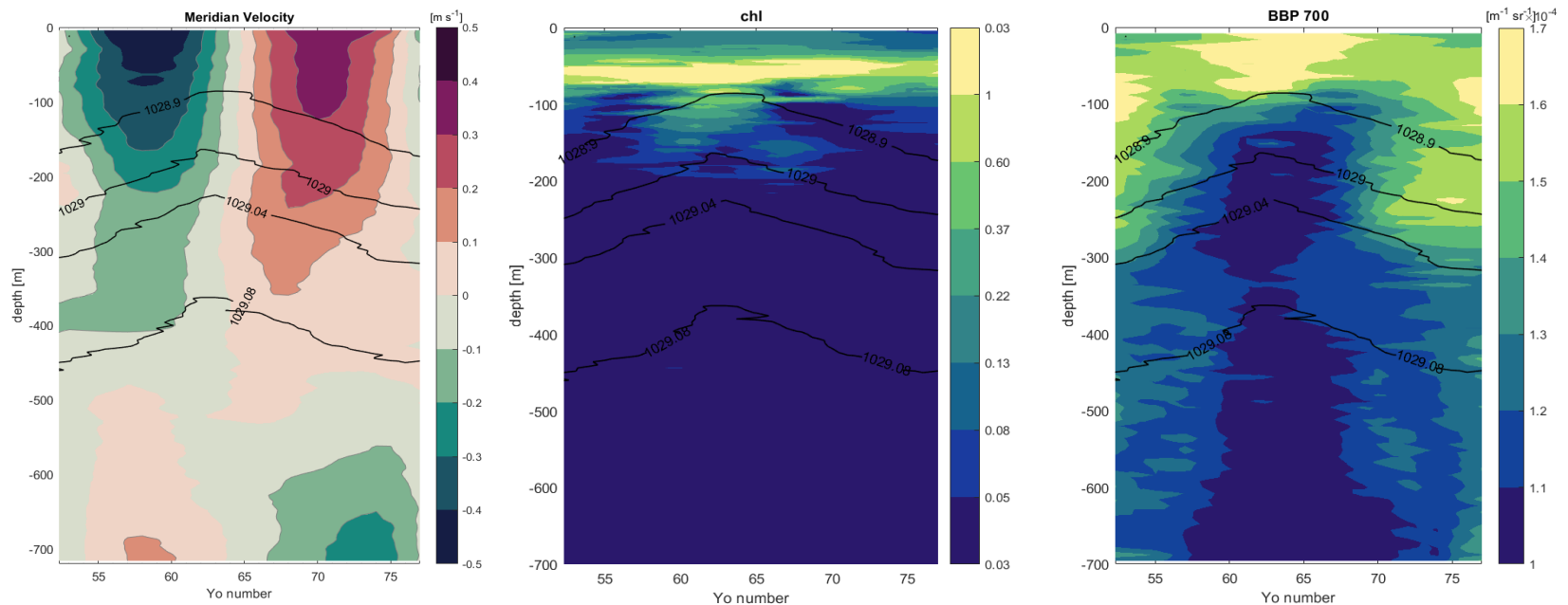
A small cyclonic-like structure was sampled. Data show the core of the structure in cyclonic rotation in the first 400m of the water column with an uplift of isopycnal levels and a counter rotative circulation in the last 200m.



# Cases study

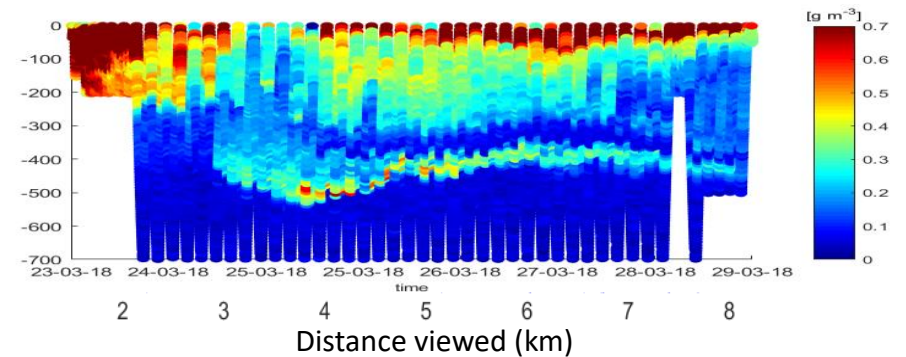
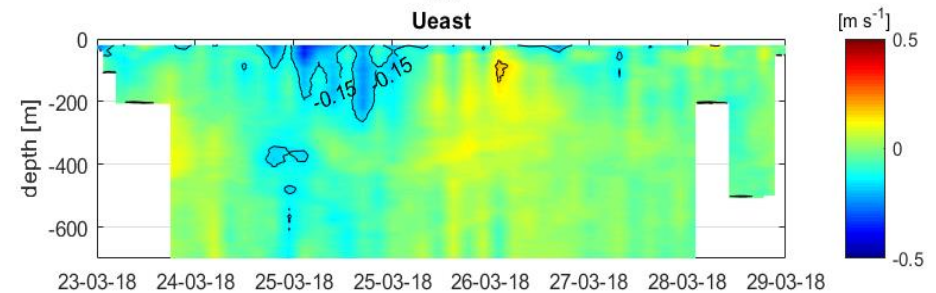
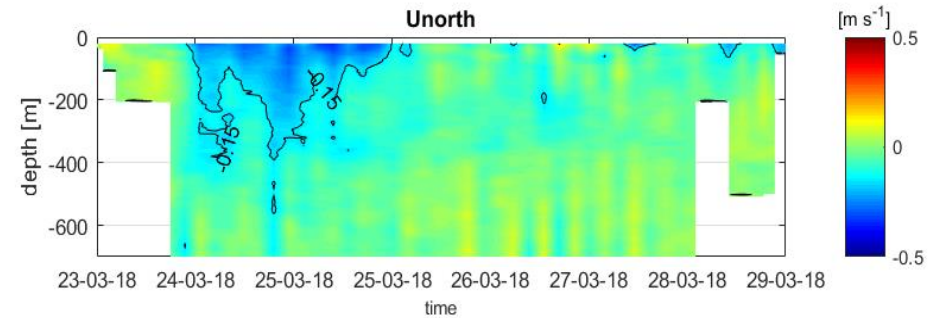
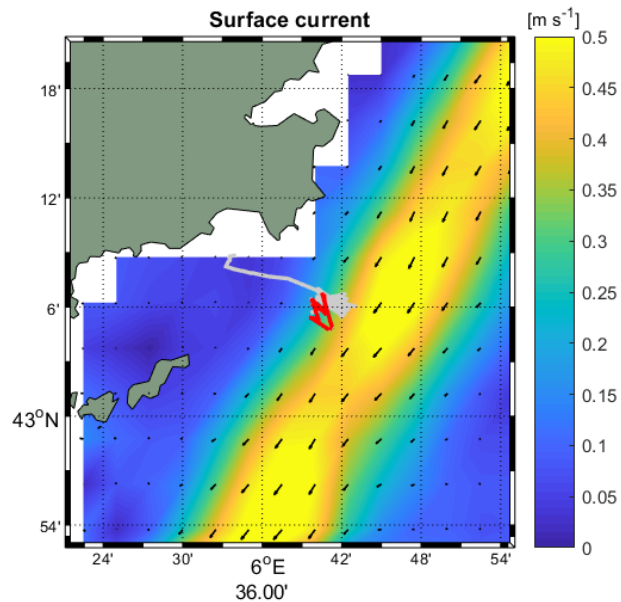
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# Cases study

- Subduction of CHL-rich water masses



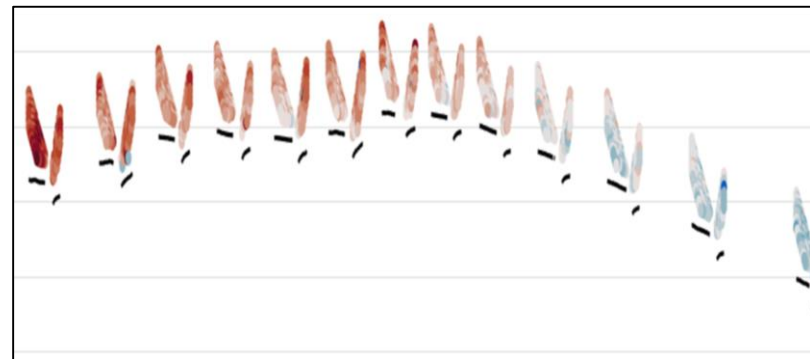
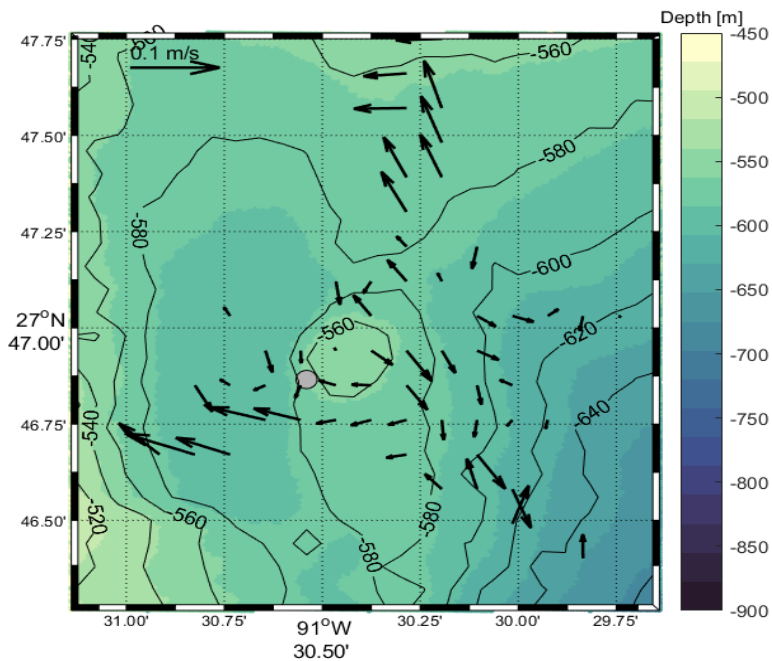
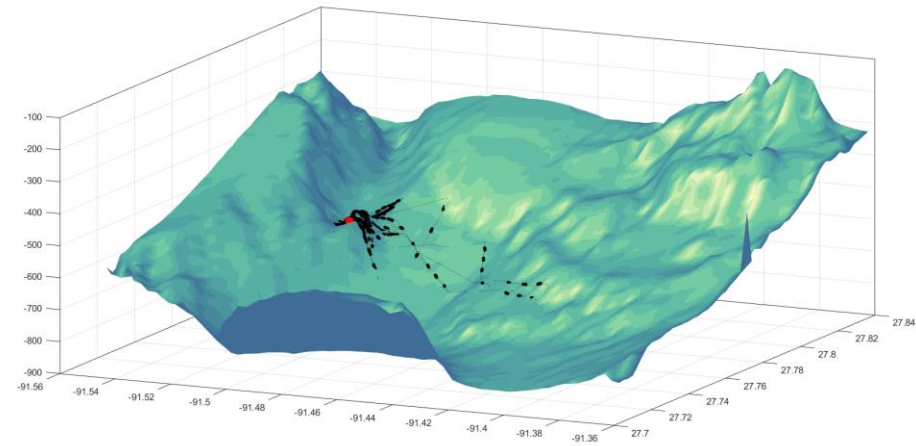
# Cases study

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Near-bottom dynamics

# Cases study

- Near-bottom currents
  - In interaction with the bathymetry
  - Bypass the submarine hill



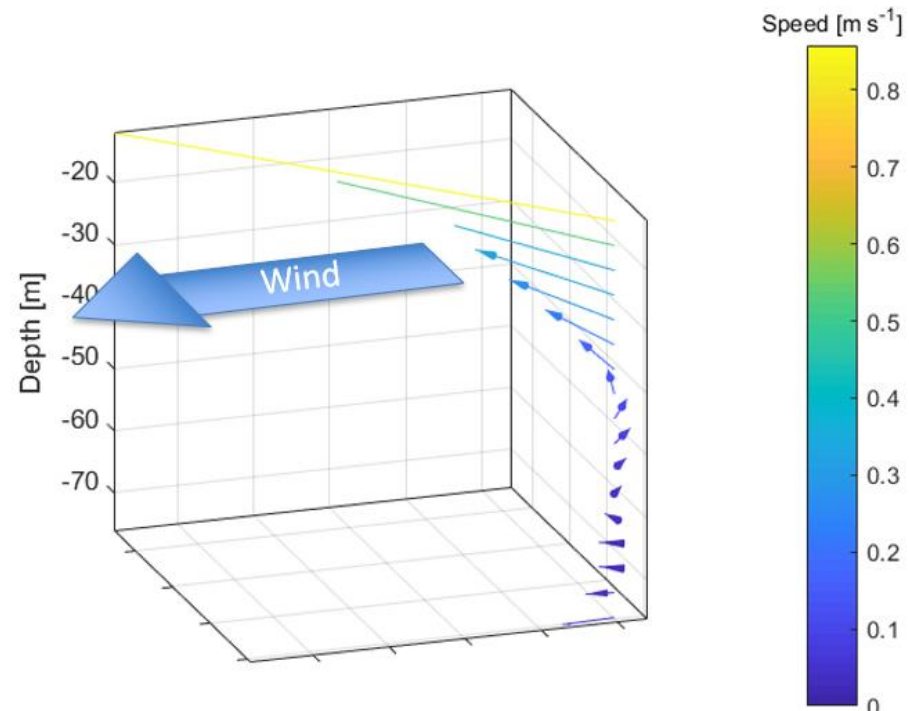
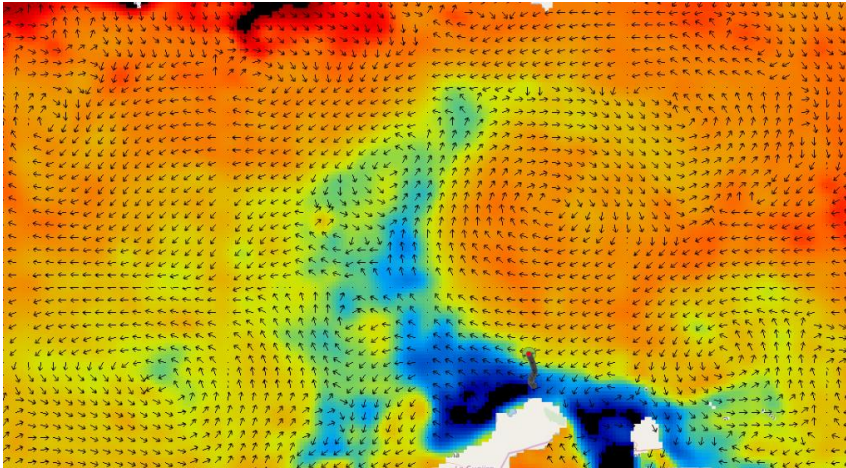
# Cases study

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Ekman layer

# Cases study

- Ekman spiral
  - Low latitude tropical upwelling system





# Conclusion and outlooks

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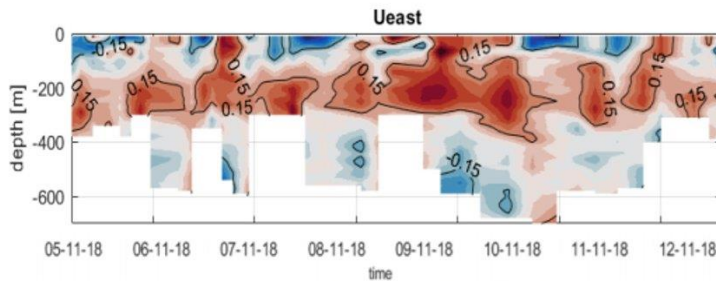
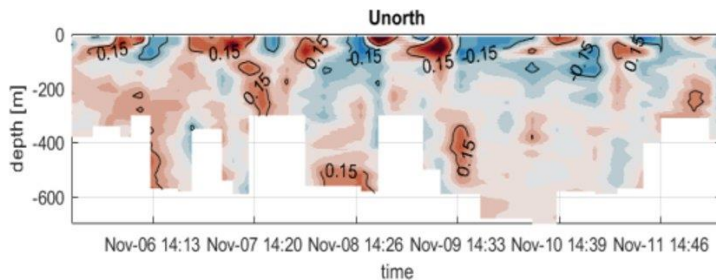
- About the results

**The SeaExplorer glider is able to measure accurately water currents in contrasted environments**

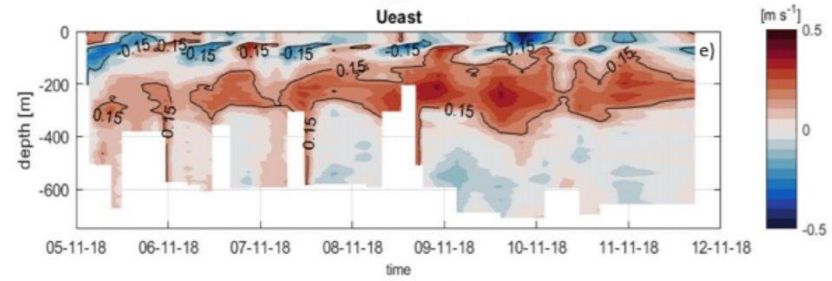
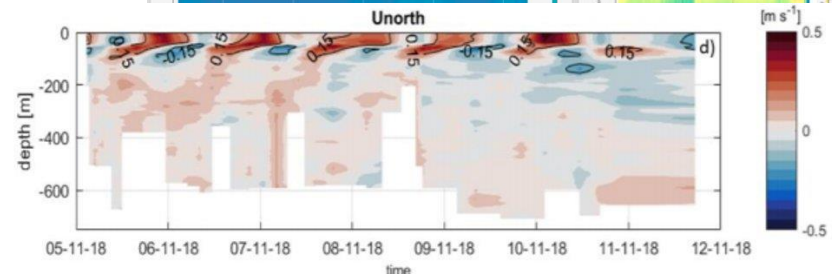
- Allow to investigate the ocean dynamics and physical-biological interactions at broad spatio-temporal-scales.
- Open new perspectives for metocean applications and can help for characterization of oceanic conditions in support of offshore operations.

# Conclusion and outlooks

- Ongoing work
  - Operational toolbox
  - Real-time processing



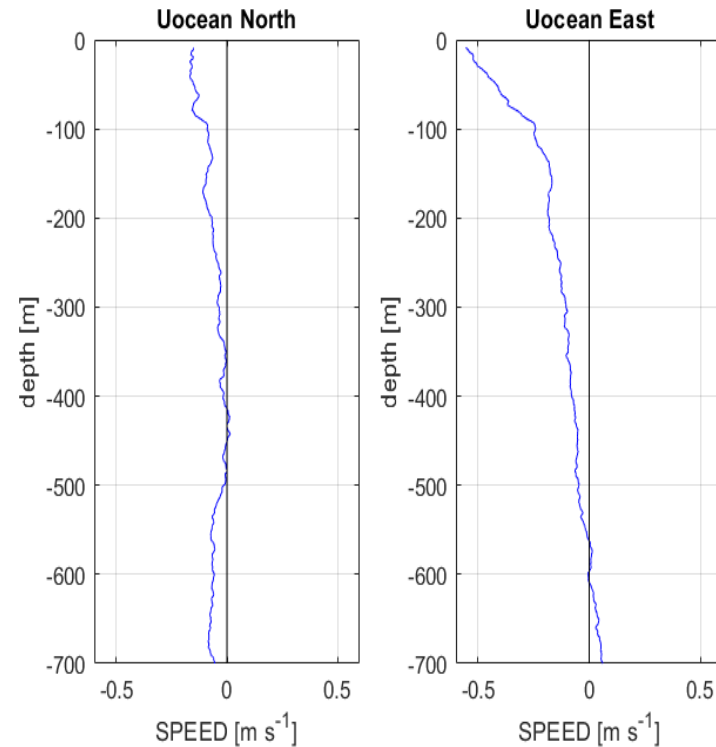
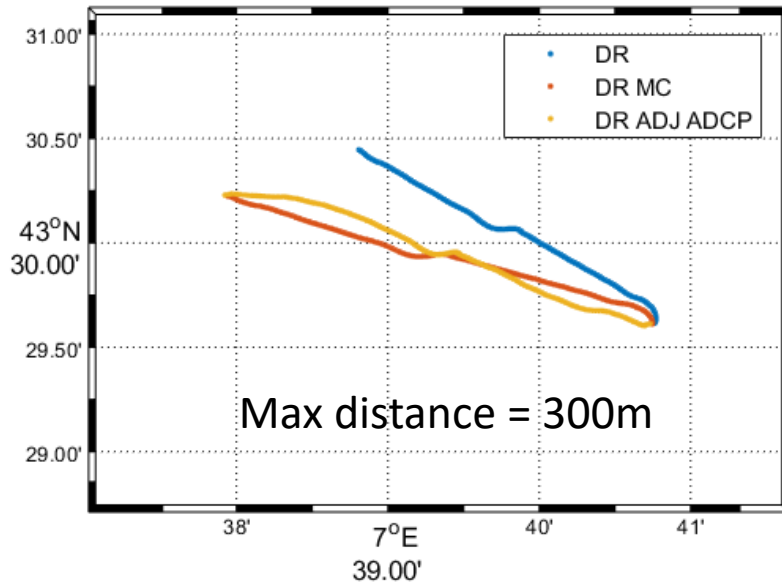
RT Water-track velocities



DM Water-track velocities

# Conclusion and outlooks

- Ongoing work
  - Improve glider positioning using ADCP currents



# Thank you

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