# Algerian Basin Circulation Unmanned Surveys
# ABACUS 3 & ABACUS 4
# WP7


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Balearic Islands Coastal Observing and Forecasting System (SOCIB)

SCIENTIFIC PRODUCTS

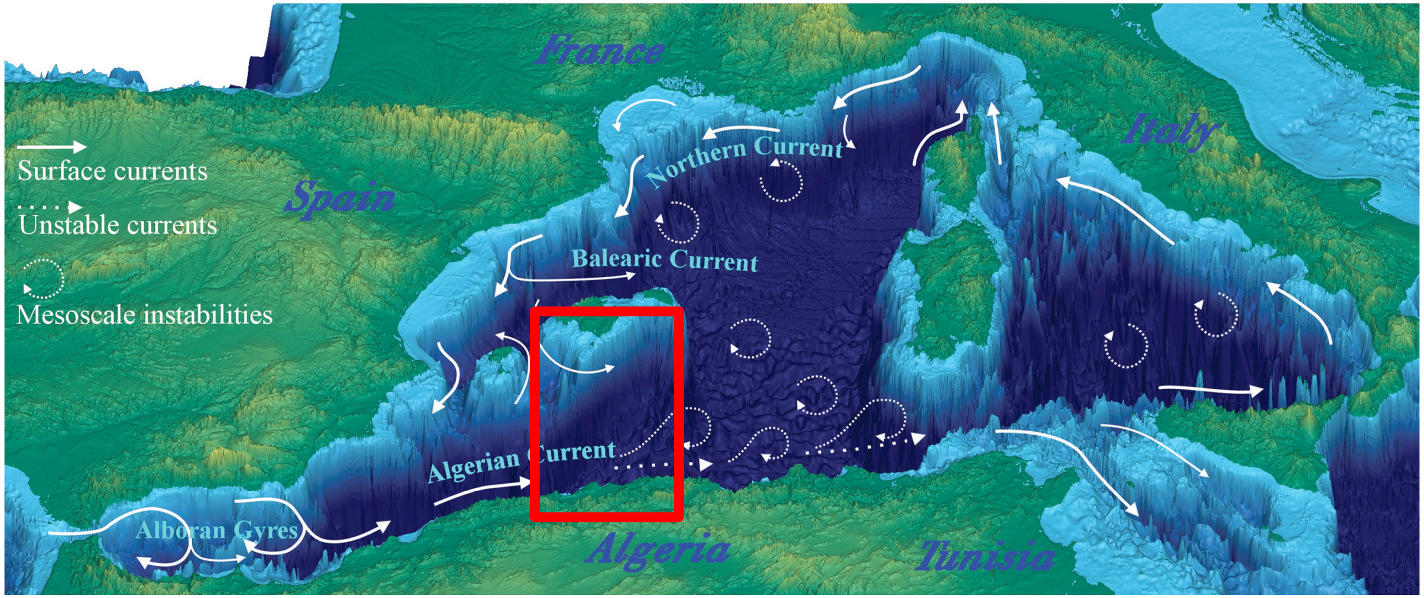
**The ABACUS scientific team contributions:**

- **16 presentations to international conferences**
- **4 papers published**
- **DOI for all data**


- Cotroneo, et al., 2016: Glider and satellite high resolution monitoring of a mesoscale eddy in the Algerian basin: Effects on the mixed layer depth and biochemistry. J. Mar. Syst. 2016, 162, 73–88.
- Aulicino, et al., 2018: Monitoring the Algerian Basin through glider observations, satellite altimetry and numerical simulations along a SARAL/AltiKa track. J. Mar. Syst., 179, 55–71.
- Cotroneo, et al., 2019: Glider data collected during the Algerian Basin Circulation Unmanned Survey. Earth Syst. Sci. Data, 11, 147–161.
- Aulicino, , et al., 2019: In Situ and Satellite Sea Surface Salinity in the Algerian Basin Observed through ABACUS Glider Measurements and BEC SMOS Regional Products. Remote Sens., 11, 1361.


**The entire ABACUS 2014-2016 dataset was quality controlled and is available through a public repository at https://http://dx.doi.org/10.25704/b200-3vf5.**

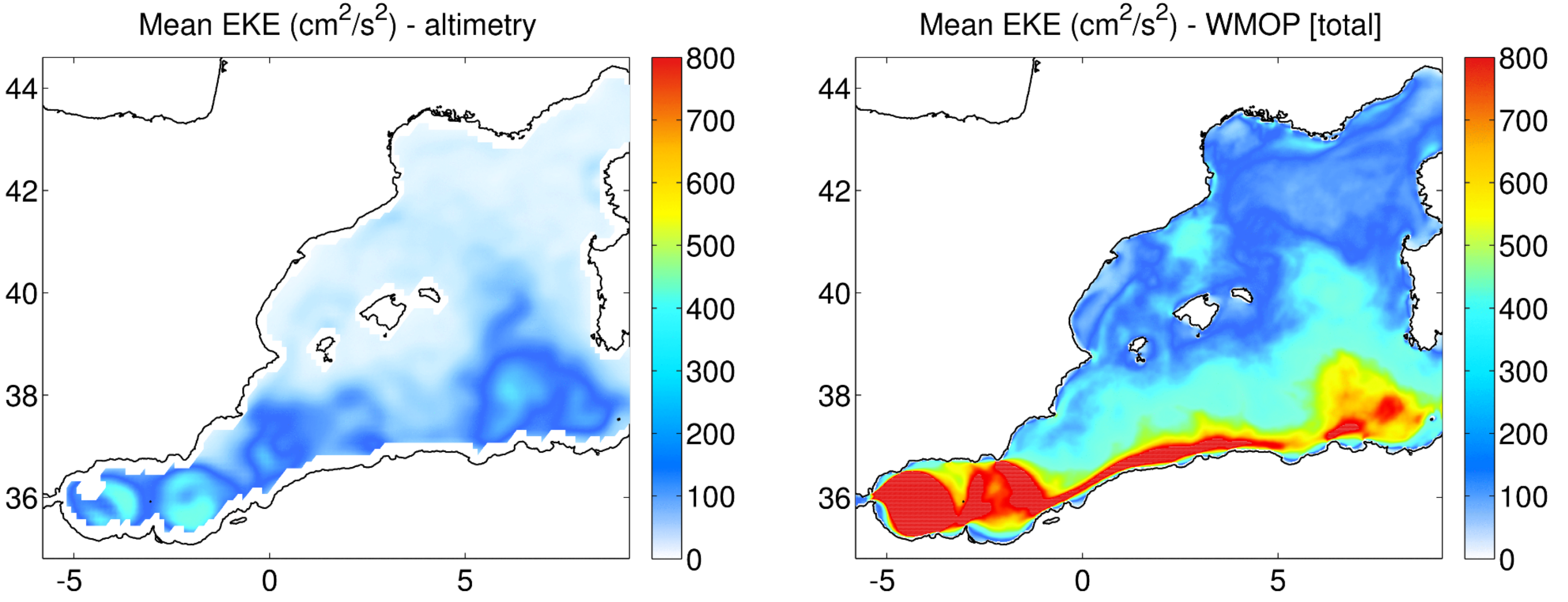
# INTRODUCTION




**The Western Mediterranean Sea. The map presents the bathymetry and the dynamical features. Adapted from Escudier et al. [2016] and Millot [1999]. Red Box identifies the ABACUS study area.**

**The southwestern Mediterranean Sea is an important transit region characterized by the presence of both fresh surface waters coming from the Atlantic and more saline waters which typically reside in the Mediterranean region. Most of this sector is occupied by the Algerian Basin, a wide and deep basin comprised between the Balearic Islands, the Algerian Coast and the Sardinia Channel, where an intense inflow/outflow regime exists and complex circulation patterns take place.**

# INTRODUCTION




**Altimetry (left) and model (WMOP – right) mean EKE for the period 2009-2015.**
**Mourre et al., 2018**

Typically, the Algerian Current becomes unstable along its path due to complex hydrodynamic processes, and forms several meanders which frequently evolve to isolated cyclonic and anticyclonic mesoscale eddies promoting an intense mesoscale activity all over the Algerian Basin.

INTRODUCTION

SCIENTIFIC QUESTION:

- UNDERSTAND EDDIES STRUCTURE AND
- VARIABILITY OF ALGERIAN BASIN CIRCULATION

# ABACUS Project

Project Mission

Filling a gap of knowledge on the vertical and internal structure of mesoscale eddies and their biophysical response;

Starting a repeated monitoring the AB water masses properties

To monitor the basin circulation at different scales collecting data on the physical and biological properties of the surface and intermediate water masses;

To demonstrate the advantages of combined use of gliders with a new generation of satellite data, including altimetry and salinity products;

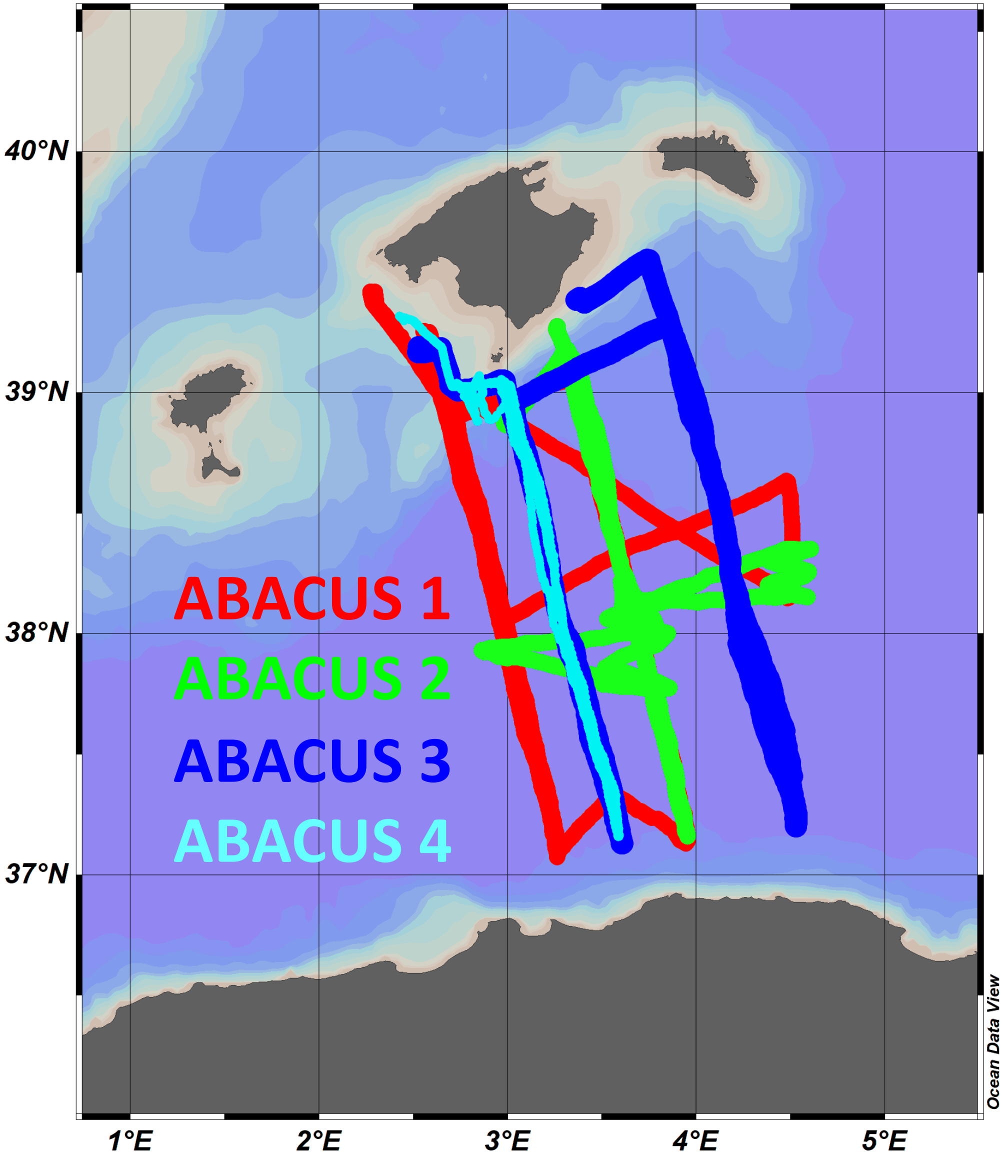
To provide a referenced in situ dataset to be compared or assimilated in numerical models.

JERICO GLIDER MISSIONS AND DATA

Since 2014 a series of deep 1000 m glider missions were conducted mainly in autumn in between the Balearic Islands and the north of the Algerian coast.

Glider missions were realized through the SOCIB external access TNA Programe from by JERICO and JERICO NEXT EU projects.

Glider tracks were designed to collect data that are also comparable among the different ABACUS missions and with satellite data.

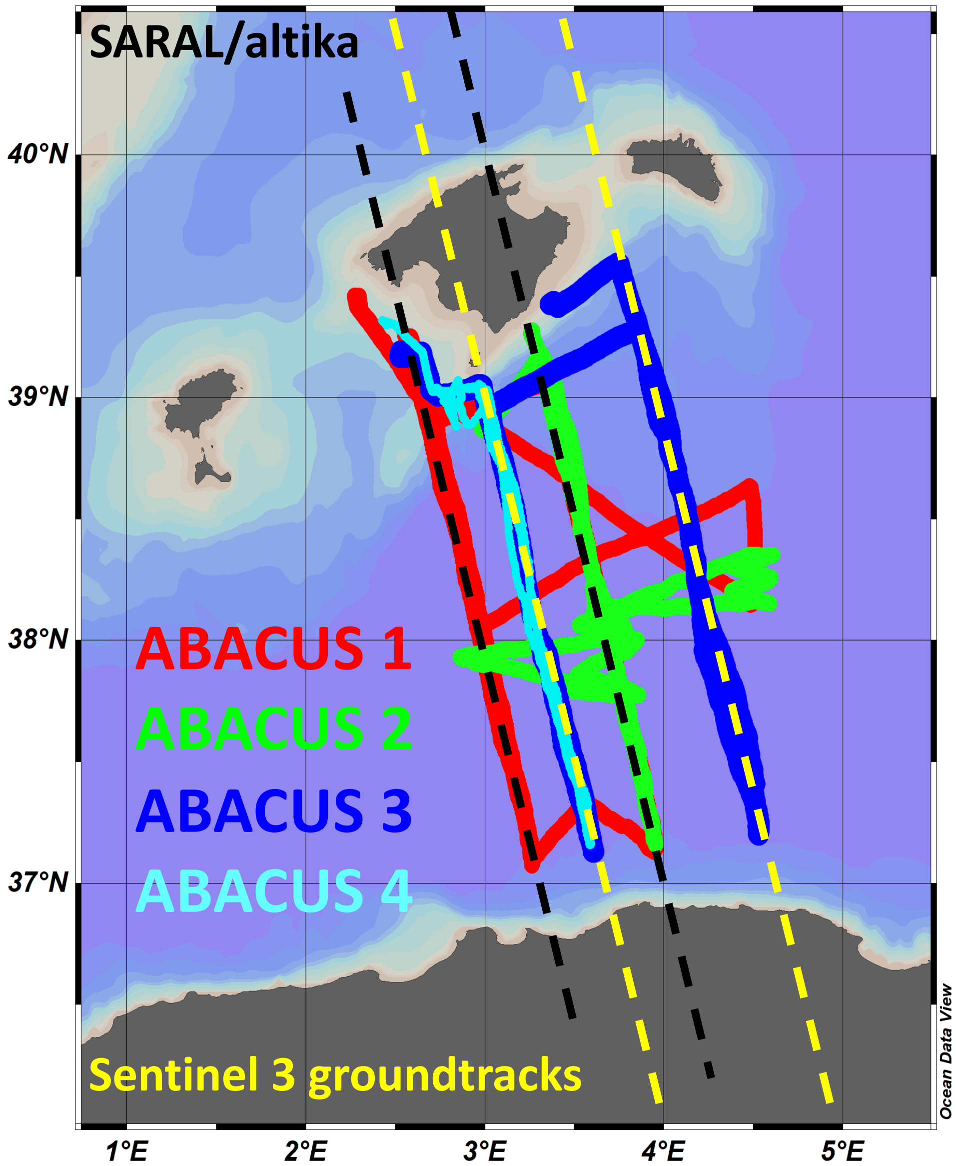



Glider tracks during the ABACUS missions

# GLIDER MISSIONS AND DATA

For these reasons, ABACUS missions have been designed to establish a repeated glider monitoring line across the Algerian Basin able to monitor the basin circulation at different scales.

Furthermore, glider tracks were designed in order to be coincident with the groundtracks of the SARAL/ALtika and Sentinel-3A satellites




Glider tracks during the ABACUS missions. Sentinel 3 and SARAL/altika groundtracks in the area are also shown

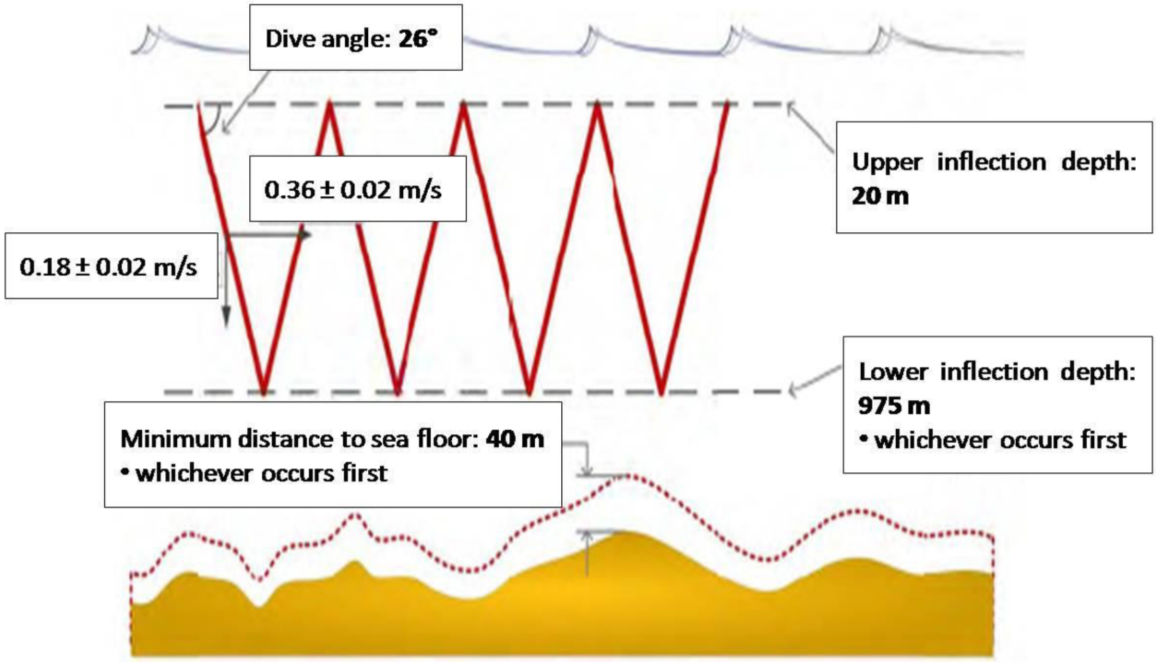
# GLIDER MISSIONS AND DATA

| PROJECT | TNA CALL | GLIDER DAYS AT SEA | PERIOD | DIRECT ACCESS TO THE FACILITY (days) |
|---|---|---|---|---|
| ABACUS 1 | Jerico 3rd Call | 68 | Sep-Dec 2014 | 6 |
| ABACUS 2 | SOCIB external access | 52 | Oct-Dec 2015 | 5 |
| ABACUS 3 | JericoNext 1st Call | 50 | Nov-Dec 2016 | 5 |
| ABACUS 4 | JericoNext 2nd Call | 53 | Nov-Dec 2017<br>May-Jun 2018 | 5 |

**More than 200 days of glider missions and more than 3000 complete casts have been realized under ABACUS**

**ABACUS missions have been realized in the framework of several calls.**
**Jerico and Jerico Next calls provided most of the funding and of the facility access, but an important contribution also derived from the fruitful cooperation with SOCIB and the application to its external access call (ABACUS 2).**

# GLIDER MISSIONS AND DATA



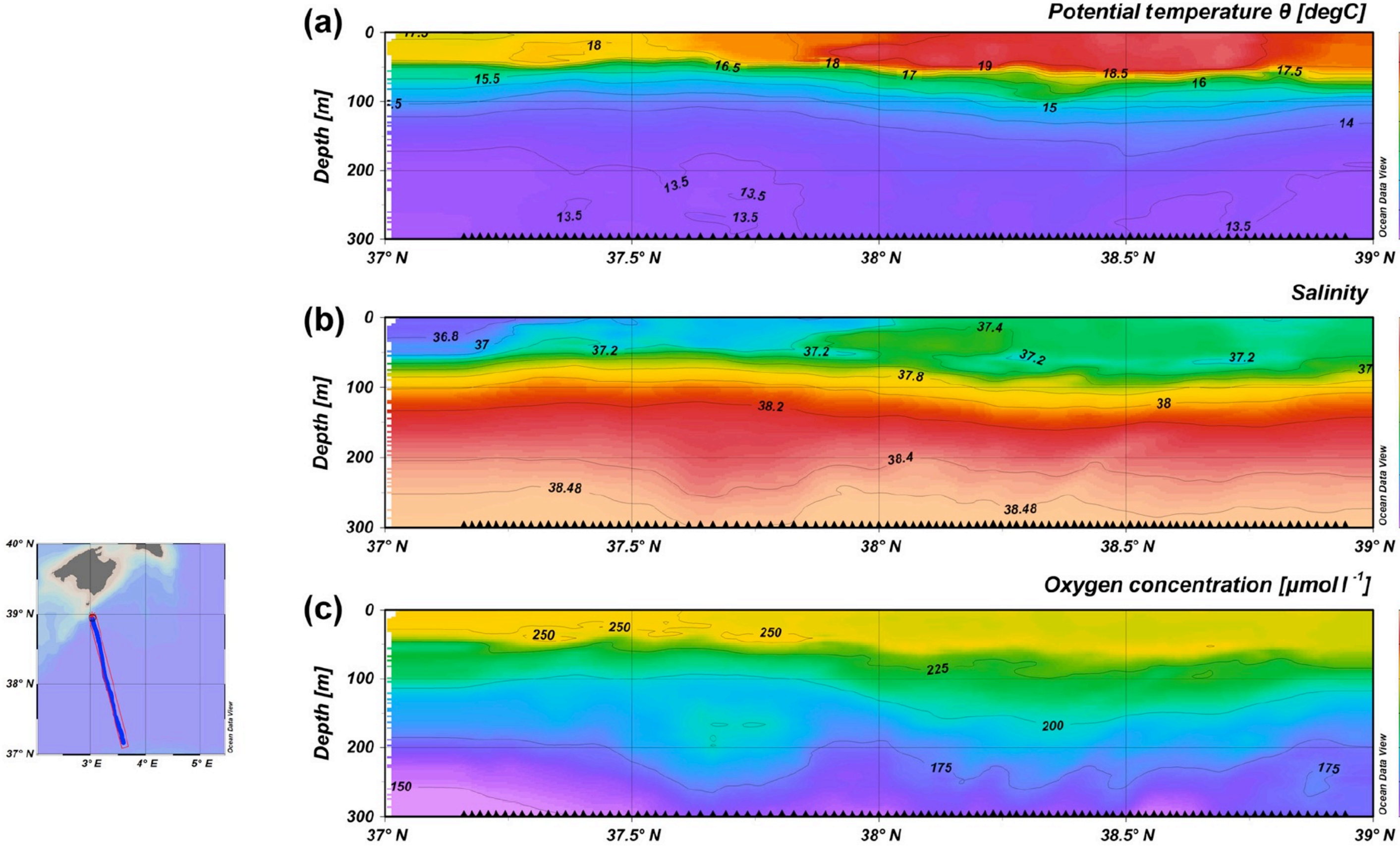

**Glider navigation scheme during the ABACUS missions**

**Measurements of temperature and salinity of the water masses in the first 975 m of the water column and with a final horizontal resolution ranging between 4 and 2 km have proved their ability to describe the main characteristics and dynamics of the basin.**

| Parameter | Instrument | Sampling rate (Hz) | Vertical resolution (m) | Depth range (m) | Accuracy | Resolution |
|---|---|---|---|---|---|---|
| Temperature, Conductivity, Depth | Seabird GPCTD Glider payload pumped CTD | 1/2 | 0.4 | -5 to -975 | T ± 0.002 °C<br>C ± 0.0003 S/m<br>D ± 0.1% fsr* | T 0.001 °C<br>C 0.00001 S/m<br>D 0.002% fsr* |
| Oxygen | AADI Optode 5013 | 1/4 | 0.8 | -5 to -975 | <8 µM or 5% | <1 µM |
| Fluorescence (F), Turbidity (Tu) | WetlabsFLNTUslk | 1/8 | 1.6 | -5 to -150 | Sensitivity<br>F 0.015÷0.123 µg/L<br>Tu 0.005 ÷0.123 NTU | |
| | | 1/16 | 3.2 | -150 to -300 | | |

**Sampling rate and vertical resolution of ABACUS glider data (adapted from Cotroneo et al., 2016; Aulicino et al., 2018; Cotroneo et al., 2019). * Full Scale Range**

# BASIN SCALE INVESTIGATIONS



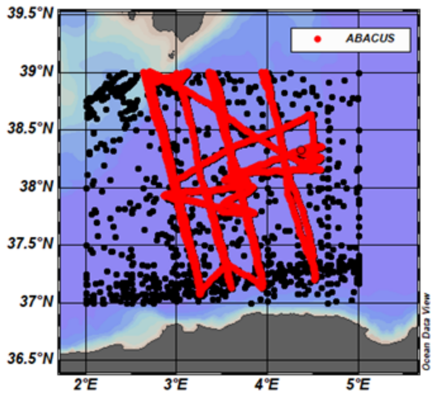

**Surface layer (0–300 m depth) along-track sections of potential temperature, salinity and oxygen concentration obtained from ABACUS 3 glider data. Black triangles indicate the position of the single glider profiles. Adapted from Cotroneo et al. (2019 ESSD)**

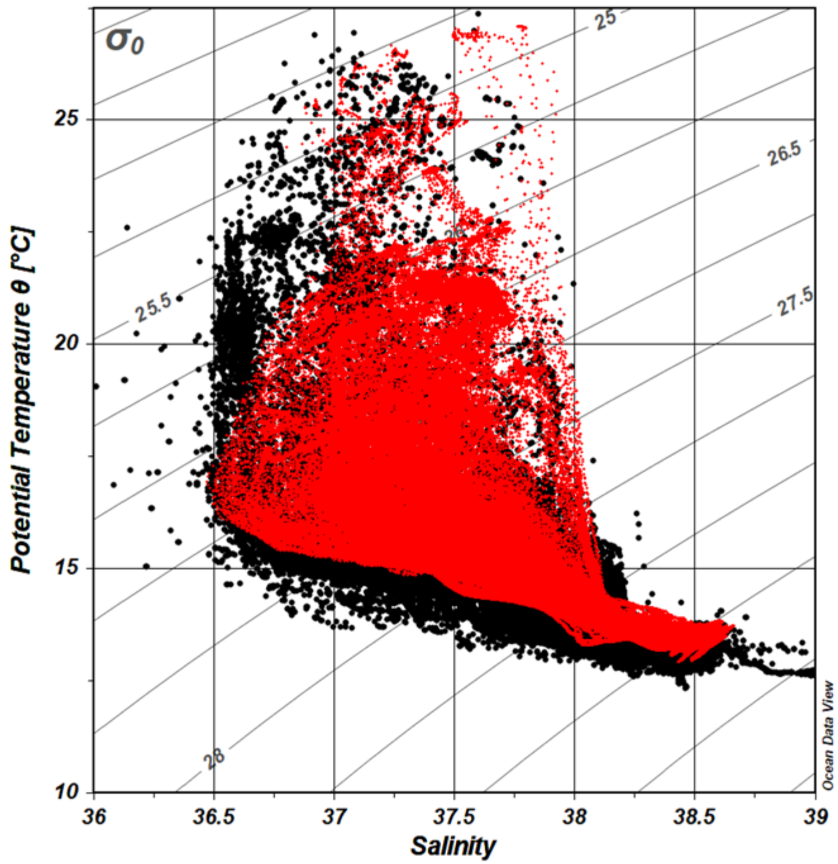
**Across the glider missions, several repeated transects were obtained which enabled us to investigate the basin scale circulation and the presence of mesoscale structures utilizing both the adaptive sampling capabilities of the gliders and the higher resolution of the data.**

# HISTORICAL/GLIDER DATA COMPARISON

A successful comparison was performed between glider data and a set of historical oceanographic measurements collected in the study area including data from the Medar Medatlas II project, from the Coriolis CORA-3.4 Dataset and from the World Ocean Hydrographic Profiles.

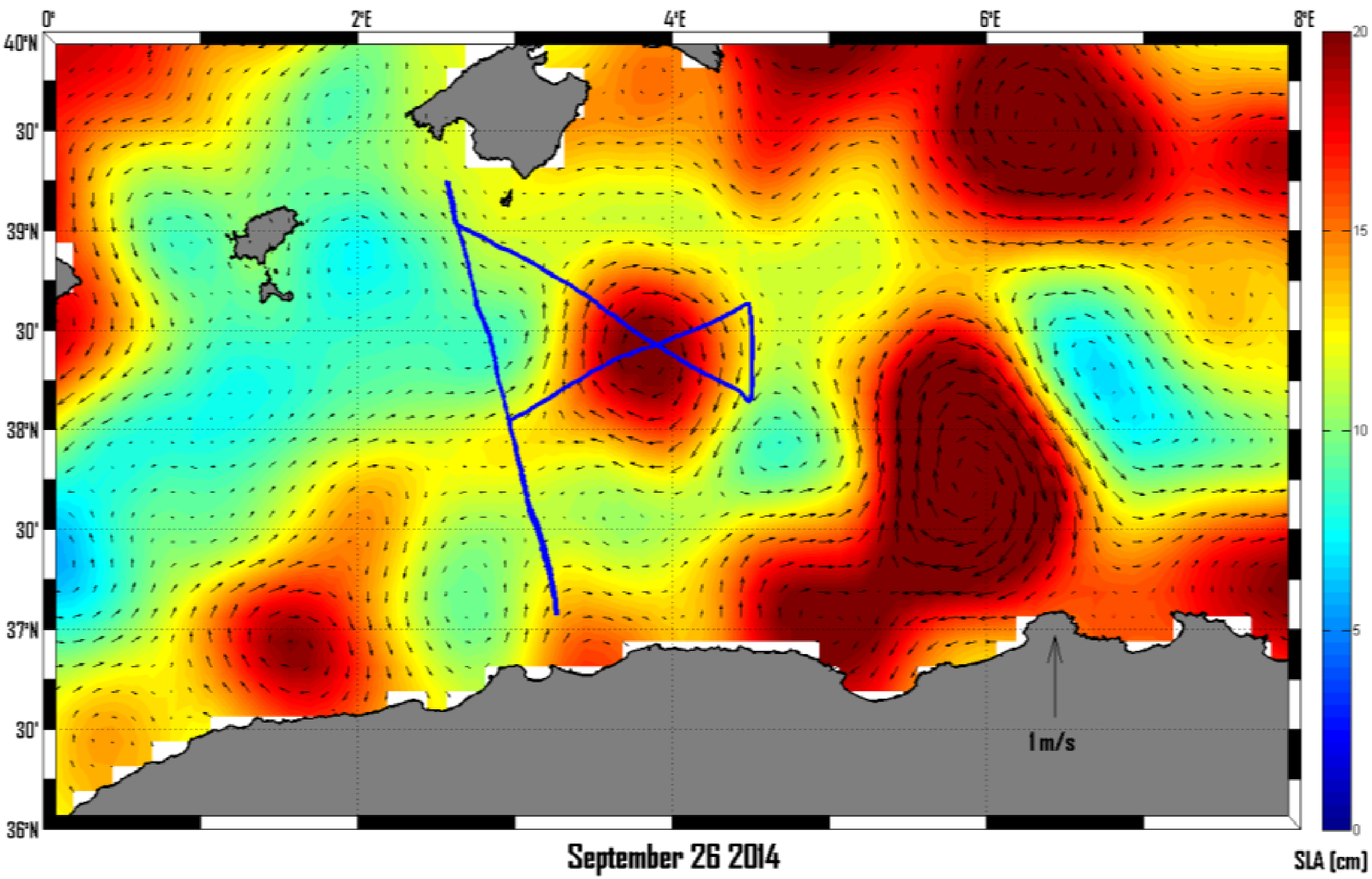
**Available historical data from 1909 to 2011 accounted for 2450 casts.**
**ABACUS realized 3000 casts in 4 years**




**Θ/S diagram comparing historical oceanographic observations from 1909 to 2011 (black dots) to ABACUS data (red dots). The associated map shows the spatial distribution of the data. From Cotroneo et al. ESSD 2019**

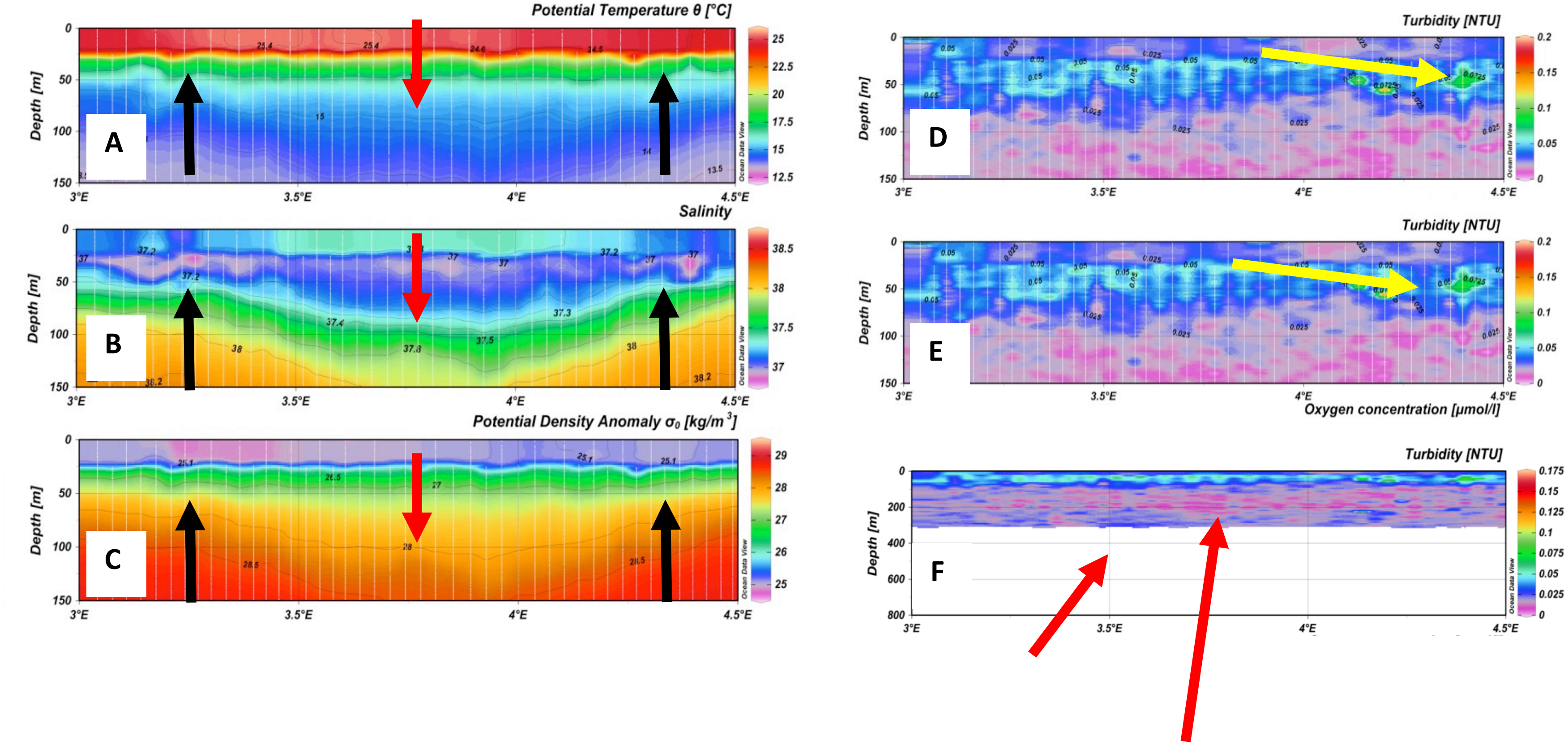
# MESOSCALE STRUCTURES




Sea level anomaly map (color scale) and associated geostrophic velocity anomalies (black arrows) from AVISO data on 26 September 2014. Blue line shows the glider track from 15 September to 20 October 2014. Adapted from Cotroneo et al. (2016 JMS)

**The glider ability to change mission plan while at sea was used to monitor a mesoscale structure in the Algerian Basin**

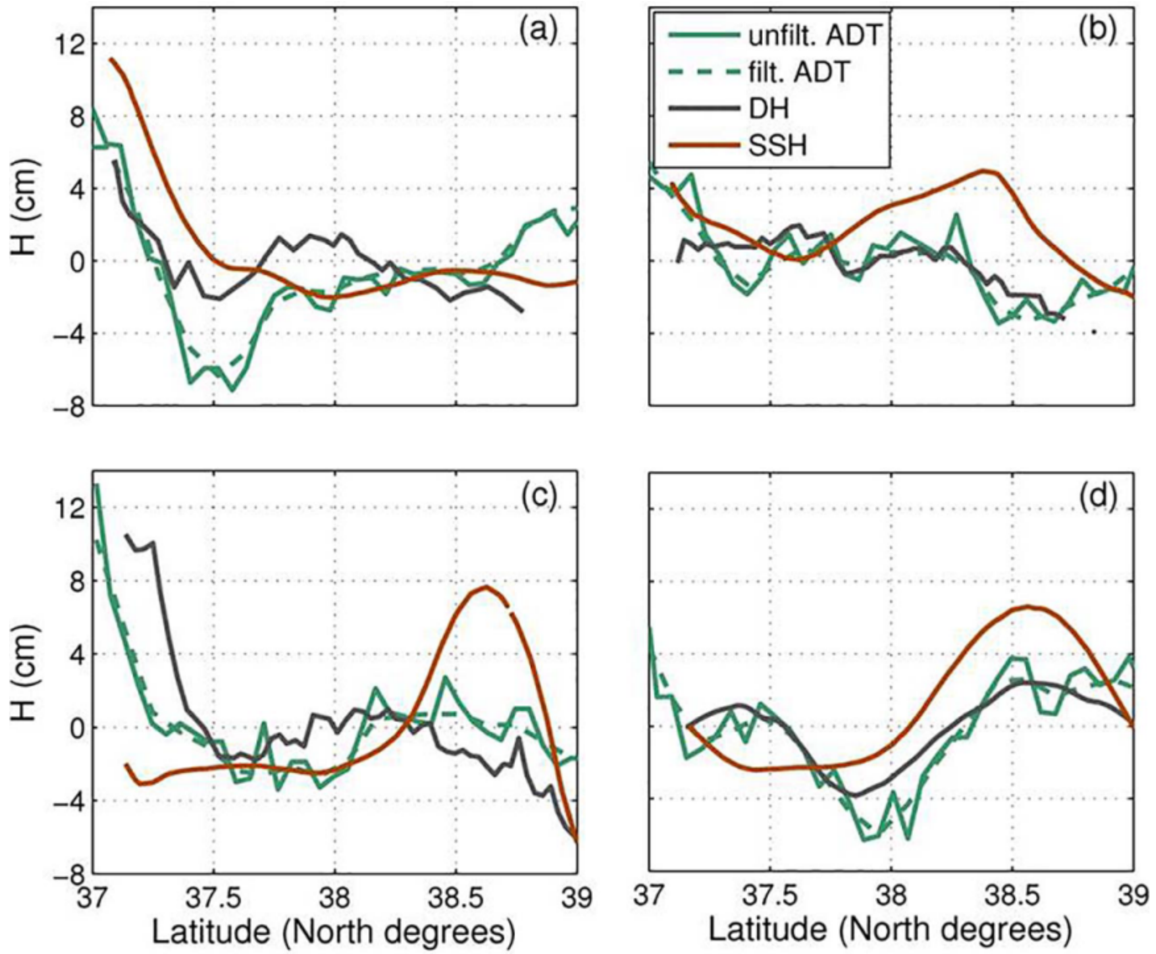
# MESOSCALE STRUCTURES




**Sections from surface to 150 m depth of potential temperature (a), salinity (b), potential density anomaly (c), turbidity (d) and chlorophyll concentration (e) along the SW/NE axis of the eddy. Oxygen concentration (f) is shown for the 0–800 m layer.**
**Adapted from Cotroneo et al. (2016 JMS)**

**The vertical structure of the eddy was observed, and high resolution data allowed us to i) retrieve vertical velocities and ii) observe oxygen subduction and nutrient upwelling along the boundaries**

# MODEL/ALTIMETRY/GLIDER DATA COMPARISON




**Filtered (dashed green line) and unfiltered (solid green line) ADT from altimetry;**

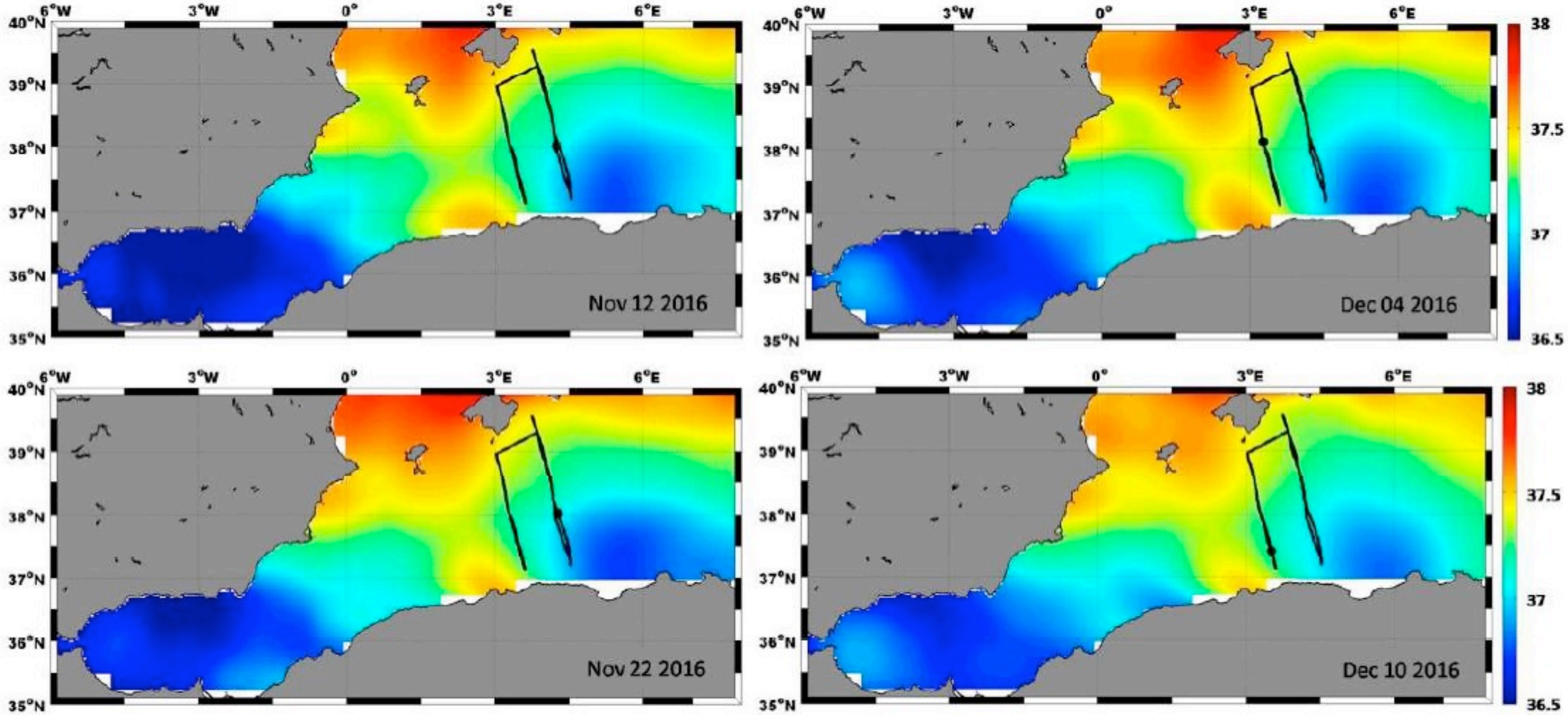
**dynamic height (gray line) computed from the ABACUS glider data along SARAL/AltiKa groundtracks 773 (upper panels) and 229 (lower panels) associated with the passage of the satellite south of the Balearic islands on**

**(a) 17 September 2014;**
**(b) 26 November 2014;**
**(c) 12 December 2014**
**(d) 23 October 2015;**

**and SSH (brown line) along the four tracks obtained from the CMEMS MFS numerical model. Adapted from Aulicino et al. (2018 JMS)**

**Along track satellite altimetry data were compared with dynamic height estimated from high resolution glider data and COPERNICUS model output**

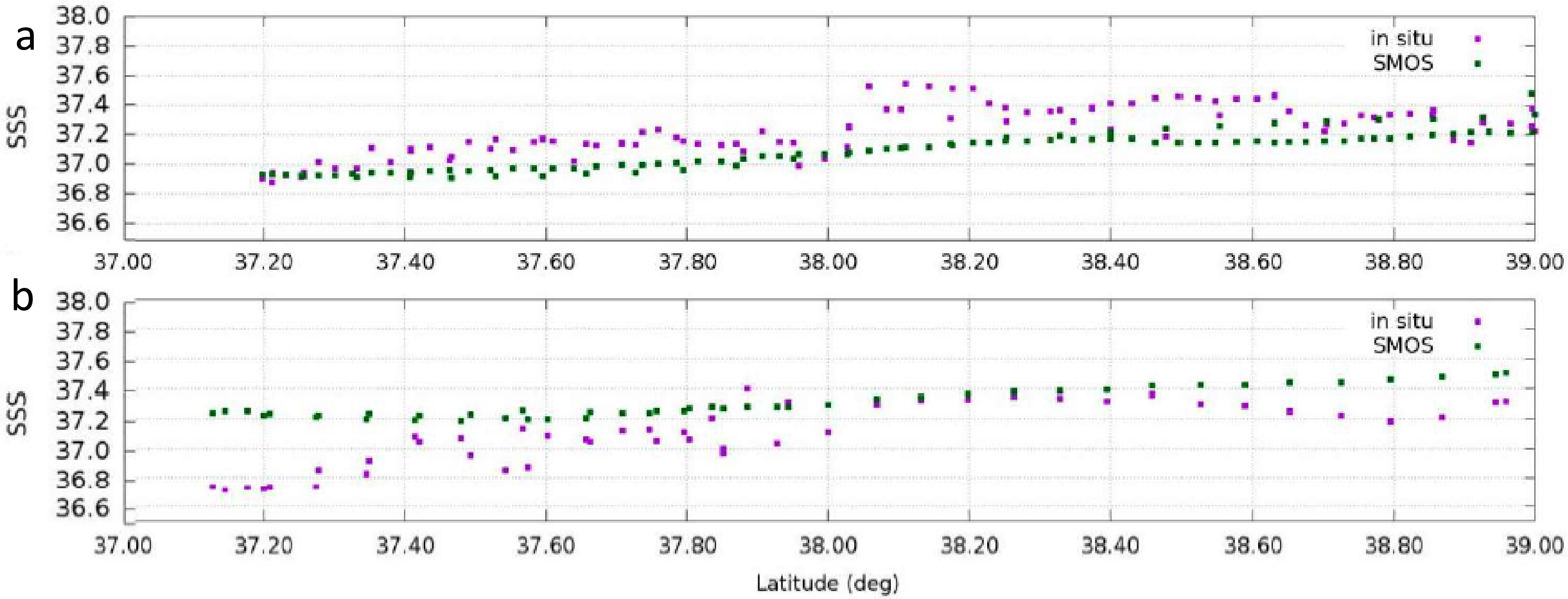
# SMOS SALINITY/GLIDER DATA COMPARISON




**SMOS L4 SSS maps of the Alboran Sea and Algerian Basin during ABACUS 3. Glider track is also shown (black dots). Adapted from Aulicino et al. (2019 Rem. Sens)**

**ABACUS glider high resolution in situ observations were used to validate SMOS sea surface salinity enhanced satellite products**

# SMOS SALINITY/GLIDER DATA COMPARISON




**Comparison between averaged in situ glider salinities (purple dots) and SMOS L3 SSS (green dots) along latitude, during the missions (a) ABACUS 3.1 (Nov 2016), and (b) ABACUS 3.2 (Dec 2016). Adapted from Aulicino et al. (2019 Rem. Sens)**

**ABACUS glider high resolution in situ observations were used to validate SMOS sea surface salinity enhanced satellite products**

# CONCLUSIONS

**DID WE KNOW ENOUGH OF THE ALGERIAN BASIN CIRCULATION?**

**Probably not…… but some improvements have been made thanks to ABACUS:**

**In situ observations provided about 3000 complete casts across the AB and more than 200 glider days at sea!!**

**We successfully monitored a mesoscale eddy and its asymmetric structure.**

**ABACUS data have been an useful tool to complete satellite and model datasets.**

**Repeated glider cruises can effectively contribute to a network of endurance lines monitoring both the short and long-term variability of the Mediterranean Sea.**

# Table of content

1. **OBJECTIVES:**

*Use EU infrastructures capabilities -such as JERICO-NEXT TNA and SOCIB- to respond to key questions that cannot be addressed by individual teams…*

**1.1. - Mesoscale eddies 3D physical & bio-geochemical structure & interactions mean currents**

**1.2. - Variability of mesoscale eddies, currents: endurance line**

3. **RESULTS**
4. **CONCLUSIONS**
5. **SCIENTIFIC PRODUCTS**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654410.