ABACUS 2014-2024
Ten years of the repeated glider monitoring line across the western Mediterranean Sea

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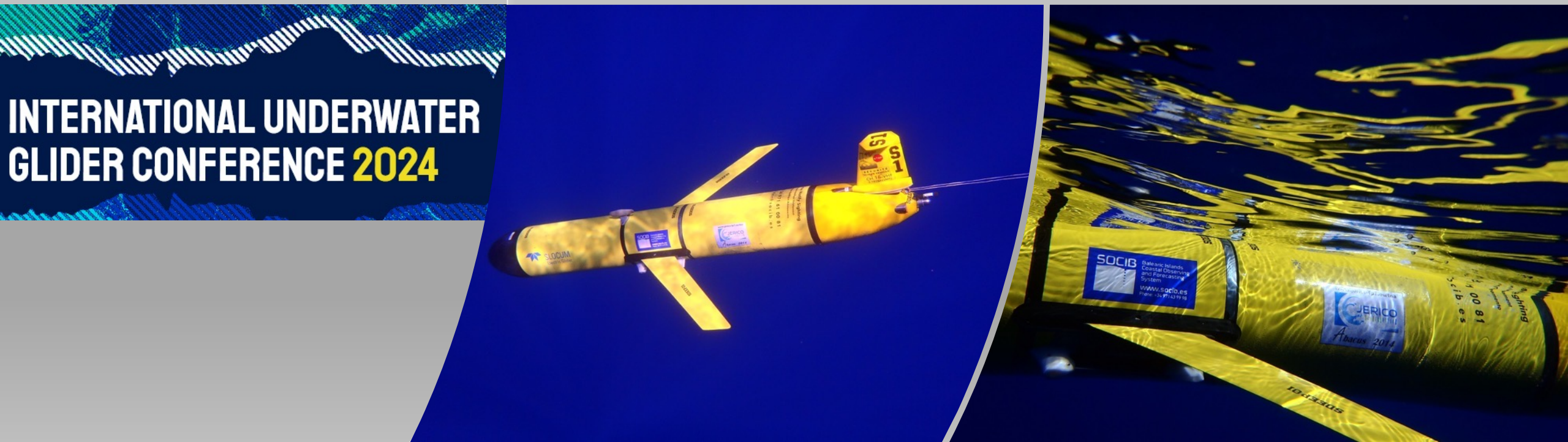
INTERNATIONAL UNDERWATER GLIDER CONFERENCE 2024



SOCIB
Balearic Islands Coastal Observing and Forecasting System

IME

CSIC
Consejo Superior de Investigaciones Científicas

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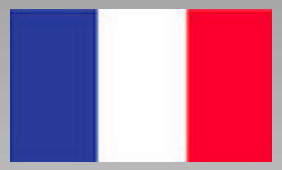


The ABACUS missions have been realized through the SOCIB external access and funded by several editions of the JERICO - Joint European Research Infrastructure network for Coastal Observatories – project.

Thanks to JERICO and SOCIB !!

2014

2019-2023

2015

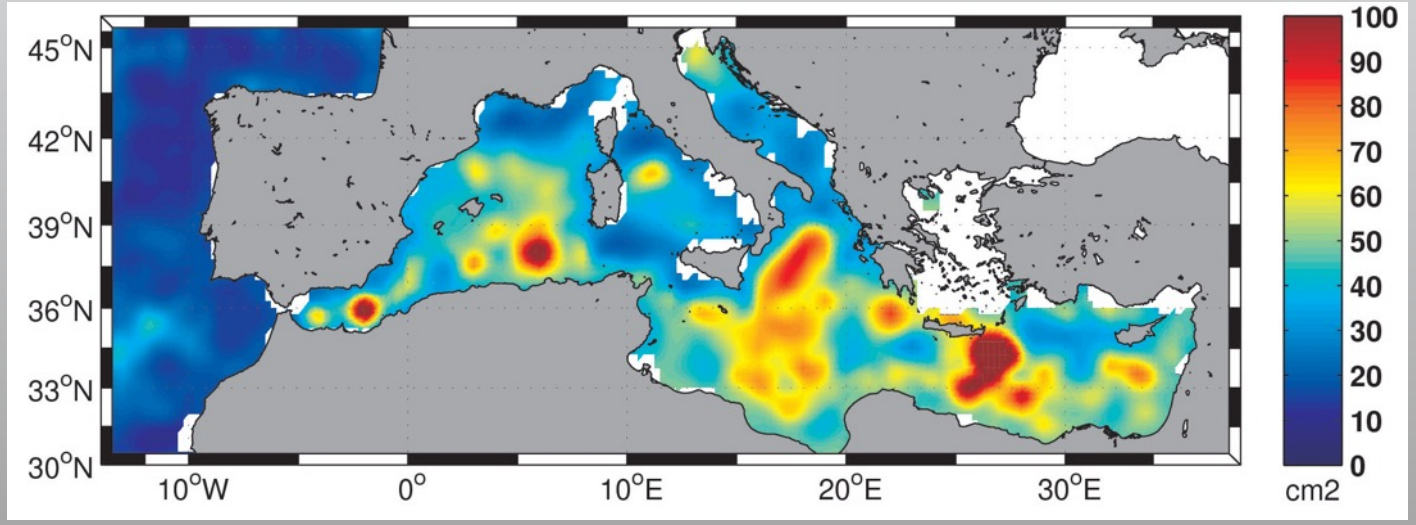
2024

Started on May 16 2024.
Glider recovered on June 5 2024

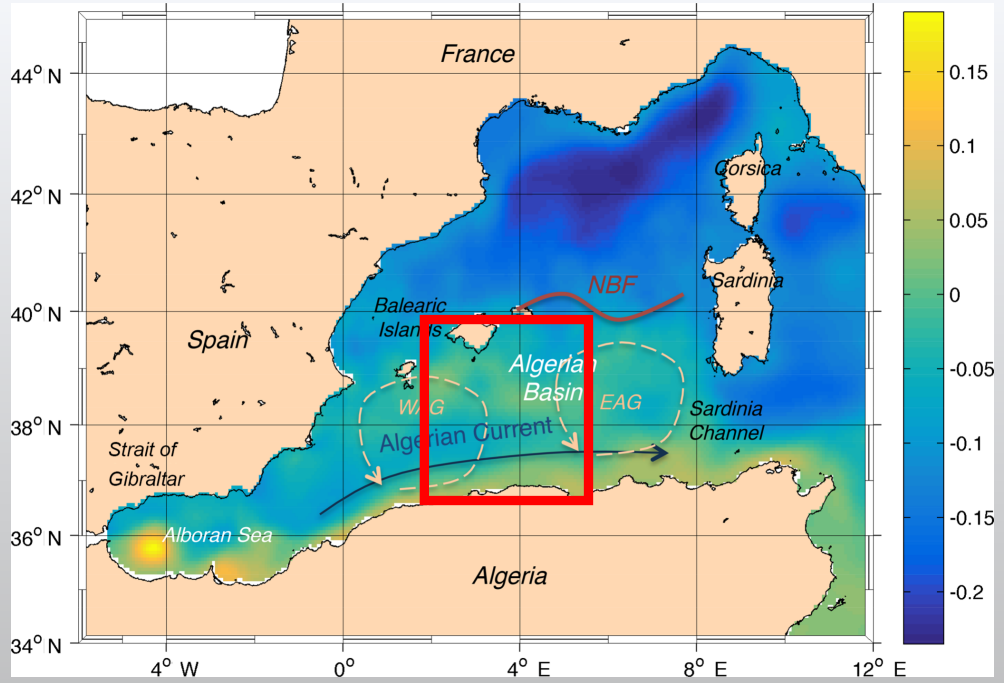
2016-2018

The Algerian Basin

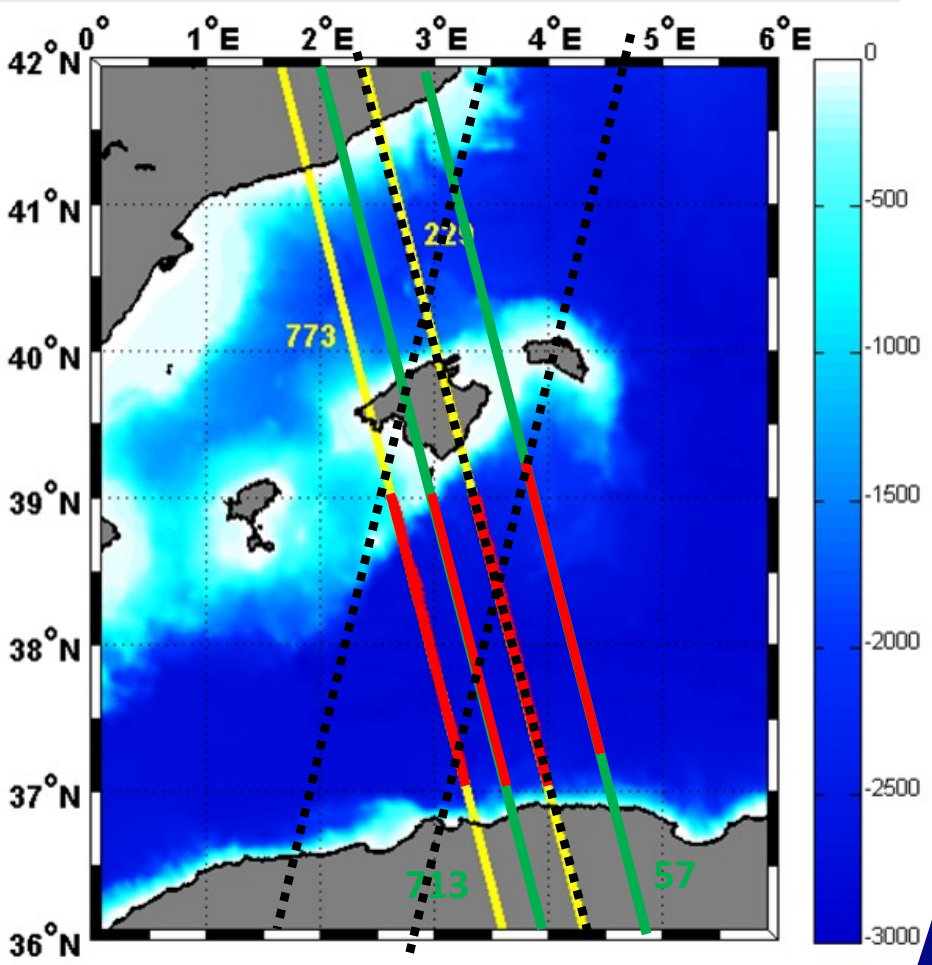
Mean dynamic topography (m) in the WMED (Pessini et al., 2018). Red Box identifies the ABACUS study area.



AVISO multimission Sea Level Anomaly variance map for the 1993-2004 period (Vidal et al. 2011).



Glider tracks are designed in order to match with SARAL/ALtiKa, Sentinel-3A and SWOT groundtracks

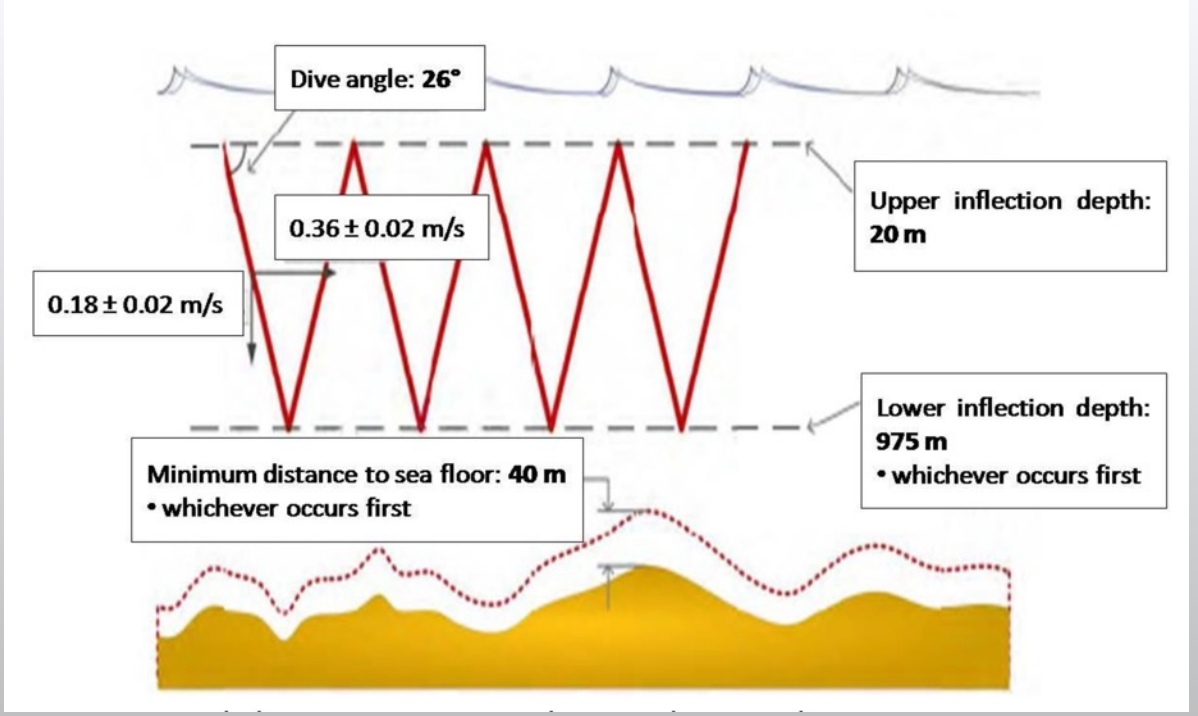


SARAL-altiKA groundtracks 773, 229

Sentinel 3 groundrtacks 713, 57

SWOT groundtracks 57, 320, 335

ABACUS tracks



Measurements of T, S of the Oxy. conc., Fluorescence and Turbidity down to 975 m depth.
Spatial resolution between 2.8 and 8 km.

Since the second mission, upcast and downcast data are collected and surfacing of the glider has been realized after every "yo" to increase surface layer sampling

Glider navigation scheme and data sampling design during the ABACUS missions (Cotroneo et al. ESSD, 2019)

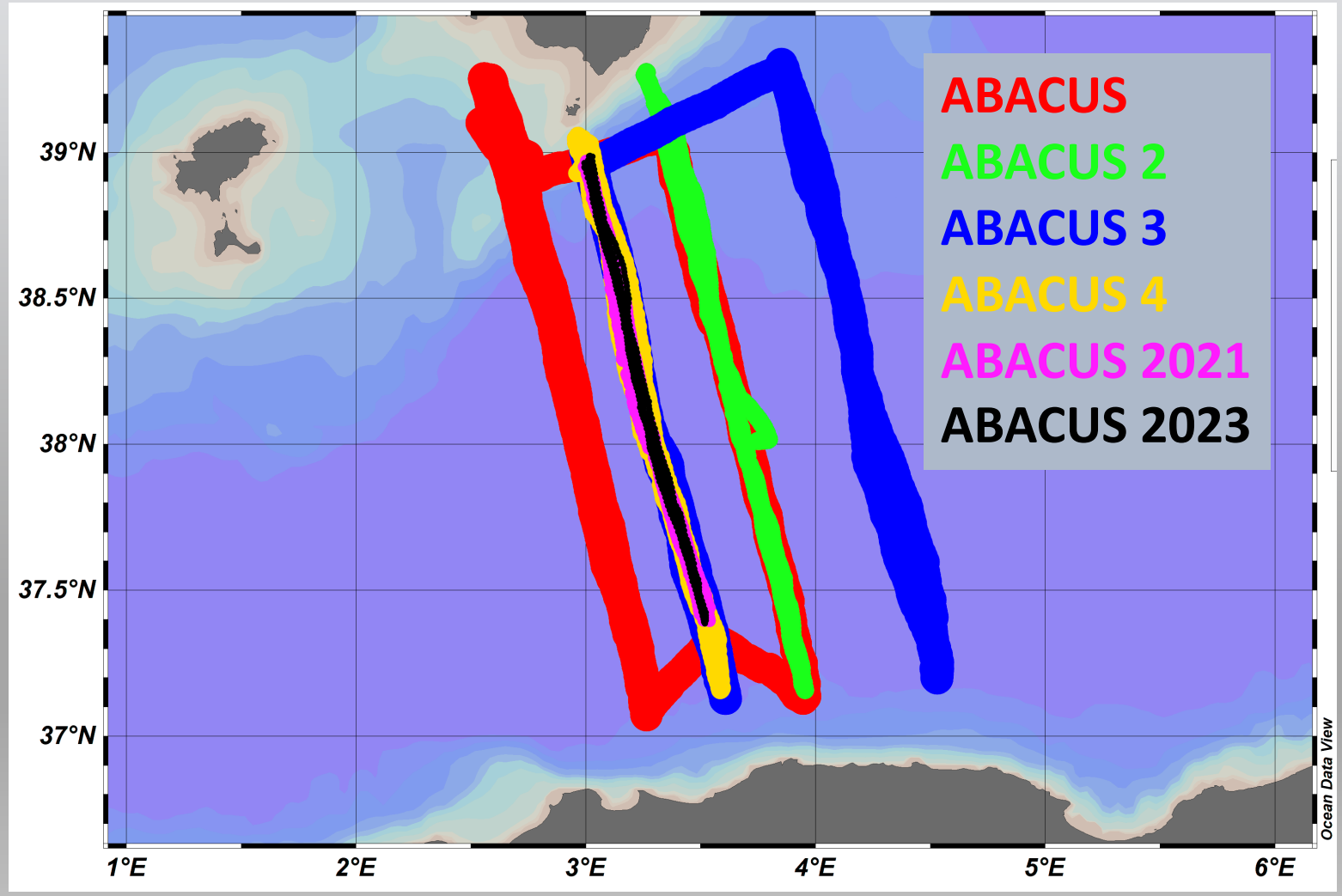
Parameter	Instrument	Sampling rate (Hz)	Vertical resolution (m)	Depth range (m)	Accuracy	Resolution
Temperature, Conductivity, Depth	Seabird GPCTD Glider payload pumped CTD	1/2	0.4	-5 to -975	T ± 0.002 °C C ± 0.0003 S/m D ± 0.1% fsr*	T 0.001 °C C 0.00001 S/m D 0.002% fsr*
Oxygen	AADI Optode 5013	1/4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

Repeated lines allow observations of seasonal/inter annual patterns and trends

About 3800 casts have been collected along the monitoring lines.

More than 6000 complete casts in the Algerian basin.

A total of 28 glider transects were completed from 2014 to 2024. Each transect has an average duration of 10 days

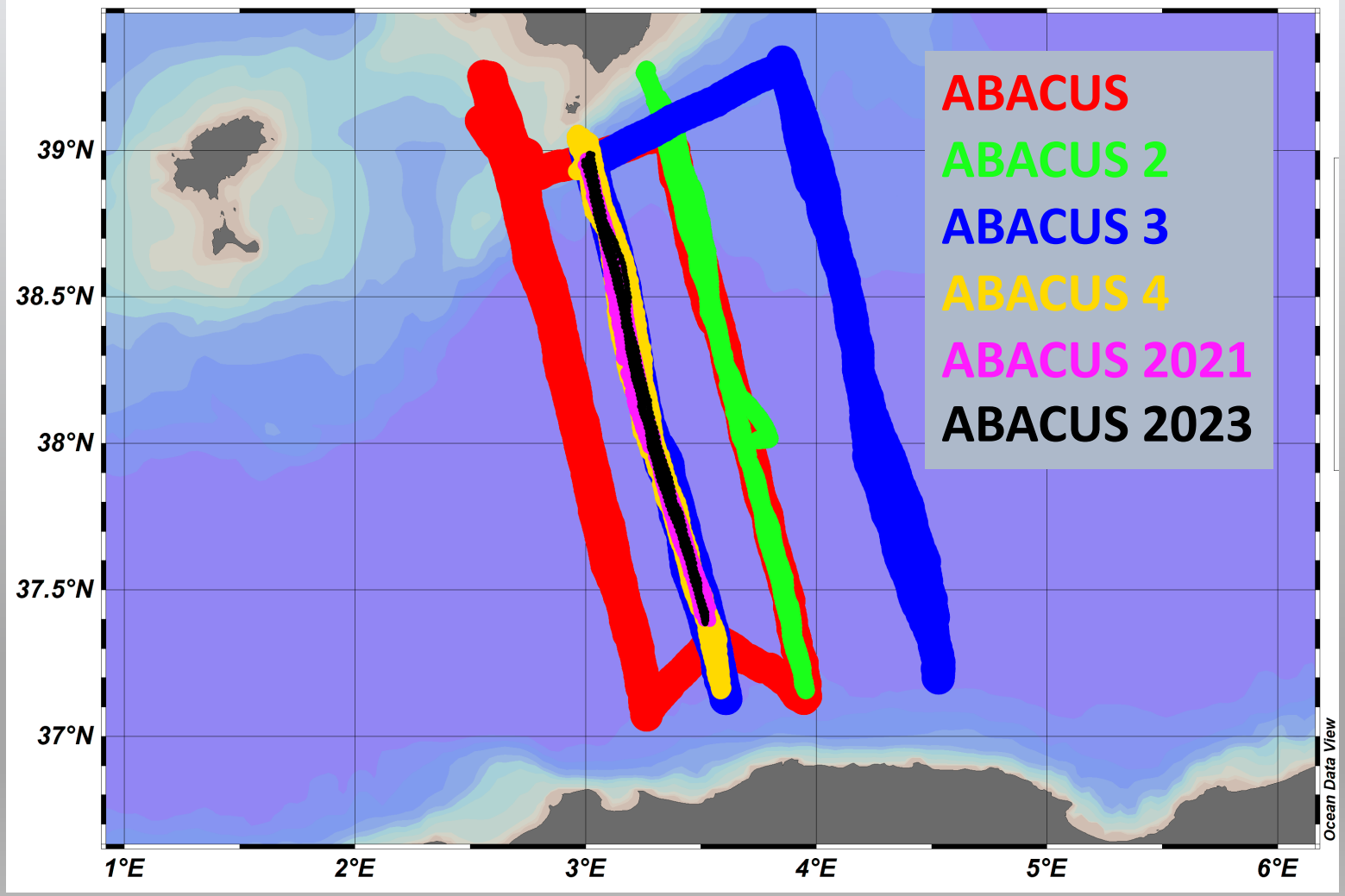


Repeated lines allow observations of seasonal/inter annual patterns and trends

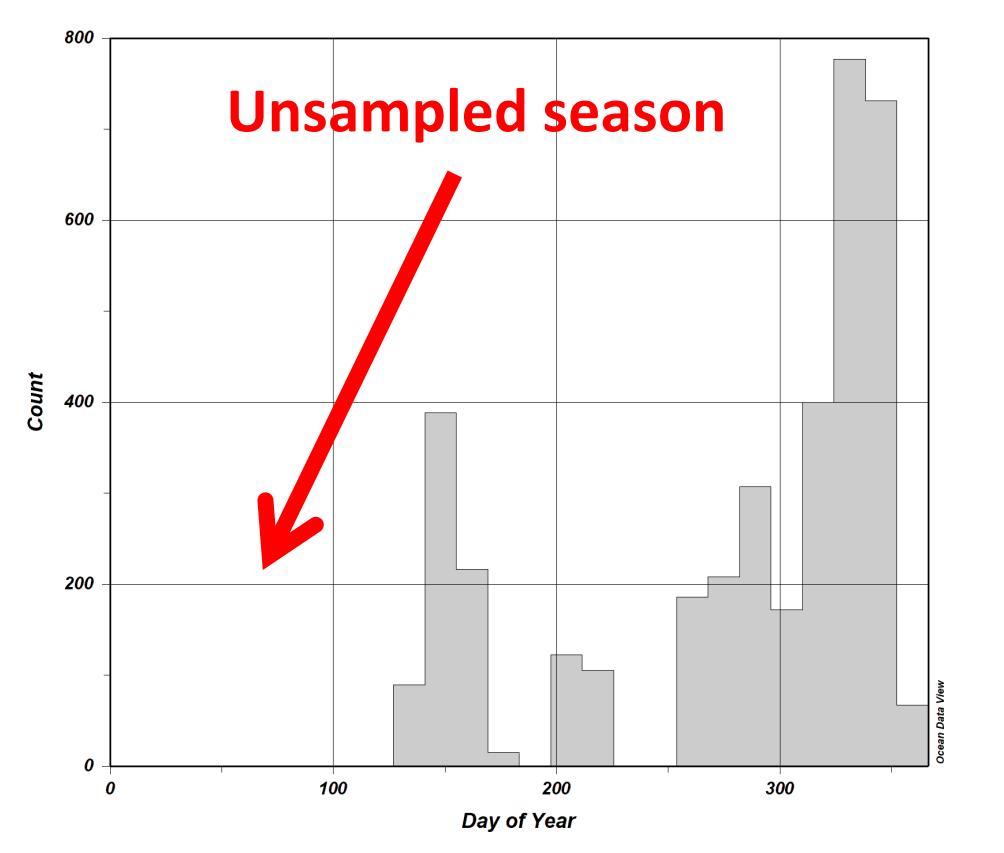
The reliability of data goes through different quality control procedures.

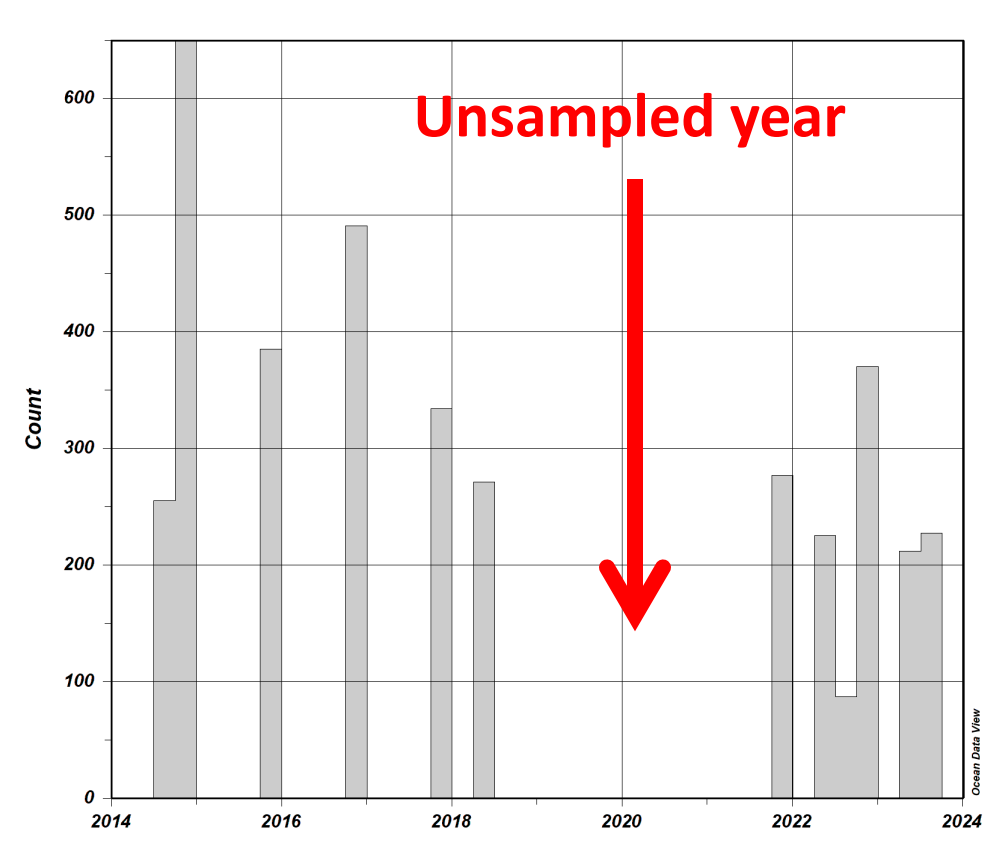
Data are compared with available datasets:
cruises previously,
ARGO since 2024

Satellite data offered supporting information on the large-scale circulation and the presence of peculiar mesoscale structures.



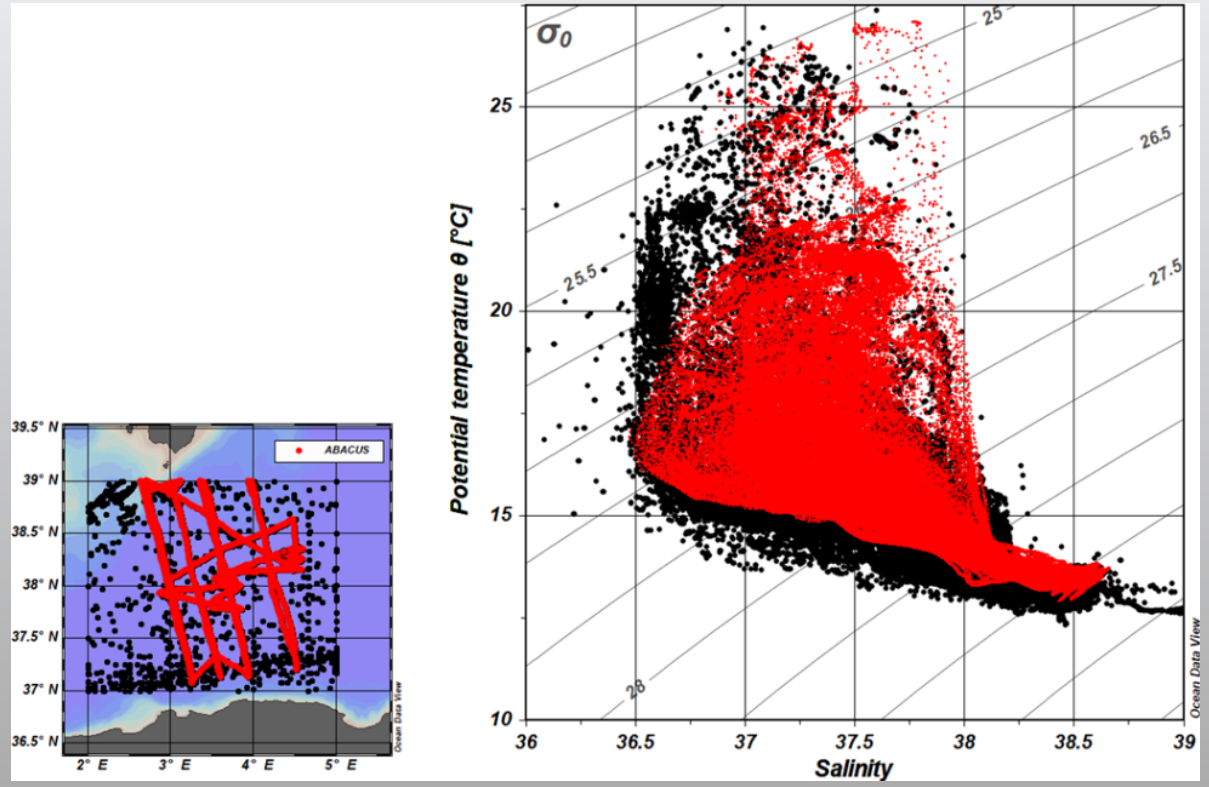
Repeated lines allow observations of seasonal/inter annual patterns and trends



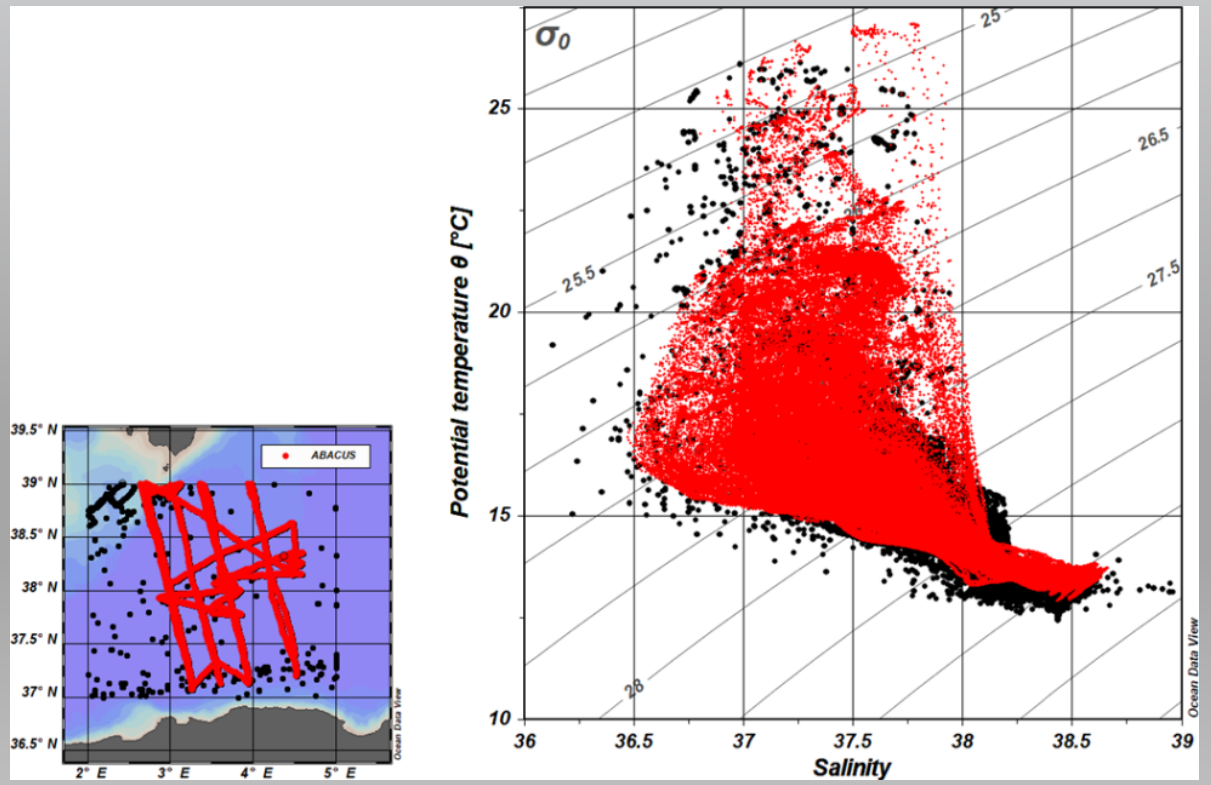


Glider transects take place during fall and/or early winter over the ten years, with additional missions in late spring and early summer in the recent years.

ABACUS data in 2016 were compared with available cruises (1909-2011) also on seasonal basis



θ–S diagram comparing historical oceanographic observations from 1909 to 2011 (black dots) to ABACUS data (red dots) on annual basis (left) and during the autumn season (September–December). The associated map shows the spatial distribution of the data. (Cotroneo et al., ESSD 2019)

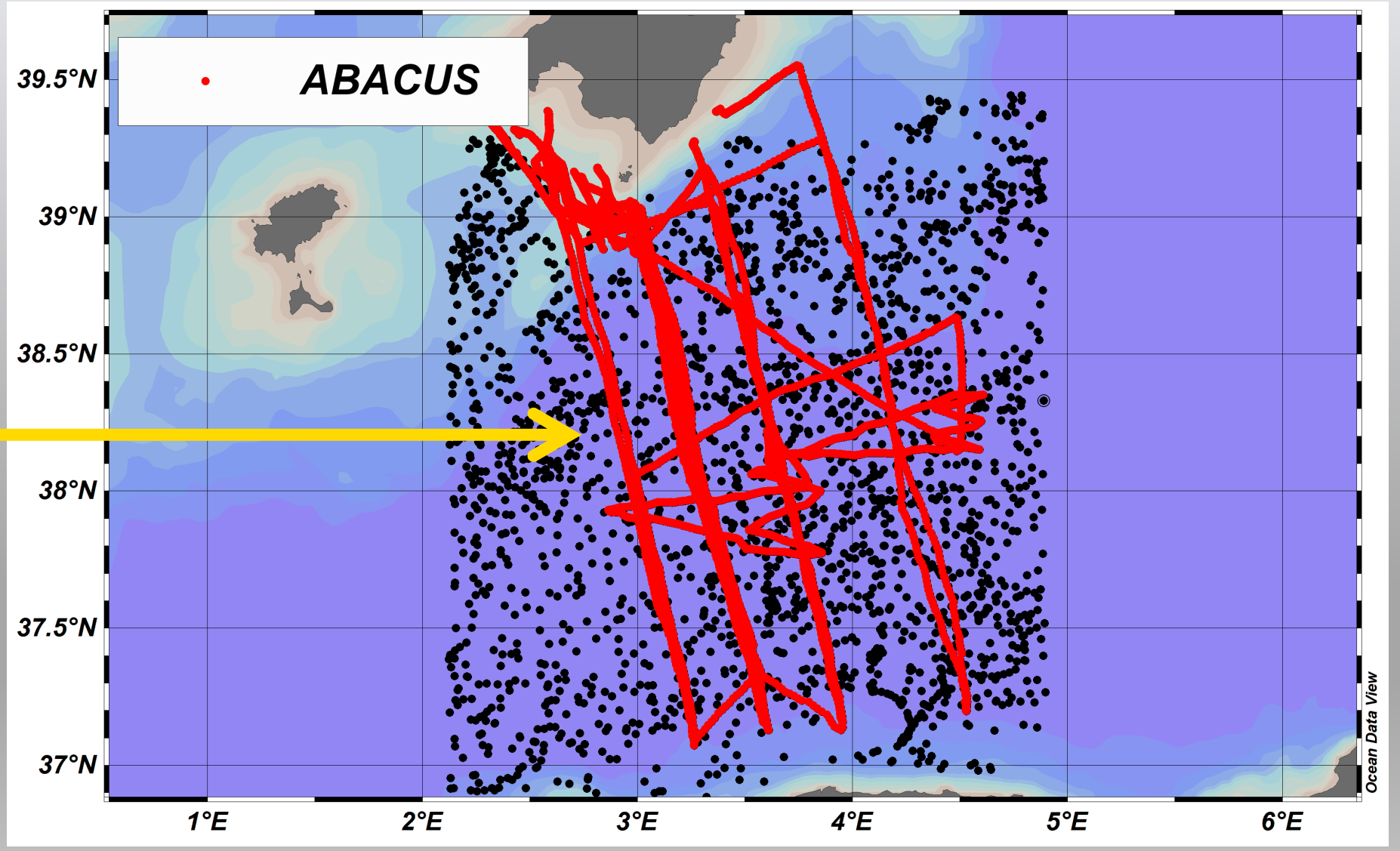


First comparison with ARGO coverage:

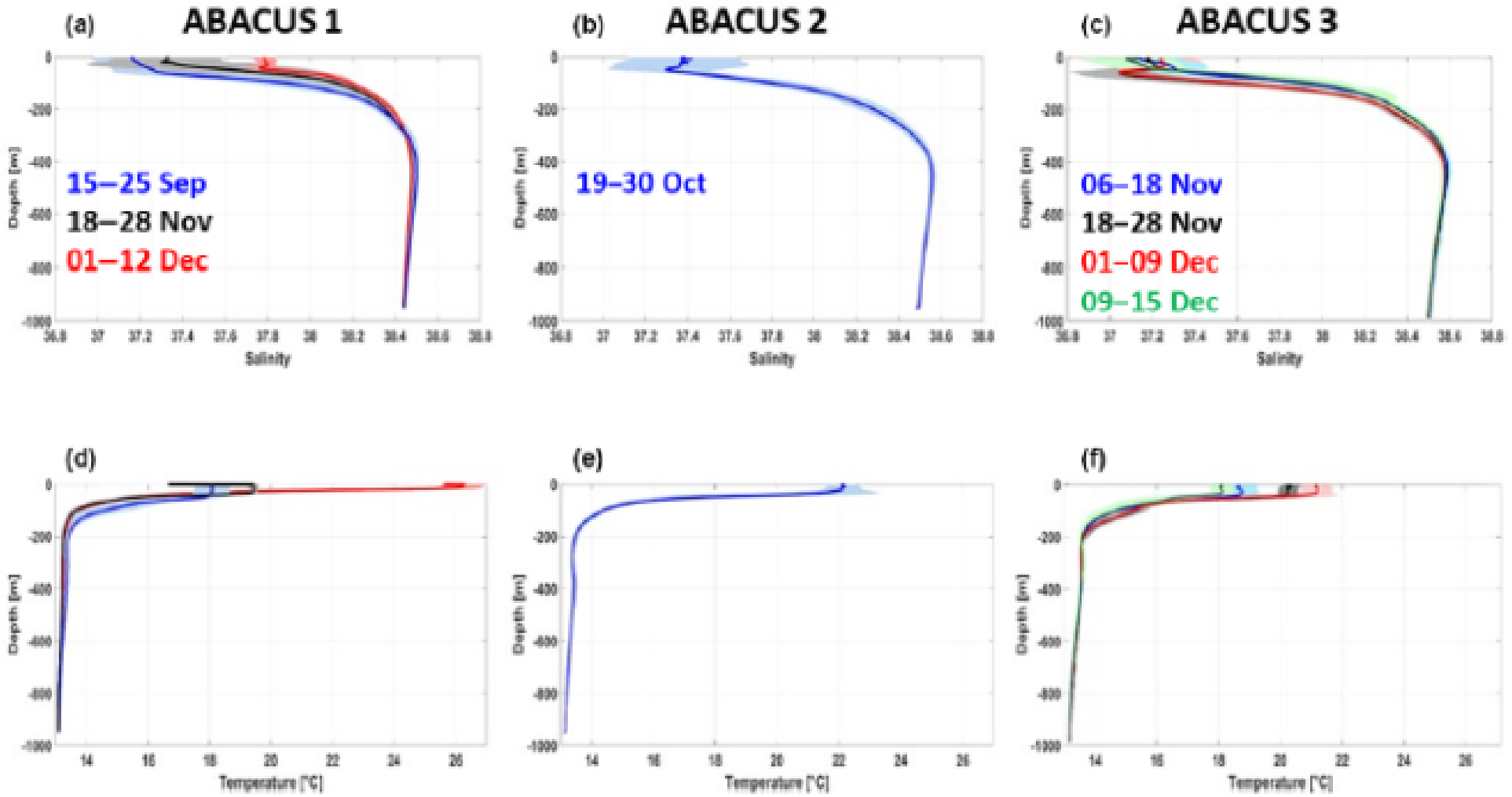
6821 ABACUS PROFILES

3229 ARGO PROFILES FROM 2014 TO 2024

Do not forget the advantages of repeated tracks during different seasons



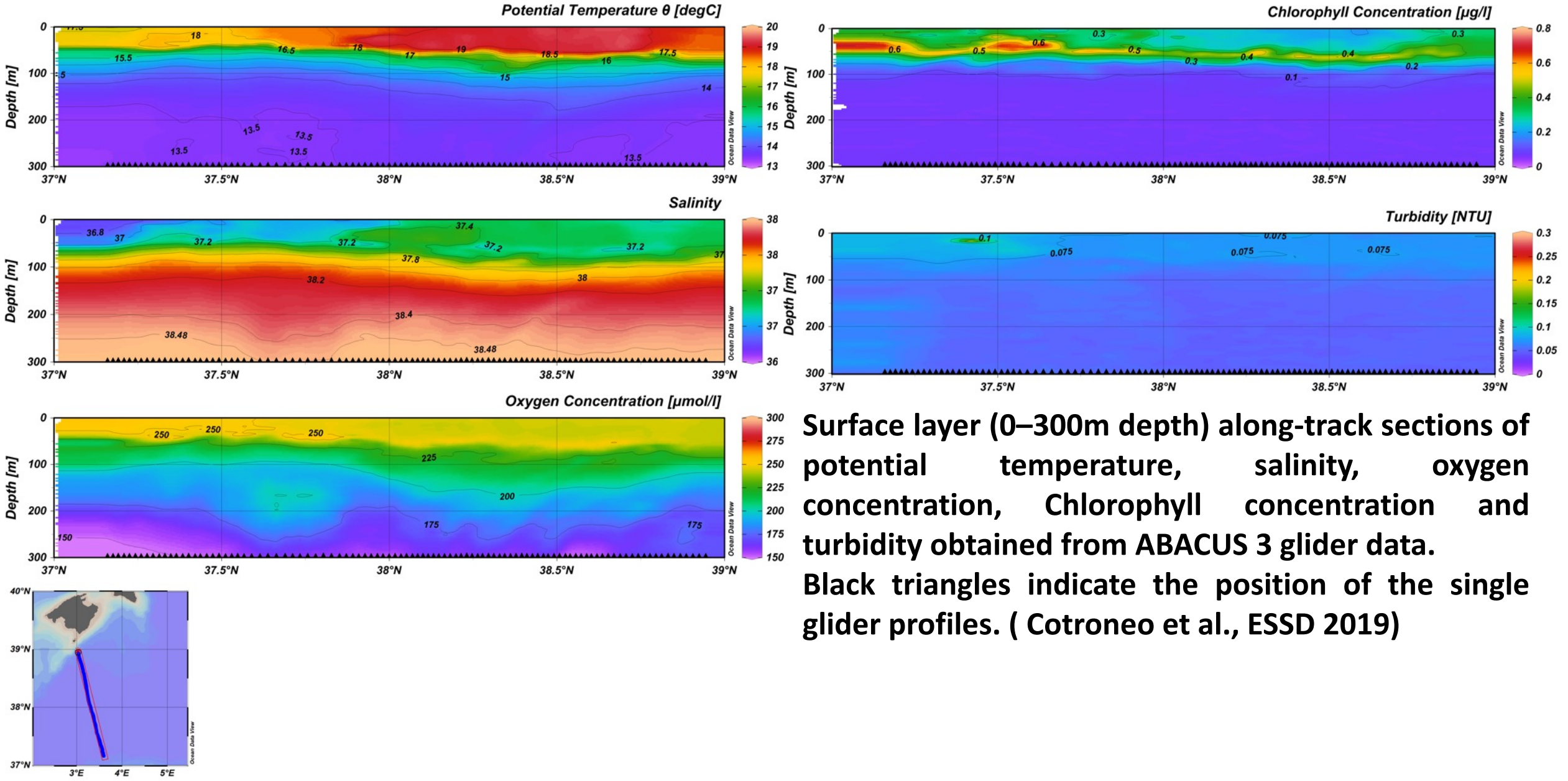
ABACUS data interannual variability



Mean salinity (**a–c**) and temperature (**d–f**) profiles (thick lines) for each ABACUS transect. From left to right, ABACUS 1, ABACUS 2 and ABACUS 3 data are represented. For each mission, the first available mean profile is shown in blue, the second in black, the third in red and the fourth in green. The shaded area represents the standard deviation calculated at each depth for each mean profile.

(Cotroneo et al., ESSD 2019)

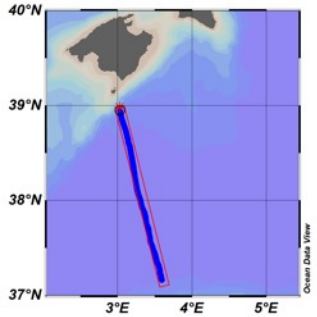
ABACUS surface layer monitoring

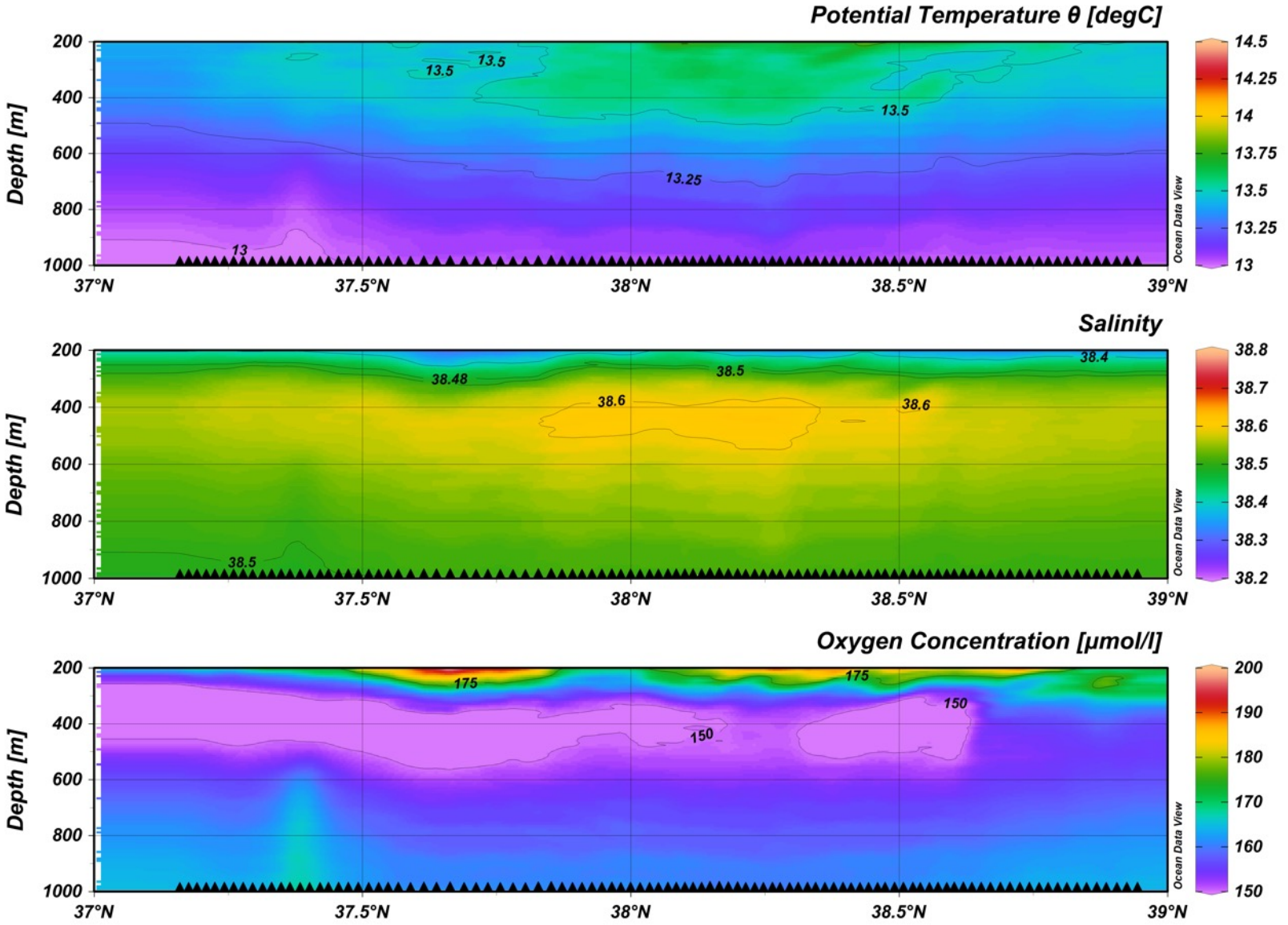


Surface layer (0–300m depth) along-track sections of potential temperature, salinity, oxygen concentration, Chlorophyll concentration and turbidity obtained from ABACUS 3 glider data.
Black triangles indicate the position of the single glider profiles. (Cotroneo et al., ESSD 2019)

ABACUS intermediate layer monitoring

Intermediate and deep layer (200–975m 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.





(Cotroneo et al., ESSD 2019)

Main published results

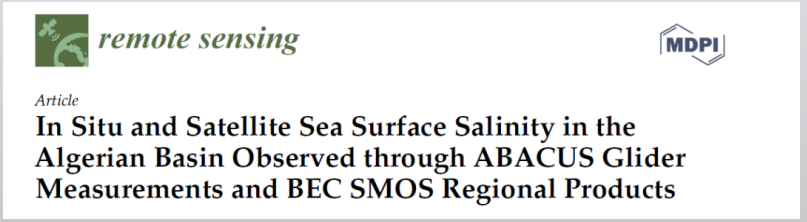
Public repository for ABACUS data and data description

https://doi.org/10.25704/b200-3vf5
https://doi.org/10.5194/essd-11-147-2019

Comparison with:

Salinity satellite data

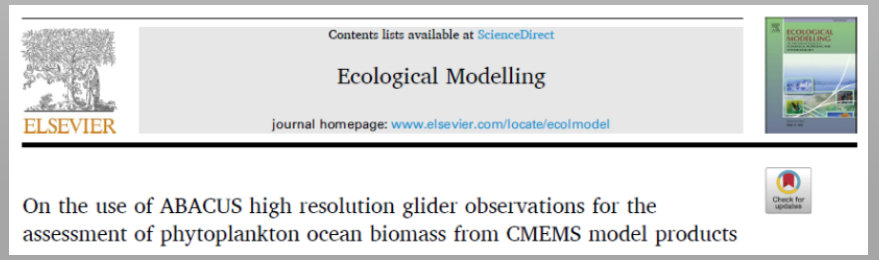
https://doi.org/10.3390/rs11111361



Altimetry data and numerical models

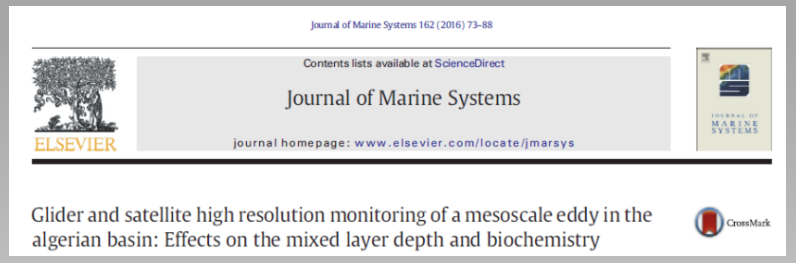
https://doi.org/10.1016/j.jmarsys.2017.11.006

https://doi.org/ 10.1016/j.ecolmodel.2021.109619

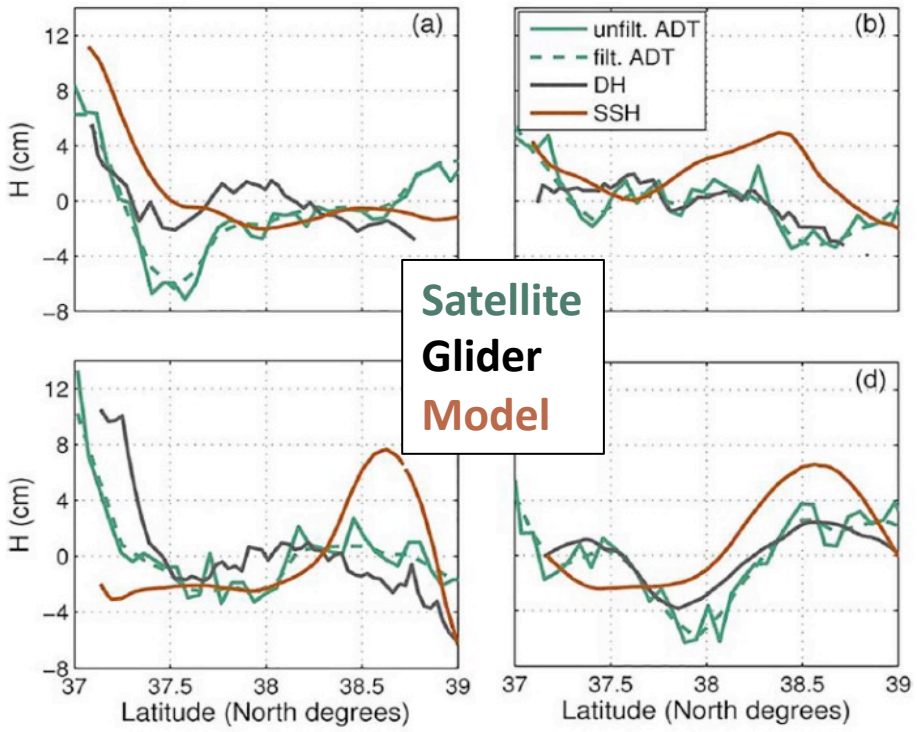


Description of a mesoscale eddie

https://doi.org/10.1016/j.jmarsys.2015.12.004



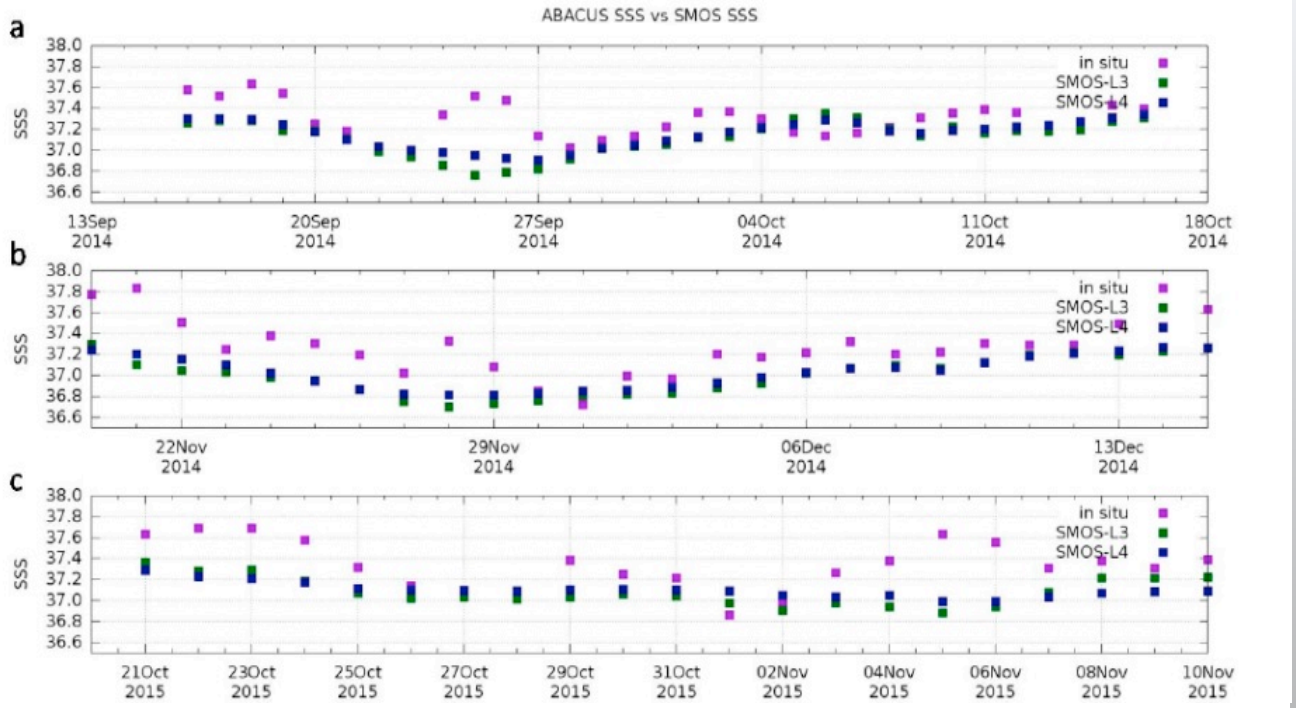
Satellite altimetry comparison



Filtered (dashed green line) and unfiltered (solid green line) absolute dynamic topography from altimetry; dynamic height (gray line) along SARAL/AltiKa groundtracks 773 (upper panels) and 229 (lower panels) associated with the passage of the satellite south of the Balearic islands of (a) 17 September 2014; (b) 26 November 2014; (c) 12 December 2014 and (d) 23 October 2015 computed from the glider data; and SSH (brown line) along the four tracks obtained from the MFS numerical model. Units in cm. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Aulicino et al., JMS. 2018

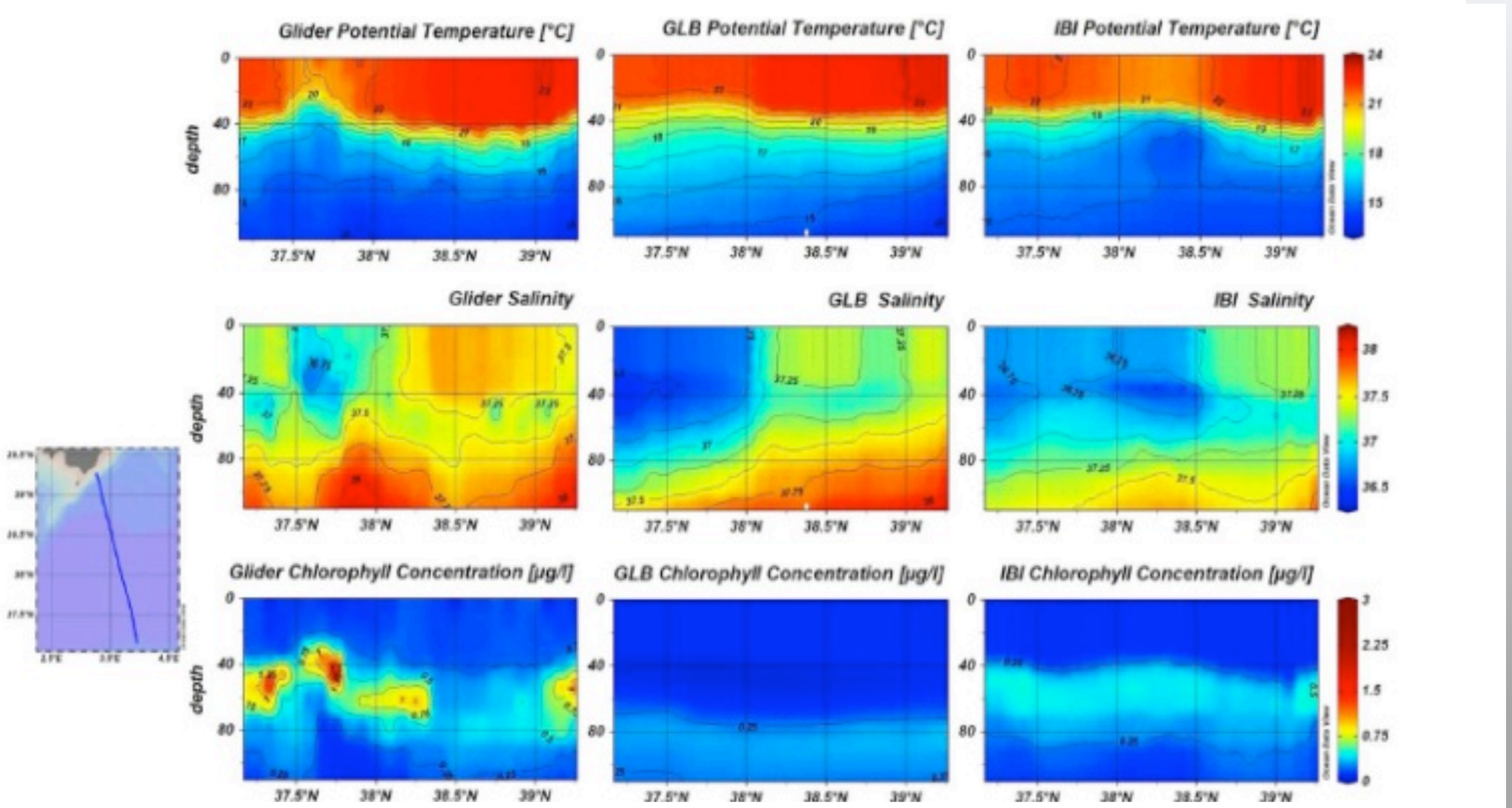
Satellite surface salinity comparison



Comparison between averaged in situ glider salinities (purple dots) and SMOS L3 (green dots) and L4 (blue dots) SSS during the missions (a) ABACUS 1.1 (Sept–Oct 2014), (b) ABACUS 1.2 (Nov–Dec 2014), (c) ABACUS 2.1 (Oct–Nov 2015), (d) ABACUS 2.2 (Nov–Dec 2015), (e) ABACUS 3.1 (Nov 2016), and (f) ABACUS 3.2 (Dec 2016).

Aulicino et al., Remote Sens. 2019

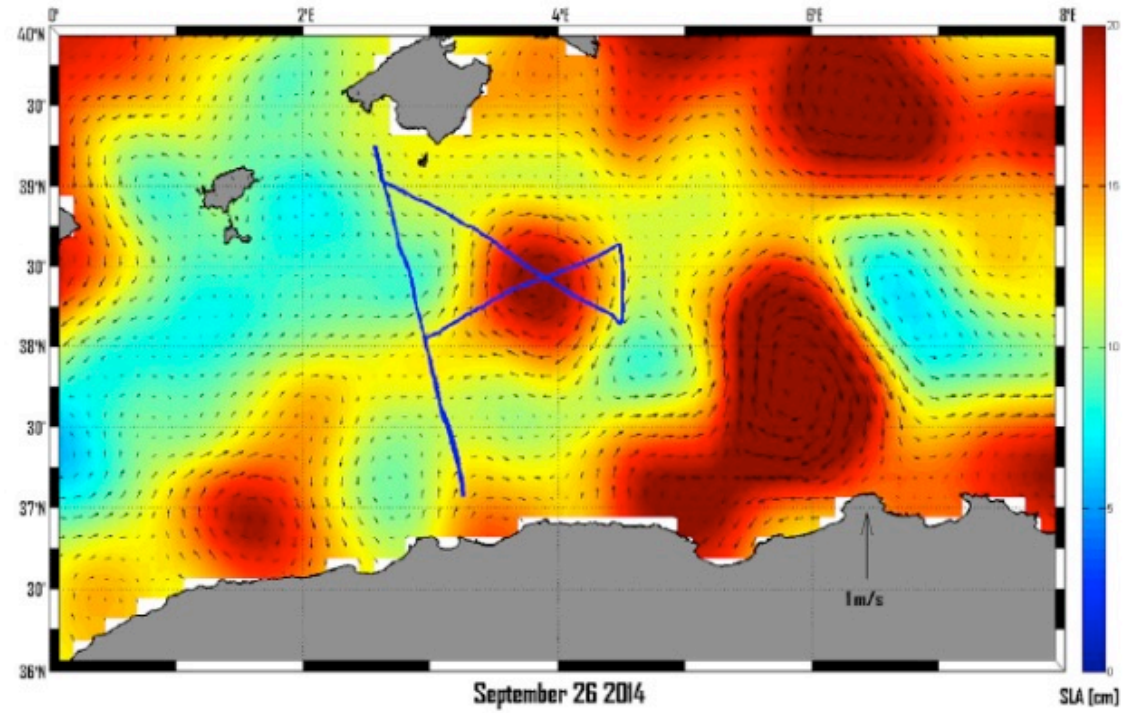
Numerical model comparison



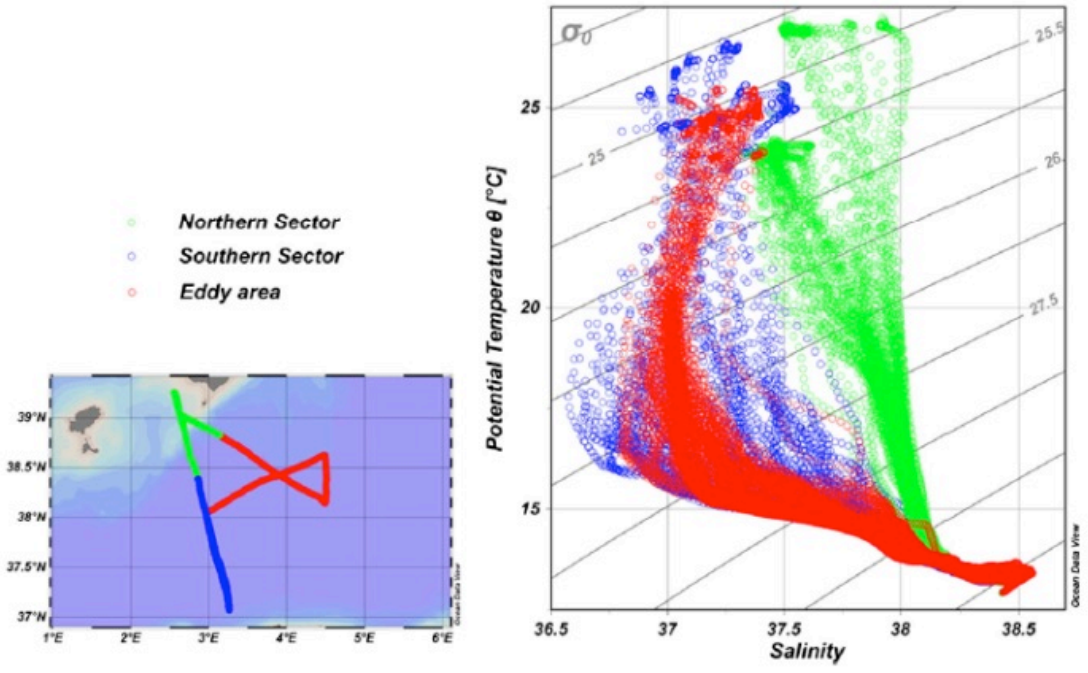
. Glider high resolution observations (left), GLB (middle) and IBI (right) simulations of (from top to bottom) potential temperature, salinity, chlorophyll concentration, and potential density anomaly derivative in the first 110 m of the water column during the ABACUS-2 survey (19–30 October 2015). The location of the analysed water column profiles is represented through blue dots in the left panel.

Aulicino et al., Ecol Model. 2021

Mesoscale Anticyclonic eddie description



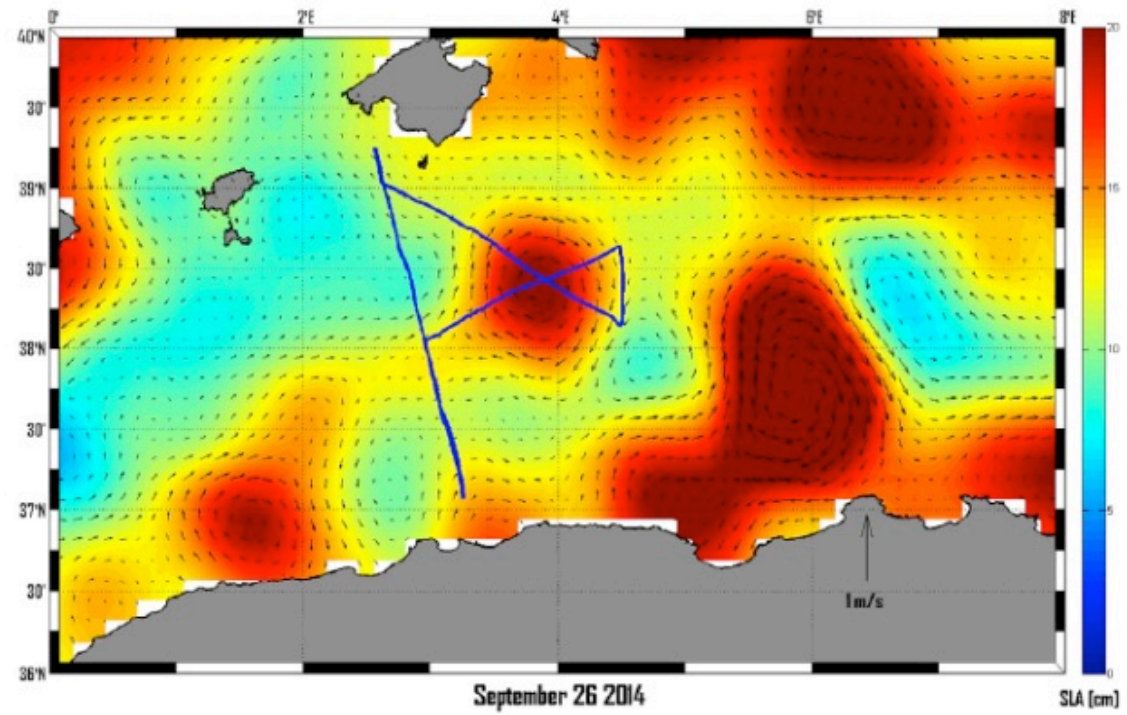
Sea level anomaly map (color scale) and associated geostrophic velocity anomalies (black arrows) from AVISO data on 26 September 2014. Blue line shows the glider track from 15 September to 20 October 2014.



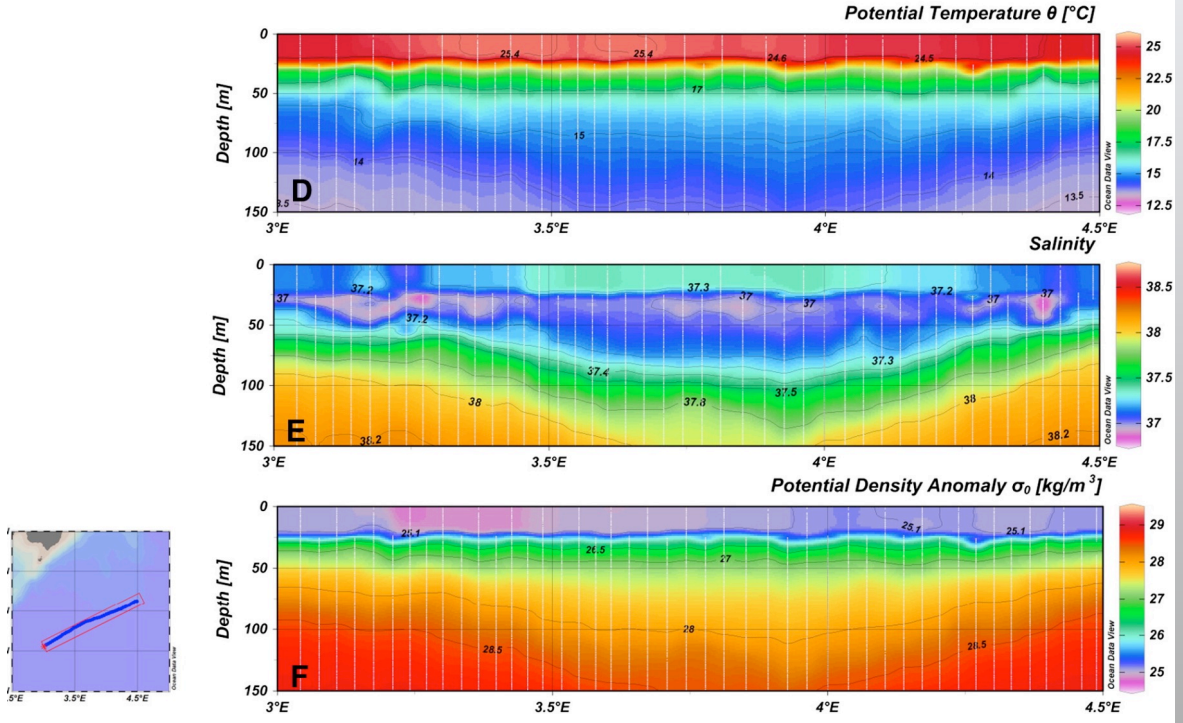
Potential temperature/salinity diagram (θ/S) for the entire glider mission. Blue and green circles identify data from the southern and northern sectors of the track respectively. Data associated with the eddy area are represented by red dots.

(Cotroneo et al., JMS 2016)

Mesoscale Anticyclonic eddie description



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.

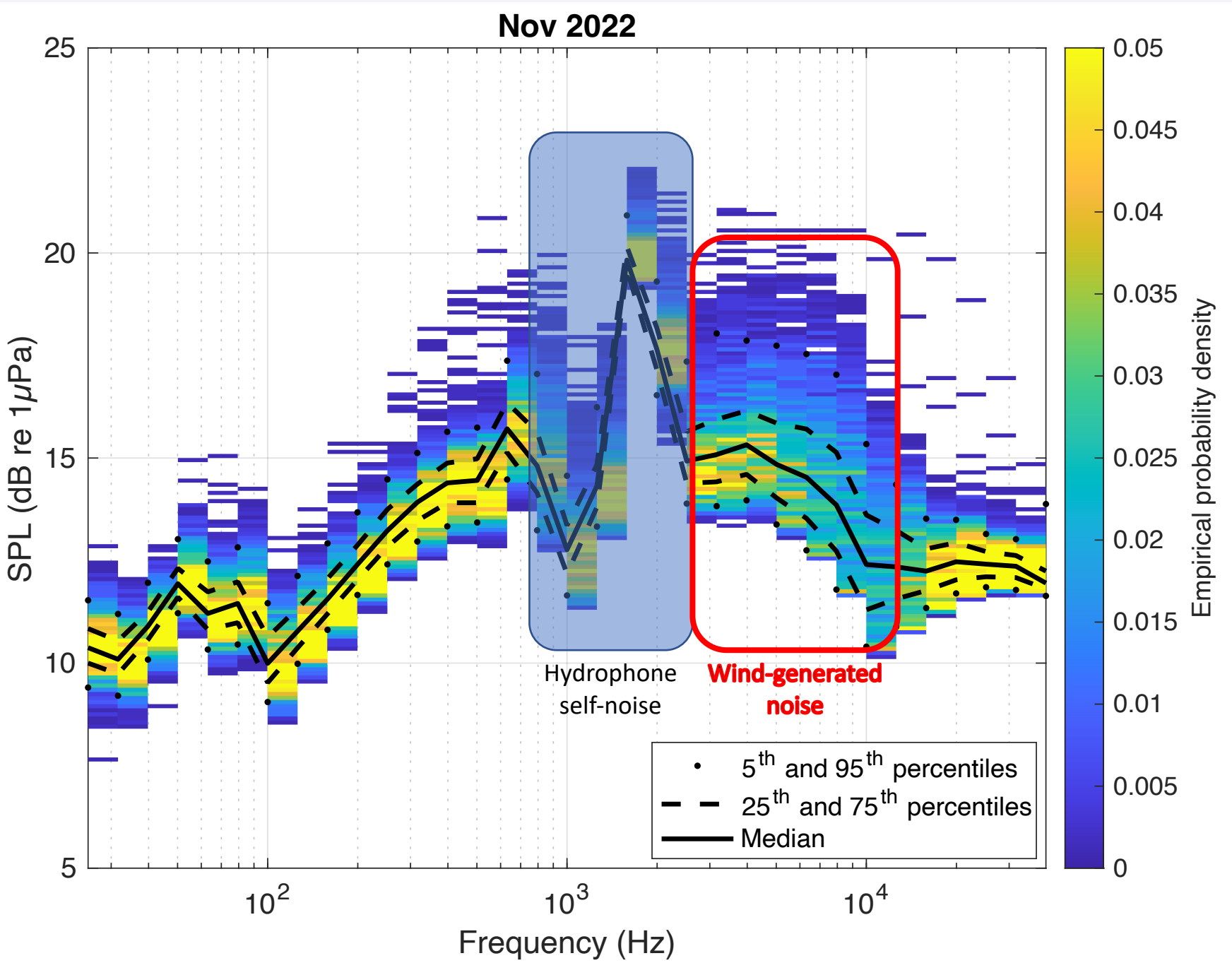


Sections from surface to 800 m depth of potential temperature θ (a), salinity (b) and potential density anomaly σ_0 (c) along the SW/NE axis of the eddy. The first 150 m of the water column for θ (d), salinity (e) and σ0 (f) are also shown.

(Cotroneo et al., JMS 2016)

Since ABACUS 2021 the glider has been equipped with an external hydrophone

We aimed at observing meteorological events co-located with the oceanographic measurements (wind and rain) as well as monitoring the distribution of marine mammals' populations along the track of the glider.

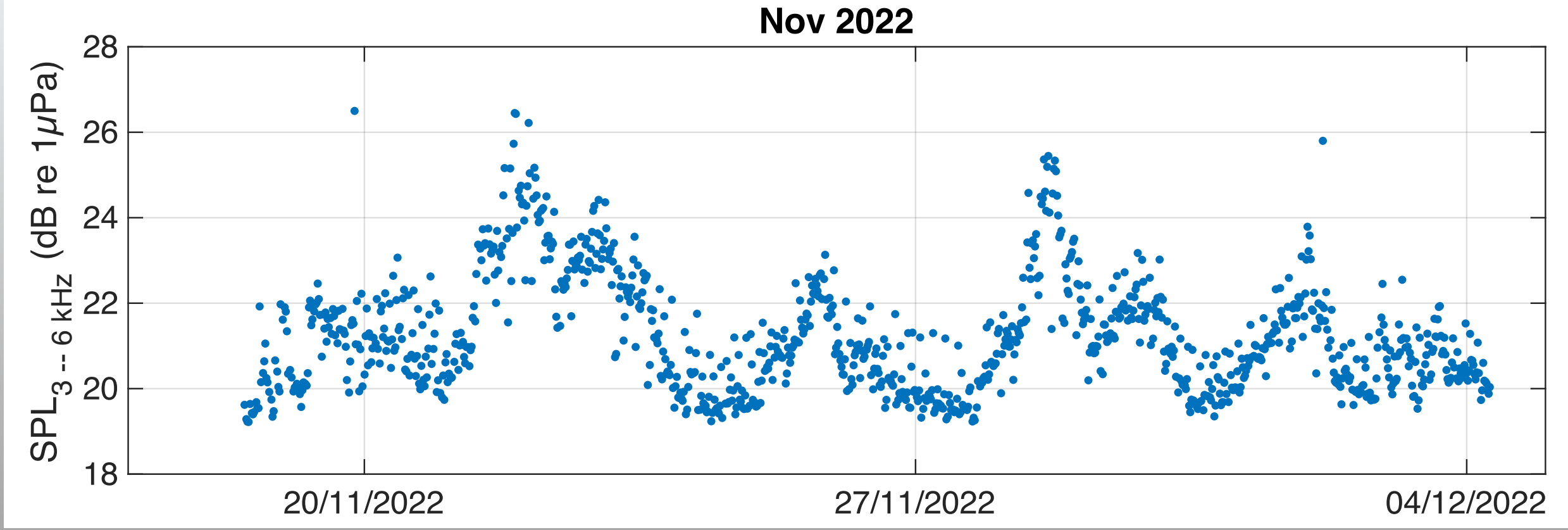


Observed sound level throughout the deployment.

The red box (3 to 10 kHz) shows the frequency bands where wind-generated noise dominates the soundscape.

The sound level distribution is more widespread, due to the variability of wind speed observed.

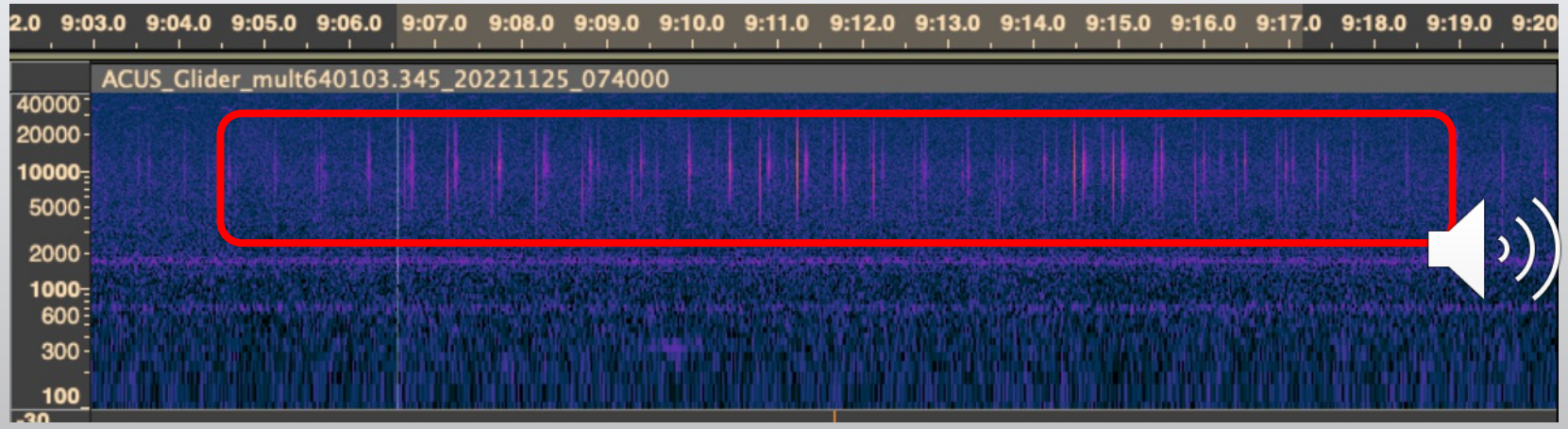
Meteorological events co-located with the oceanographic measurements



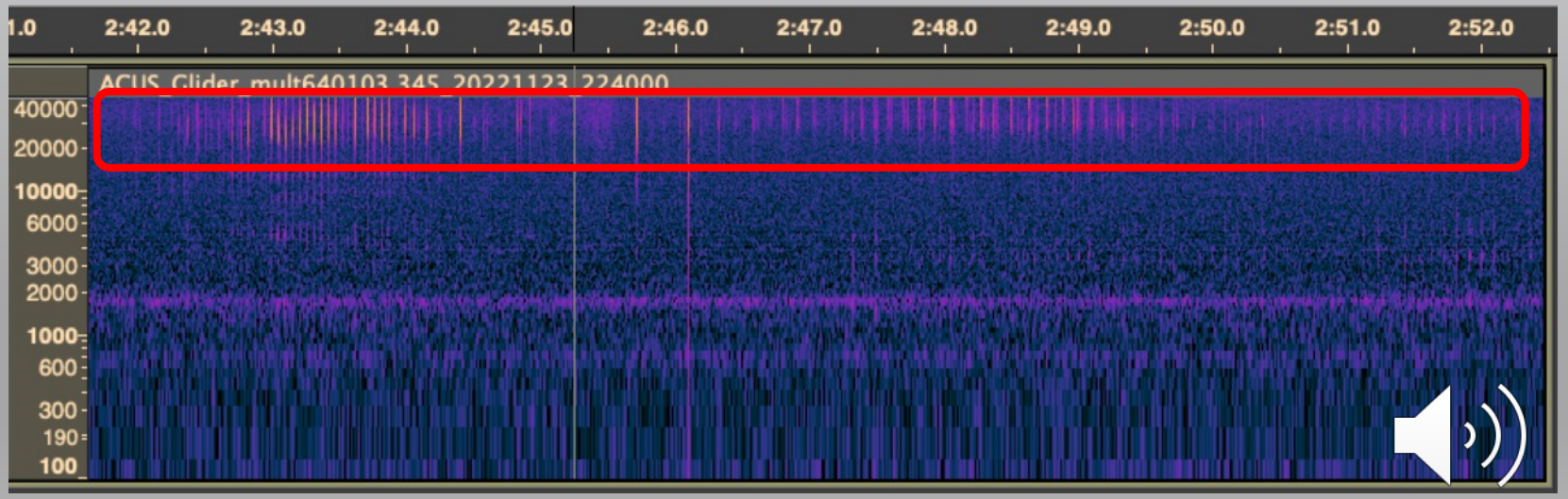
Wind noise is a proxy for surface wind speed, spatial scale is 1-4 km radius.

Can help detecting exact start/end time of a wind event at the glider location.

Marine mammals



Sperm whale echolocation sounds
Very regular trains of clicks
~ 10 kHz, 2 clicks/s



Dolphin echolocation clicks
Rapid and variable click patterns
~ 30 kHz, 10 – 20 clicks/s

Final Remarks

Supporting glider data collection with satellite data and surface autonomous vehicles can be an outstanding strategy for implementing new observatories for marine science research.

ABACUS cruises contribute to the network of endurance lines monitoring both the short and long-term variability of the main physical and biochemical parameters of the Mediterranean Sea.

Future plans

- To confirm ABACUS missions for the next years
- To accurately compare ABACUS with ARGO data
- To study long term variability

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