

# EuroSea

## Assimilation of gliders in the Western Mediterranean

Ali Aydogdu<sup>1</sup> on behalf of EuroSea WP4 Task 4.1 and 4.2

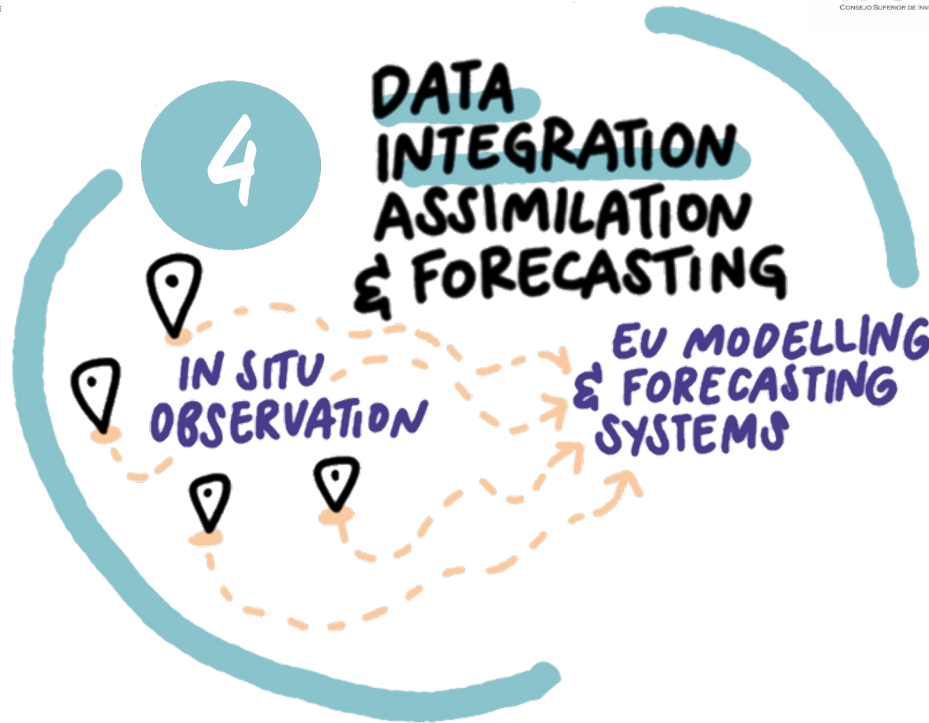
Elisabeth Remy<sup>2</sup>, Baptiste Mourre<sup>3</sup>, Romain Escudier<sup>2</sup>, Jaime Hernandez-Lasheras<sup>3</sup>,

Jenny Pistoia<sup>1</sup>, Alessandro Grandi<sup>1</sup>

# Data Integration, Assimilation & Forecasting



Puertos del Estado

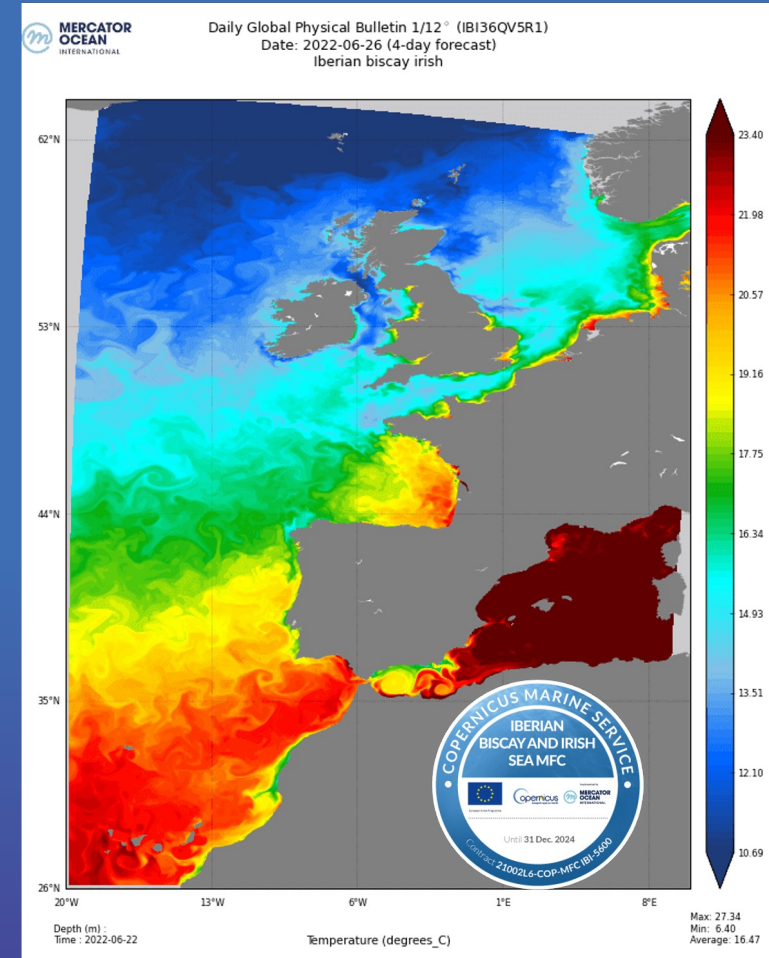


## Impact of glider and floats assimilation

Goal of the OSEs with the IBI system:

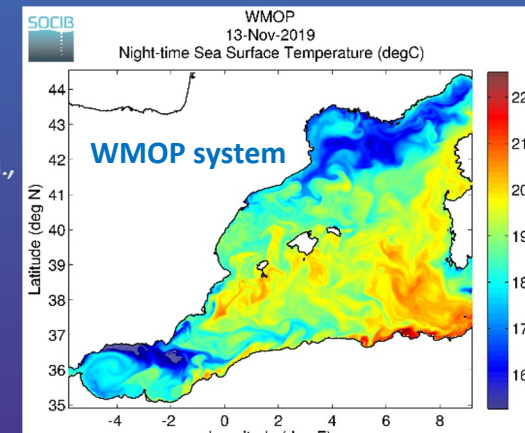
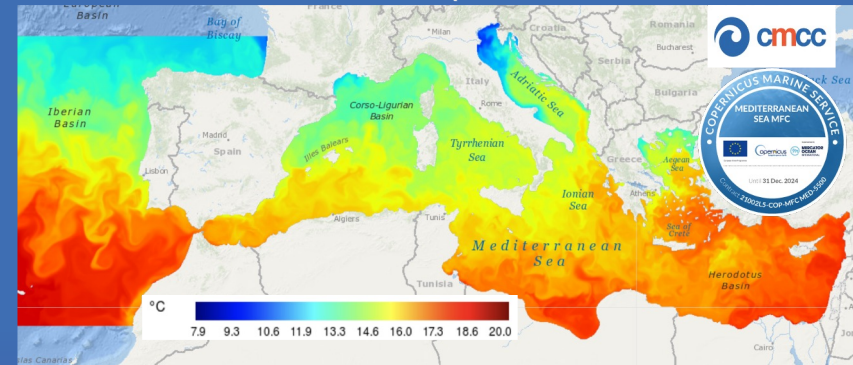
- ➔ Understand the impact of high frequency / high resolution glider observations on the IBI 1/36° regional analysis
- ➔ Improve the data assimilation strategy of HF/HR in situ profiles
- ➔ Assess the efficiency of gliders for routine monitoring of coastal environment. Focus on specific physical feature: transport through key section (Canary Islands), eddy reconstruction (Bay of Biscay).

In the Mediterranean sea, multi system experiments comparison for the 2017 OSEs

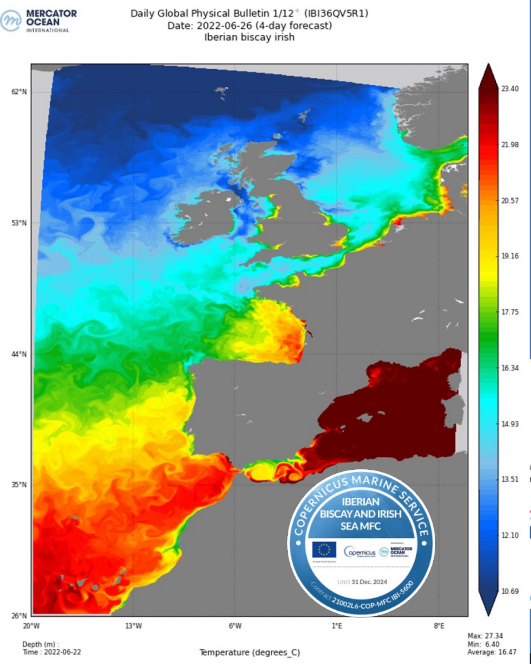


## Impact of glider and floats assimilation

- ➔ the future configurations of the CMEMS MED-PHY (*Clementi et al., 2021*) system
- ➔ coordinated experiments using the CMEMS Med-PHY and WMOP (*Juza et al., 2016, Mourre et al., 2018*) systems in the Western Mediterranean
- ➔ build knowledge in the use of BGC glider data
- ➔ evaluate the impact of the assimilation of glider T,S observations on the MED-MFC BIO (*Salon et al., 2019, Feudale et al., 2021*)
- ➔ BGC multiplatform and multivariate assimilation (*Teruzzi et al., 2021*)



# Some other contributions in the workshop using



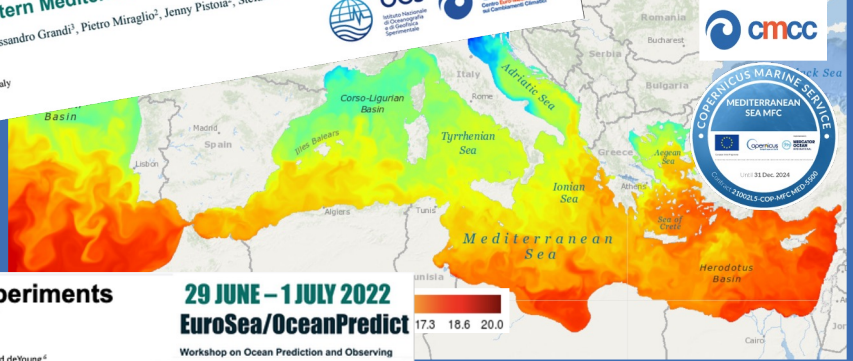
**Effectiveness of an operational forecasting system to predict anomalous 2022 water formation and intense bloom event in the southeastern Mediterranean Sea**

Anna Teruzzi<sup>1</sup>, Ali Aydogdu<sup>2</sup>, Carolina Amadio<sup>1</sup>, Gianpiero Cossarini<sup>1</sup>, Laura Feudale<sup>1</sup>, Alessandro Grandi<sup>1</sup>, Pietro Miraglio<sup>3</sup>, Jenny Pistoia<sup>2</sup>, Stefano Salon<sup>1</sup>

<sup>1</sup>National Institute of Applied Oceanography and Geophysics, Trieste, Italy  
<sup>2</sup>National Institute of Applied Oceanography and Geophysics, Trieste, Italy  
<sup>3</sup>Ocean Modeling and Data Assimilation Division, Centro Euro-Mediterraneo sui Cambiamenti Climatici, Lecce, Italy

29 JUNE – 1 JULY 2022  
**EuroSea/OceanPredict**  
 Workshop on Ocean Prediction and Observing

OGS, CMCC



**Leveraging the multi-system glider data assimilation experiments within EuroSea to the international level**

Victor Turpin<sup>1</sup>, Elisabeth Remy<sup>2</sup>, Ali Aydogdu<sup>3</sup>, Baptiste Mourre<sup>4</sup>, Romain Escudier<sup>5</sup>, Pierre Testor<sup>6</sup>, Jaime Hernández-Lasheras<sup>7</sup>, Nikos Zarokanellos<sup>8</sup>, Brad deYoung<sup>4</sup>

<sup>1</sup>OPS, World Meteorological Organization / Intergovernmental Oceanographic Commission, Brest, France, <sup>2</sup>Mercator Ocean International, Toulouse, France, <sup>3</sup>Ocean Modeling and Data Assimilation in, Centro Euro-Mediterraneo sui Cambiamenti Climatici, Bologna, Italy, <sup>4</sup>SOIB, Spain, <sup>5</sup>LOCEAN / CNRS, Sorbonne University, Paris, France, <sup>6</sup>Memorial University of Newfoundland, Halifax, Canada

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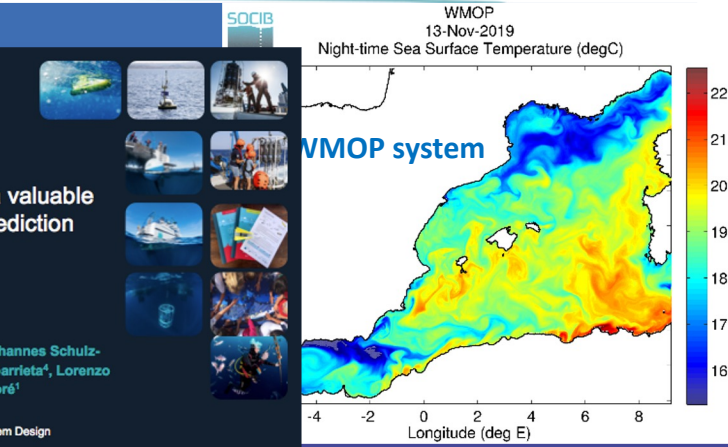
OceanPredict  
 Advancing the science of ocean prediction

EuroSea

**European high-frequency radars as a valuable asset to validate and improve ocean prediction in coastal areas**

Emma Reyes<sup>1</sup>, Baptiste Mourre<sup>1</sup>, Jaime Hernández-Lasheras<sup>1</sup>, Johannes Schulz-Stellenfieth<sup>2</sup>, Jochen Horstmann<sup>2</sup>, Pablo Lorente<sup>3</sup>, Lohitzune Solabarrieta<sup>4</sup>, Lorenzo Corgnati<sup>5</sup>, Anna Rubio<sup>4</sup>, Julien Mader<sup>4</sup>, Joaquín Tintoré<sup>1</sup>

EuroSea/OceanPredict Workshop - Ocean Prediction and Observing System Design  
 29 Jun 2022 - 1 Jul 2022, Met Office, Exeter (UK)

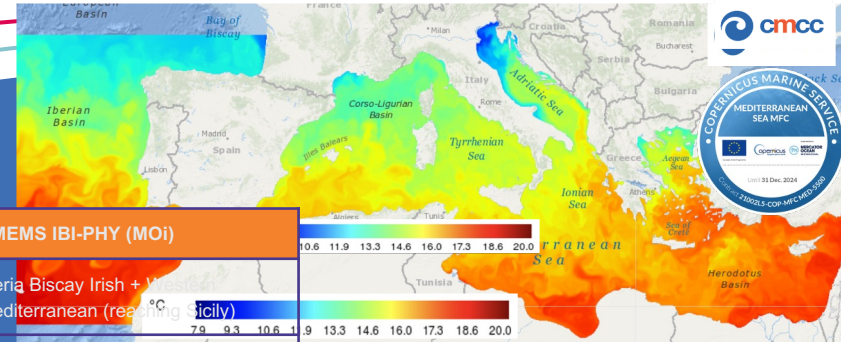


**The September 2020 Medcane Ianos predicted by the Copernicus Mediterranean Forecasting systems**

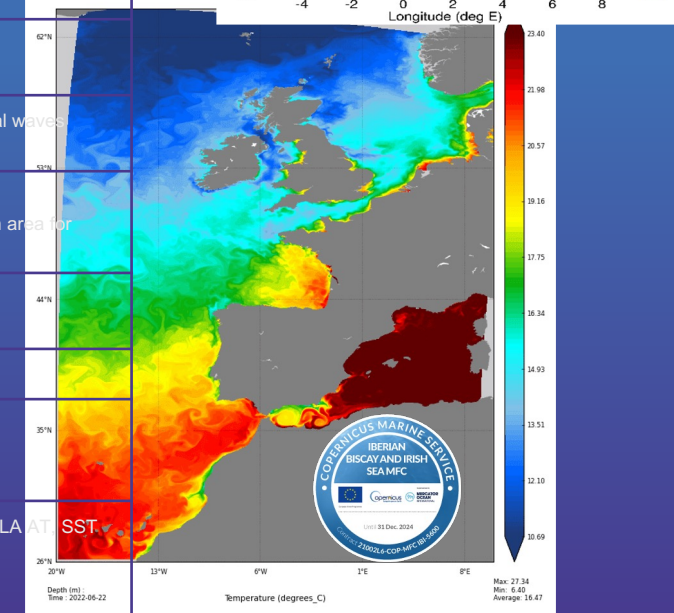
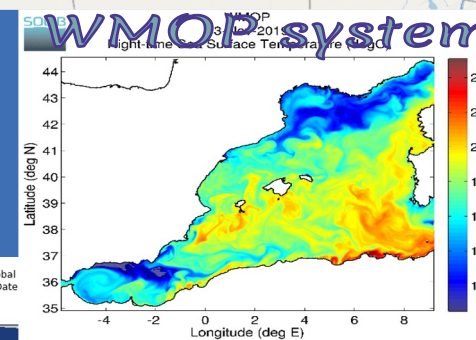
Emanuela Clementi(1), Gerasimos Korres(2), Gianpiero Cossarini(3), Michalis Ravdas(2), Ivan Federico(1), Anna Chiara Goglio(1), Stefano Salon (3), Anna Zacharioudaki(2), Matilde Pattanaro(3), Giovanni Coppini(1)

CMCC: Centro Euro-Mediterraneo sui Cambiamenti Climatici, Italy  
 HCMR: Hellenic Centre for Marine Research, Greece  
 OGS: National Institute of Oceanography and Applied Geophysics, Italy

# System descriptions

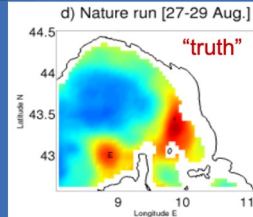
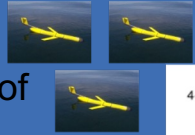


	CMEMS MED-PHY (CMCC)	WMOP (SOCIB)	CMEMS MED-BIO (OGS)	CMEMS IBI-PHY (MOI)
<b>Domain</b>	Mediterranean Sea (+ Atlantic box)	Western Med. Gibraltar to Corsica-Sardinia	Mediterranean Sea (+ Atlantic box)	Iberia Biscay Irish + Mediterranean (reaching Sicily)
<b>Resolution</b>	1/24° degree (~4.5km) 141 z* vertical levels	~1/50° degree (2km) 32 vertical sigma-levels	1/24° degree (~4.5km) 125 vertical levels	1/36° degree 50 z* vertical levels
<b>Numerical model</b>	NEMO v3.6 < - > WW3 v3.14	ROMS v3.4	MedBFM (OGSTM-BFM )	NEMO v4.2
<b>Time step</b>	120 sec (Barotropic step 2.4sec)	120 sec (Barotropic step 6sec)		150 sec (Barotropic step 5sec)
<b>Parameterizations</b>	Tides, atmospheric pressure	No tides, No atm. pressure	plankton functional types: 4 phytoplankton groups, 4 zooplankton groups, 1 bacteria group Describes the biogeochemical cycle of N, P, C, Si and O. It includes the carbonate system dynamics	Tides, atmospheric pressure
	climatological inputs from 39 rivers.	climatological inputs from 6 major rivers.	climatological inputs from 39 rivers.	33 rivers climatology
	Richardson number-dependent vertical diffusion	Generic model of two-equations GLS turbulent closure.		GLS k-epsilon - Internal waves parametrization
	Flather for barotropic currents and SSH. Orlanski for baroclinic currents	Flather for 2-D momentum. Chapman for surface elevation. Mixed radiation-nudging for 3-D.		Flather for barotropic Prescribed + relaxation area for baroclinic
<b>Atmospheric forcing</b>	ECMWF HR 10km, 6hr resolution	AEMET (Spanish meteo agency) HARMONIE 2.5km 1hr		ECMWF IFS (3h)
<b>Ocean forcing</b>			MED-MFC PHY	
<b>Lateral open boundary condition</b>	From CMEMS GLO-MFC NRT system	From CMEMS MED-MFC		CMEMS GLO-MFC
<b>Data Assimilation</b>	<b>OceanVar:</b> SLA along tracks, ARGO vertical T/S profiles	<b>EnOI:</b> SLA along-track, ARGO vertical T/S profiles, SST L4 satellite product, HF-Radar (Ibiza Channel)	<b>3DVarBio:</b> surface chlorophyll concentration from satellite observations	<b>SAM2 (SEEK Filter):</b> SLA, SST, L3s, ARGO profiles

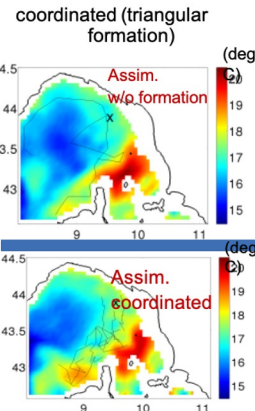


# Earlier studies of the task team and systems

Impact of data assimilation of glider observations in the Ionian Sea



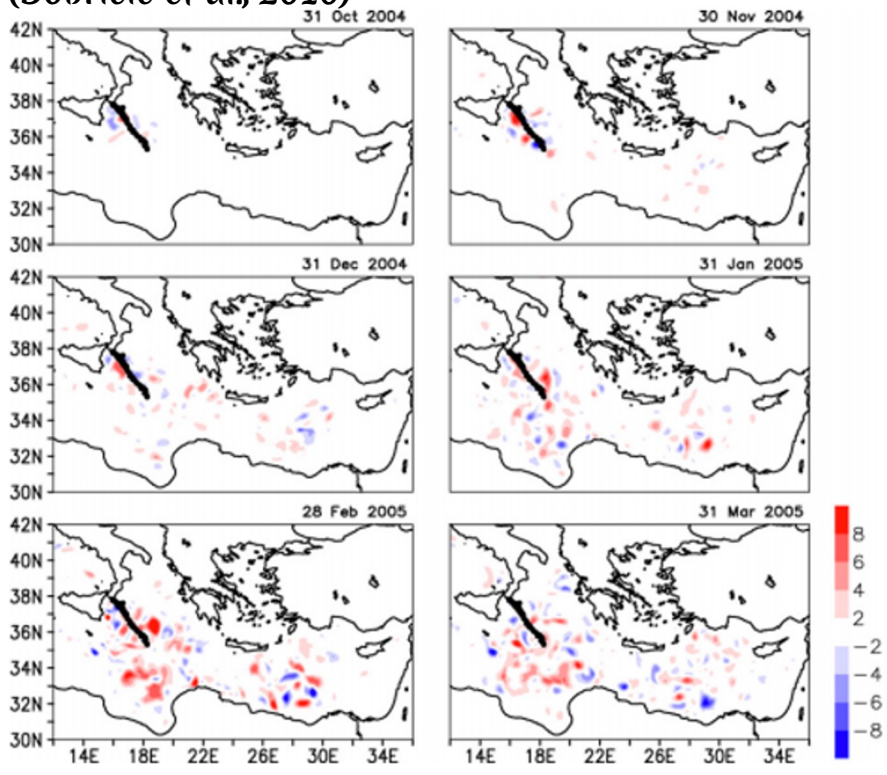
without formation



(Alvarez and Mourre, 2014)

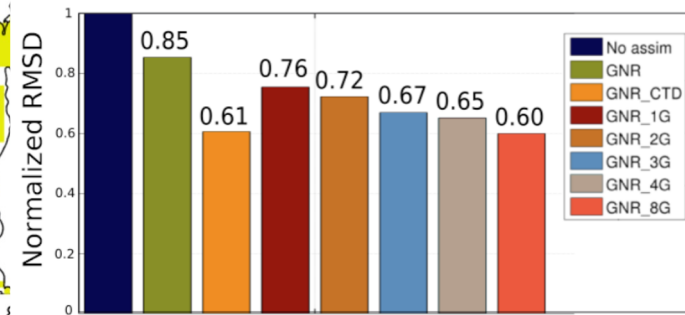
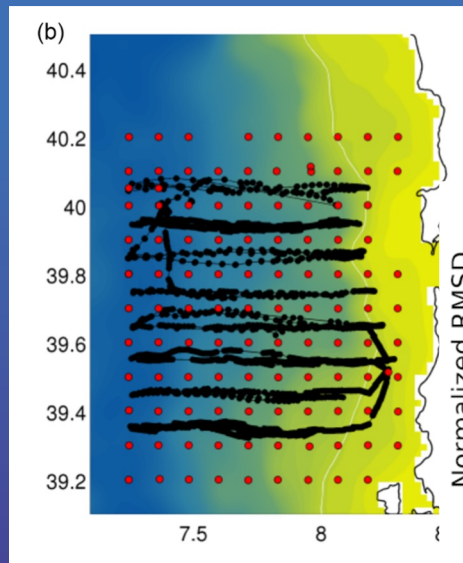
Cooperation or coordination of underwater glider networks? An assessment from Observing System Simulation Experiments in the Ligurian Sea

(Dobricic et al., 2010)



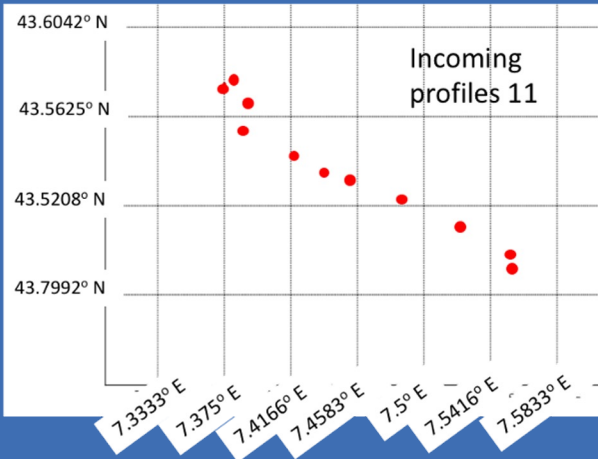
Dense CTD survey versus glider fleet sampling

(Hernandez-Lasheras and Mourre, 2018)



# Data preparation and preprocessing

## BEFORE SUB-SAMPLING



## AFTER SUB-SAMPLING

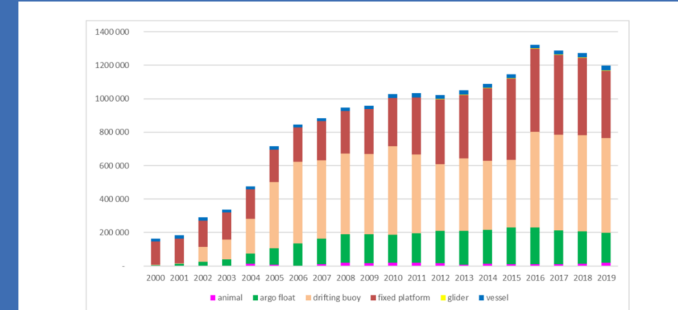
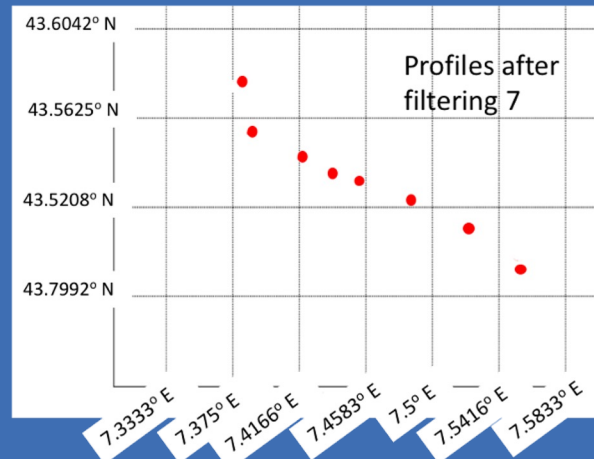
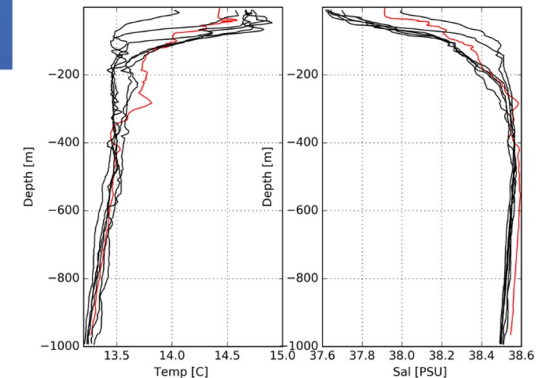
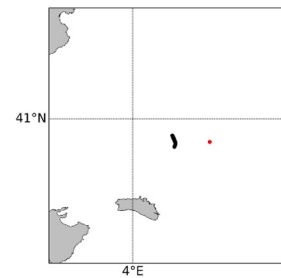
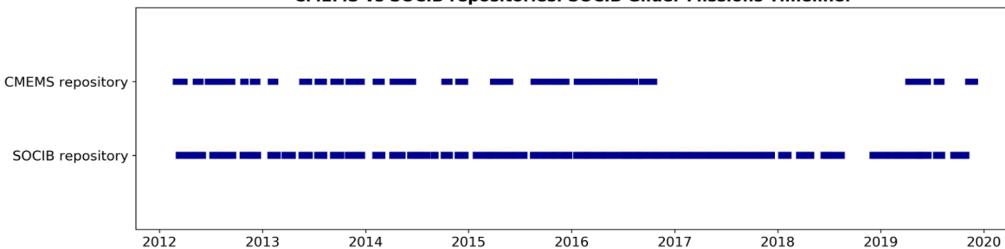


Figure IV.1.3: T&S observations per platform-day, one platform – one day – one or many observations = +1. Years 2000 – 2019.

### Managing the high-resolution profiles from gliders in the DA systems

- Subsampling? vs Superobbing?
- Vertical? vs Horizontal?
- Consistency in T,S? too different?

CMEMS vs SOCIB repositories. SOCIB Glider Missions Timeline.





# Workshop with observation scientists/providers

- ➡ the *best practices* in use of glider and floats in-situ observations by operational forecasting systems
- ➡ On the *accessibility* to the glider / Argo floats observations in NRT and DT mode.
- ➡ On the *quality control* (QC) in the assimilation systems



## Internal Milestone #28

*Joint workshop between CMCC SOCIB Task 4.2, Task 4.3, Task 4.4 partners and WP3 on sharing best practices on how to use novel sensors (glider, floats) data for assimilation and validation in the CMEMS (global and MED) and SOCIB operational systems (physical and biogeochemical)*

**Date:** 24 June 2021 10:00-12:00 CET

**Goal:** EuroSea Task 4.2 aims at evaluating the impact of the glider and BGC Argo observations on marine forecasting systems in the Mediterranean Sea. The question of where and how to access the data in both near-real-time (NRT) and delayed-time (DT) is critical for this task. Several issues have been identified concerning the glider data availability, especially for NRT systems. The objective of this workshop is to bring together European experts on glider data collection, processing and management with the data assimilation experts to open a discussion on this issues and propose solutions to use glider and float observations in operational forecasting systems in the best possible way.

### AGENDA

**10:00-10:15** Objectives and overview of the status (Ali Aydogdu)

**10:15-10:25** Update on SOCIB experience (Jaime Hernandez)

**10:25-10:35** NRT and delayed mode data exchange strategy and further opportunities  
(Victor Turpin / Daniel Hayes)

**10:35-10:45** The status of glider observations in the CMEMS (Thierry Carval)

**10:45-12:00** Discussion

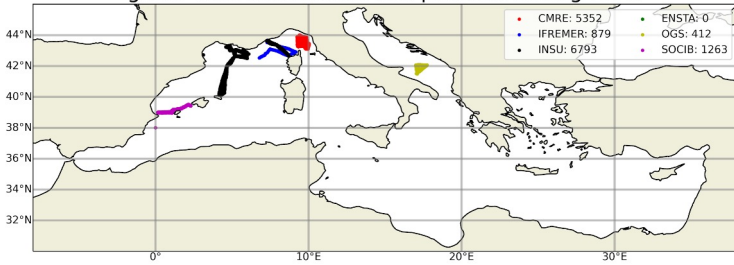
## Best practices on how to use novel sensors (gliders and floats) for assimilation and validation

### A need...

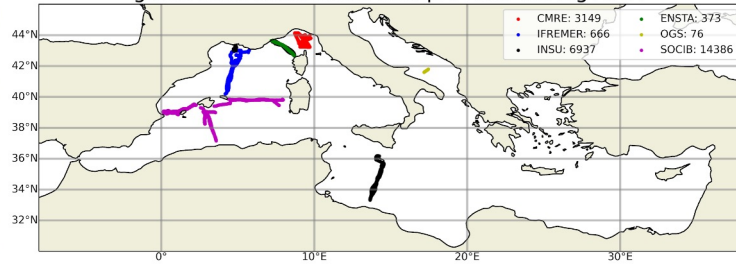
- for *more time* to assimilate the high-quality glider and BGC-Argo observations in the NRT systems however, DM observations are already high-quality and synchronized to the required repositories.
- to come up with a *universal solution*. CMEMS (European) and SOCIB (Balearic) systems involved in EuroSea can be taken as a base to detect the need for improvements and propose solutions for every step of the data flow and usage.
- for *communication* between the communities, e.g., Argo vs. Glider communities to converge on coherent procedure and avoid inconsistencies, Argo + Glider vs. modelling + assimilation communities for the best practices on the use of observations in forecasting and reanalysis systems, e.g., on QC standards.

# Observational Datasets

glider data distribution and provider during 2016

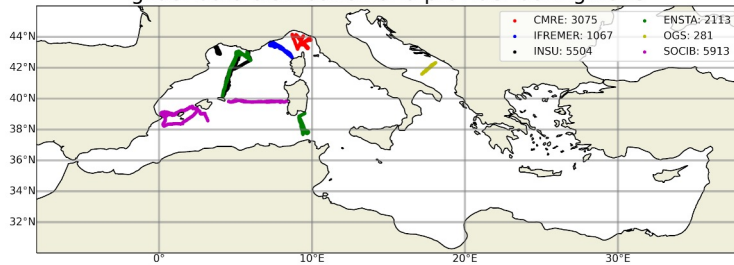


glider data distribution and provider during 2017



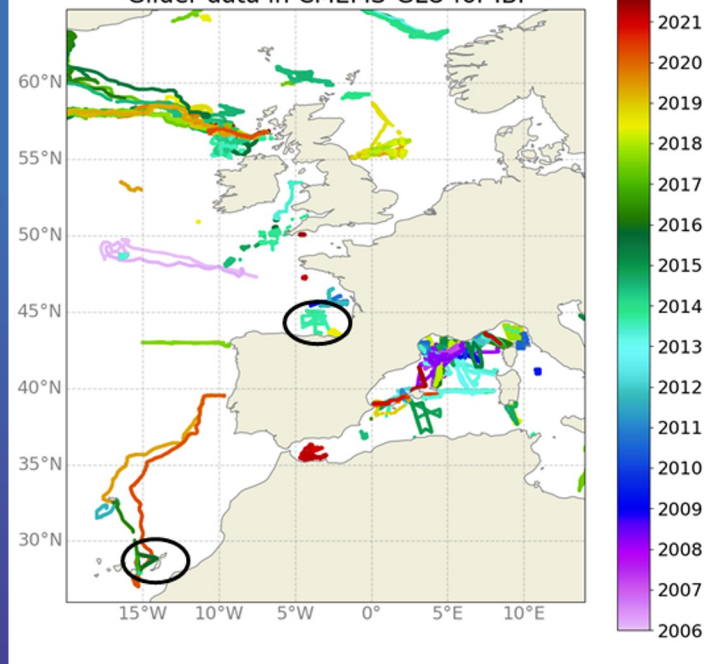
← Observations in the MEDSEA

glider data distribution and provider during 2018



Observations in the IBI domain →

Glider data in CMEMS-GLO for IBI



	SOCIB	OGS	IFREMER	INSU	ENSTA	CMRE	Total
<b>2016</b>	1263	412	879	6793	0	5352	14699
<b>2017</b>	14386	76	666	6937	373	3149	25587
<b>2018</b>	5913	281	1067	5504	2113	3075	17953

# Assimilation in the Mediterranean Sea

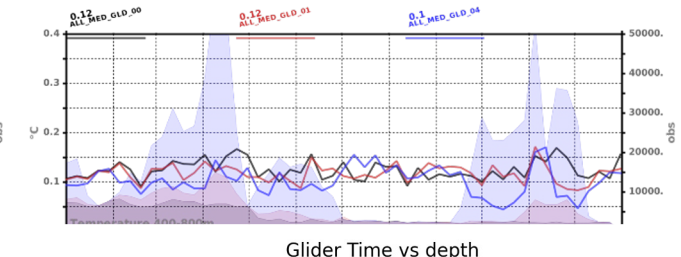
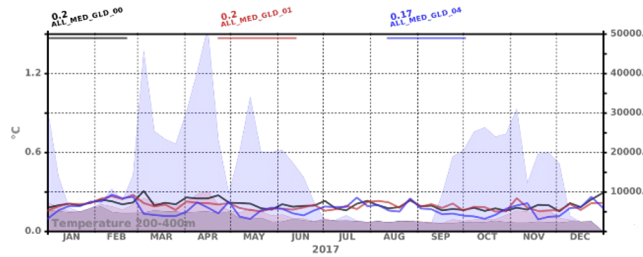
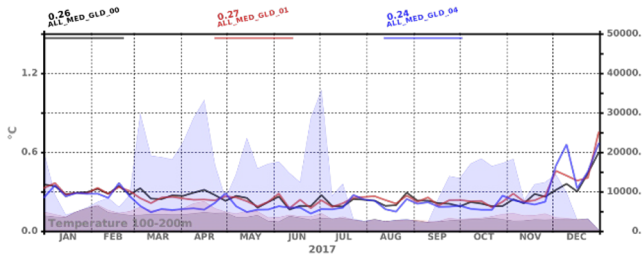
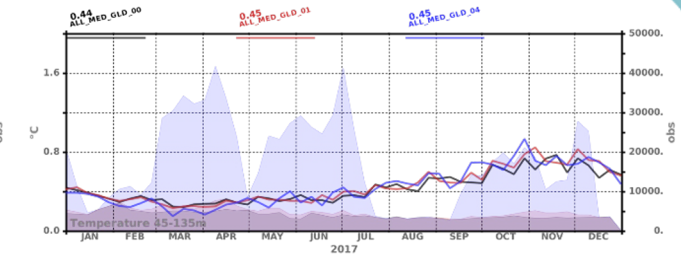
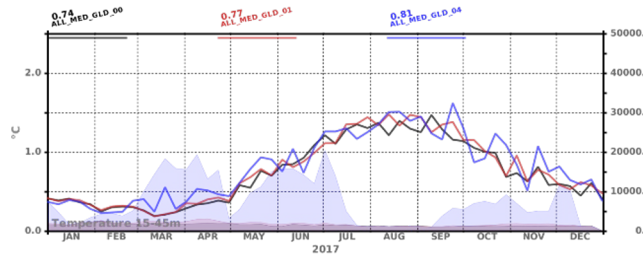
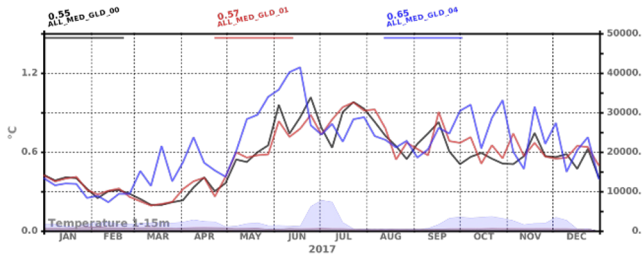
Name	Glider	Subsampling scheme	Status
ALL_MED_GLD_00	✗	----	✓
ALL_MED_GLD_01	✓	last profile of the day for each mission	✓
ALL_MED_GLD_02	✓	Subsampling according the position to have only one profile for grid point	✓
ALL_MED_GLD_03	✓	Superobs (spatial/time average of profiles)	✓
ALL_MED_GLD_04	✓	no subsampling, only ascending profile	✓

# Assimilation in the Mediterranean Sea

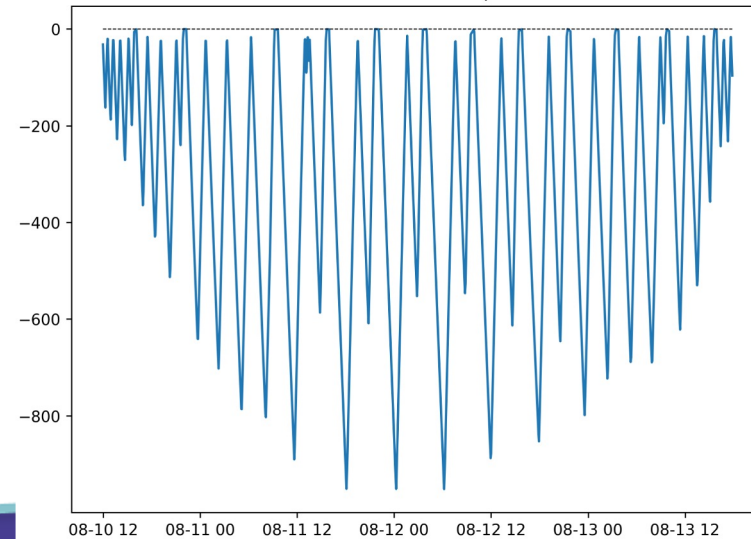
**no glider**

**1 ascending profile**

**all ascending profiles**

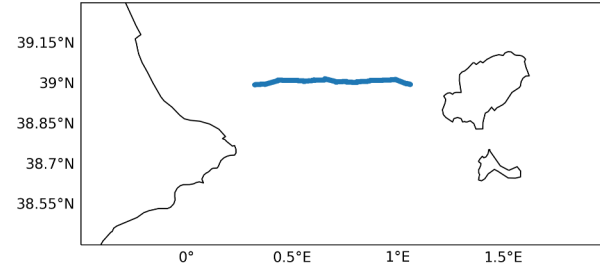


Glider Time vs depth

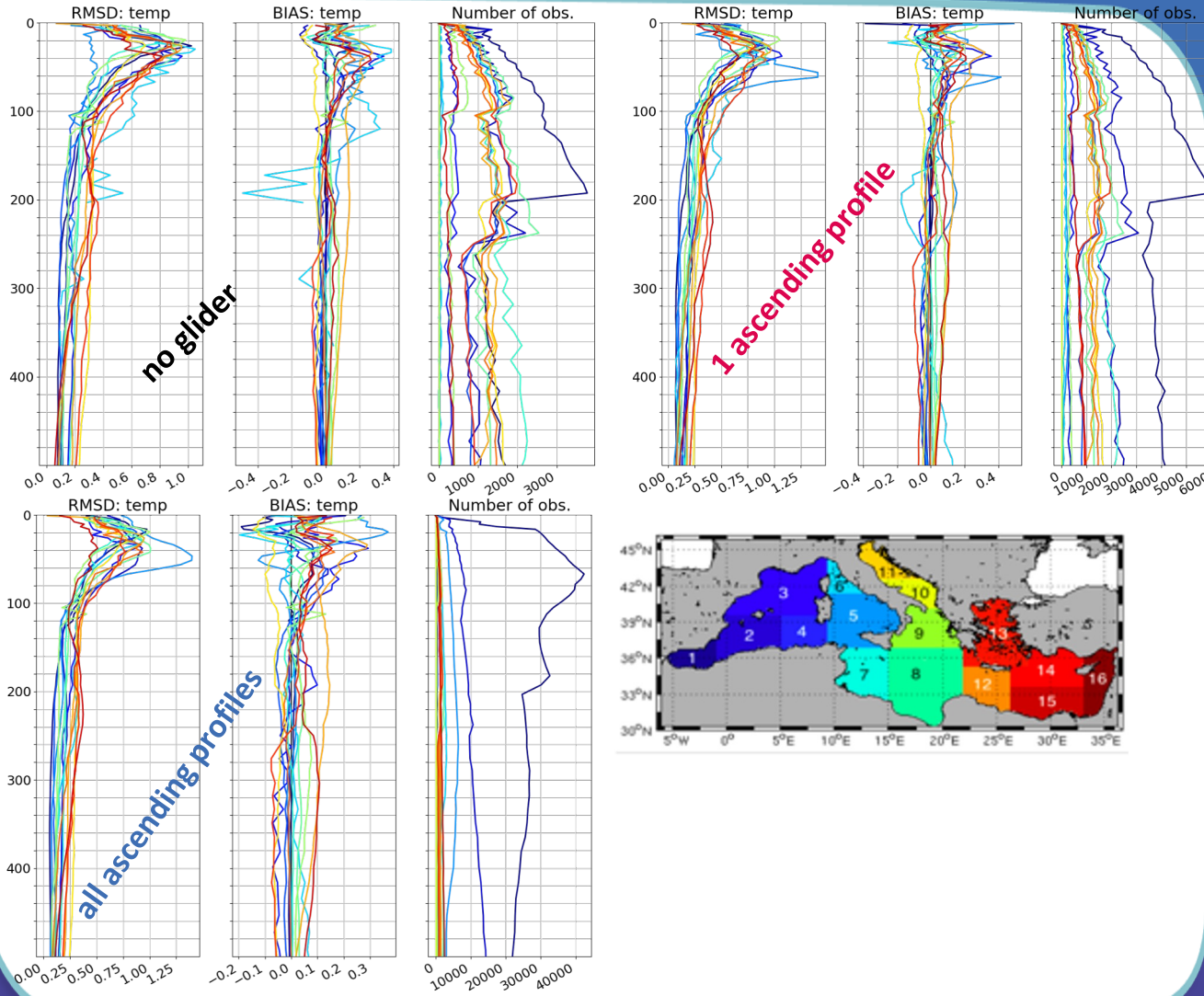


- ➔ Significant increase in the number of observations
- ➔ Improvement in the deeper layers while a degrading at the surface layers
- ➔ Perform experiments with only surfacing profiles

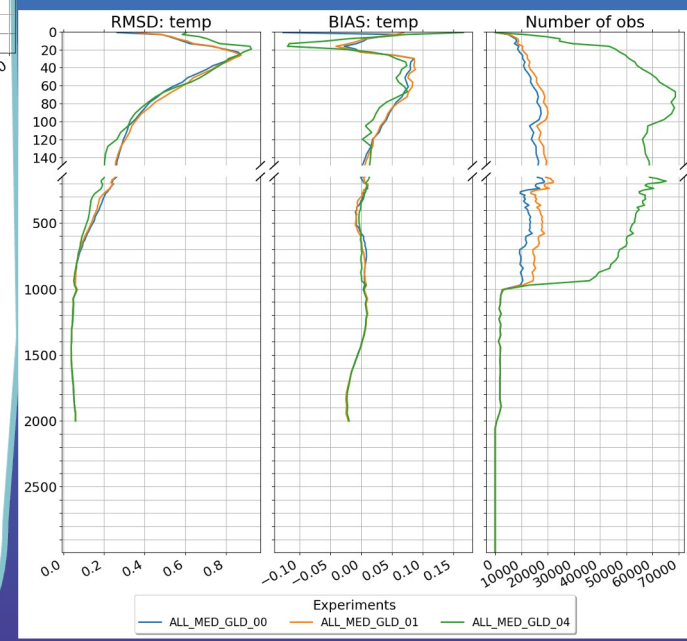
SOCIB sdeep04 Glider trajectory 20170810 - 20170813



# Assimilation in the Mediterranean Sea



**RMSD of temperature in the whole basin**



# Assimilation in the Western Mediterranean Sea

## WMOP. Experiments

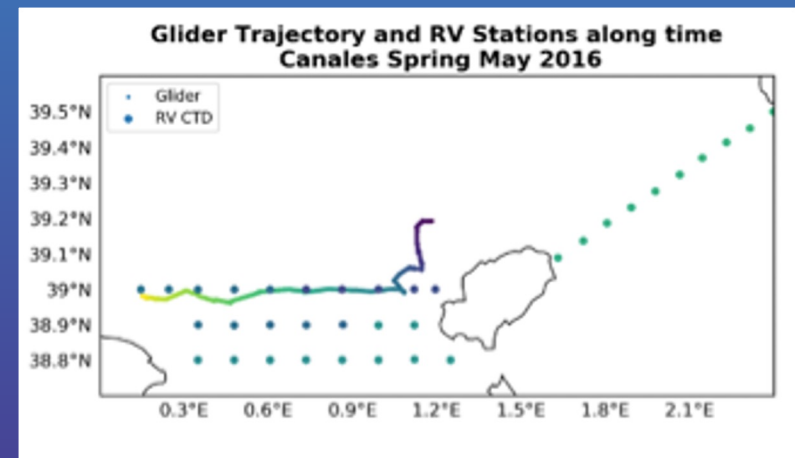
- 3 Simulations
- 1 year reanalysis, 2017 (+1 month spin-up)
- 3 day assimilation cycle
- Multimodel local EnOI, with nudging initialization step after analysis

**noGLIDERS**  
(SLA + SST + Argo T-S + HFR)

**GLIDERS**  
(SLA + SST + Argo T-S + HFR  
**Gliders**)

**NO ASSIM**  
(Free run)

- CTD data from RV campaign to be used for independent validation.
- Seasonal campaigns in the Ibiza Channel.

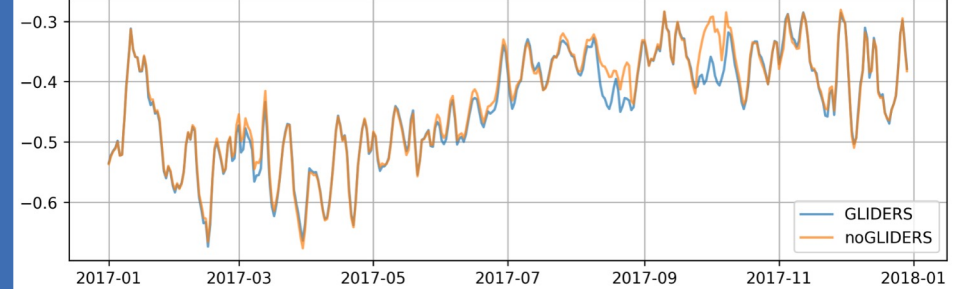


# Assimilation in the Western Mediterranean Sea

## WMOP. First Results

- First analysis show a good agreement between simulations assimilating data, without any anomalous impact of glider observations.
- More comprehensive evaluation in progress

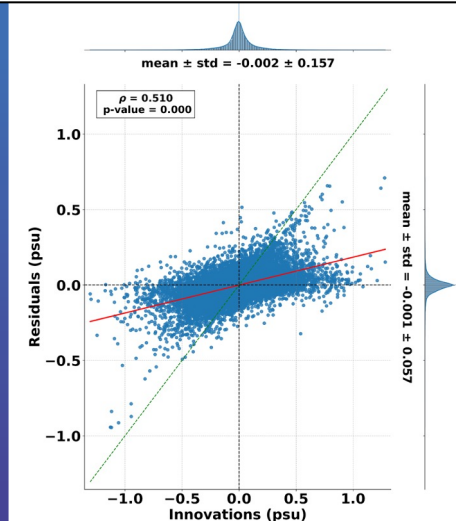
### SSH evolution during Reanalysis Simulation



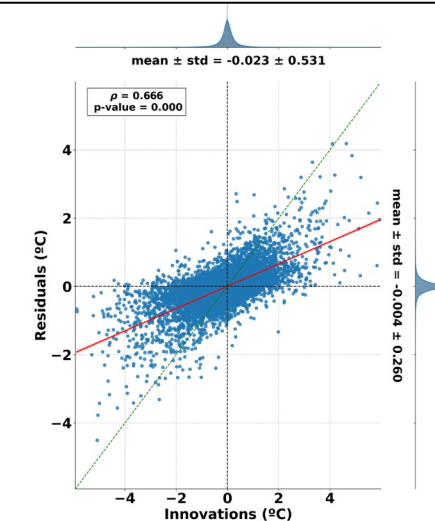
### SST evolution during Reanalysis Simulation



### Innovations vs Residuals Argo Temp (all period). Gliders exp



### Innovations vs Residuals Argo Sal (all period). Gliders exp

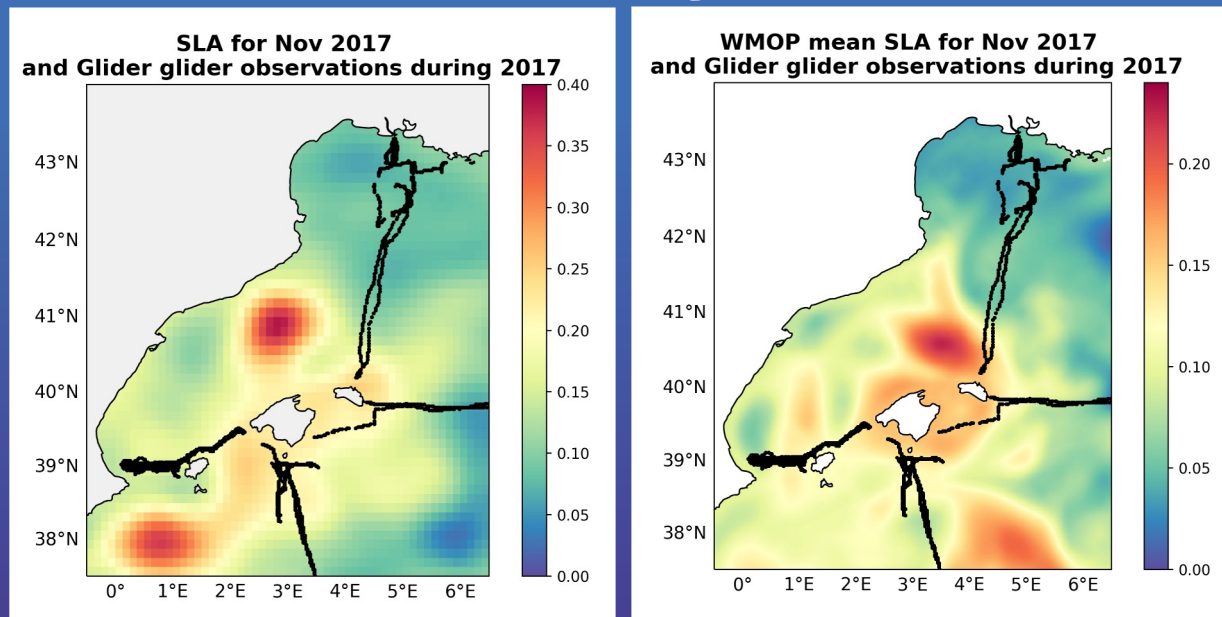


- The DA analysis is systematically closer to observations (for all observing sources, in both simulations), improving the forecast:

**Residuals (analysis - obs) << Innovations (background - obs)**

# Further steps

- ➔ Intercomparison in the Western Mediterranean common domain in the MED-MFC IBI-MFC and WMOP systems
- ➔ Statistical improvement will be assessed in the individual systems, some glider data can be left aside for completely independent validation
- ➔ Evaluation of the ability of glider DA to correct mesoscale structures (fronts, eddies) e.g., intense anticyclonic eddy in the Balearic Sea (Aguiar et al. 2019; OSR3, Aguiar et al. 2022, JGR-Oceans)





# Engagement with OceanGliders community

OceanGlidersCommunity / data\_assimilation\_practices Public

[Code](#)
[Issues](#)
[Pull requests](#)
[Actions](#)
[Projects](#)
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[Insights](#)
[Settings](#)

[main](#)
[1 branch](#)
[0 tags](#)
[Go to file](#)
[Add file](#)
[Code](#)

Commit	Message	Time
soerenthomsen	Update README.md	ce5c437 8 minutes ago 12 commits
DYNAT-D-09-00020-3.pdf	early glider data assimilation experiment	1 hour ago
README.md	Update README.md	8 minutes ago
key_literature.md	Update key_literature.md	44 minutes ago

**README.md**

## Data Assimilation Practices

In this repo we collect literature and approaches on glider assimilation practices. Please feel free to add literature or reports on this topics.

Read key literature [here](#)

You have [issues](#) with glider data assimilation?

### Short term goals

- collect glider data assimilation practices
- reports and papers
- share lessons learns

### Mid- and longterm goals

- develop best practices and Standard Operating Procedures (SOPs)
- harmonize approaches

**About**

In this repo we collect literature and approaches on glider data assimilation practices.

[Readme](#)  
 0 stars  
 1 watching  
 0 forks

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**Contributors** 3

- [soerenthomsen](#) Sören Thomsen
- [aydogduali](#) Ali Aydogdu
- [ptestor](#) Pierre Testor

Members of OceanPredict community are welcome to contribute to the effort!

# Task 4.{1,2} Assimilation in the Mediterranean and IBI Seas

## Analysis/forecast quality assessment

- Clementi E., Aydogdu A., Goglio A. C., Pistoia J., Escudier R., Drudi M., Grandi A., Mariani A., Lyubartsev V., Lecci R., Cretí S., Coppini G., Masina S., & Pinardi N. (2021). Mediterranean Sea Physical Analysis and Forecast (CMEMS MED-Currents, EAS6 system) (Version 1) [Data set]. Copernicus Monitoring Environment Marine Service (CMEMS), [https://doi.org/10.25423/CMCC/MEDSEA\\_ANALYSISFORECAST\\_PHY\\_006\\_013\\_EAS6](https://doi.org/10.25423/CMCC/MEDSEA_ANALYSISFORECAST_PHY_006_013_EAS6)
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