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Centro Euro-Mediterraneo
sui Cambiamenti Climatici

Mediterranean Sea Analysis and Forecasting System (MedFS)

Recent data assimilation developments

Ali Aydogdu, Jenny Pistoia, Pietro Miraglio, Andrea Cipollone, Alessandro Grandi, Massimiliano Drudi, Paolo Oddo, Emanuela Clementi, Simona Masina, and Nadia Pinardi

9-11 May 2023 - OceanPredict DA-TT Rome

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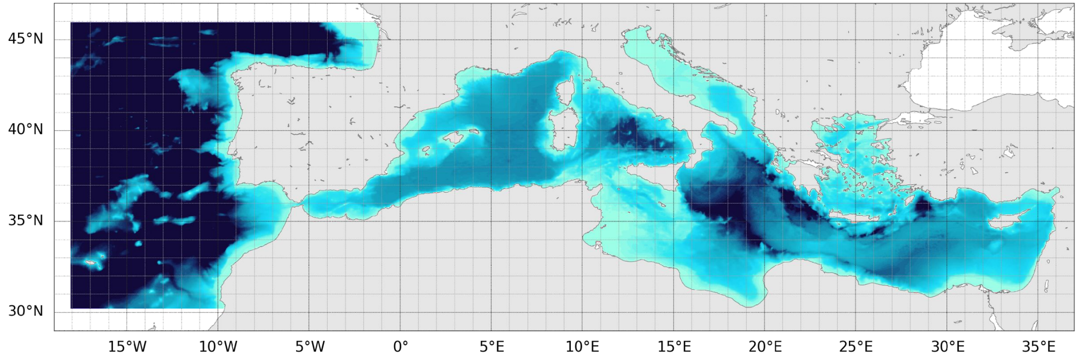
Mediterranean Analysis and Forecasting System (MedFS)

MedFS systems major characteristics and evolutions

MedFS system	Model	Resolution	Start (initial) time	Time Step [sec]	Tides	N. River inputs	Lateral Open Boundaries	Atm. forcing	Data Assimilation	SST nudging
EAS1	NEMOv3.4 + WWIIIv3.14 + OceanVar	H: 1/16˚ V: 72 z lev.	12.00 UTC	300	No	7 + Dardanelles strait: climatologies	Atlantic box	ECMWF 1/8˚	Dobricic and Pinardi (2008) SLA Barotropic Model: T/S profiles & SLA	Whole day towards SST L4
EAS5	NEMOv3.6-VVL + WWIIIv3.14 + OceanVar	H: 1/24˚ V: 141 z* lev.	00.00 UTC	240	No	39: climatologies	Atlantic box + Dardanelles strait	From Dec 2020: ECMWF 1/10˚	Storto at al. (2015) SLA Dynamic Height T/S profiles & SLA	Close to Midnight
EAS7	NEMOv3.6-VVL + WWIIIv3.14 + OceanVar	H: 1/24˚ V: 141 z* lev.	00.00 UTC	240	Yes: 8 components	38 climatologies + Po river: daily obs.	Atlantic box + Dardanelles strait	ECMWF 1/10˚	Storto at al. (2015) SLA Dynamic Height T/S profiles & SLA	Close to Midnight

Higher resolution (1/16° → 1/24°) with tides and more rivers, and upgraded DA scheme.



MedFS is the blue ocean component of Copernicus Marine Service MED-MFC (Coppini et al., 2023)

Still maintaining 3 different operational system in the Mediterranean Sea.

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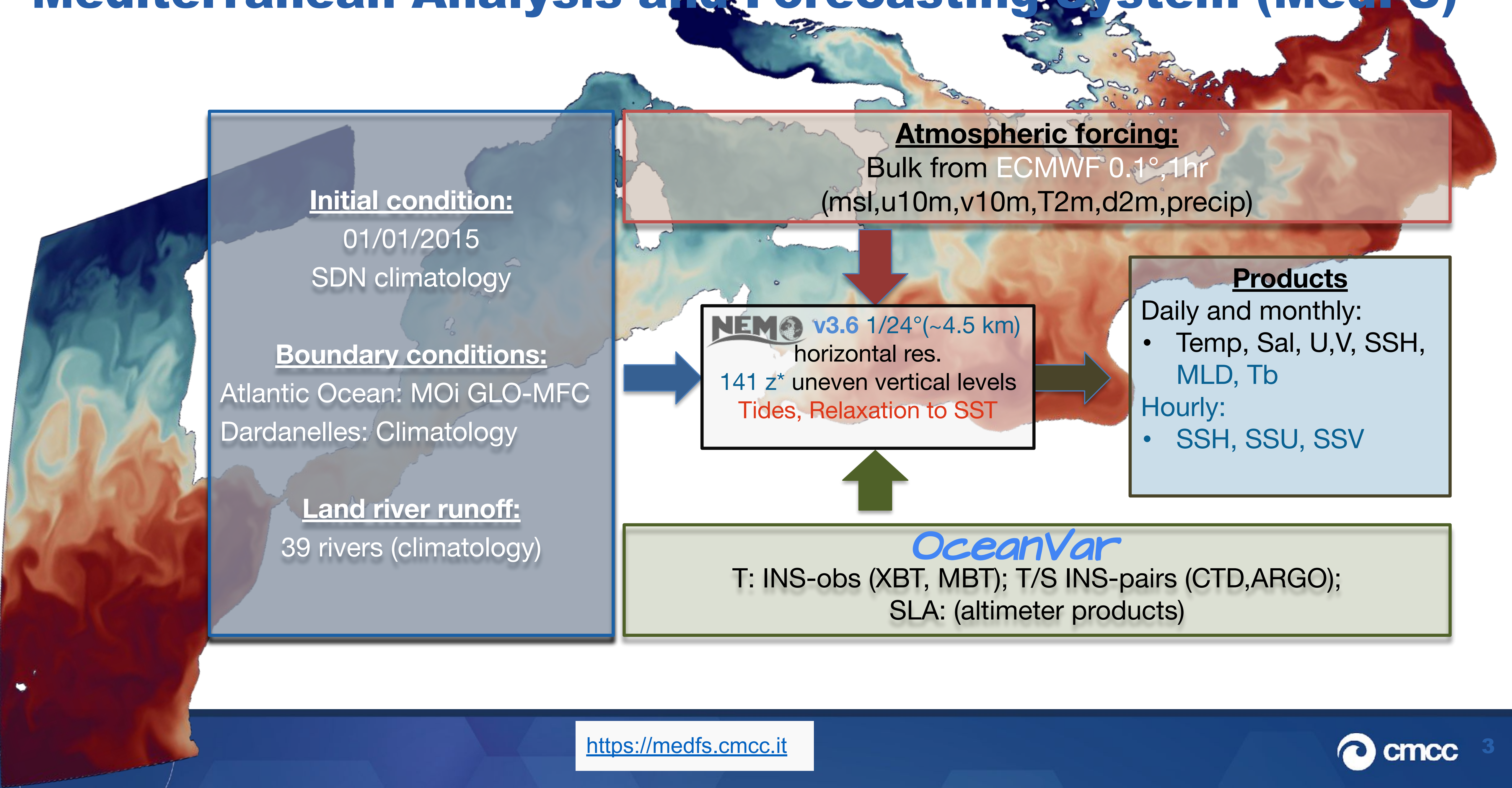
Mediterranean Analysis and Forecasting System (MedFS)



Initial condition:
01/01/2015
SDN climatology

Boundary conditions:
Atlantic Ocean: MOi GLO-MFC
Dardanelles: Climatology

Land river runoff:
39 rivers (climatology)

Atmospheric forcing:
Bulk from ECMWF 0.1°,1hr
(msl,u10m,v10m,T2m,d2m,precip)

NEMO v3.6 1/24°(~4.5 km) horizontal res.
141 z* uneven vertical levels
Tides, Relaxation to SST

Products
Daily and monthly:
- Temp, Sal, U,V, SSH, MLD, Tb

Hourly:
- SSH, SSU, SSV

OceanVar
T: INS-obs (XBT, MBT); T/S INS-pairs (CTD,ARGO);
SLA: (altimeter products)

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OceanVar - 3DVar-FGAT Ocean DA scheme

In 3dvar, we want to minimize the cost function:

$$J(\delta x) = \underbrace{\frac{1}{2}\delta\mathbf{x}^T\mathbf{B}^{-1}\delta\mathbf{x}}_{\text{Error Background}} + \underbrace{\frac{1}{2}\left[\mathbf{H}(\delta\mathbf{x}) - \mathbf{d})\right]^T \mathbf{R}^{-1}\left[\mathbf{H}(\delta\mathbf{x}) - \mathbf{d})\right]}_{\text{Error Observations}}$$

$$\delta\mathbf{x} = \mathbf{x} - \mathbf{x}_b \rightarrow \text{increment}$$

$$\mathbf{d} = [H(\mathbf{x}_b) - \mathbf{y}_o] \rightarrow \text{misfit}$$

FGAT, in NEMO at observation time

Currently, the oceanic vector state is defined as:

$$\mathbf{x} = [\mathbf{T}, \mathbf{S}, \eta]^T$$

The background error covariance matrix can be written as:

$$\mathbf{B} = \mathbf{V}\mathbf{V}^T$$

(Dobricic and Pinardi, 2008, Storto et al., 2011)

OceanVar

$$\mathbf{B} = \mathbf{V}\mathbf{V}^T$$

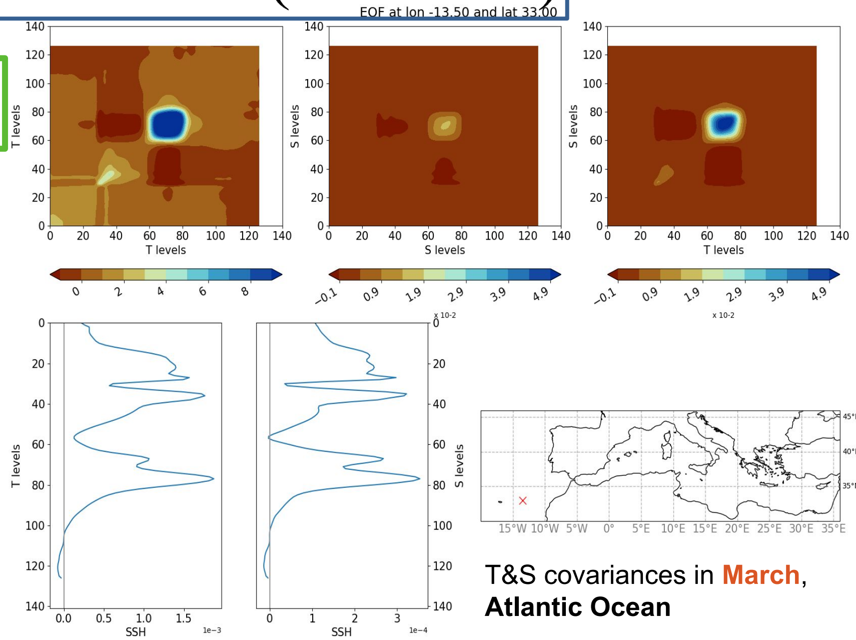
Then with the variable change, $\delta x = Vv$ the cost function is:

$$J(v) = \frac{1}{2} v^T v + \frac{1}{2} [\mathbf{H} V v - \mathbf{d})]^T \mathbf{R}^{-1} [\mathbf{H} V v - \mathbf{d})]$$

And the gradient is:

$$J'(v) = v - V^T \mathbf{H}^T \mathbf{R}^{-1} (d - \mathbf{H} V v)$$

No B matrix to invert



T&S covariances in **March**, **Atlantic Ocean**

$\mathbf{V}$ is modeled as a sequence of linear operators:

$$\mathbf{V} = \mathbf{V}_\eta \mathbf{V}_\mathbf{H} \mathbf{V}_\mathbf{V}^{\mathbf{t_S}}$$

$\mathbf{V}_\mathbf{V}^{\mathbf{t_S}}$ Vertical EOFs: tri-variate monthly every gridpoint for Eta-T-S from 35 year MEDREA24 also in the Atlantic box.

$\mathbf{V}_H$ - Horizontal covariance (a recursive filter)

$\mathbf{V}_\eta$ - Dynamic Height operator (Balance operator, 1000 m level of no motion)

$$\mathbf{x} = [\mathbf{T}, \mathbf{S}, \eta]^T \rightarrow v = [EOF]^T$$

OceanVar

$$\mathbf{B} = \mathbf{V}\mathbf{V}^T$$

Then with the variable change, $\delta x = Vv$ the cost function is:

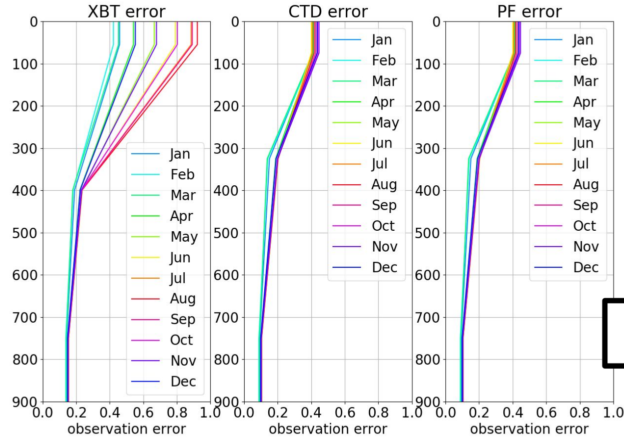
$$J(v) = \frac{1}{2} v^T v + \frac{1}{2}[\mathbf{H}Vv - \mathbf{d})]^T \mathbf{R}^{-1}[\mathbf{H}Vv - \mathbf{d})]$$

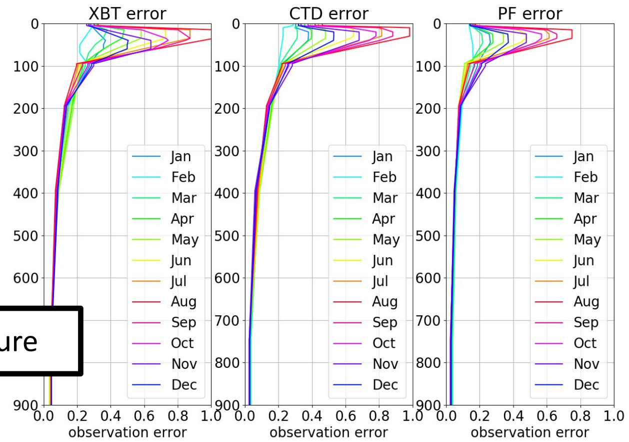
And the gradient is:

$$J'(v) = v - V^T \mathbf{H}^T \mathbf{R}^{-1}(d - \mathbf{H}Vv)$$

No B matrix to invert

R diagonal - different for instrument same for all domain





Temperature

$\mathbf{V}$ is modeled as a sequence of linear operators:

$$\mathbf{V} = \mathbf{V}_\eta \mathbf{V}_\mathbf{H} \mathbf{V}_\mathbf{V}^{\mathbf{t_S}}$$

$\mathbf{V}_\mathbf{V}^{\mathbf{t_S}}$ Vertical EOFs: tri-variate monthly every gridpoint for Eta-T-S from 35 year MEDREA24 also in the Atlantic box.

$\mathbf{V}_H$ - Horizontal covariance (a recursive filter)

$\mathbf{V}_\eta$ - Dynamic Height operator (Balance operator, 1000 m level of no motion)

$$\mathbf{x} = [\mathbf{T}, \mathbf{S}, \eta]^T \rightarrow v = [EOF]^T$$

Desroziers (2005)

MedFS evolution in Copernicus Marine Service

Development activities are planned for Copernicus Marine Service 2

Nilsson et al., (2011)

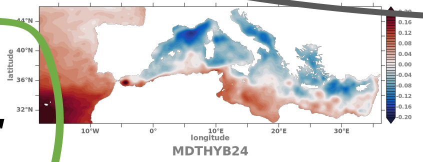
2022

2023

2024

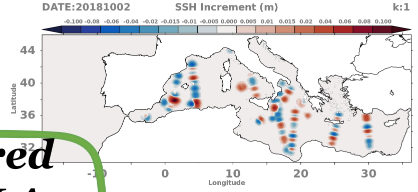
Post-2024

New MDT

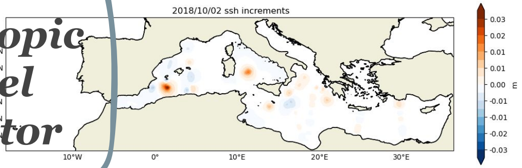


Assimilation in the Atlantic-box

Filtered 7km SLA + HY-2B and S-6

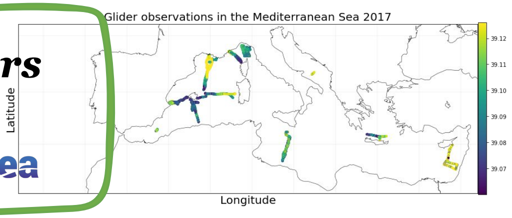


Barotropic model operator

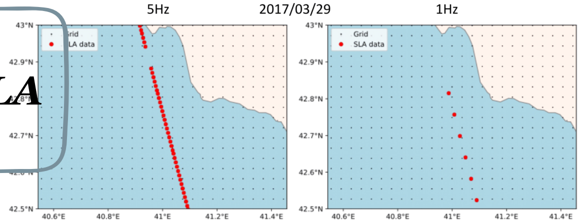


Gliders

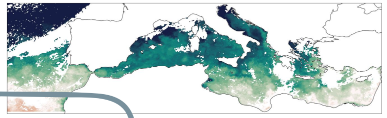
EuroSea



5Hz SLA

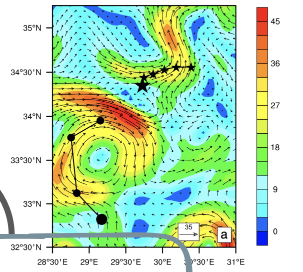


SST



Shorter assimilation cycle

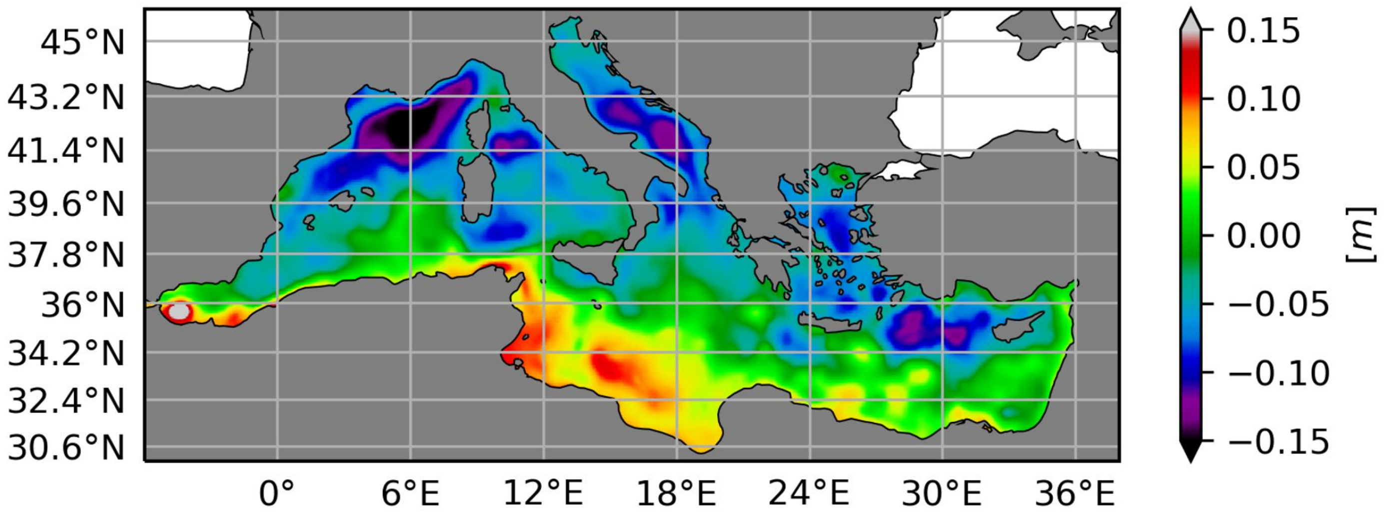
Currents

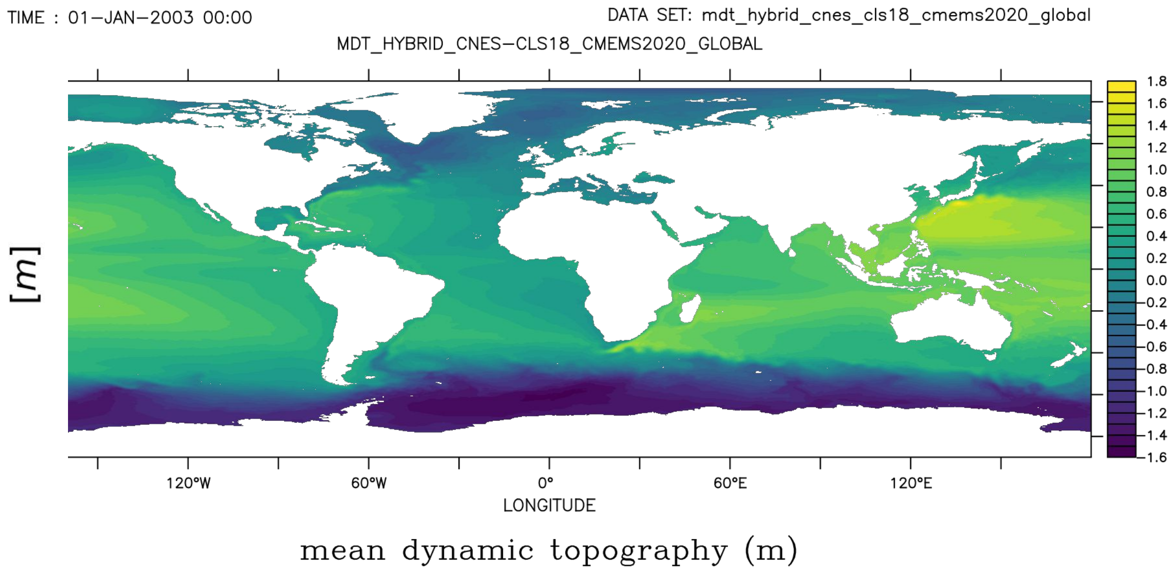


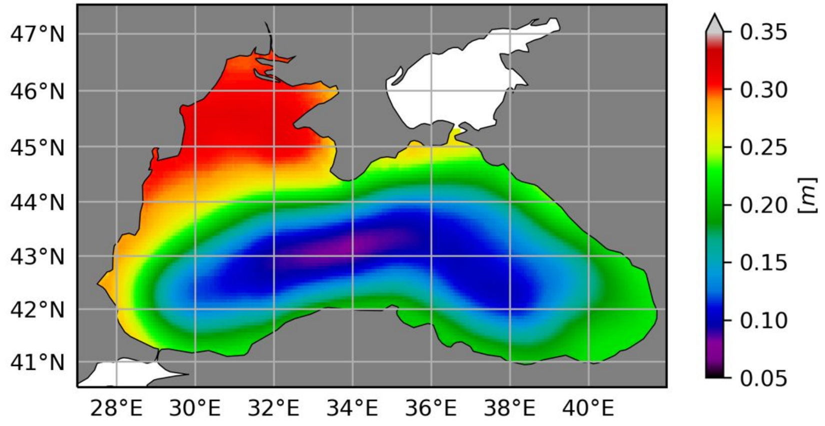
ML/DA

SWOT and correlated obs

New MDT from SL-TAC







References:

- For **MDT-CNES-CLS22**: Jousset S., Mulet S., Wilkin J., Greiner E., Dibarboure G. and Picot N.: "New global Mean Dynamic Topography CNES-CLS-22 combining drifters, hydrological profiles and High Frequency radar data", OSTST 2022, https://doi.org/10.24400/527896/a03-2022.3292.

- For **MDT CMEMS 2020**: Jousset S., Aydogdu A., Ciliberti S., Clementi E., Escudier R., Jansen E., Lima L., Menna M., Mulet S., Nigam T., Sanchez A., Tarry D. R., Pascual A., Peneva E., Poulain P.-M. and Taupier-Letage I. (2022). New Mean Dynamic Topography of the Mediterranean and Black Seas from altimetry, gravity and in-situ data. In preparation.

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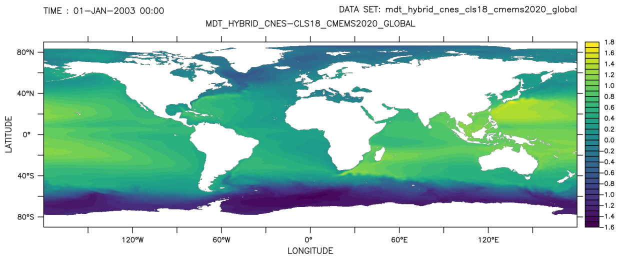
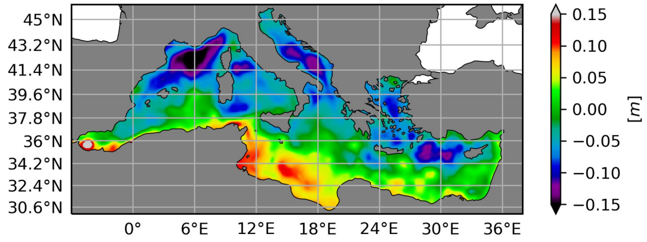
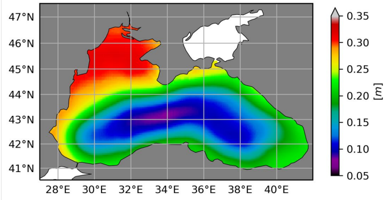
MDT-HYBRID-CNES-CLS22-CMEMS2020	access via MY AVISO+ and select the product "MDT_CNES_CLS (Global Mean Dynamic Topography)"	gridded	NetCDF4	48Mb

New MDT for MedFS

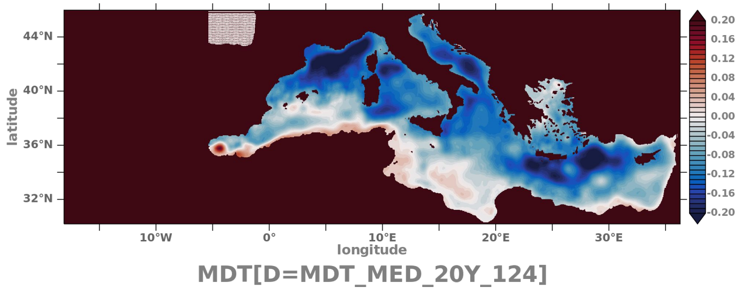
Updated MDT from Rio 2014 to Jousset 2020 by using MED (1/24°) and HYBRID MDT (1/8°) to extend into the Atlantic Ocean



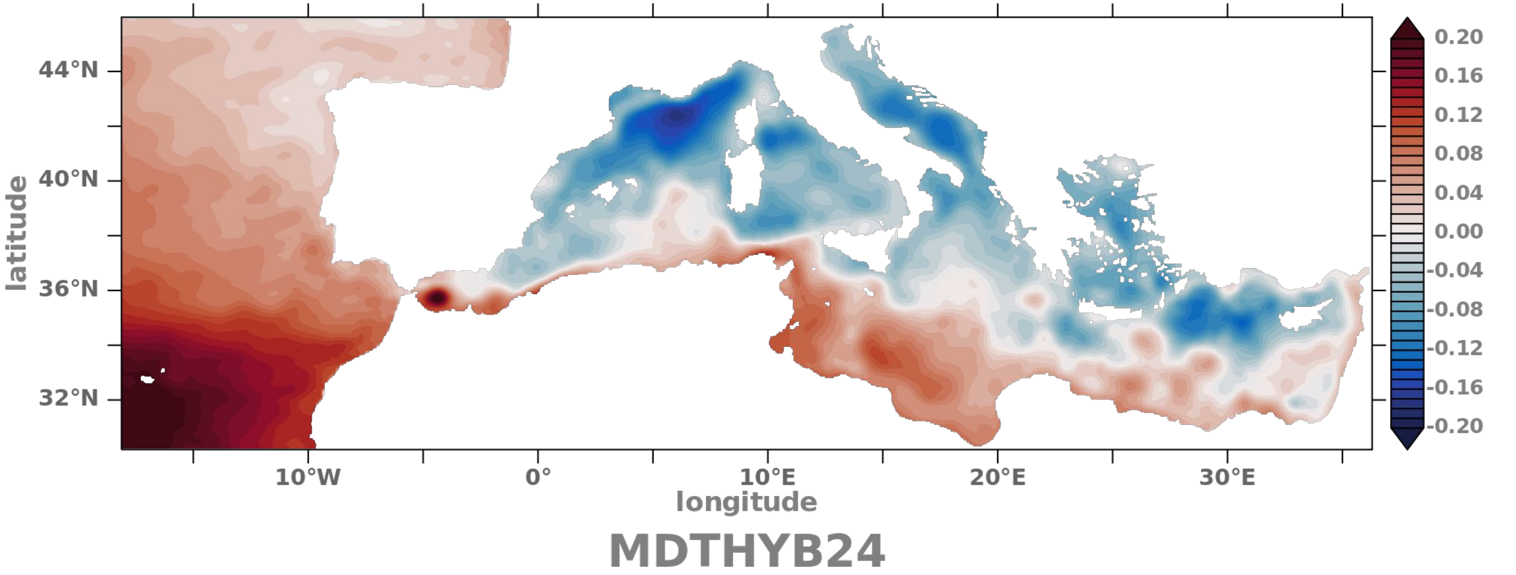




Rio et al., 2014



New MDT (*Jousset et al.,2020*)



Difference of 1/8°and 1/24° product on the MedFS grid

References:

- For MDT-CNES-CLS22: Jousset S., Mulet S., Wilkin J., Greiner E., Dibarboure G. and Picot N.: "New global Mean Dynamic Topography CNES-CLS-22 combining drifters, hydrological profiles and High Frequency radar data", OSTST 2022, https://doi.org/10.24400/527896/a03-2022.3292.

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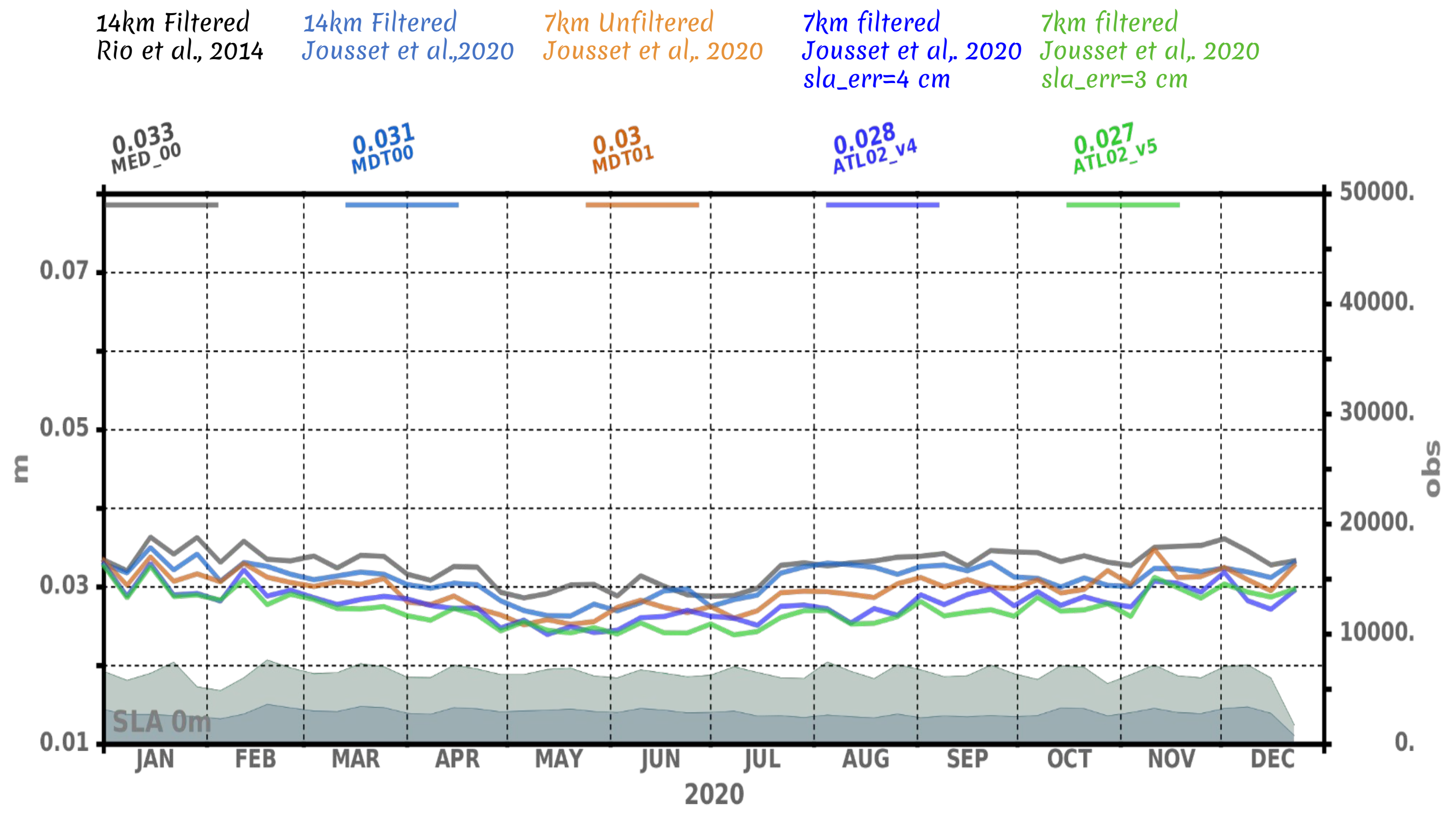
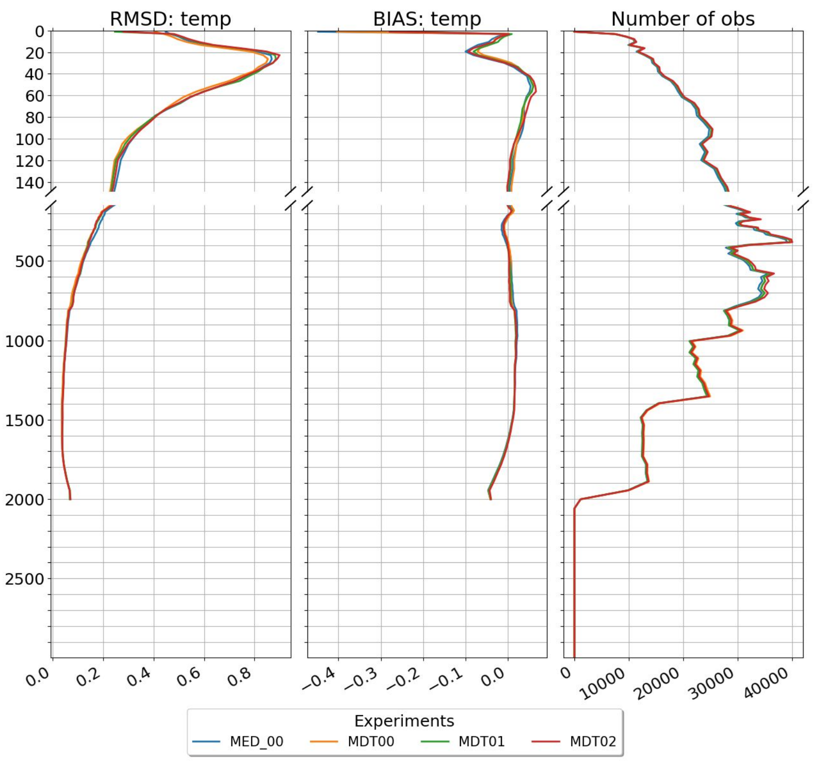
MDT-HYBRID-CNES-CLS22-CMEMS2020	access via MY AVISO+ and select the product "MDT_CNES_CLS (Global Mean Dynamic Topography)"	gridded	NetCDF4	48Mb

Assimilation of SLA from altimeters

New MDT + 7km along-track + 3 cm sla error



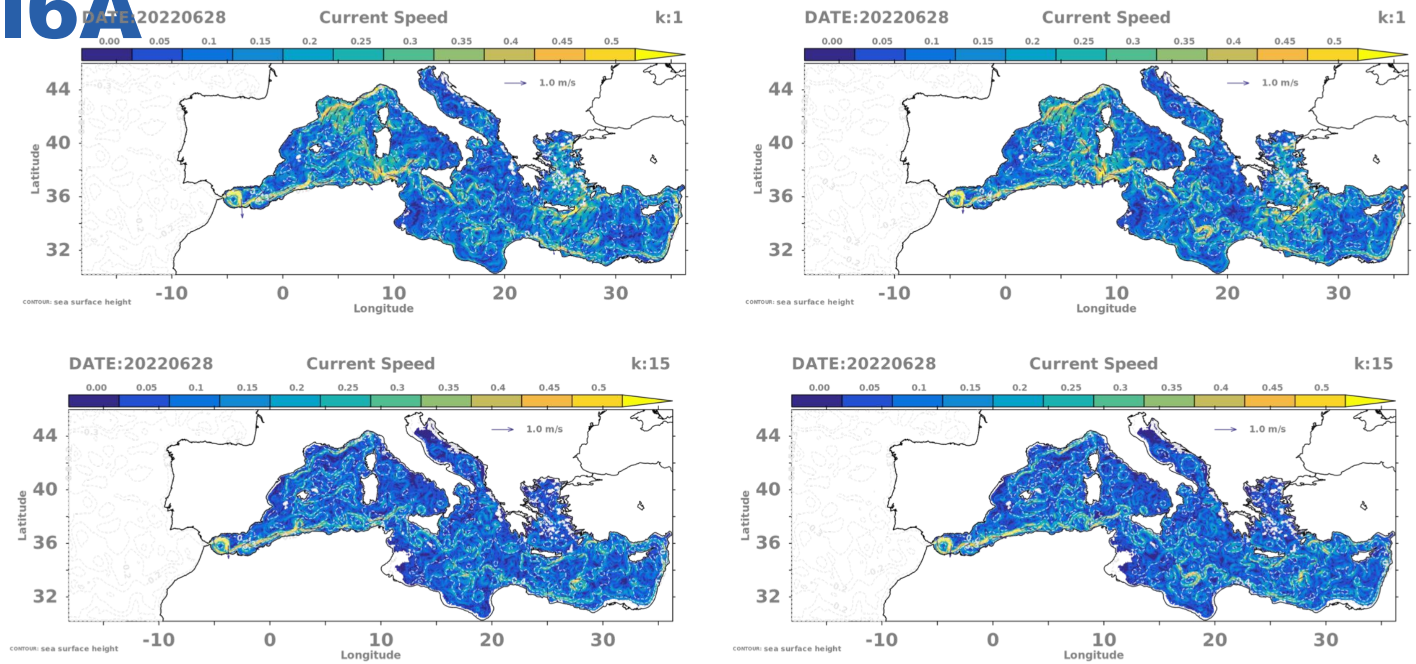


Not much impact on T,S

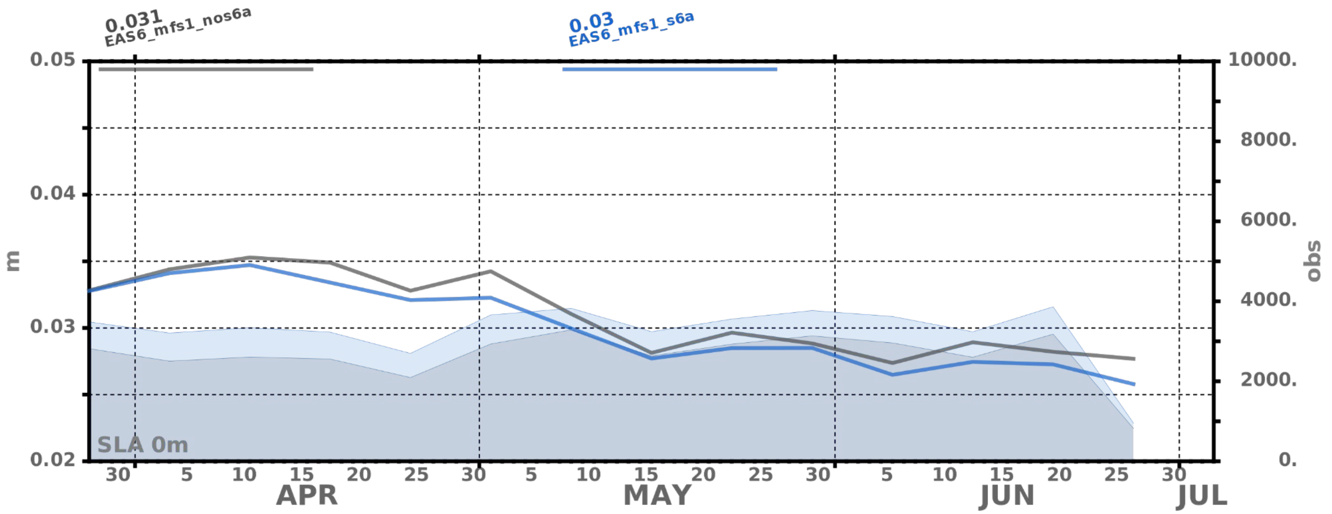
RMS of SLA misfits reduced from 3.3 cm to 2.7 cm.

Assimilation of Sentinel6A

RMS of SLA misfits improved.



Assimilation of Sentinel 6



Slightly different mesoscale circulation. Not validated with observations yet.

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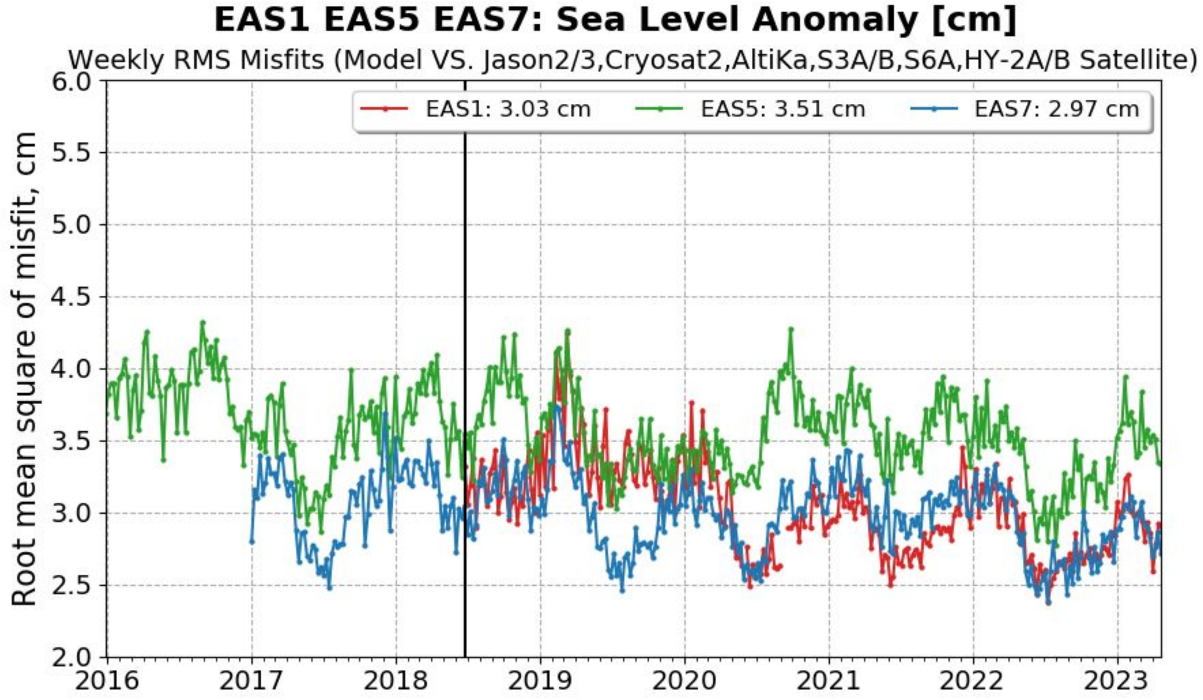
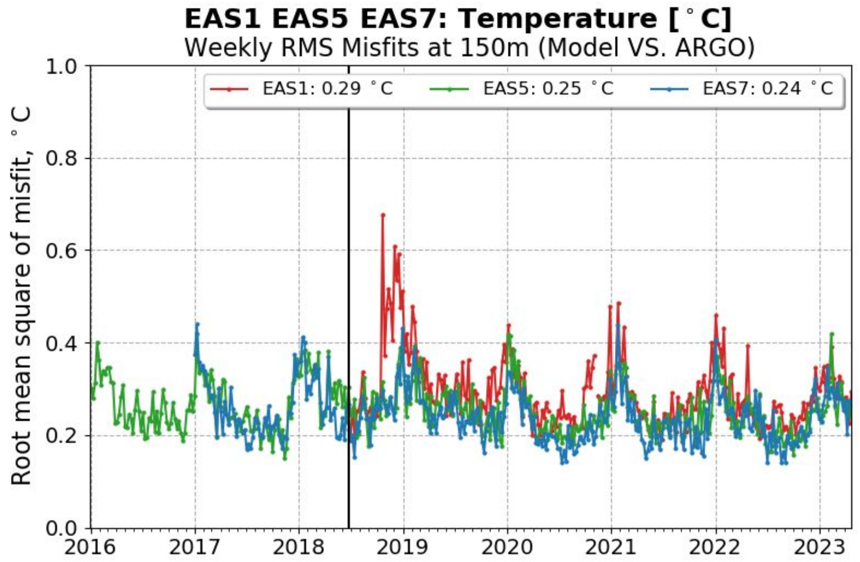
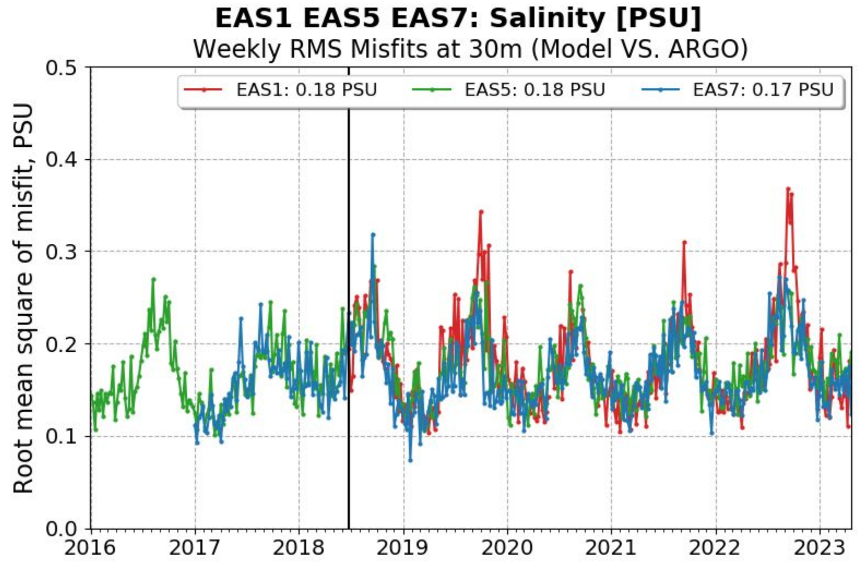
Evolution of MedFS





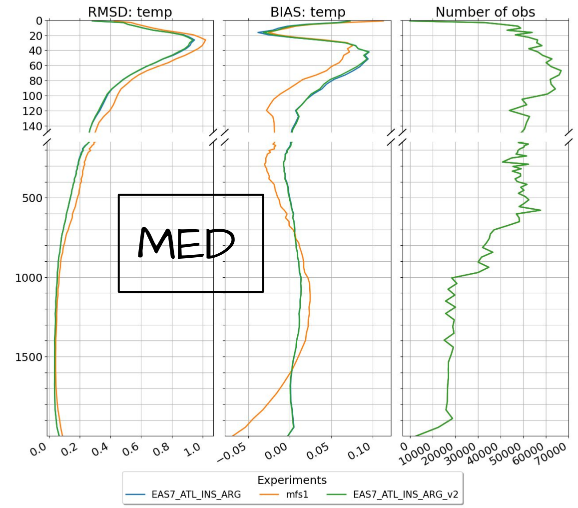
Continuous improvement throughout evolution.

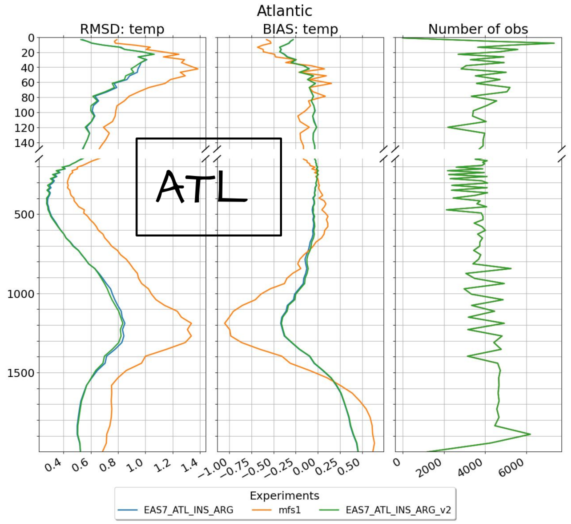


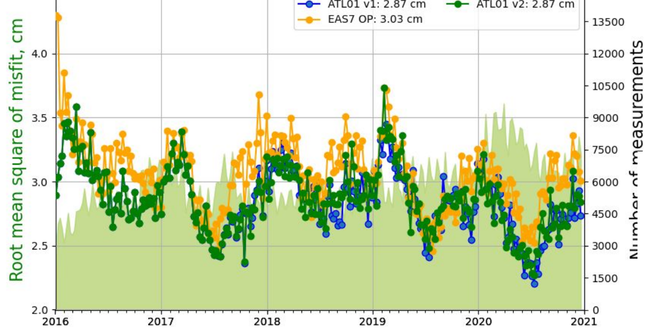
In-situ in the North-east Atlantic

EAS7 OP → the operational system
ATL01_v1 → in-situ observations in Atlantic box + relaxed QC
ATL01_v2 → ATL01_v1 + more in-situ observations in MedSea

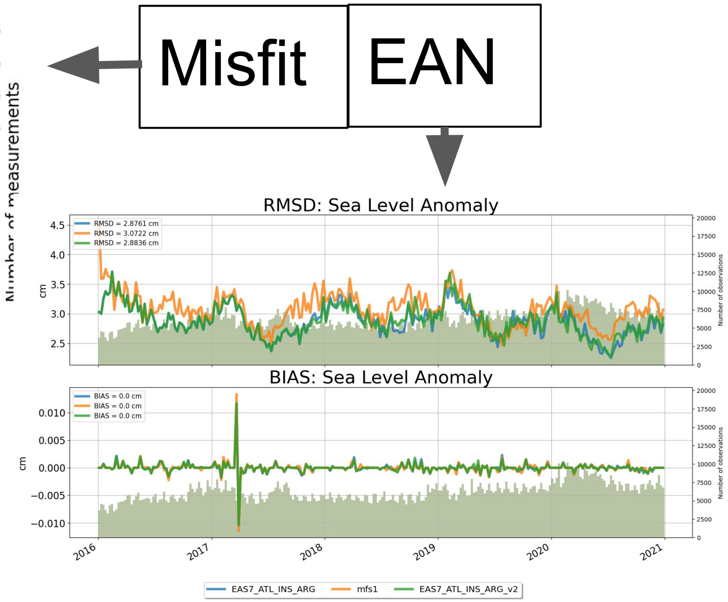
*Average values on the legend are calculated in the overlapping period 2016-2020

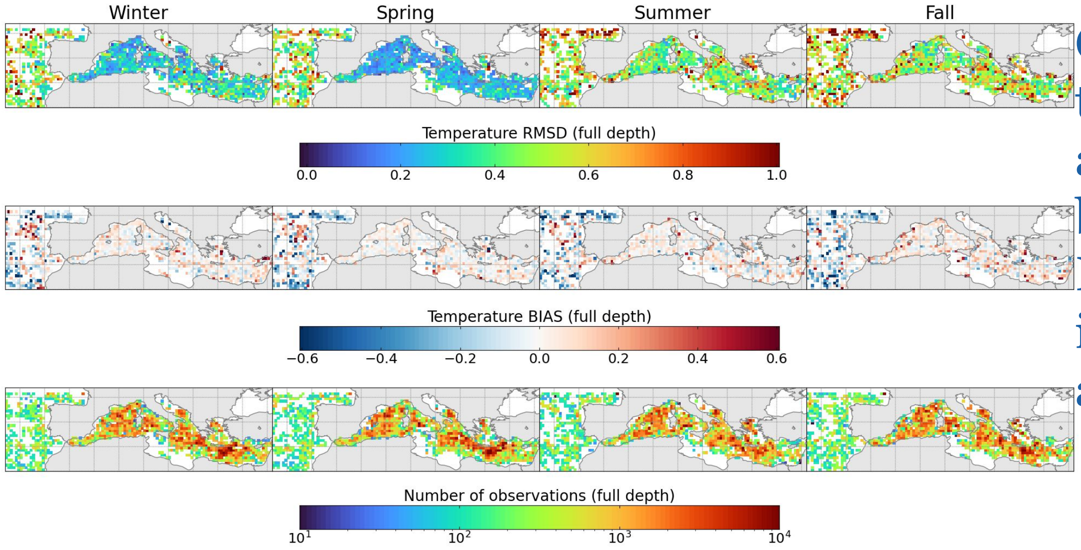






Improving the SLA misfits in MED





Cold bias in the Atlantic and warm bias in MED. Larger errors in summer and fall.

EAN shows an improving RMSD and BIAS in the entire water column for both temperature and salinity in ATL01_v1. Not much change in ATL01_v2

Assimilation of glider observations

EuroSea

- 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

EuroSea

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

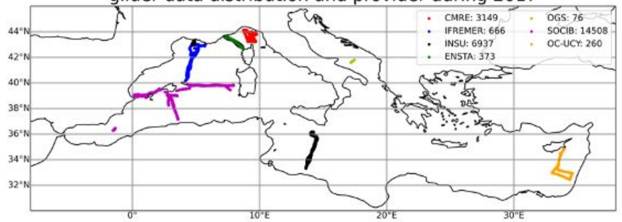
A need…

- 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 (Baleric) 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 communities to converge on coherent procedure anc inconsistencies, Argo + Glider vs. modelling + assi communities for the best practices on the use of observa forecasting and reanalysis systems, e.g., on QC standards.

Joint work of Task 4.1 and 4.2 with WP3

Ali Aydogdu on behalf of EuroSea WP4 Task 4.1 and 4.2 Romain Escudier, Jaime Hernandez-Lasheras, Carolina Amadeo, Elisabeth Remy, Baptiste Mourre, Gianpiero Cossarini, Jenny Pistoia

glider data distribution and provider during 2017



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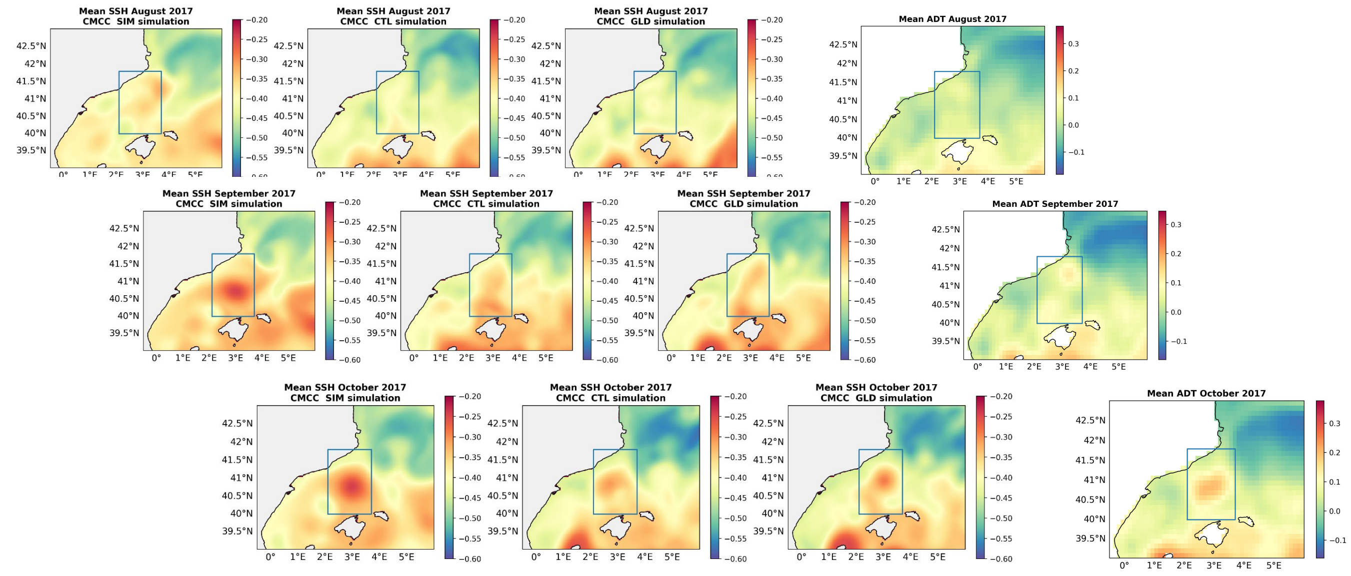
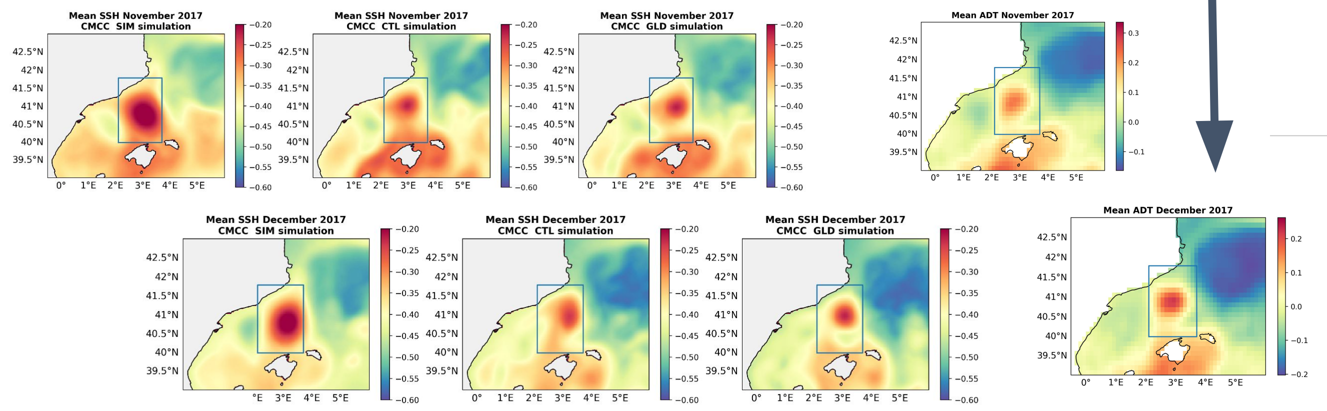
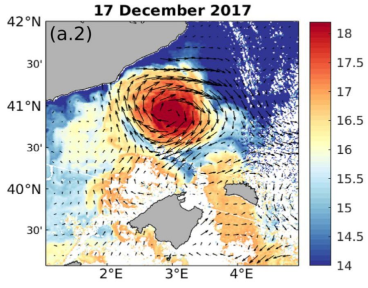
Assimilation of glider observations

EuroSea

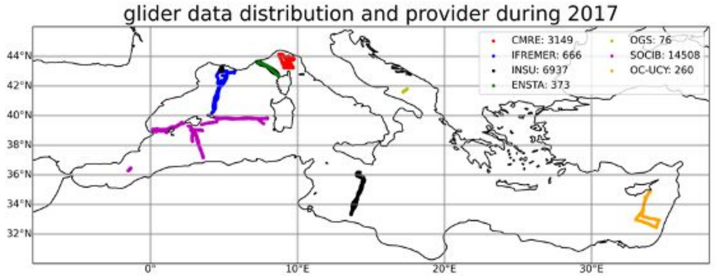






Aguiar et al., (2022)

A case study: Balearic Eddy in 2017



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Intercomparison of WMED systems - COMING SOON - Impact on BGC

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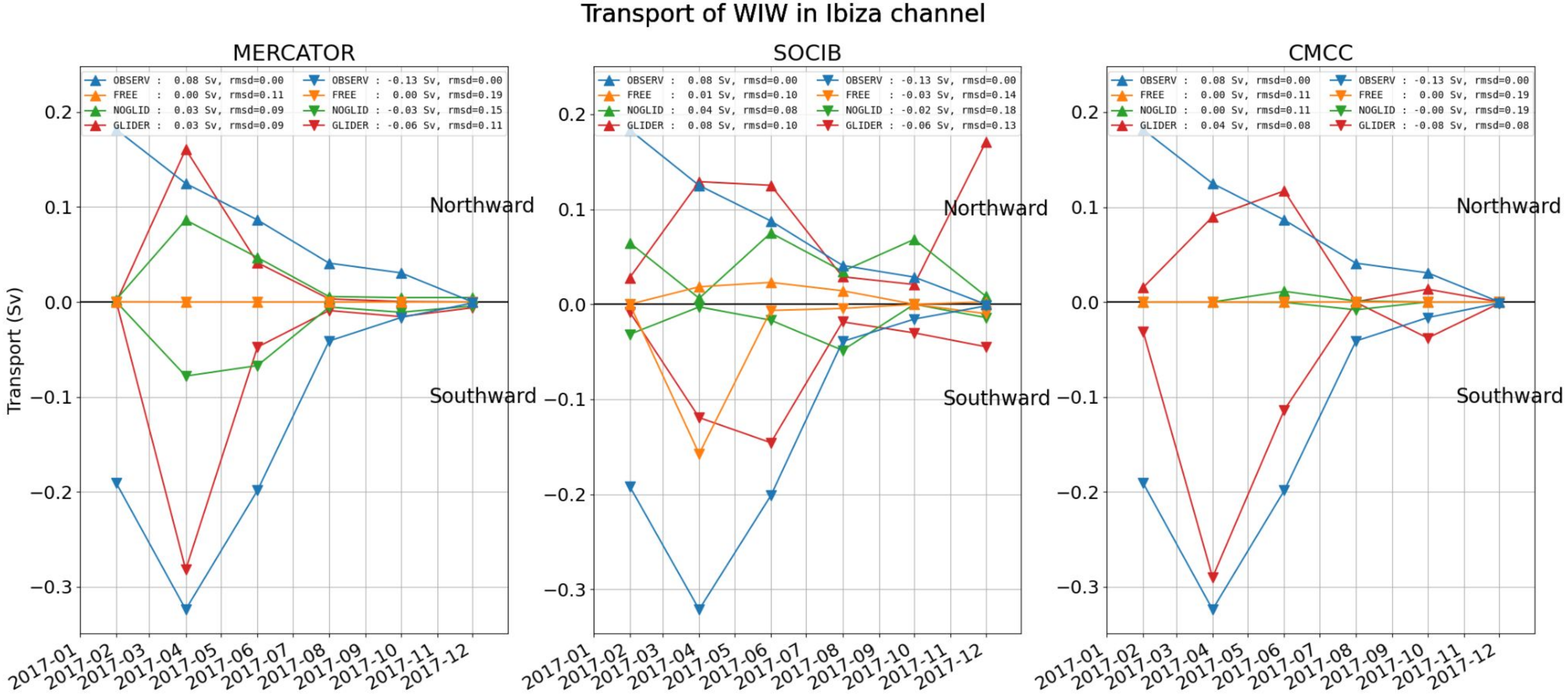
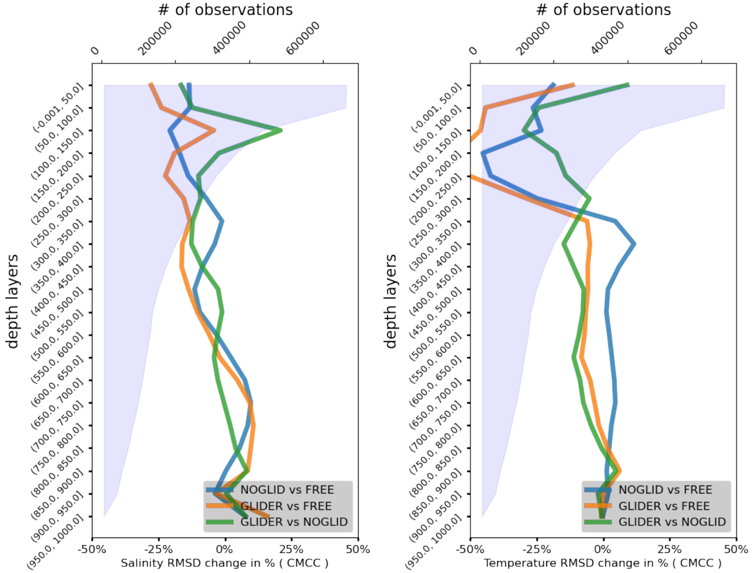
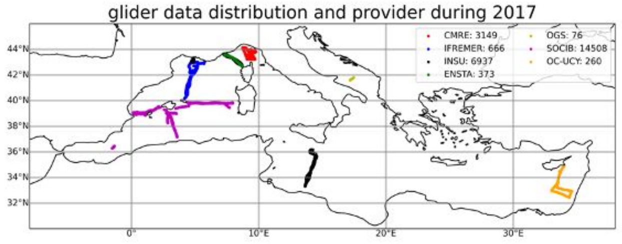
Assimilation of glider observations



Comparison of transports in the Ibiza channel





A study case in 2017 for the assimilation of glider observations

Ali Aydogdu on behalf of EuroSea WP4 Task 4.1 and 4.2 Romain Escudier, Jaime Hernandez-Lasheras, Carolina Amadeo, Elisabeth Remy, Baptiste Mourre, Gianpiero Cossarini, Jenny Pistoia

Intercomparison of WMED systems - COMING SOON - Impact on BGC

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Assimilation of glider observations

EuroSea

OceanGlidersCommunity / data_assimilation_practices Public

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vturpin Update key_literature.md 0760ddd on Sep 19, 2022 16 commits

DYNAT-D-09-00020-3.pdf	early glider data assimilation experiment	last year
README.md	Update README.md	last year
key_literature.md	Update key_literature.md	8 months ago

README.md

Data Assimilation Practices

In this repo we collect literature and approaches on glider data 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 Procudures (SOPs)
- harmonize approaches

approac…
practices.

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Contributors 4

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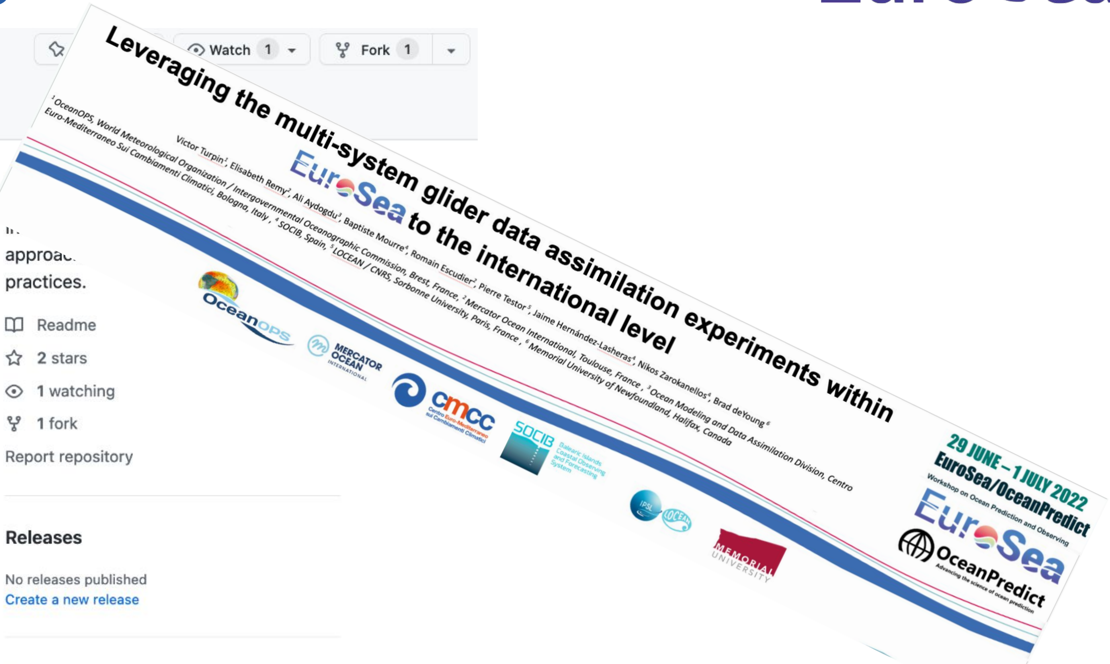
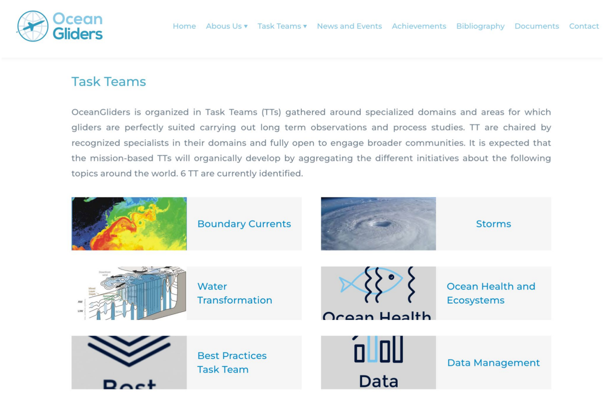


A possible OceanGliders DA-TT



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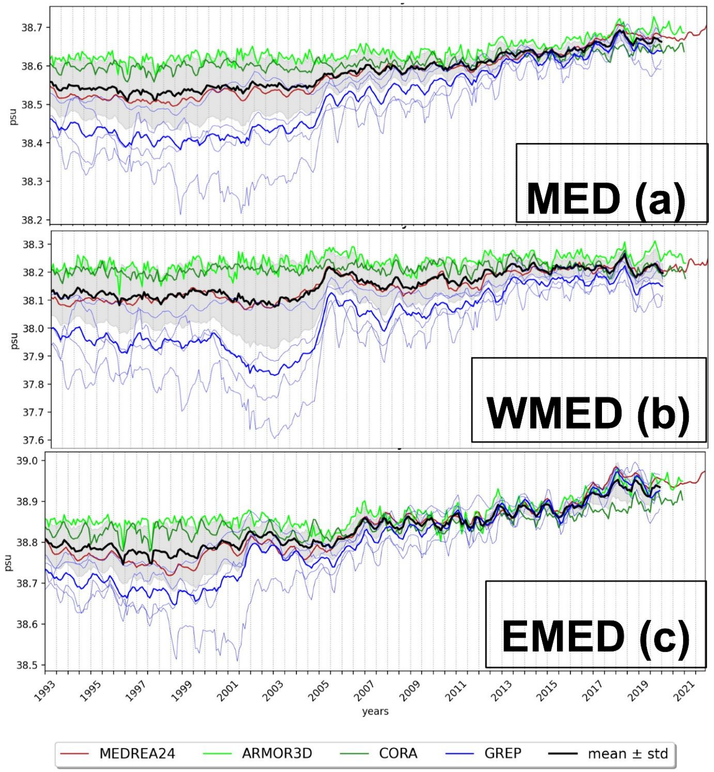
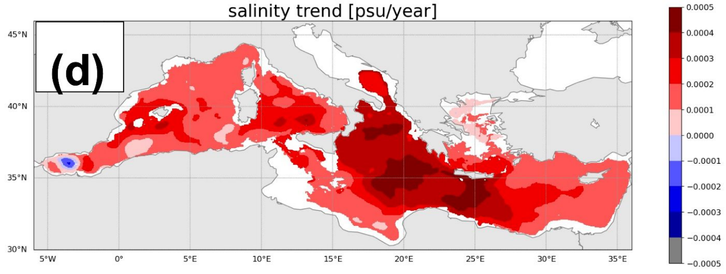
Ocean State Report





https://doi.org/10.5194/sp-2022-11

Abstract | Discussion

26 Sep 2022

Status: a revised version of this preprint was accepted for the journal SP and is expected to appear here in due course.

Received: 25 Aug 2022 – Discussion started: 26 Sep 2022 – Revised: 14 Apr 2023 – Accepted: 02 May 2023

The dynamical role of upper layer salinity in the Mediterranean Sea

Ali Aydogdu, Pietro Miraglio, Romain Escudier, Emanuela Clementi, and Simona Masina

Abstract. The Mediterranean Sea is a semi-enclosed basin with an excess amount of evaporation compared to the water in-flux through precipitation at the surface and river runoff on the land boundaries. The deficit in the water budget is balanced by th inflow in the Straits of Gibraltar and Dardanelles connecting the Mediterranean with the less saline Atlantic Ocean and the Marmara Sea, respectively. There is evidence that the Mediterranean region will be a hotspot with the warming Earth (T Tahir, 2020) which will possi ... but with a large uncertainty (Cos et al., 2022). The inevitable to monitor the e ... (EOVs) to respond to the associated risks and r related problems. In this work ... salinity content and anomaly in the Mediterran last decades using the Copernicus Marine Service products. The results show an increasing mean salinity wit the eastern basin. The spread of the products implies a larger variability in the western basin while the sta in the eastern side, especially in the Ionian and the Levantine basins.

How to cite. Aydogdu, A., Miraglio, P., Escudier, R., Clementi, E., and Masina, S.: The dynamical role Mediterranean Sea, State Planet Discuss. [preprint], https://doi.org/10.5194/sp-2022-11, in revie

Received: 25 Aug 2022 – Discussion started: 26 Sep 2022

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Short summary
This paper investigates the salinity content and anomaly in the Mediterranean Sea using...
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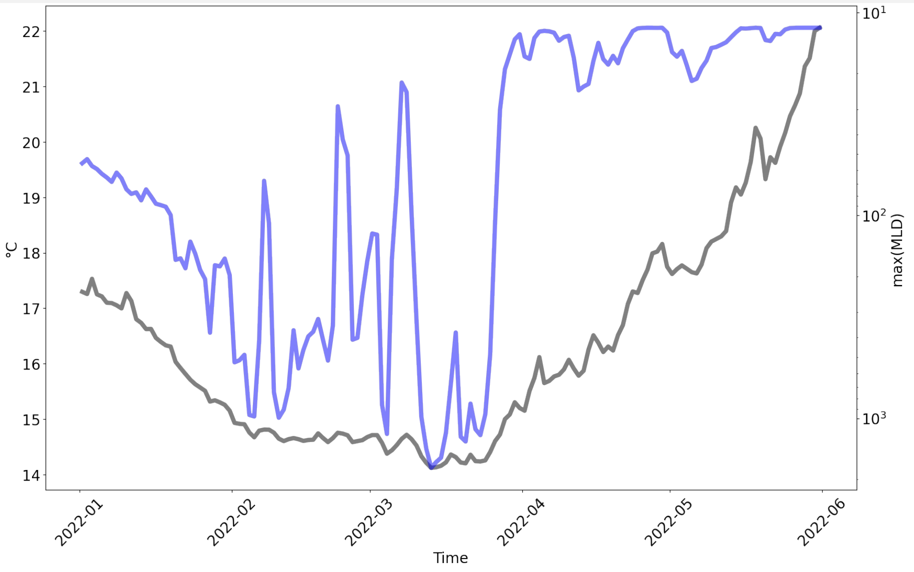
OSR7

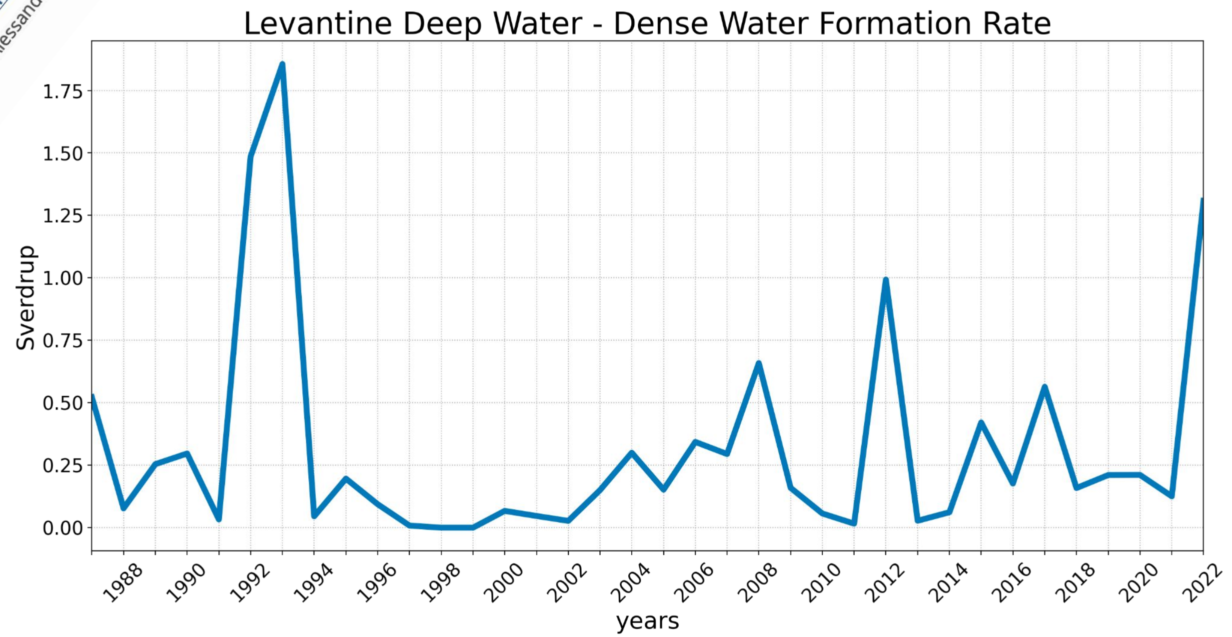
EGU23-5442 | Orals | OS2.3

Anomalous 2022 deep water formation and intense bloom event in the southeastern Mediterranean Sea

Anna Teruzzi, Ali Aydogdu, Carolina Amadio, Gianpiero Cossarini, Laura Feudale, Alessandro Grandi, Pietro Miraglio, Jenny Pistoia, and Stefano Salon

OSR8





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