Heat content and temperature trends in the Mediterranean Sea as derived by Argo float data (2005 – 2020)

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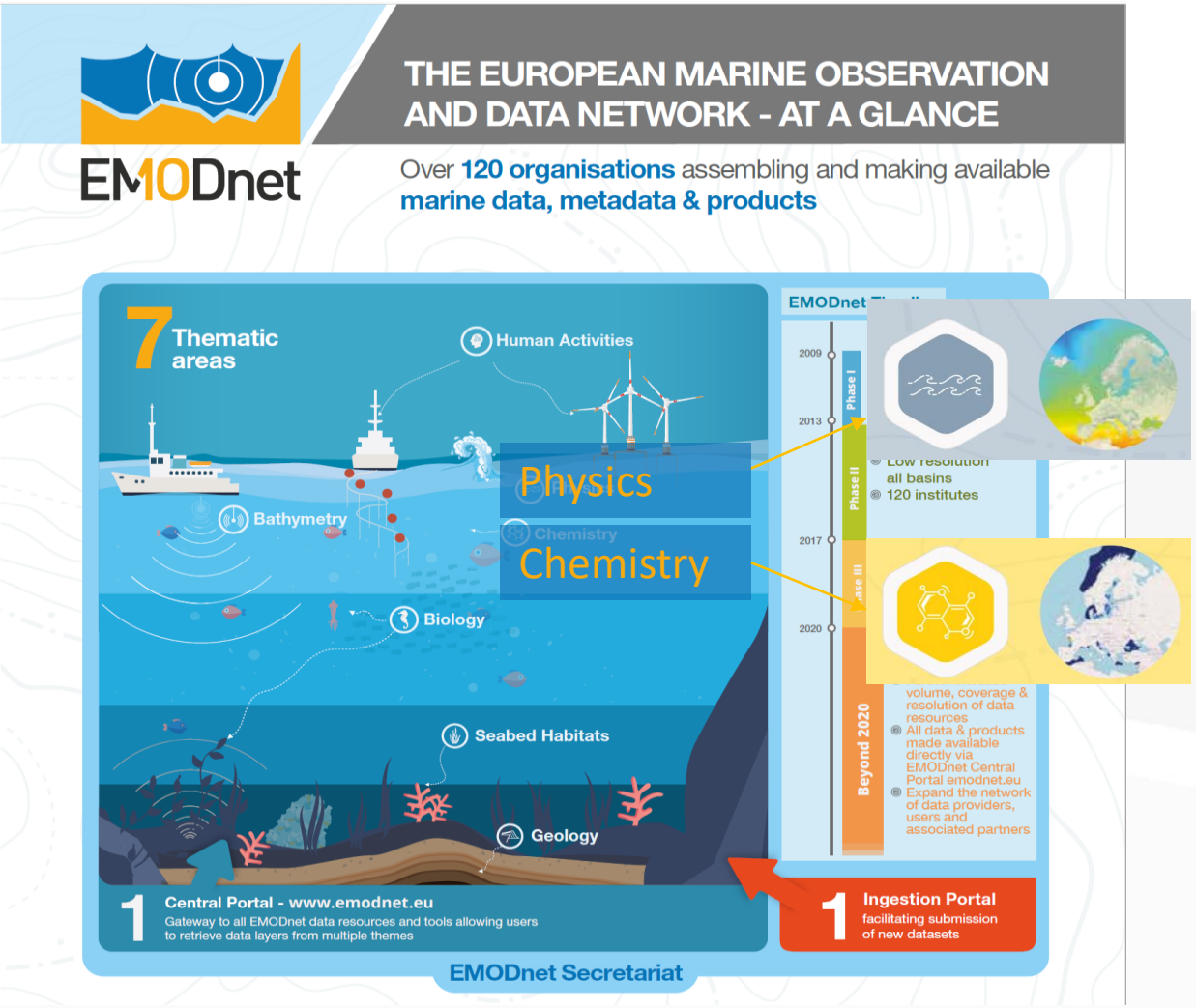
EURO ARGO and EMODnet
Memorandum of Understanding, July 2022



- Argo is an important observing system for EMODnet.
- The Memorandum of Understanding will maximize and facilitate the use and exchange of Argo data.
- To extend the spatio-temporal coverage of observations to
  - depths greater than 2000 m,
  - high latitudes and shallower areas,
  - with increased focus on biogeochemical measurements.

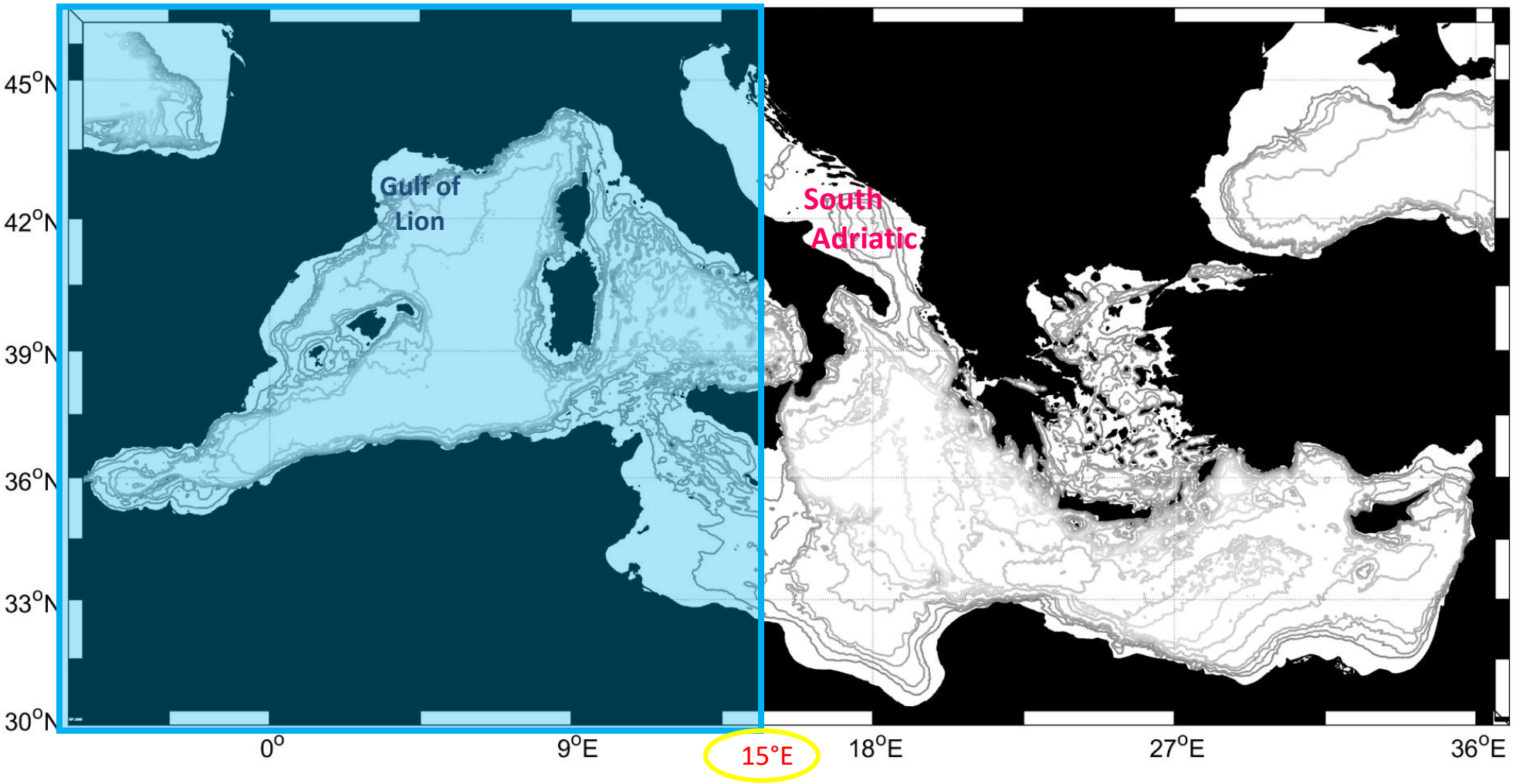
Heat content and temperature trends in the Mediterranean Sea as derived by Argo float data (2005 - 2020)

Outline

1. Description of the area of study
2. Dataset and Methods
3. Results: → Distribution of Ocean Heat Content (OHC)

   → Temperature and OHC trends
4. Conclusions and Outcomes

1) Area of study: The Mediterranean Sea and its subbasins



Western Med:
< 15 °E

Eastern Med:
> 15 °E

Gulf of Lion

South Adriatic

→ Very sensitive to climatic changes due to its semi-enclosed nature.
→ Defined as one of the hotspots in future climate change projections (Giorgi et al., 2006).

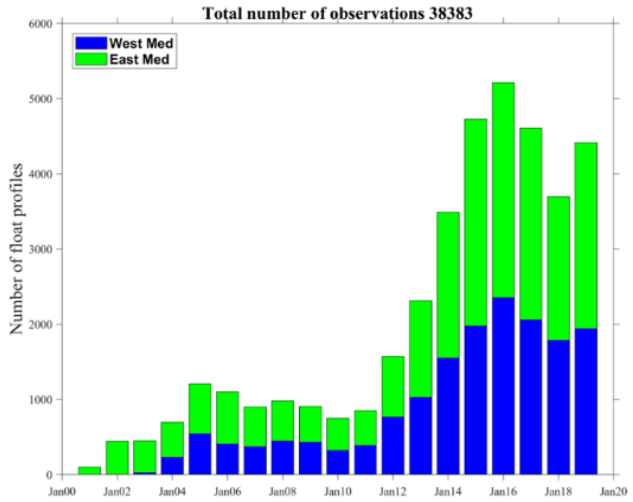
2) **Dataset** and Methods

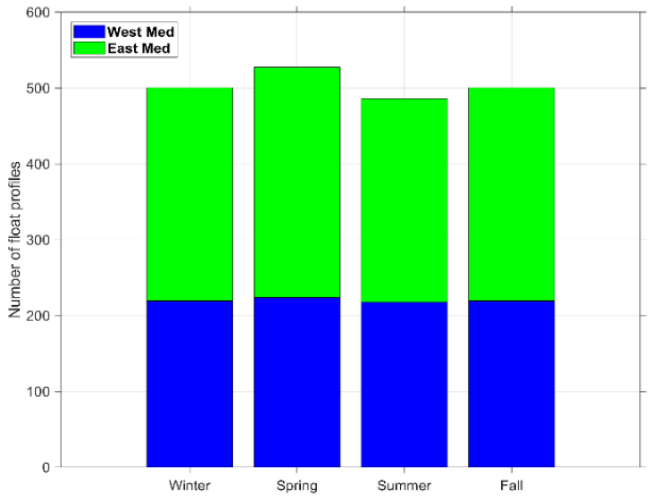
Annual distribution of float profiles
(2001 - 2020)

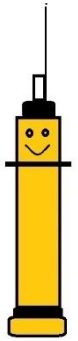
Seasonal distribution of float profiles
(2001 - 2020)

Total number of Observations:

38.383 profiles







→ Only the best quality controlled data (qc=1) were considered for each float profile.
→ A visual inspection of float profiles has been done.
→ To obtain a homogenous data set, a sub-sampling over time intervals of 5 days has been done.

→ Over 38.000 profiles analyzed.
→ The geographical distribution is consistent even between seasons.

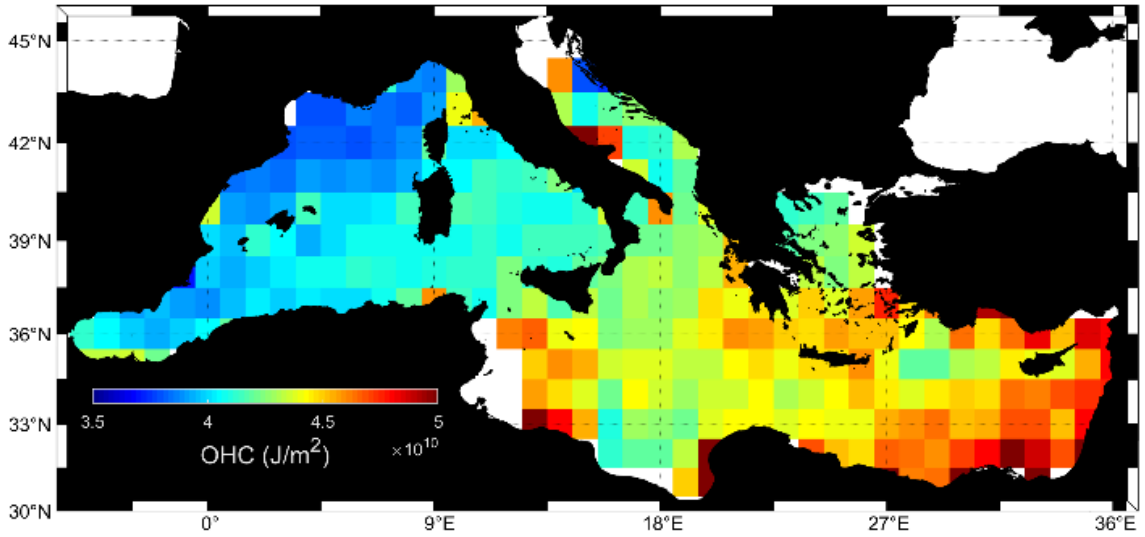
2) Dataset and **Methods**

Methods

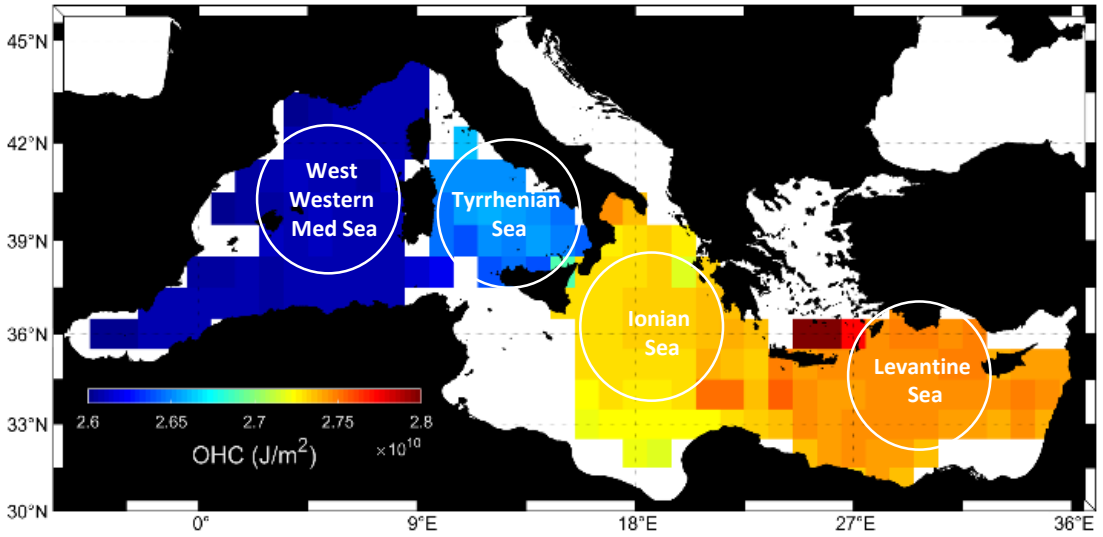
- ***Climatologies*** for OHC were calculated within 1°x1° grid boxes from 2001 – 2020.
- The depth intervals for which the OHC was estimated, are the whole layer measured by Argo floats (5 – 2000 m), the surface and intermediate layers together (5 – 700 m) and the surface, intermediate and deeper layers separately.
- The ***warming trends of the temperature and the OHC*** were estimated in the period 2005 – 2020, due to a limited number of float profiles available before 2005 .
- The trend analysis was done for the whole Mediterranean Sea as well as for specified sub-basins.
- The trend was computed using the linear least-squares method to fit a linear regression to the data.

3) Distribution of Ocean Heat Content - Climatologies from 2001 to 2020

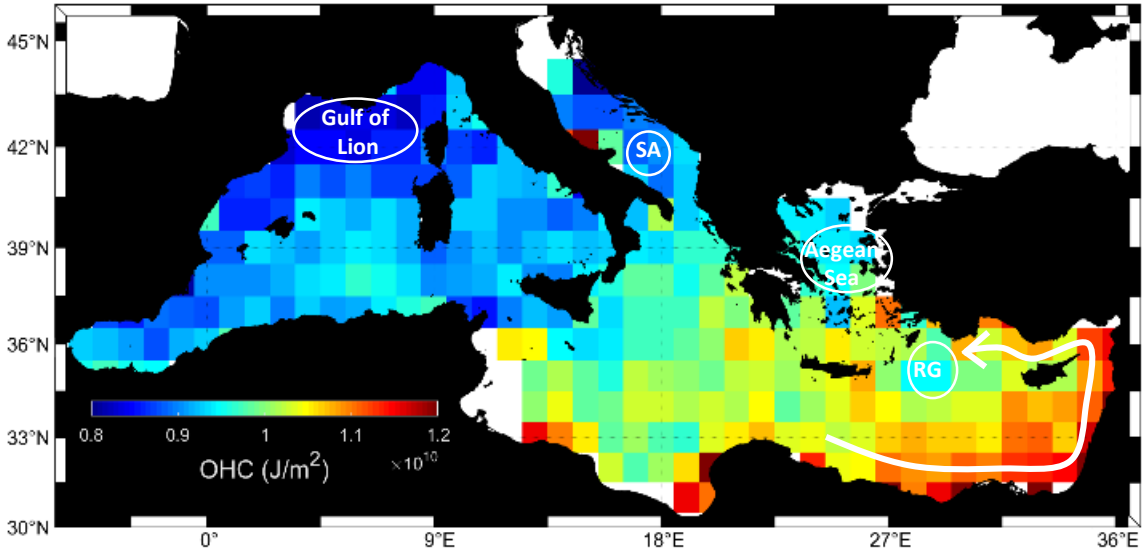
Surface and intermediate layers: *5 – 700 m*



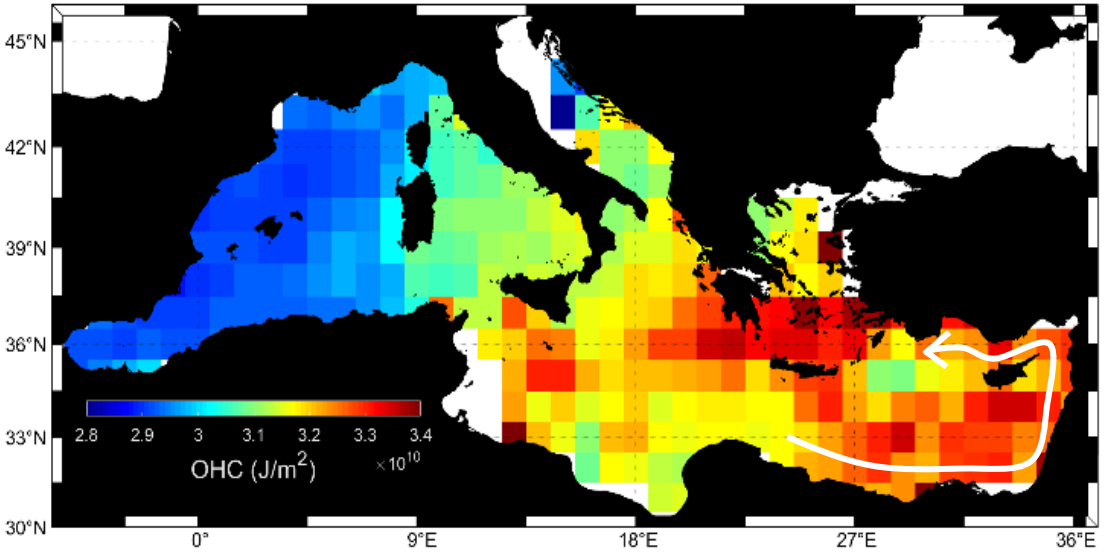
Deeper layers: *1500 – 2000 m*



Surface layers: *5 – 150 m*

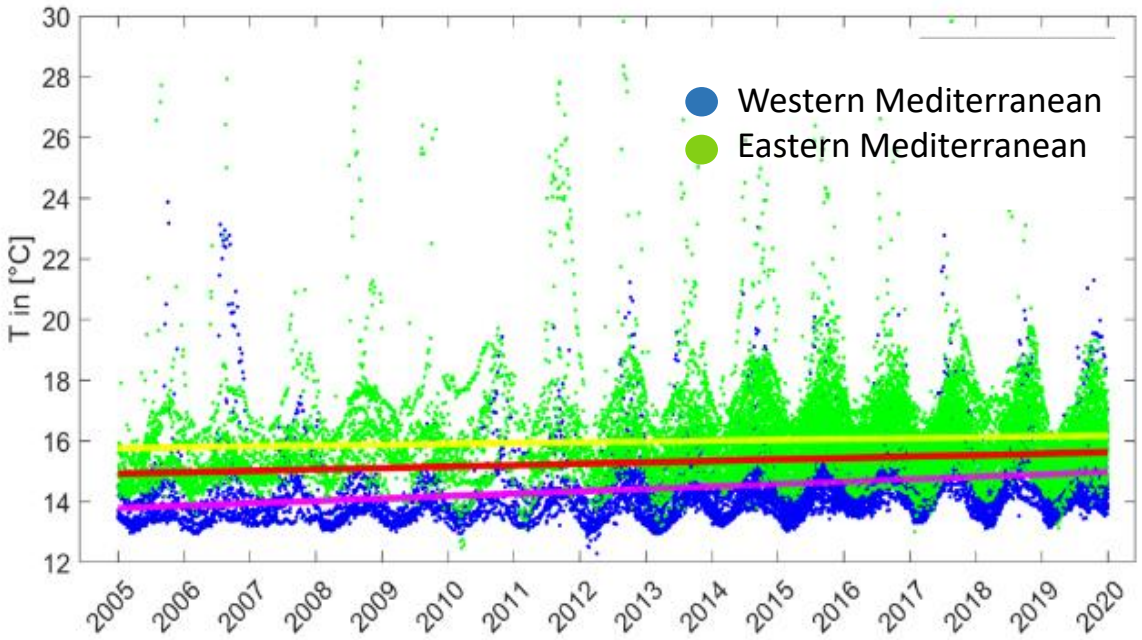


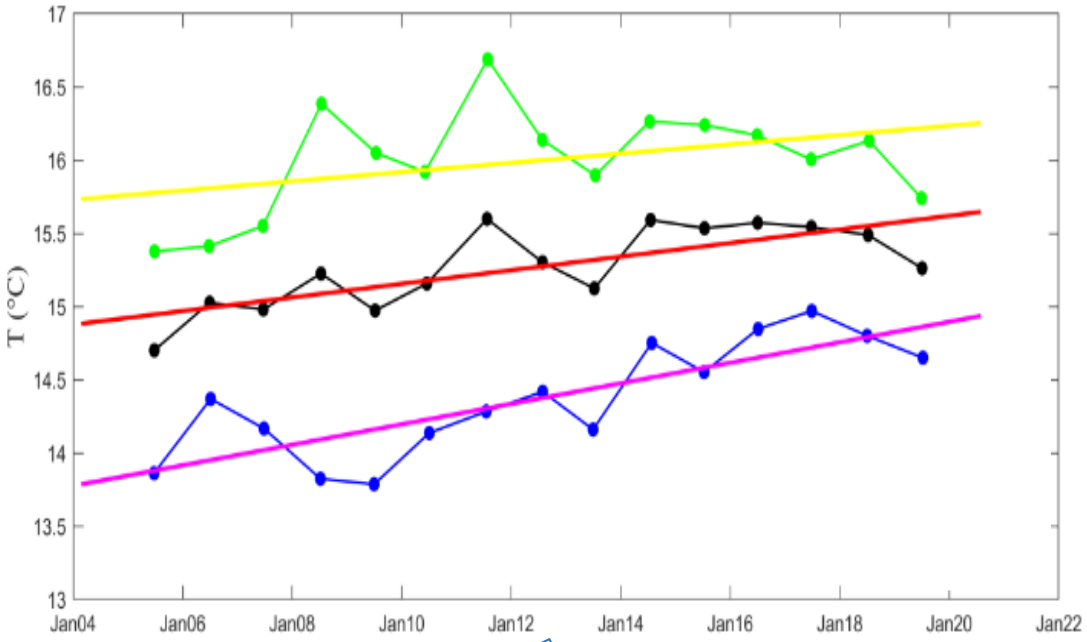
Intermediate layers: *150 – 700 m*



3) Results: Temperature and Ocean Heat Content trends (2005 - 2020)

Surface and intermediate layers: *5 – 700 m*





2005 – 2020

Med Sea:	**0.041 °Cyr^{-1}**	**/ 3.59 Wm^{-2}yr^{-1}**
Eastern Med Sea:	*0.025 °Cyr^{-1}*	*/ 2.18 Wm^{-2}yr^{-1}*
Western Med Sea:	0.070 °Cyr^{-1}	/ 5.72 Wm^{-2}yr^{-1}

DOUBLE!

Copernicus:
Ocean Monitoring Indicator
1993 – 2018 for the Mediterranean Sea:

OHC trend: **1.5±0.2 Wm^{-2}yr^{-1}**

3) Results: Temperature and Ocean Heat Content trends (2005 - 2020)

- Trends for ***deeper layers (700 – 2000 m)*** of the ***entire*** Mediterranean Sea were not significant due to a lack of data.
- The ***deeper layers of the two main Mediterranean deep water formation sites*** (Gulf of Lion, South Adriatic) show ***significant warming***.

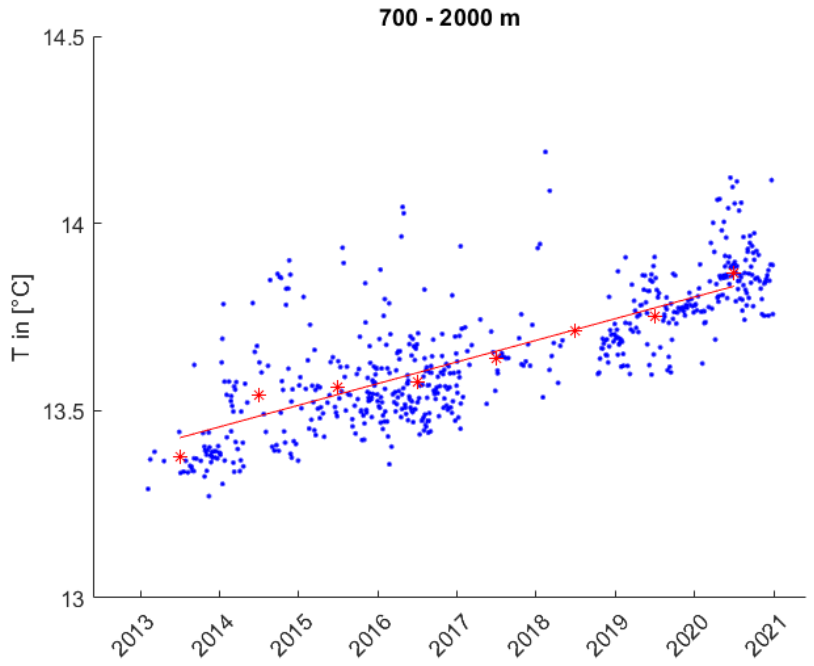
South Adriatic: Deeper layers: *700 – 2000 m*

- ***Example: South Adriatic***

Trends calculated from 2013 to 2020:

Temperature trend: ↑ **0.058±0.005 °C·yr^{-1}**

OHC trend: ↑ **9.43±0.85 W·m^{-2}**



4) Conclusions and Outcomes

- Time series of temperature and OHC from 2005 to 2020 ***reveal significant warming trends and an increase of OHC***: the **upper 700 m** of the Mediterranean Sea show a warming trend of ***0.041±0.012 °Cyr^{-1}***, corresponding to a yearly increase in ***OHC of 3.59±1.02 Wm^{-2}***.

~0.5 °C/decade

- The **upper 700 m** of the Western Mediterranean Sea are warming fastest with an increase in temperature at a rate of ***0.070±0.015 °Cyr^{-1}***, corresponding to a yearly increase in ***OHC of 5.72±1.28 Wm^{-2}***. The Southwestern part of the Western Mediterranean Sea shows the strongest sub-basins warming rate for surface and intermediate layers: ***0.074±0.007 °Cyr^{-1}***, corresponding to a yearly increase in ***OHC of 6.47±0.10 Wm^{-2}***.

- Mixing and convection events transport and disperse the temperature and OHC changes: **significant warming trends** are evident in the **deeper layers (700-2000 m)** of the two deep convection sites in the Mediterranean Sea (Gulf of Lion, South Adriatic), with an exceptionally strong warming trend in the **South Adriatic** from 2013 to 2020 of ***0.058±0.005 °Cyr^{-1}***, corresponding to a yearly increase in **OHC of *9.43±0.85 Wm^{-2}***.

- The warming of different water masses will show its ***feedback on ocean dynamics and the atmosphere (air-sea fluxes)*** in the next years, decades or even centuries when these warming waters spread or re-emerge.

→ ***This will stress ecosystems and accelerate the extinction of several marine species.***

This study should act as another wake-up call for policy makers and society…

.... Together

Thank you for your attention !

... Shift of consciousness

For questions please write to:
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