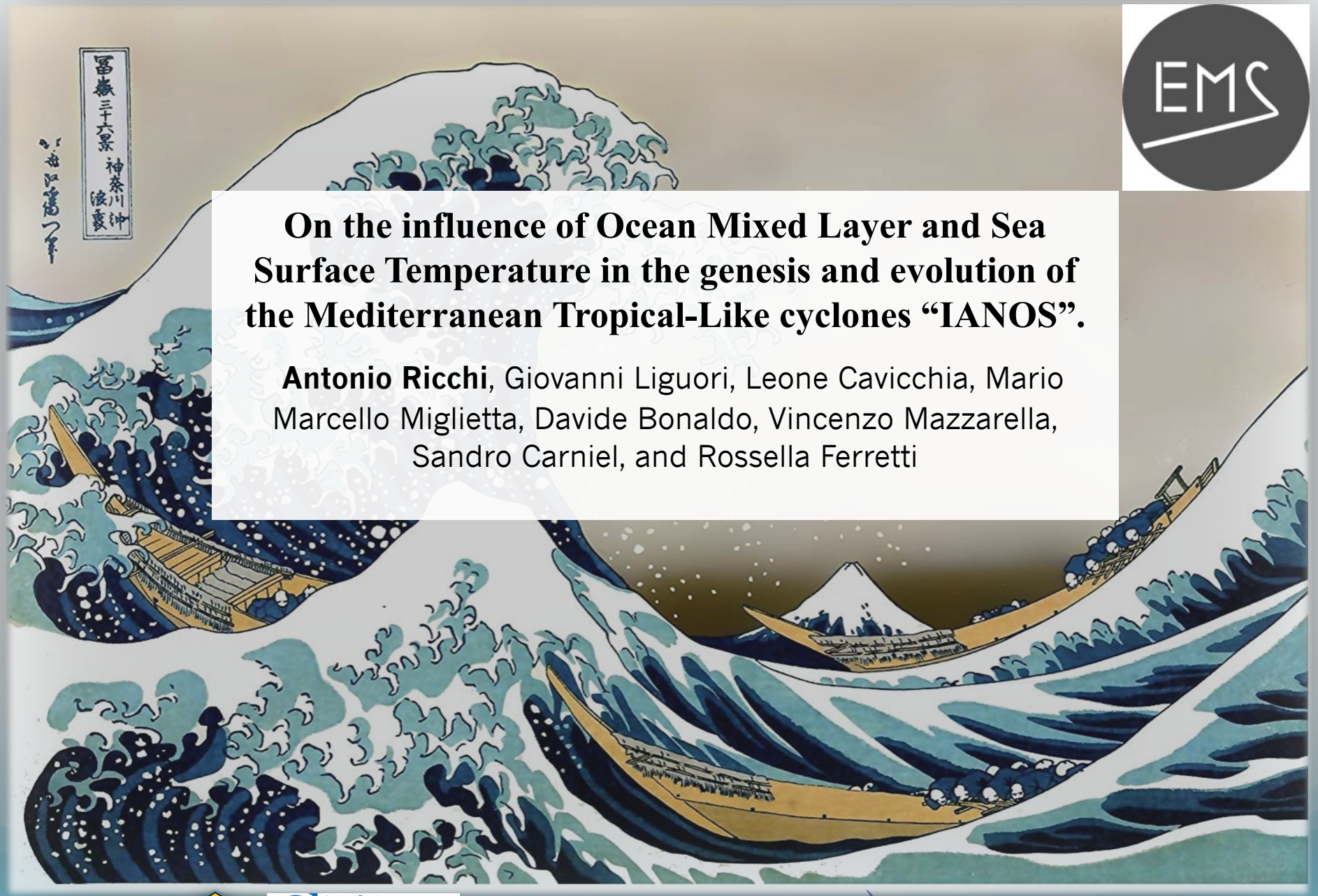


On the influence of Ocean Mixed Layer and Sea Surface Temperature in the genesis and evolution of the Mediterranean Tropical-Like cyclones “IANOS”.

Antonio Ricchi, Giovanni Liguori, Leone Cavicchia, Mario Marcello Miglietta, Davide Bonaldo, Vincenzo Mazzarella, Sandro Carniel, and Rossella Ferretti

Objectives of the study

1. **Investigate the impact of Mixed Layer Depth (MDL) on the genesis of a Tropical-Like Cyclones (TLC)**
2. **Compare the impact of the Sea Surface Temperature (SST) Vs MDL**

State of art (Sea Surface Temperature - SST)

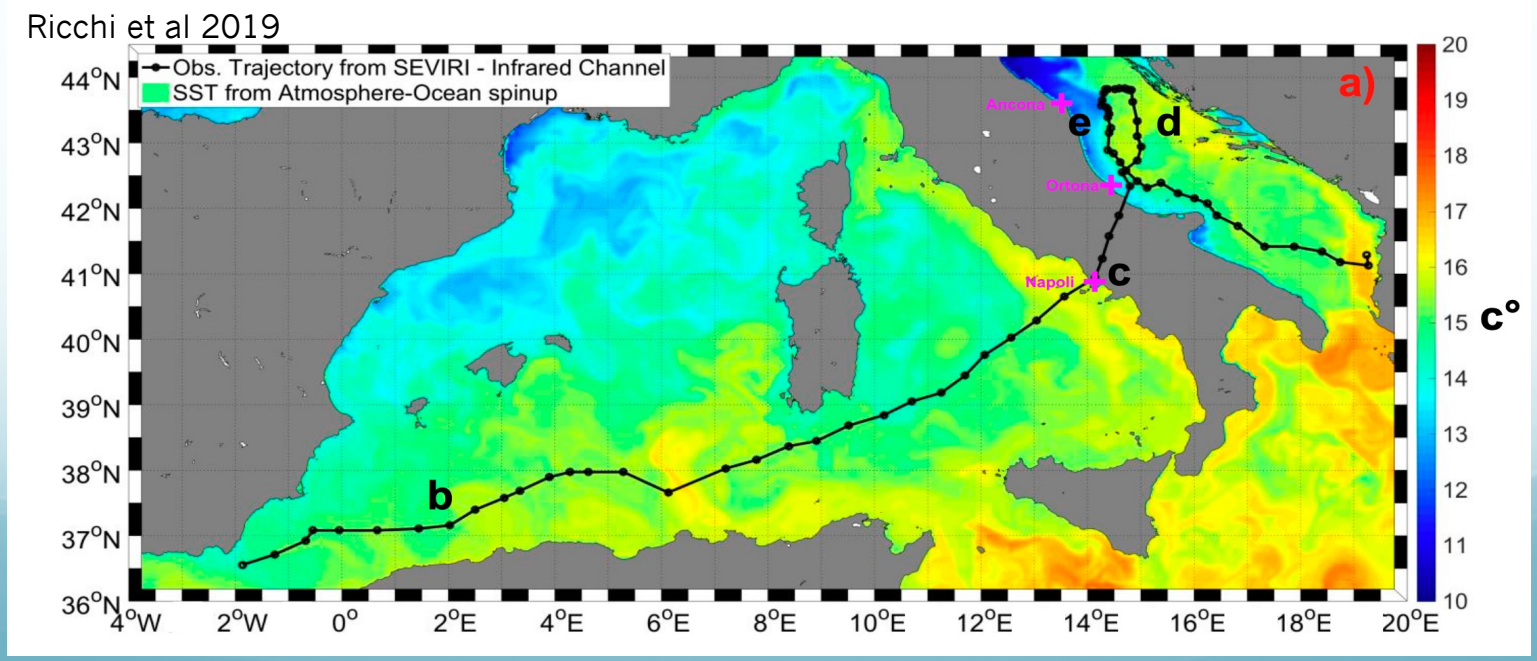
Many studies focused on the impact of Sea Surface Temperature (SST) on trigger mechanism that drive formation and/or intensification of cyclones and other atmospheric phenomena

BUT the study of air-sea interactions is extremely complex, both physically and numerically.

- However, the SST is the variable that interacts directly with the atmosphere and drive the air-sea interaction, it is quite easy to represent in atmospheric models (with numerous techniques), and it is an easy data to find.

- But… the SST represents ONLY the first 2-3 mm of sea.

Ricchi et al 2019



Objectives of the study

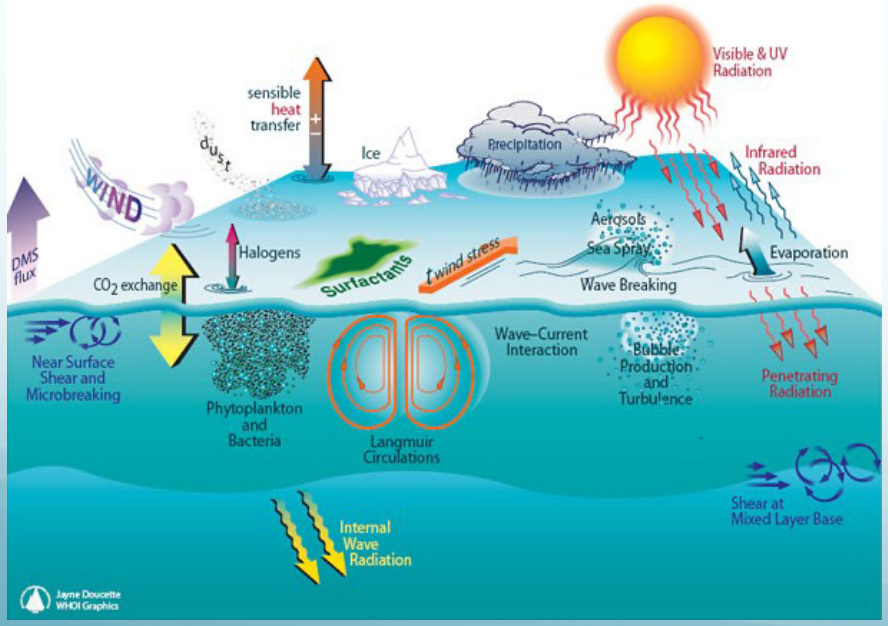
1. **Investigate the impact of Mixed Layer Depth (MDL) on the genesis of a Tropical-Like Cyclones (TLC)**
2. **Compare the impact of the Sea Surface Temperature (SST) Vs MDL**

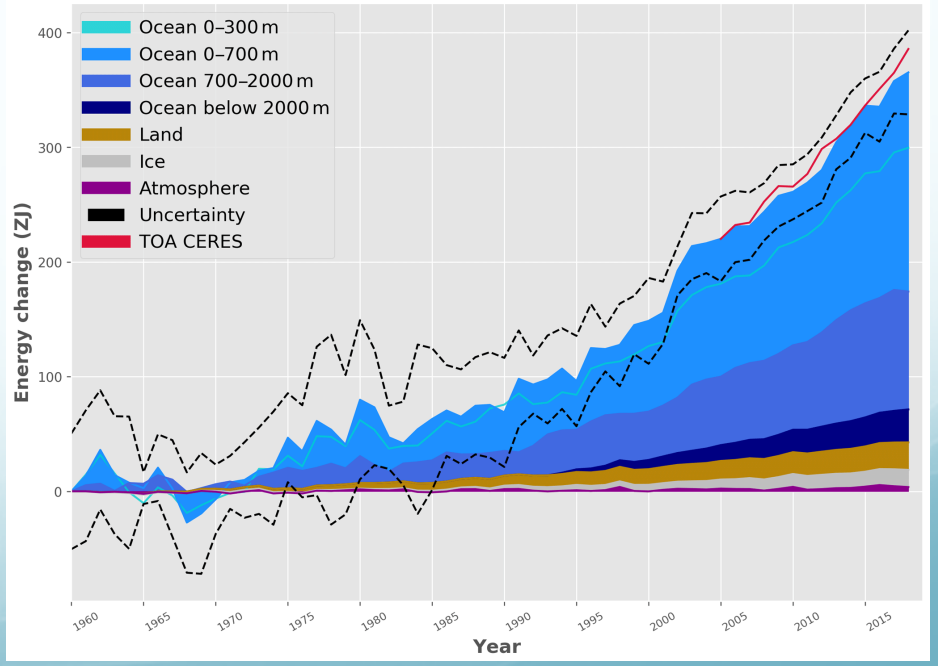
State of art (Ocean Heat Content - OHC)

Ocean is not "two-dimensional» (obviously). Therefore, in the models it should be represented three-dimensionally, to evaluate the impact of the heat it contains, not just the heat on the surface.

The Ocean Heat Content (OHC) plays a crucial role driving the atmospheric dynamics on an event scale up to a climatological scale…***BUT***

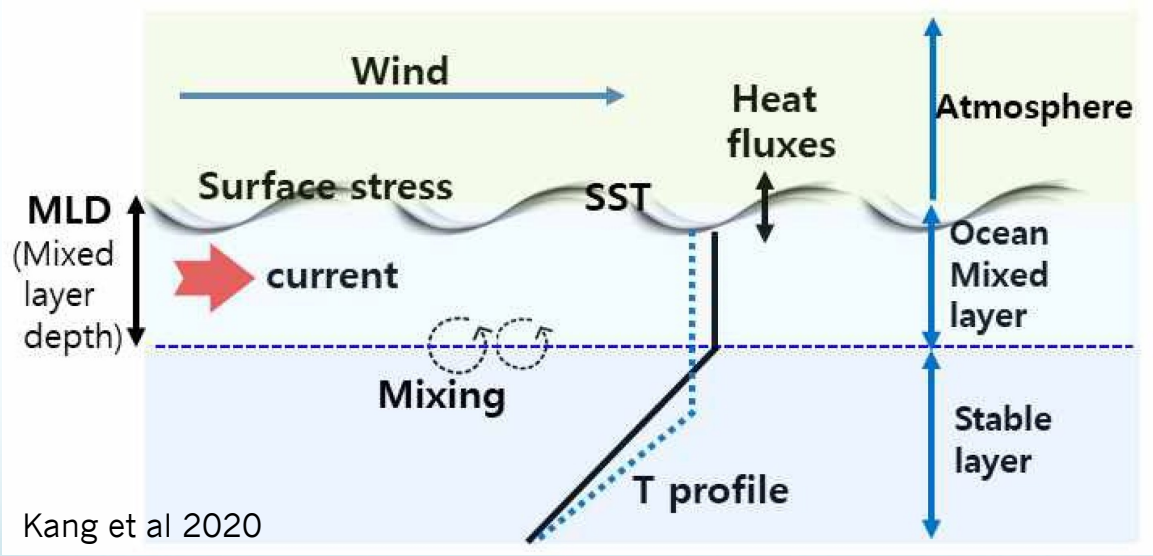
- The OHC is difficult to represent "as it is" in an atmospheric model.
- For this, coupled atmosphere-ocean numerical models are used.
- In the other hand it is complicated, in a coupled model, to isolate the impact of the numerous variables, on a single atmospheric event.





Introduction

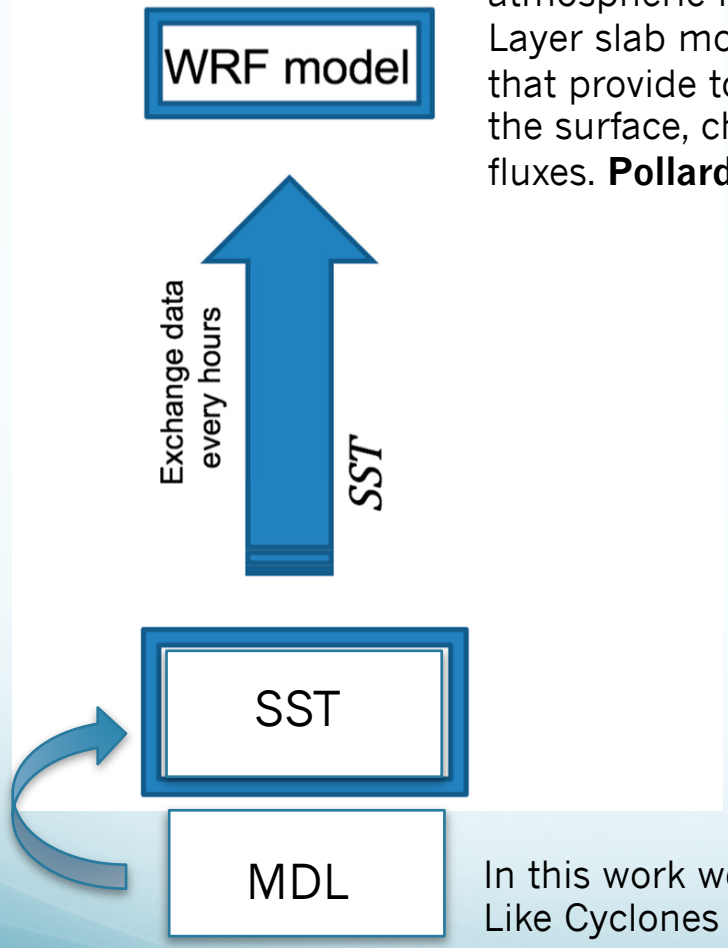
- An intermediate way is to «implement» the OHC using a 1D model, in atmospheric models.
- Using this way we can easily implement the SST variations, caused by heat fluxes and marine mixing, in the atmospheric model.
- It is a «solid», rapid and very representative approach of the heat acting with the atmosphere, in particular for at short time scales (order of days).



Kang et al 2020

Available numerical approach

In this work we use the WRF numerical model, which allows its use of a 1D ocean model, which represents, and processes depth of the Mixed Layer, the SST and the Lapse rate, as influenced by the atmospheric fields (and vice versa). This approach is called OML (Ocean Mixed Layer slab model). OML is a 1D ocean model «***coupled***», inside atm model, that provide to exchange the heat from mixed layer to the atmosphere, through the surface, changing the SST value for each grid point, driving by atm. heat fluxes. **Pollard et al. (1973)**



The limitations are:

1. Fixed MDL in space (over all domain)
2. No advection in ocean
3. No direct waves effect (but it is parameterized according to the rougheness scheme)

In this work we use this approach to study the impact of the MDL on Tropical-Like Cyclones "IANOS" which took place between 14 and 20 September 2020.

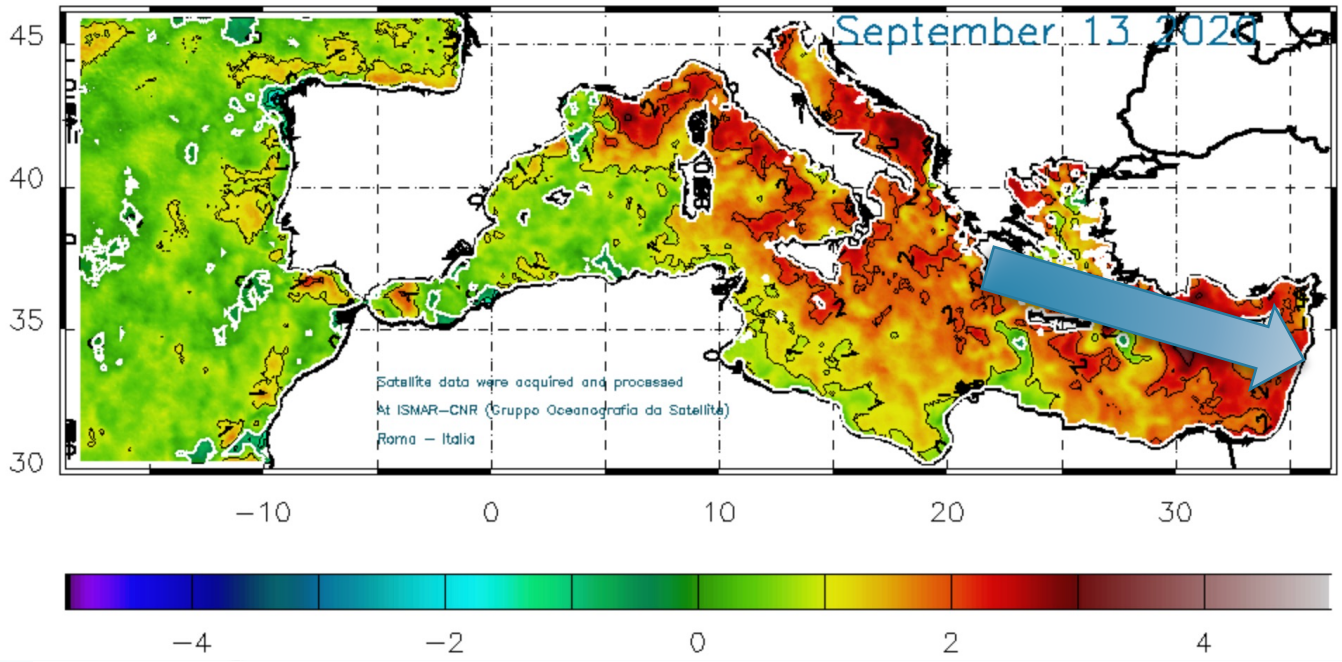
The IANOS Tropical-Like Cyclone (TLC)

- 14-20 September 2020 on the southern Ionian Sea
- Winds up to 140 km/h and pressure minimum around 980 hpa (durante il landfall), wave Hs greater than 9 meters (model estimate).
- Intensified without an apparent ground trigger (unlike how it happened in the case of Zorbas TLC during Sept. 2018 over same area).
- SST anomaly recorded over the Ionian before IANOS up to +2 ° C
- SST anomaly recorded over the Ionian after IANOS up to -2 ° C...
- Probably show a fully tropicalization caracter. in the most intense phase

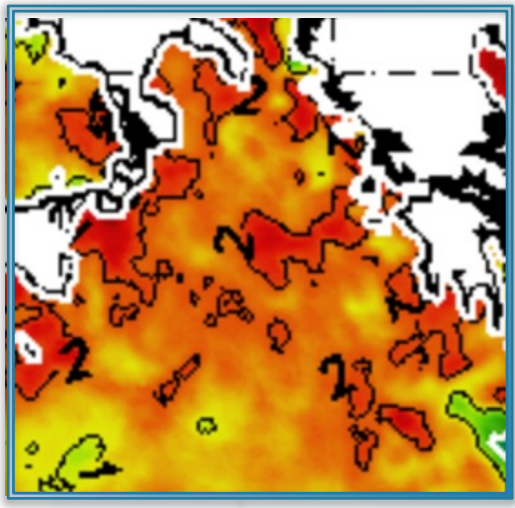


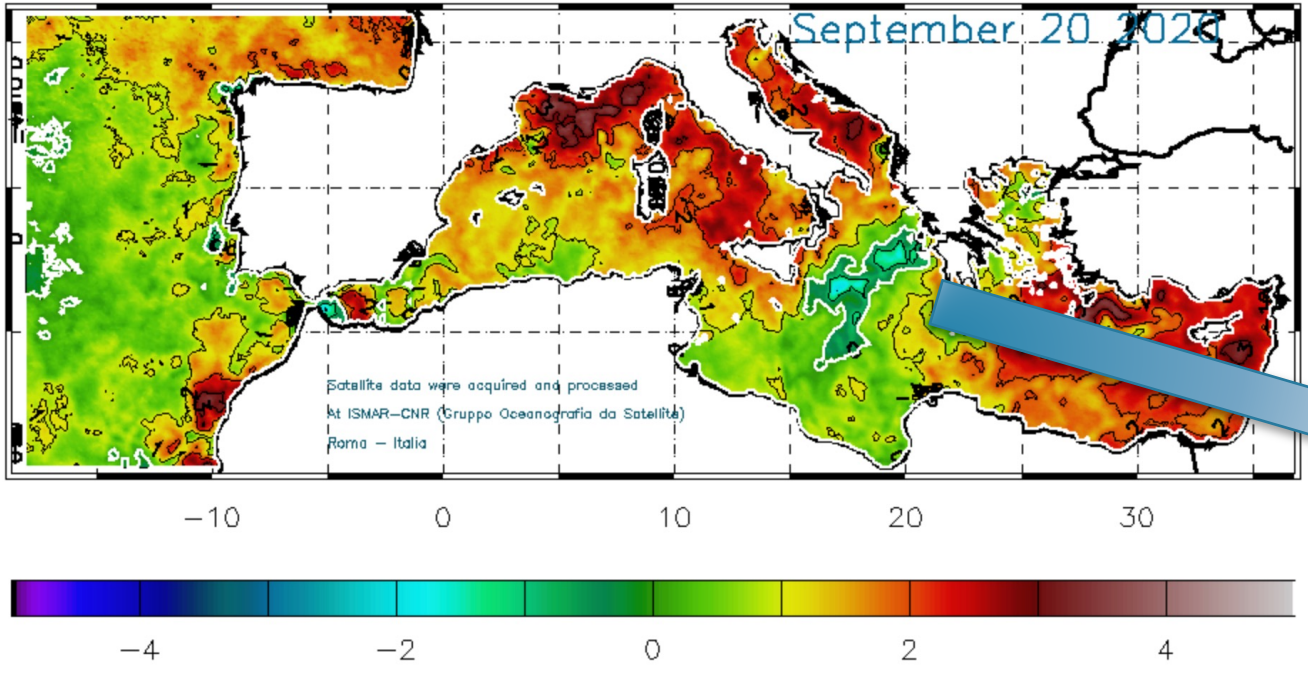


IANOS - Sea Surface Temperature Anomaly (SST anomaly)

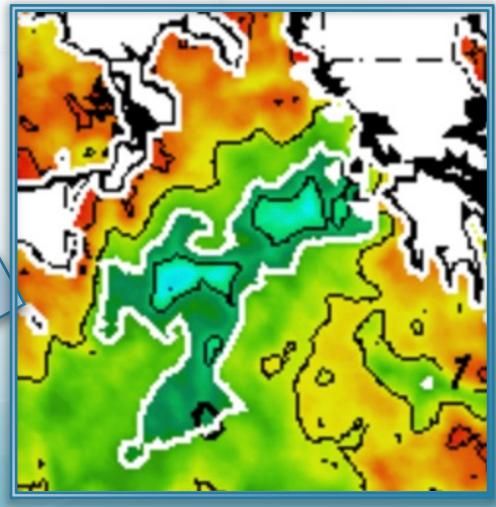


Anomaly SST 13 Sept (+2 °C)

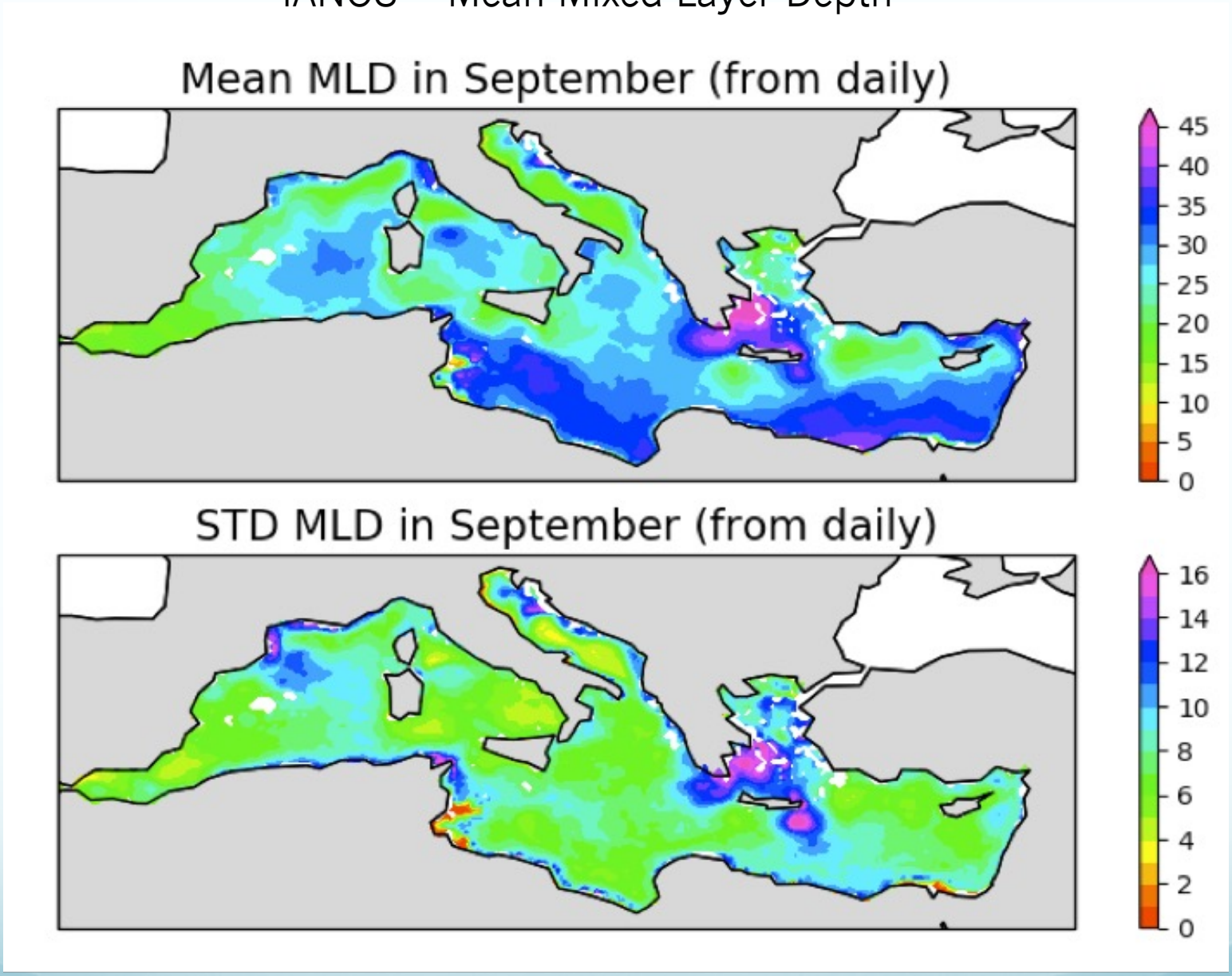




Anomaly SST 20 Sept (-2°C)

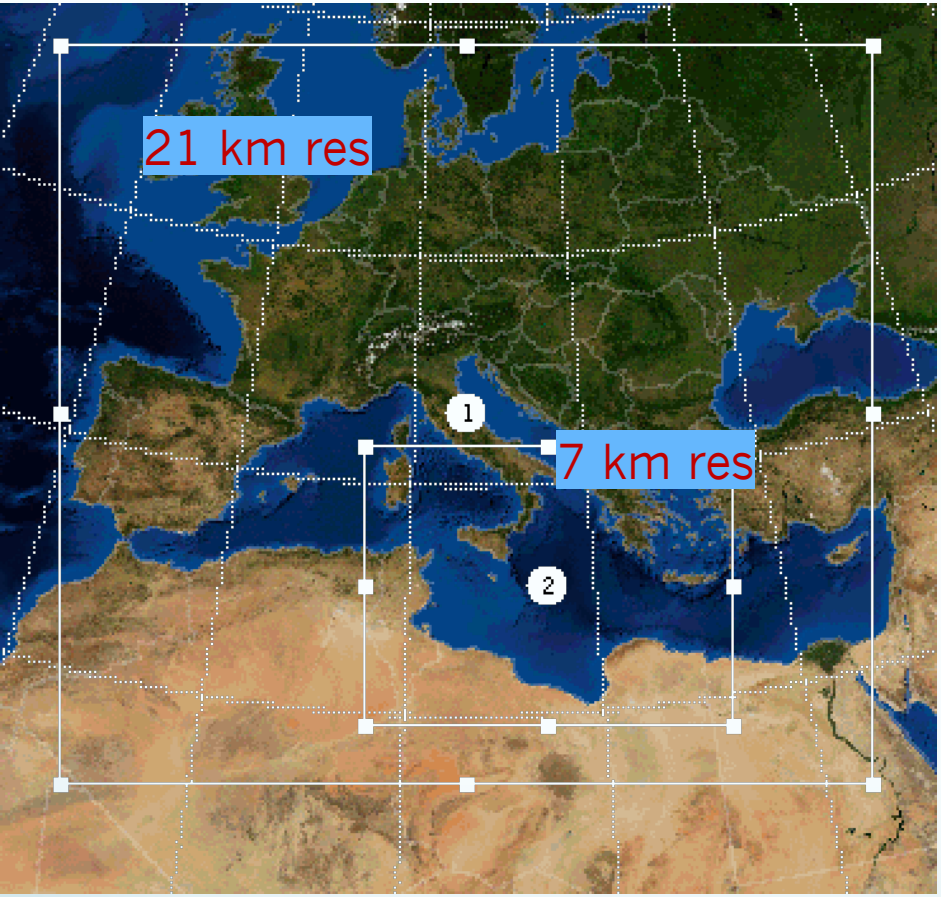


IANOS - Mean Mixed Layer Depth



Mixed Layer Depth (and STD MDL) for September estimated from CMEMS Ocean Model - climatology based on 1979-2019 period

IONAS - WRF CONFIGURATION



Res = 21-7km
MP = 8
CU=Kain (1)
PBL = (MJY)
75. vert. Levels (with first level at 15 mt above the sea).
OML Activated (Prince 1981)
Radiation : LW 4, SW 4
SST from CMEMS Copernicus (4.5 km res)
Init. GFS-FNL 0.25 deg

OML (Simple Ocean Model, or slab ocean model) simplified 1D model that change SST starting from Net Heat Fluxes, Mixed Layer Depth and Lapse rate (most common (or…defaut option in WRF model) value is 50 mt for MDL and Lapse Rate 0.14).

Approach : MDL 10 mt, 25 mt, 50 mt, 100 mt, SST +1°C (MDL 50 mt), SST +2°C (MDL 50 mt)