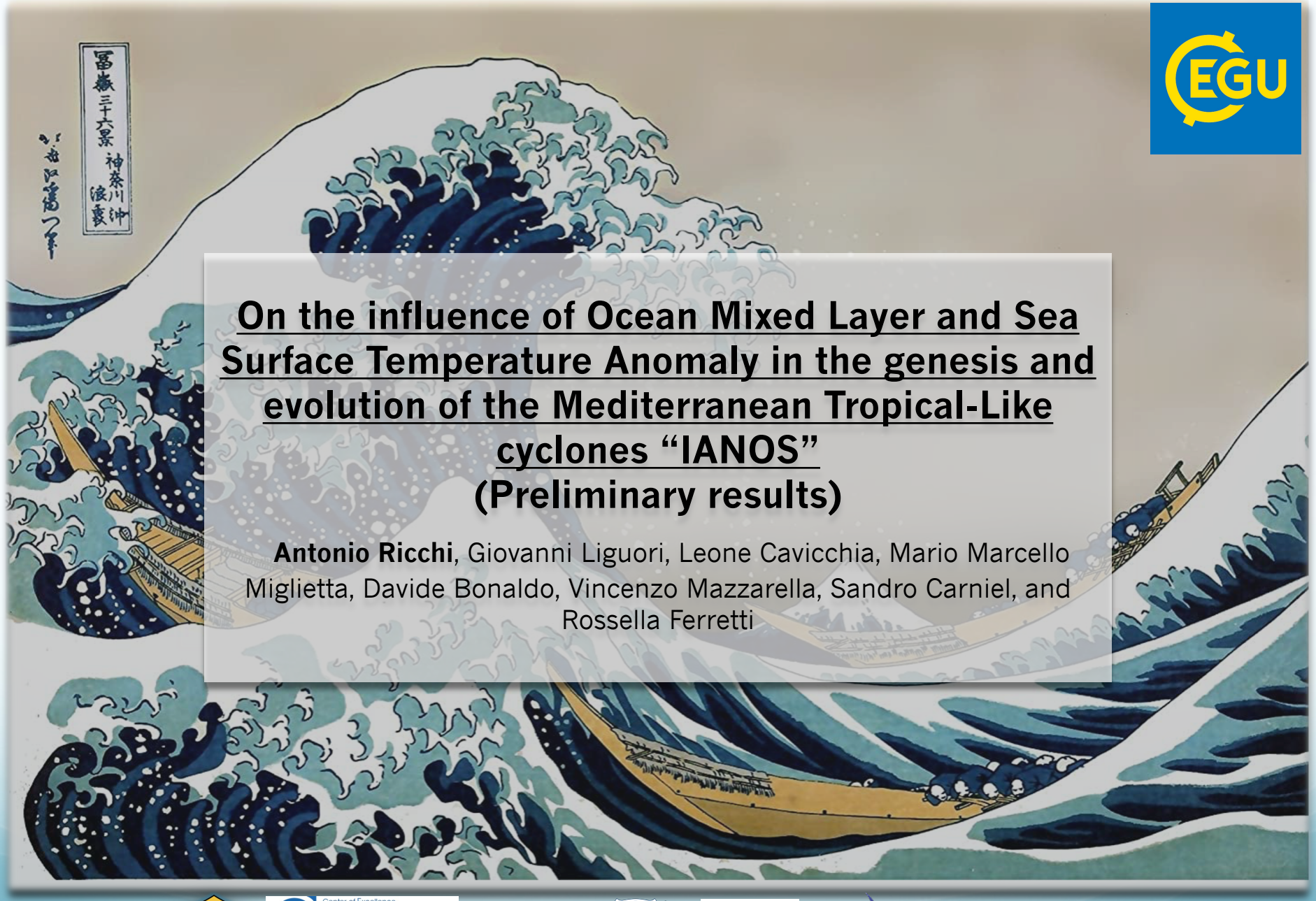

On the influence of Ocean Mixed Layer and Sea Surface Temperature Anomaly in the genesis and evolution of the Mediterranean Tropical-Like cyclones "IANOS" (Preliminary results)

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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

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

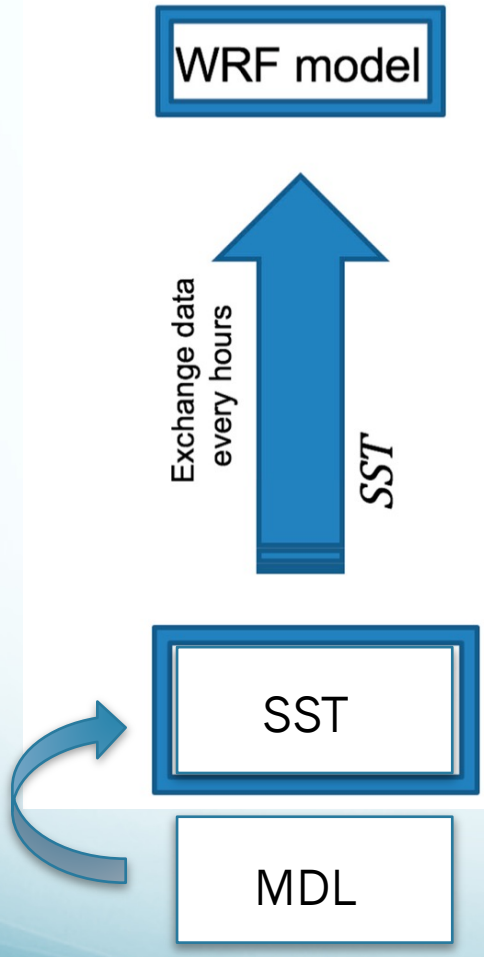
1) using numerical models that implement the SST and do not update it over time. Or...
2) using coupled numerical models (atmosphere-ocean, at best!)

- The SST is very important and plays a fundamental role in the intensification of TC and TLC.
- **but the ocean is three dimensional and we cannot use a two dimensional approach (using only SST) to study some energy exchanges.**
- **BUT in the other hand, in some cases, using fully-coupled models (atmosphere-ocean-waves) is counter-productive, because it does not allow us to focus on a single physical dynamic.**
- **for these reasons it is important to implement the Ocean Heat Content (3D content of heat in first tens of meters of ocean) in an atmospheric model.**

"Open questions"

- *What is the impact of the MDL depth on the dynamics of the TLC*
- *«Comparison» MDL Vs SST impact on cyclone caracteristics*

Available numerical approach



OML (Ocean slab model) is a 1D ocean model «coupled» in WRF that provide to exchange the heat from mixed layer to the atmosphere through the surface, changing the SST for each grid point, driving by atm. heat fluxes. **Pollard et al. (1973)**

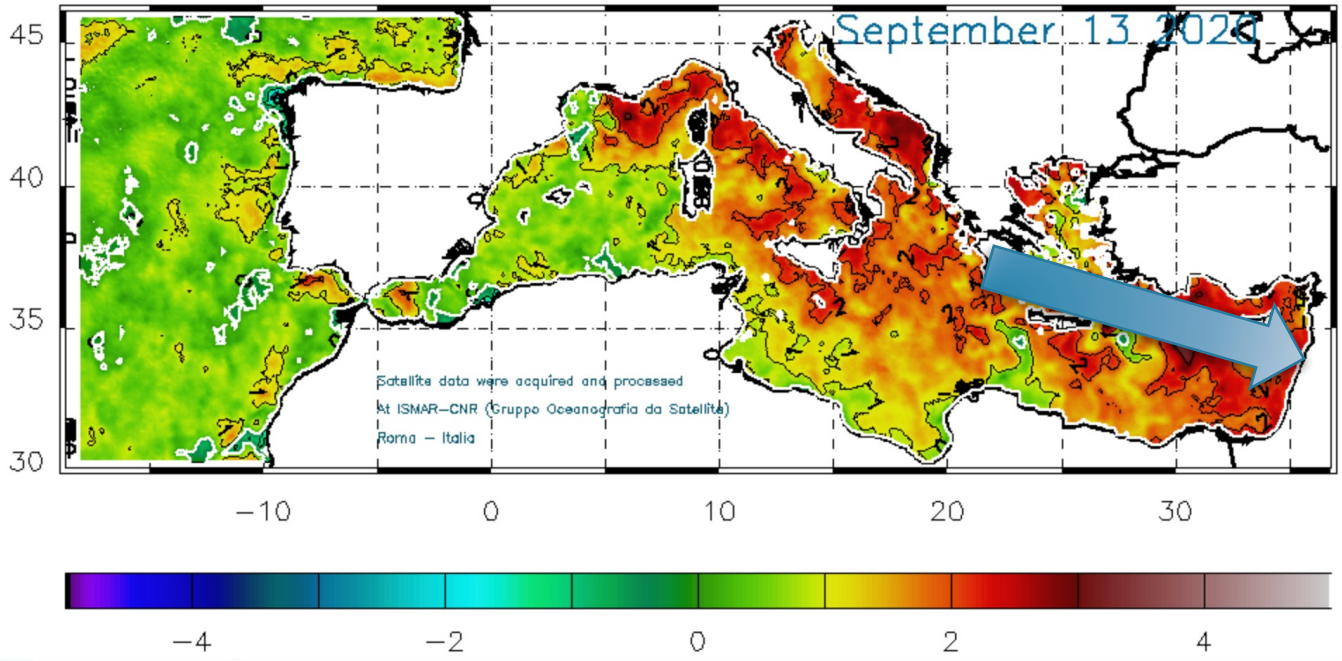
1) Fixed MDL
2) Updated SST
3) No advection in ocean
4) No waves effect

This numerical approach is the most "rigorous/simple" for these studies. Using a coupled model and imposing an MDL of 100 meters (for example) This MDL would settle on other depths during the spinup of the ocean model, which can last several months.

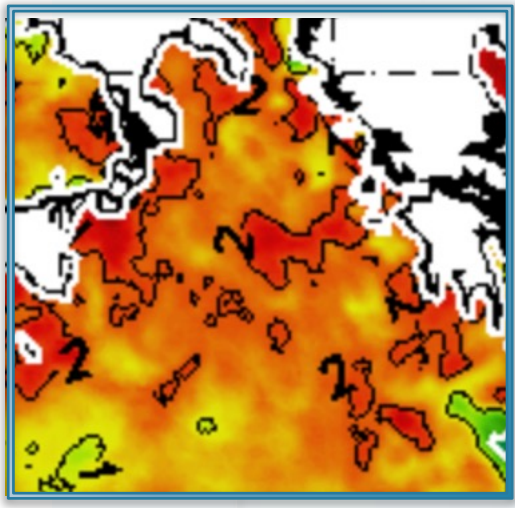
The IANOS Tropical-Like Cyclone (TLC)

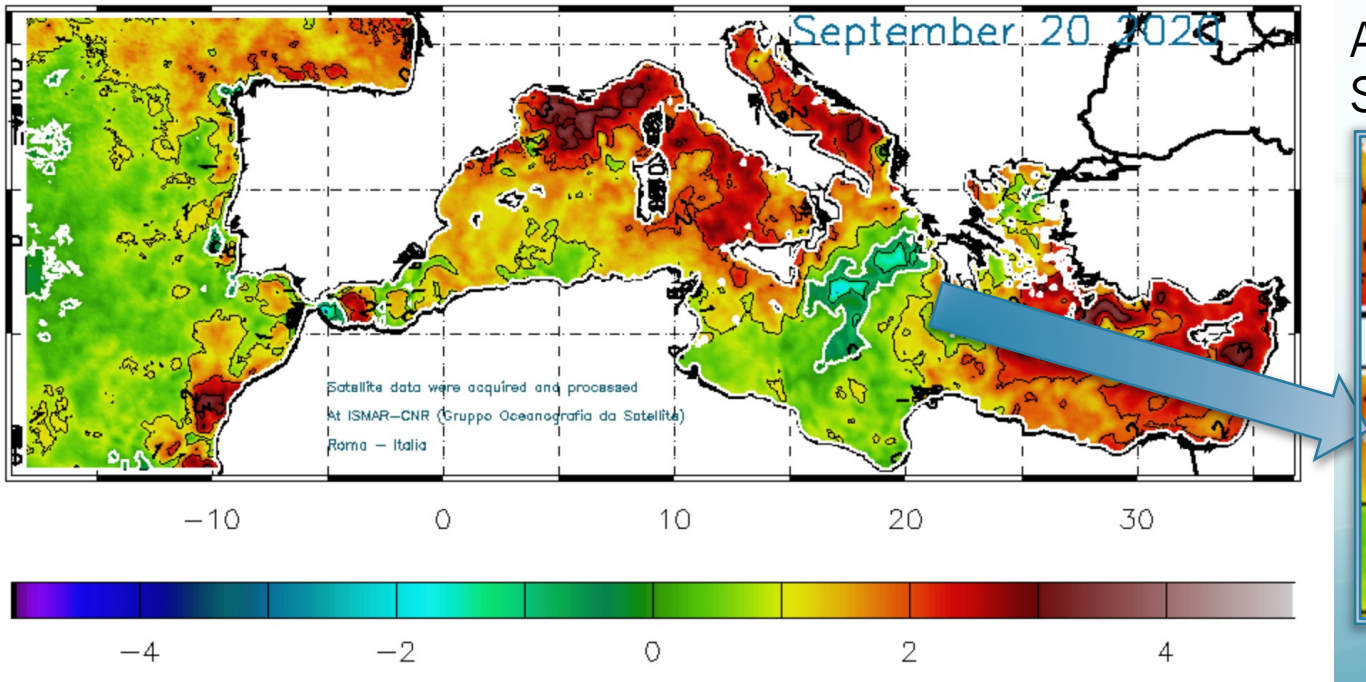
- 14-20 September 2020 on the southern Ionian Sea
- Winds up to 120 km/h and pressure minimum around 980 hpa, wave Hs greater than 9 meters (model estimate).
- Intensified without an apparent ground trigger (unlike how it happened in the case of Zorbas TLC during Sept. 2018 over same area).
- SST anomaly 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)

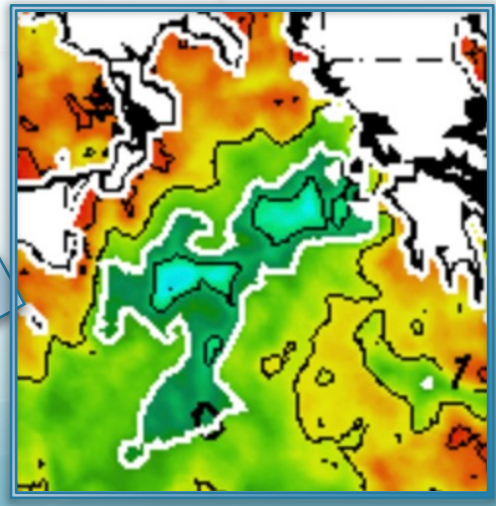


Anomaly SST 13 Sept (+2 °C)

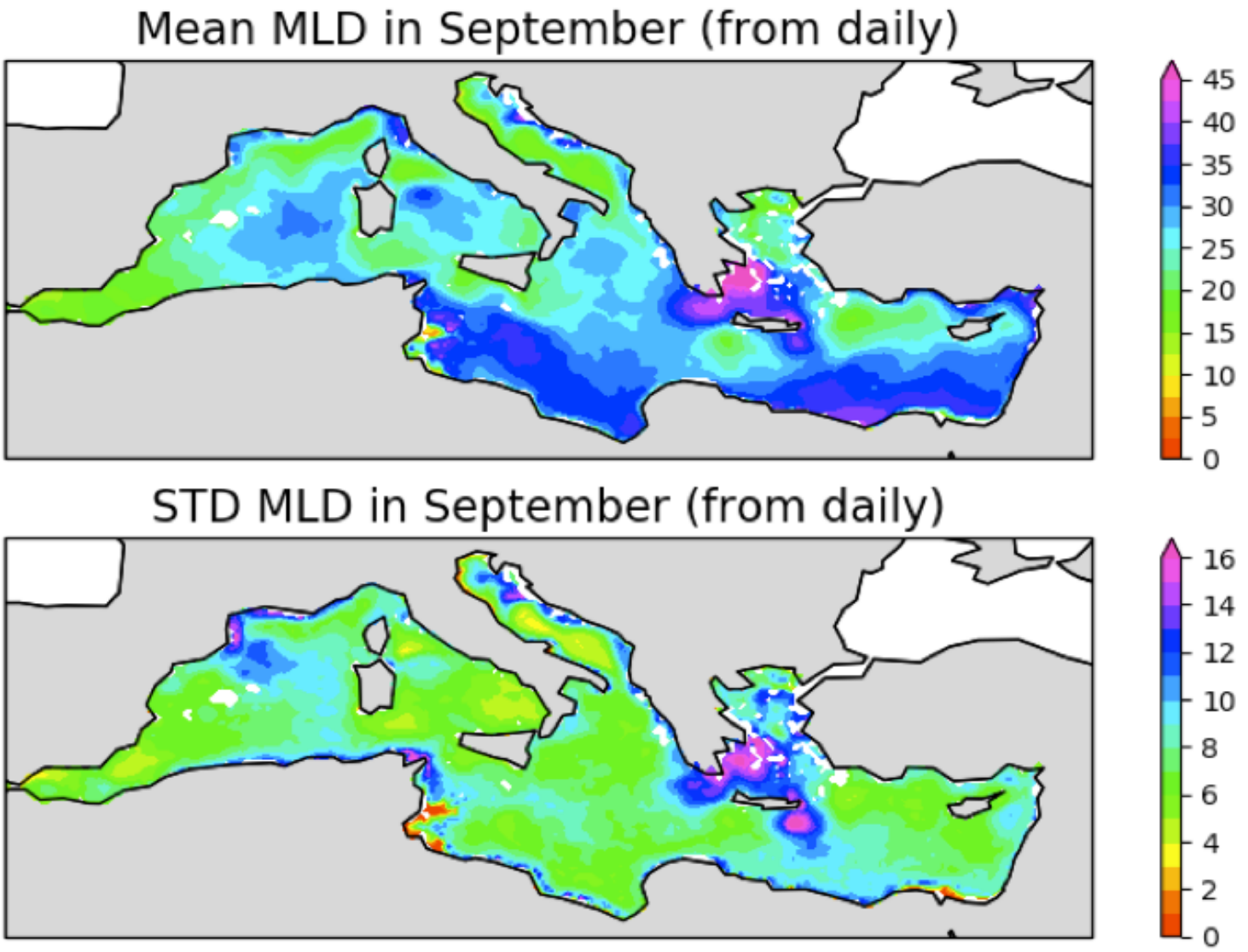




Anomaly SST 20 Sept (-2°C)

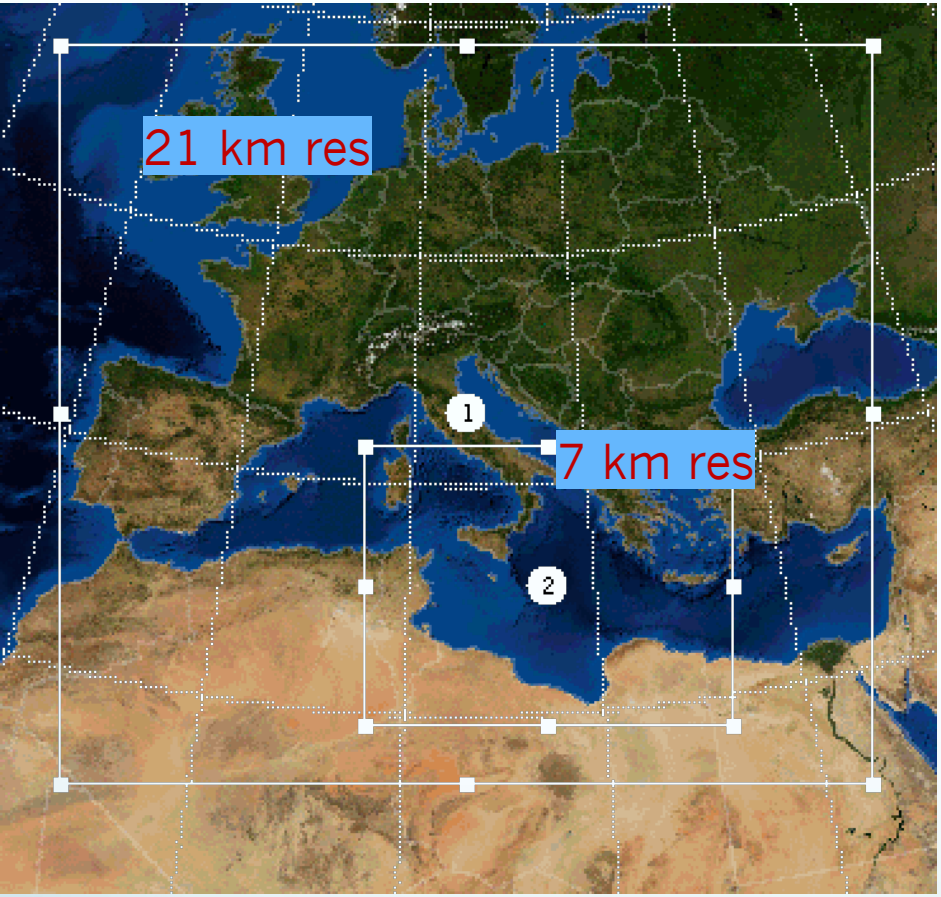


IANOS - Mean Mixed Layer Depth



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

IONAS - WRF CONFIGURATION

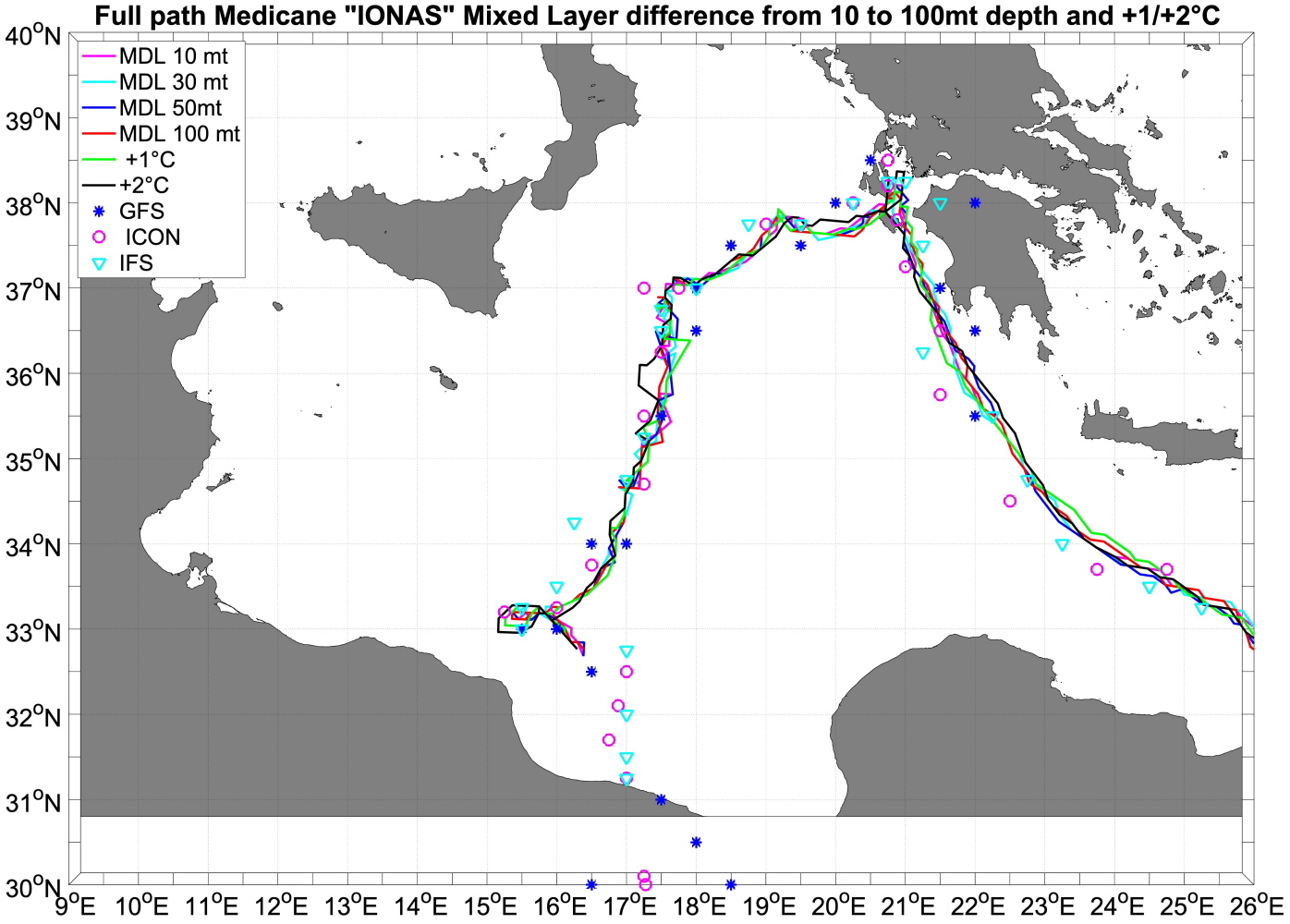


Res = 21-7km
MP = 8
CU=Kain (1)
PBL = (MJY)
75. vert. Levels (with first level at 15 mt above the sea).
OML Activated (Prince 1981)
Radiation : LW 4, SW 4
SST from MFS Copernicus (4 km res)
Init. GFS-FNL 0.25 deg

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, 30 mt, 50 mt, 100 mt, SST +1°C (MDL 50 mt), SST +2°C (MDL 50 mt)

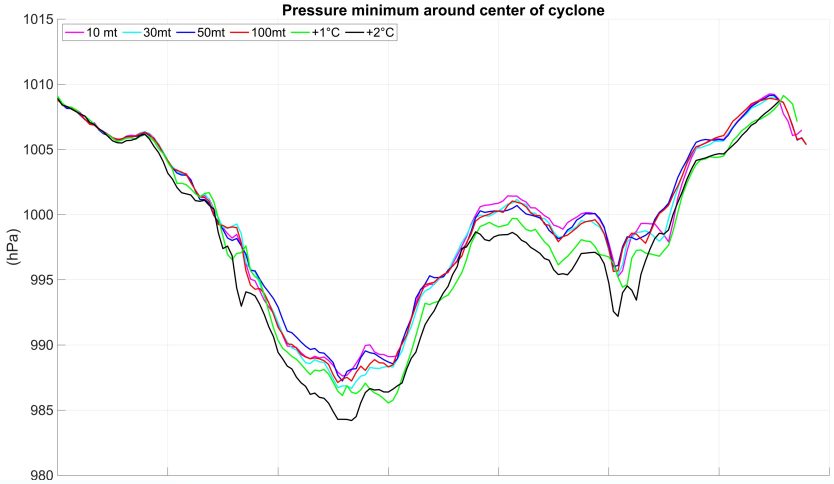
RESULTS – Track Different approach

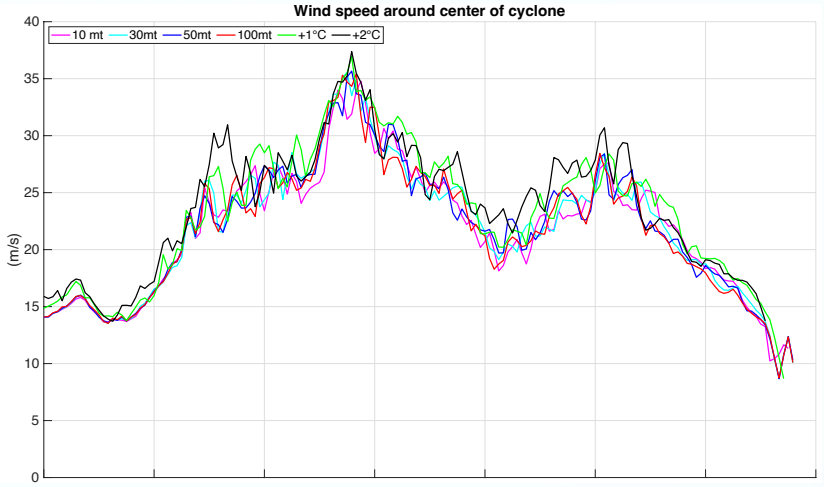


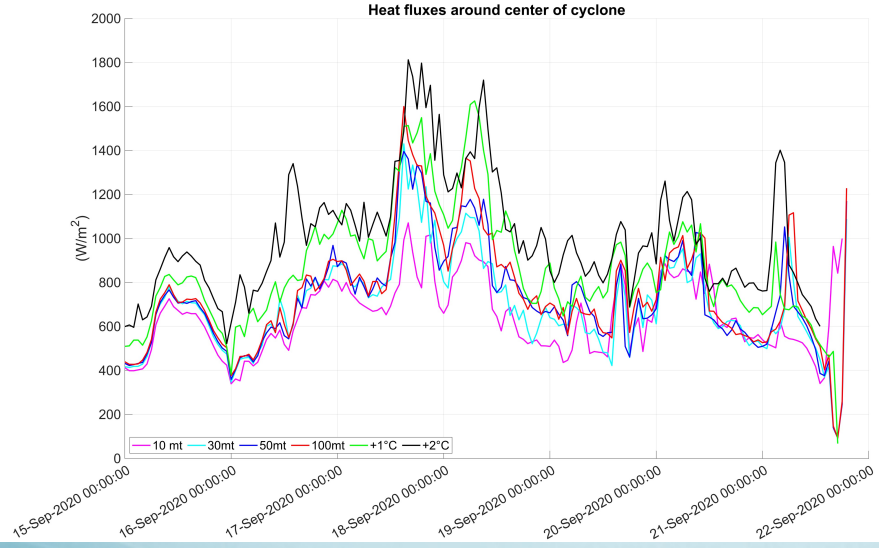
The track of the TLC are very similar, MDL and SST do not significantly impact the development of the TLC in terms of trajectory and landfall

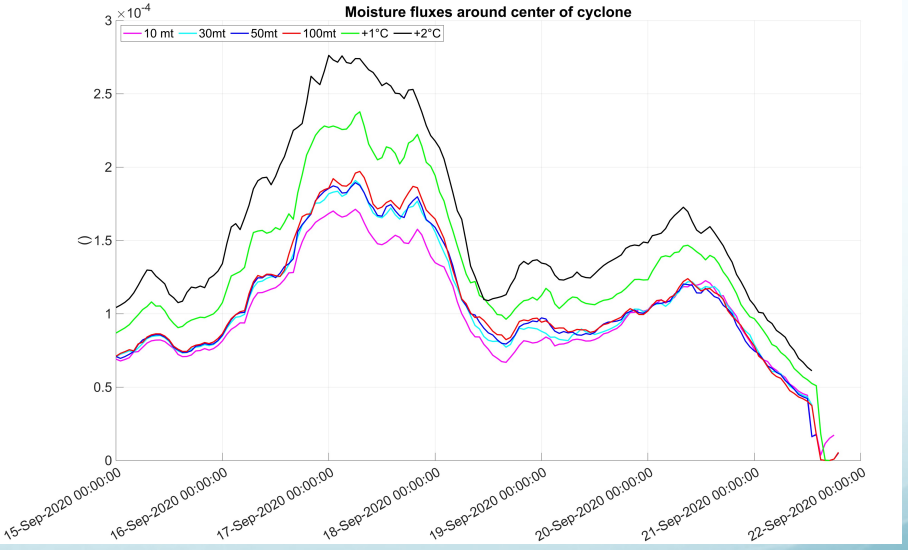
Thanks to Philipp Zschenderlein and DynForMed initiative for Global model TLC track

RESULTS – Around the center cyc (radius 200km)





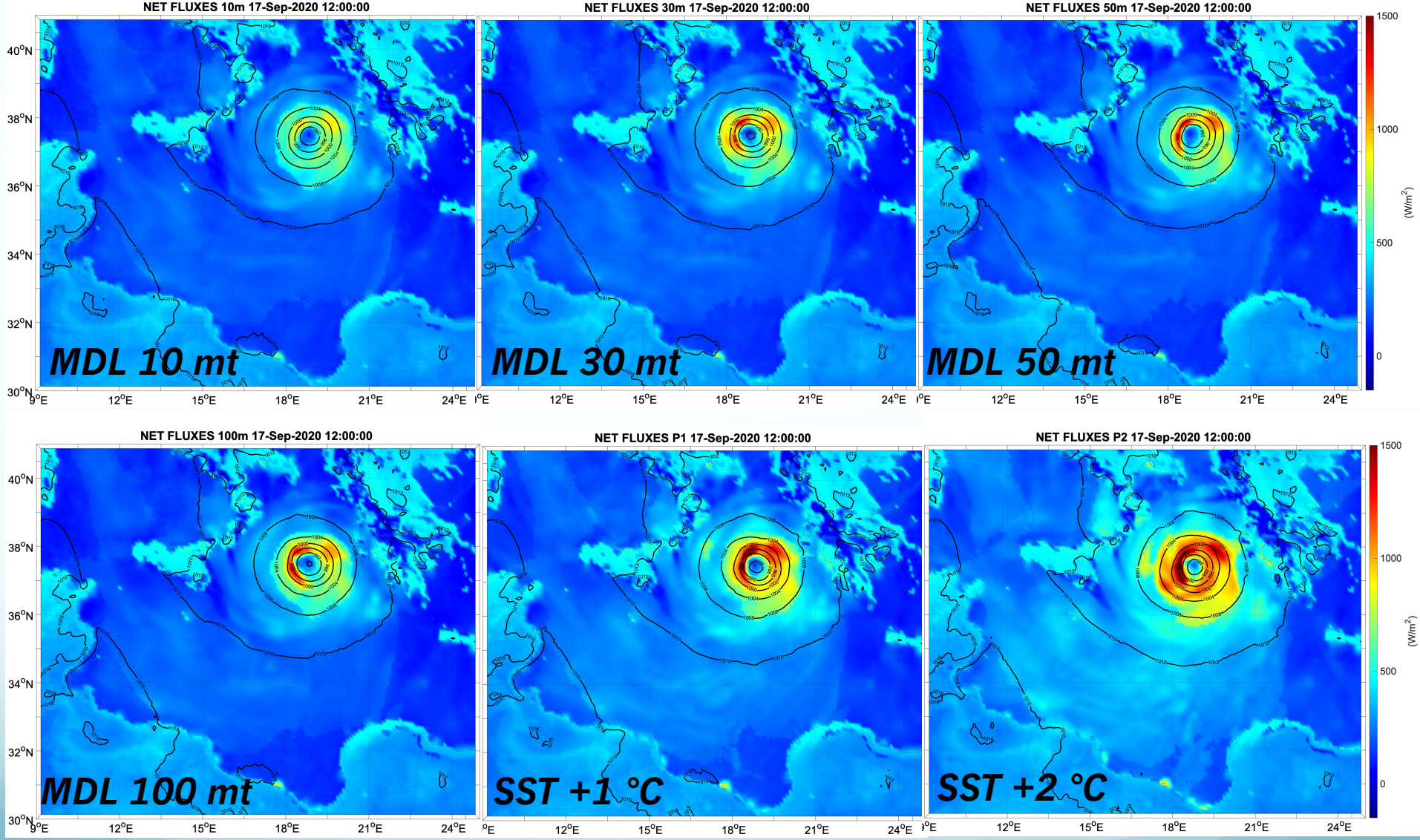




- If the SST increases, the heat fluxes increases, and the intensity of the cyclone increases.
- The increase in the depth of the MDL only impact the heat and moisture fluxes,

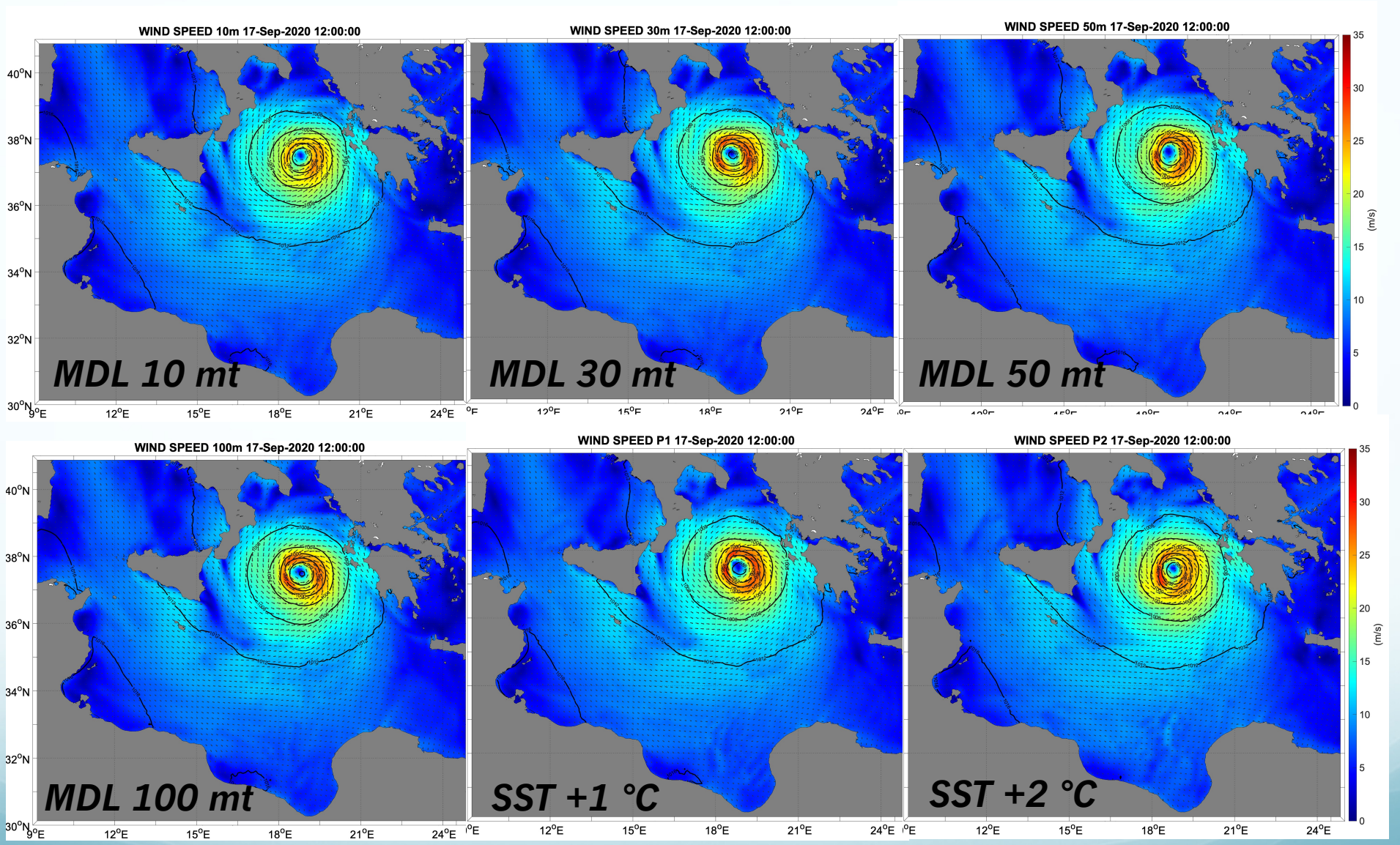
but it does not seem to have a significant impact in term on the intensity of the cyclone.

RESULTS – Net Heat fluxes at interfaces



The distribution and the value of the net heat fluxes increases as the depth of the MDL increases and as the SST increases. *SST is much more effective*

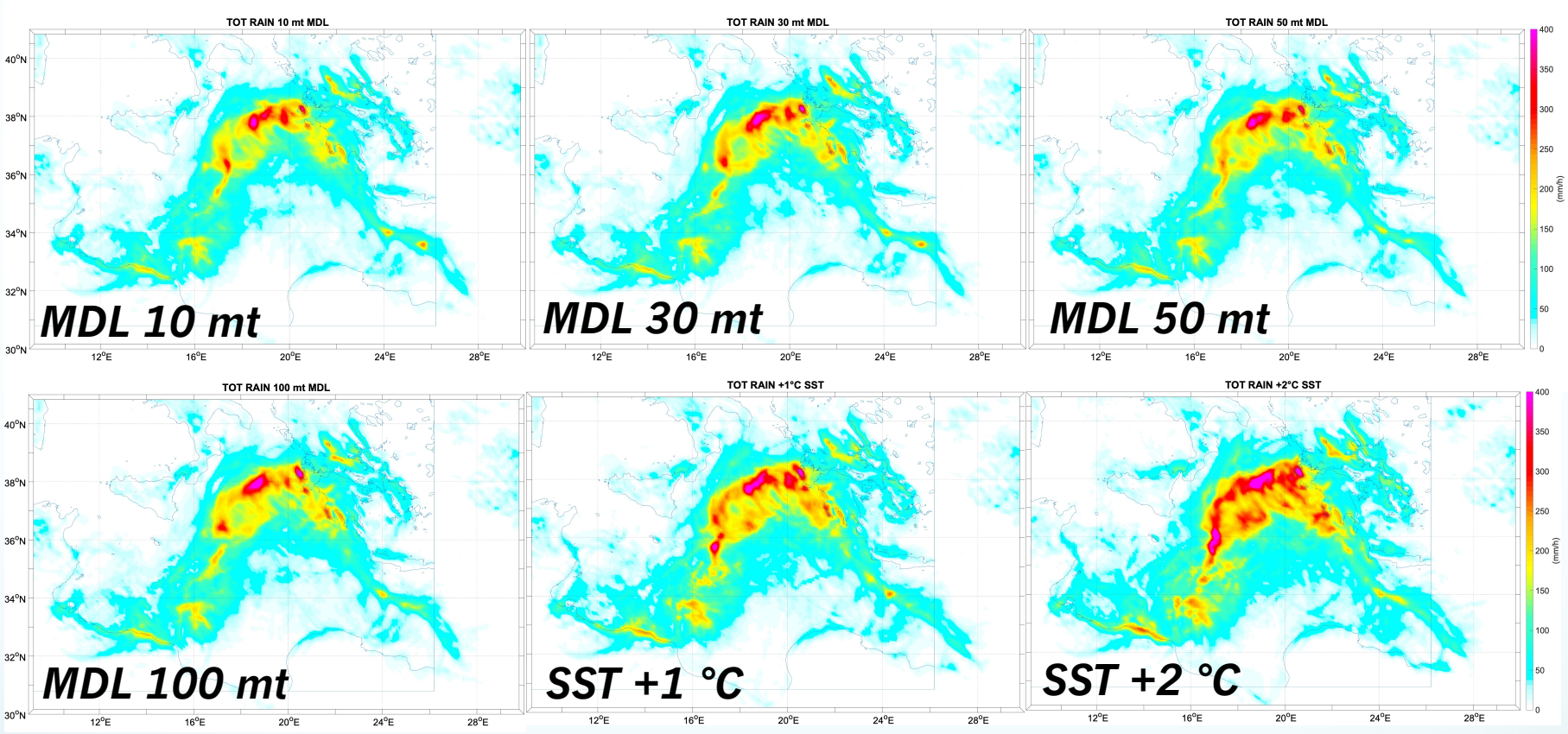
RESULTS – Wind Speed at 10 mt



Maximum value of wind speed around the TLC it's the same (or very simular) but the distribution of the wind around the cyclone is very different in the various cases

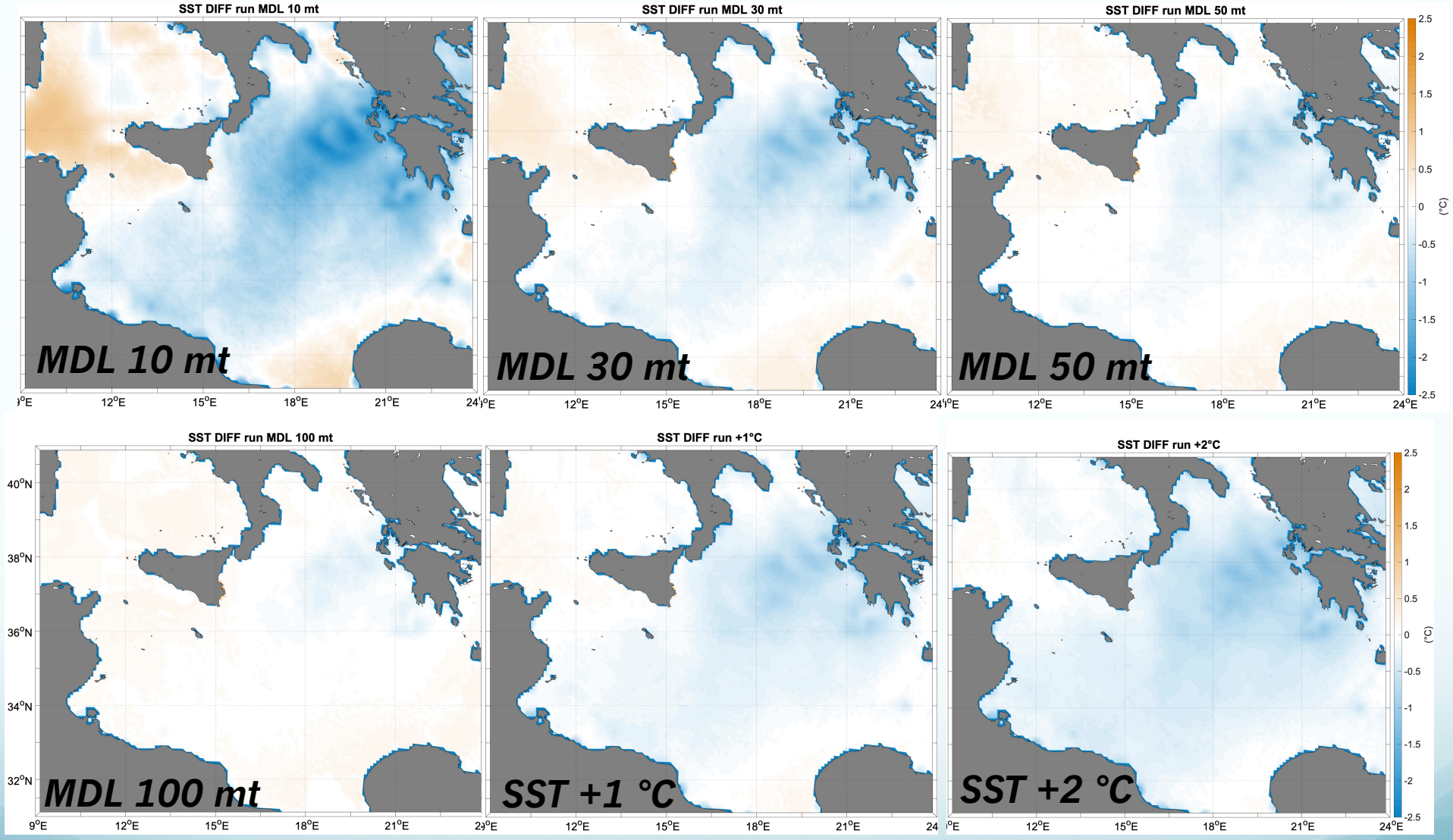
more extensive with deeper MDL, more extensive and intense with higher SST

RESULTS – Total accumulated precipitation



As the MDL increases, the cumulate rainfall increase, in particular the "convective" rain component. Higher SST increases heat and moisture fluxes, and consequently, precipitation increases.

RESULTS – SST change (case – CTL)



SST differences from the 14/09/2020 to 19/09/2020

PRELIMINARY…CONCLUSION

- The depth of the MDL is very important under the point of view of the ***heat content in the ocean***, but the heat transfer from the ocean depth to the surface (and atmosphere) act slower if compared with the impact/reaction of the SST.

- The development and evolution of TLC could only be partially driven by the MDL in particular on the structure of the TLC, on the precipitations and on the intensity of the heat and humidity fluxes
- it impacts VERY little on trajectory and timing of the cyclone.

Difference in SST (19-14 sept) are highter where the MDL is lower, but in this case fluxes, wind and rain are lower if compared to other MDL CTL run.

- Probably because thin MDL exchange quickly the heat content and therefore also to the SST. As the MDL depth increases, the SST cools more slowly, although the amount of heat supplied by the sea to the atmosphere is greater.