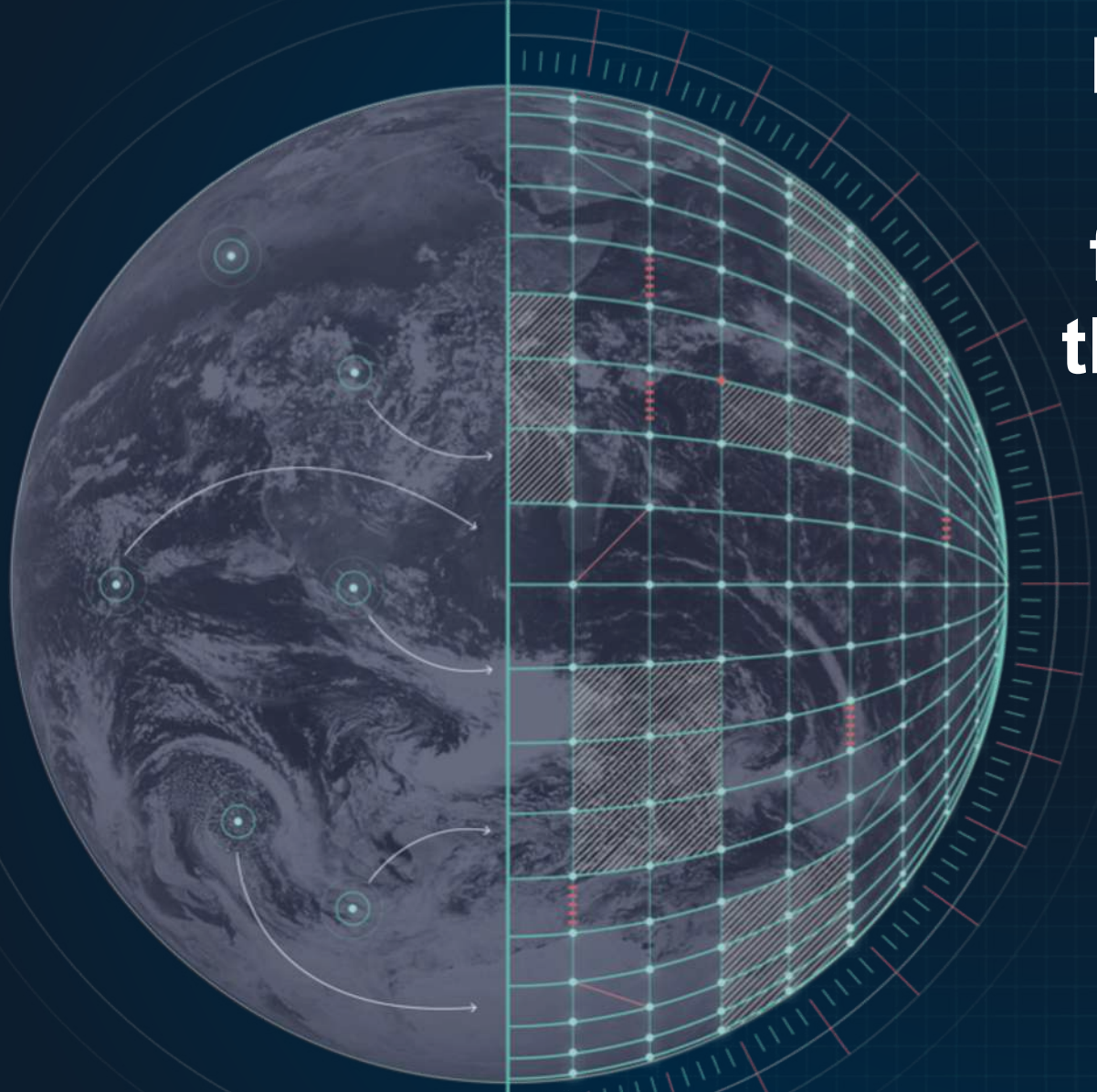
DESTINATION EARTH



Extreme weather forecasting at kilometre-scale: insights from two case studies within the Destination Earth Initiative

Estibaliz Gascon, Michael Maier-Gerber, Benoît Vannière, Irina Sandu, Linus Magnusson, Josh Kousal, Kristian Mogensen

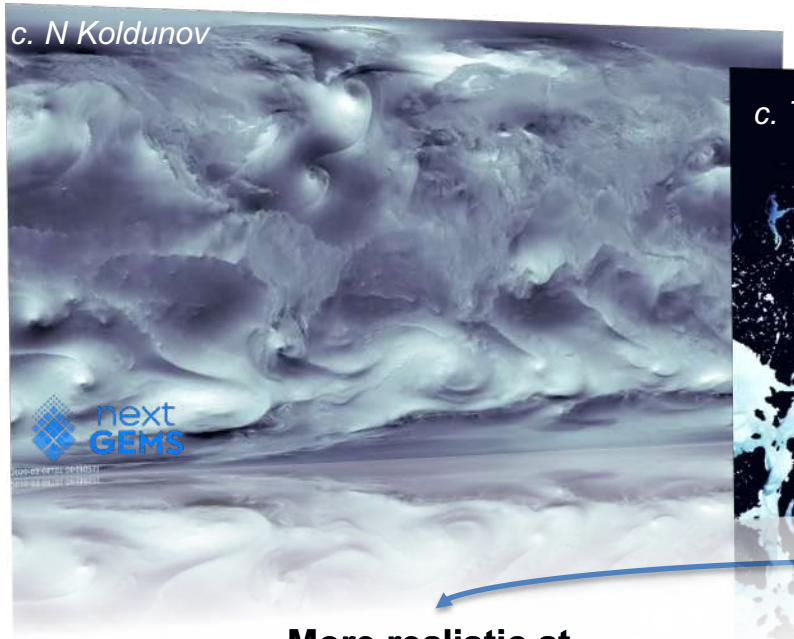
DIGITAL TWINS OF THE EARTH SYSTEM

Funded by the European Union

ECMWF

DestinE's Digital Twins: Quality + Impacts + Interaction

1. **Better simulations** based on **more realistic models**
2. **Better ways of combining all observed and simulated information** from entire Earth system = physical + food/water/energy/health **supporting action scenarios**
3. **Interactive and configurable access to all data, models and workflows**



More realistic at *global* scale

More realistic at *local* scale

Include impacts where they matter

Trial different adaptation and mitigation scenarios

ECMWF

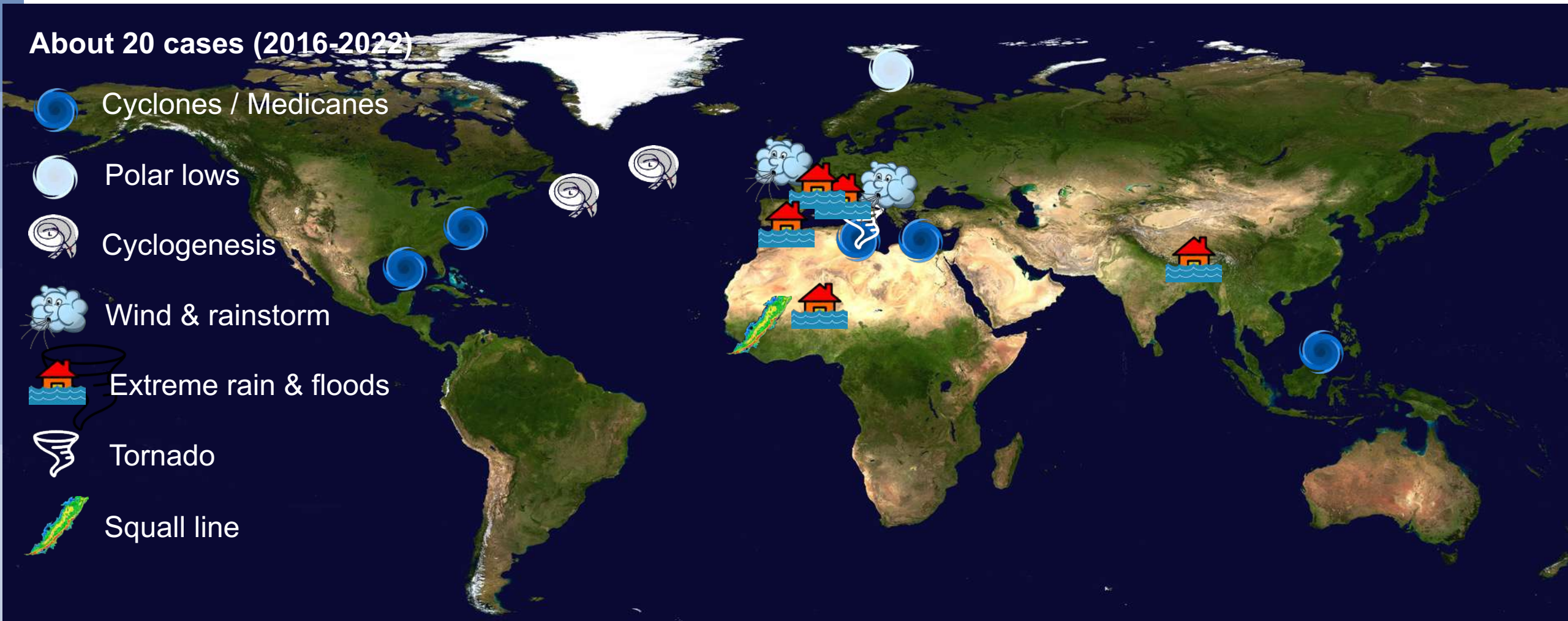
Continuous Extremes DT (ECMWF) – initial extreme events cases

Global forecasts with ECMWF IFS at **4.5 km, 2.8 km** (and 25 and 9km equivalent) :

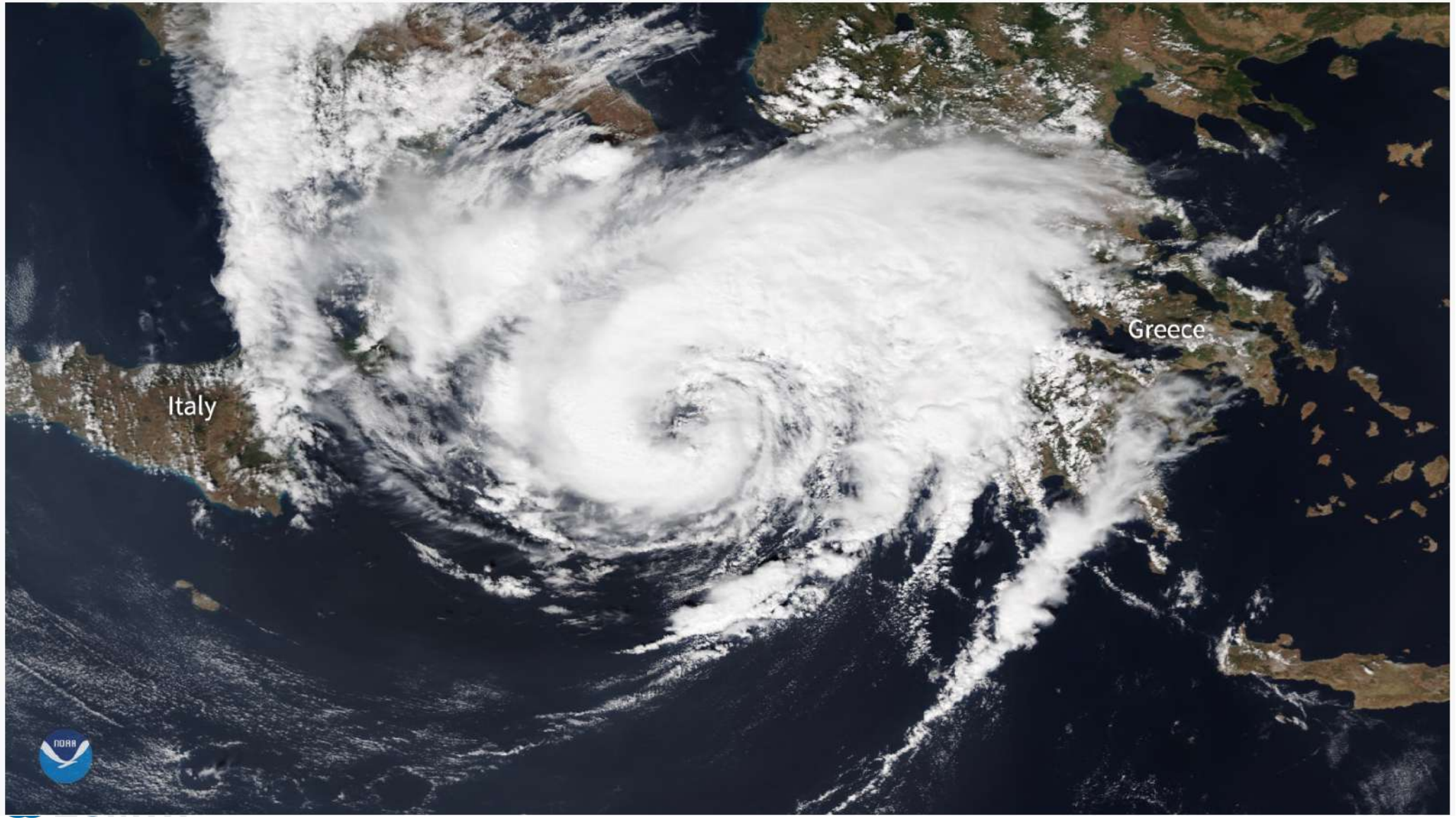
- 5 days global forecasts of a selection of **20 Extreme cases**
- 10 days **daily forecasts** for Jul-Aug 2021 and Jan-Feb 2022

Medicane Ianos

Alex storm



Medicane Ianos (Sept 2020)



Medicane Ianos experiments in the context of DestinE

- Test 9 km and 4.5 km resolution global forecasts, deep convection parametrized. Some extra 2.8 km only for partial coupling.

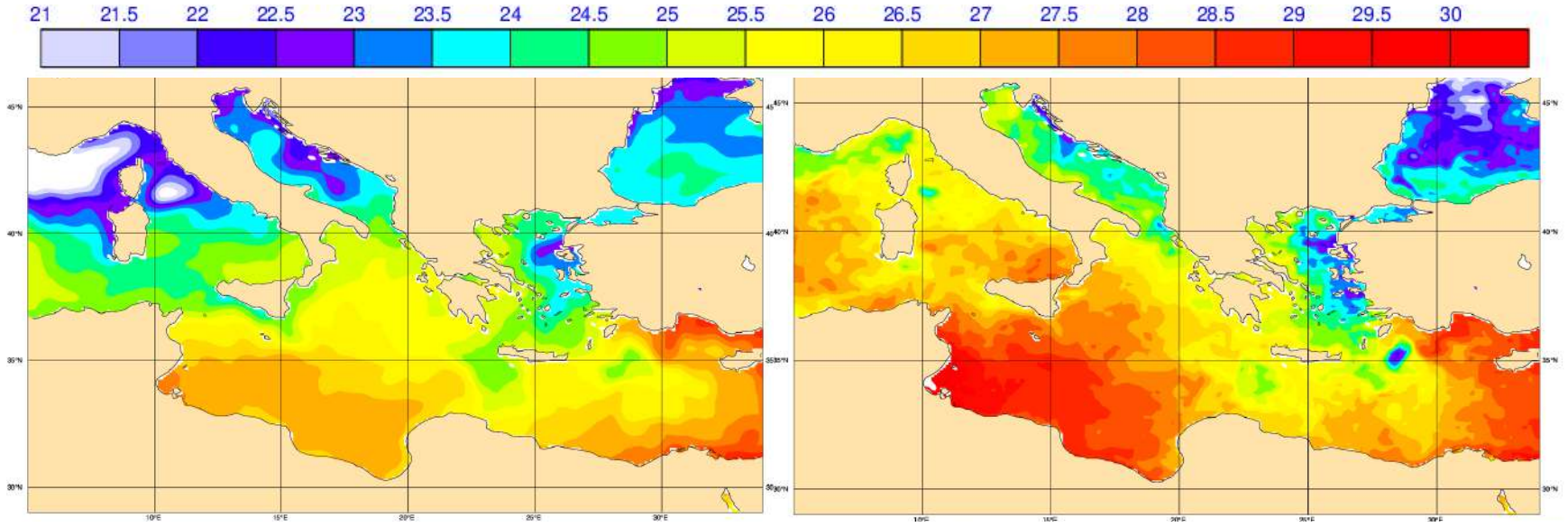
- Use **NEMO V3.4** (current ECMWF Ocean model): 0.25 degree (~28km)

    1. Full coupling, partial coupling and uncoupled with the ocean

    2. Use initial conditions from different years? Different SST
       2017 (colder) and **2022** (warmer)

a) OSTIA 15/09/2017

b) OSTIA 15/09/2022



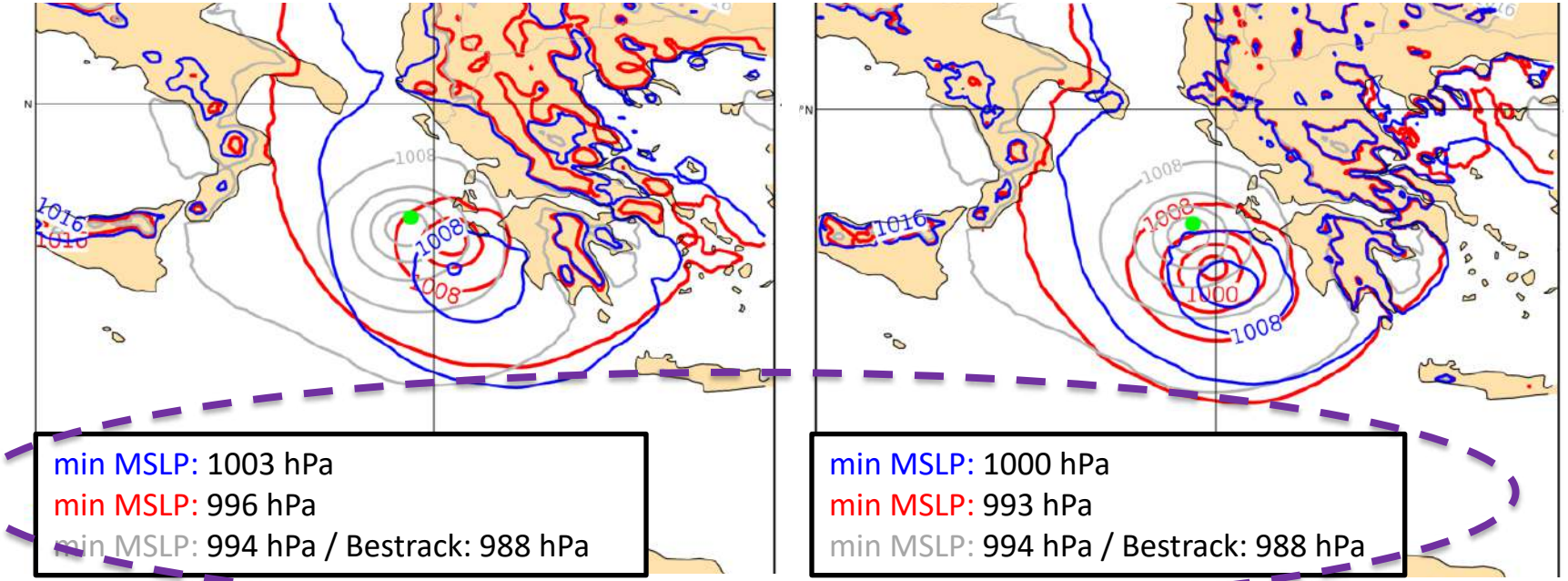
Different initial SST

2017 (colder)

2022 (warmer)

c) MSLP 9 km

d) MSLP 4.5 km

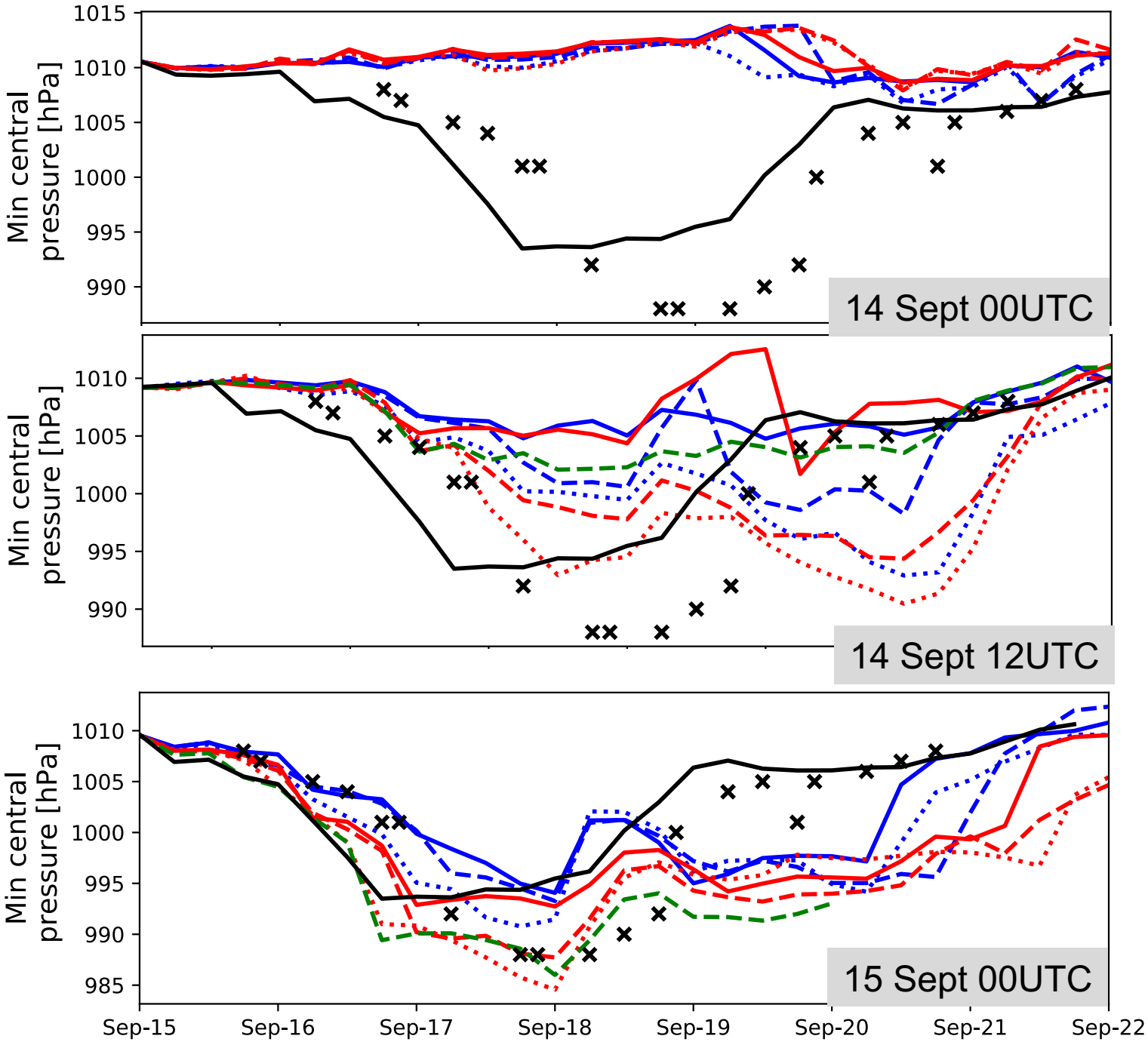


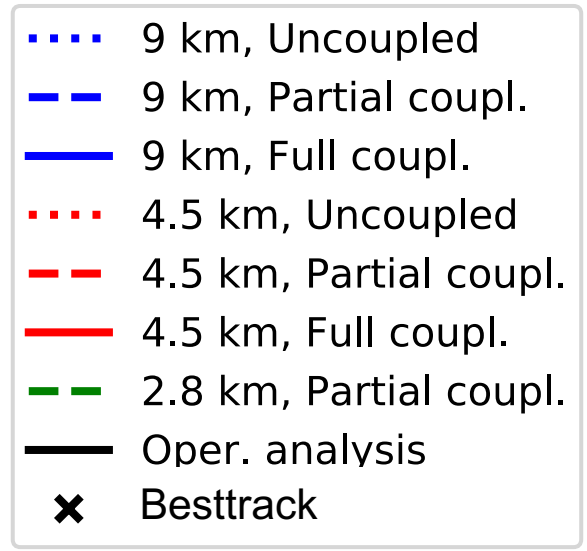
min MSLP: 1003 hPa
min MSLP: 996 hPa
min MSLP: 994 hPa / Bestrack: 988 hPa

min MSLP: 1000 hPa
min MSLP: 993 hPa
min MSLP: 994 hPa / Bestrack: 988 hPa

Blue – OSTIA 2017
Red – OSTIA 2022
Grey – analysis

Intensity

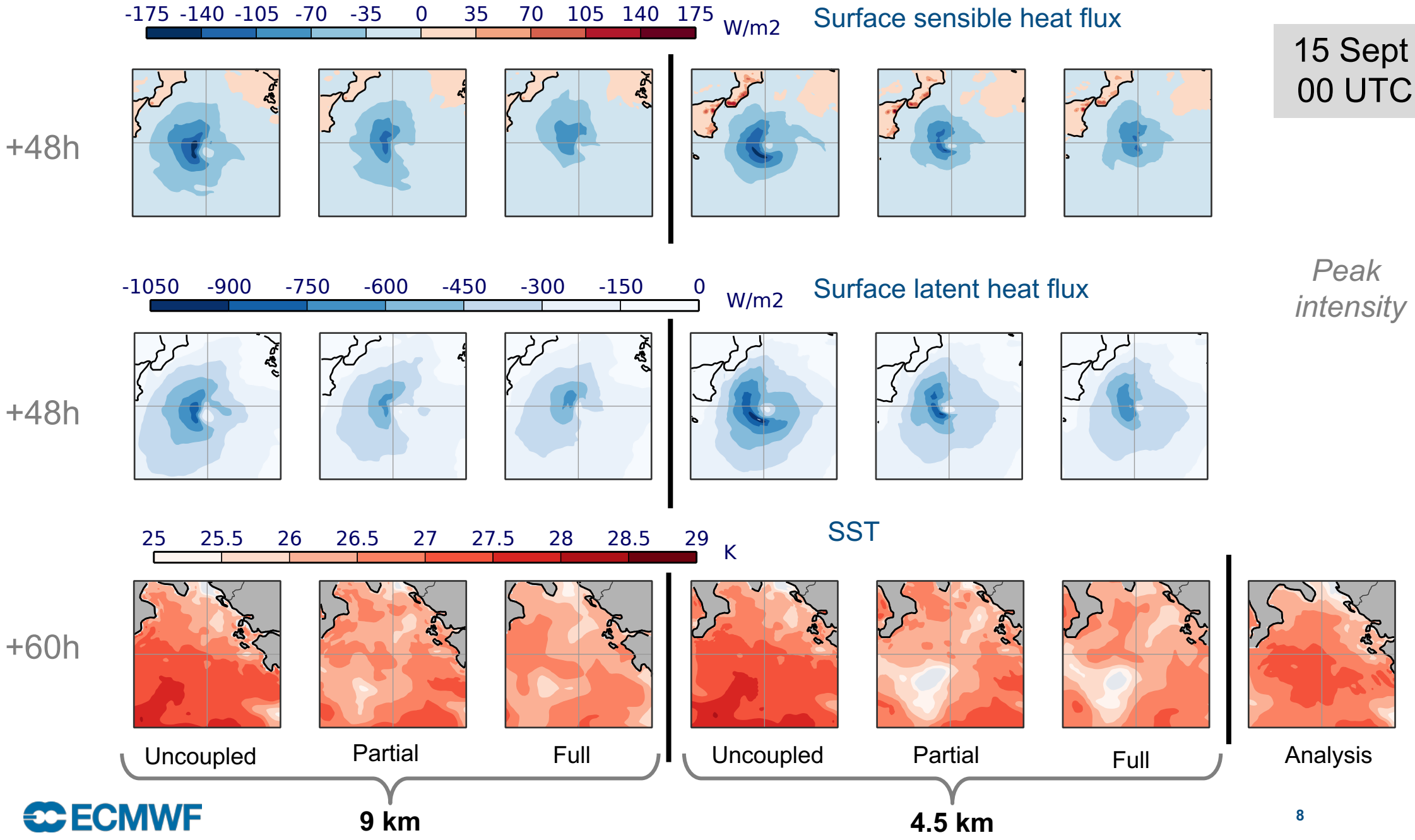




- **2.8 km** does not improve the predictability and it is just slightly deeper than 4.5 km on 15 Sept 00 UTC)

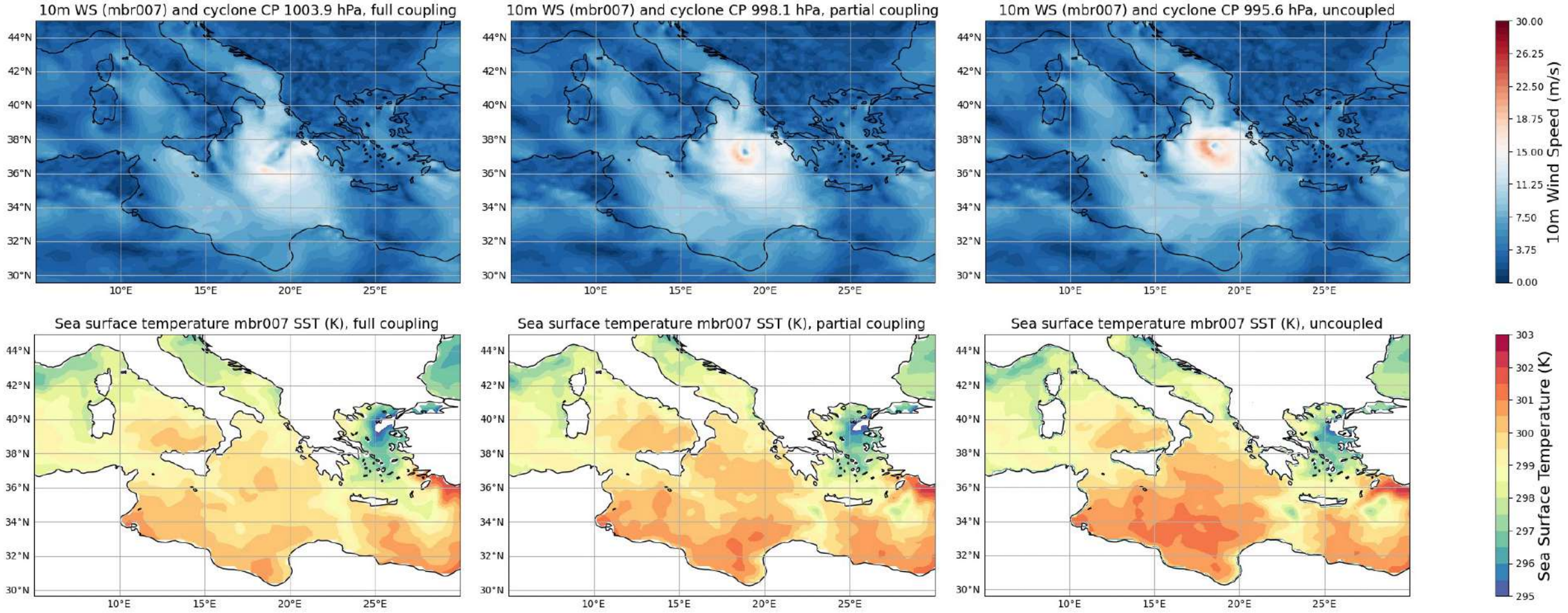
- **Uncoupled** experiments always **deeper** than coupled for similar resolution.

- **Fully coupled too weak** medicane compared to partial coupling and uncoupled (on 15 Sept 00 UTC). On 14 Sept 12 UTC no medicane


-175 -140 -105 -70 -35 0 35 70 105 140 175
W/m2
Surface sensible heat flux
15 Sept
00 UTC
+48h
-1050 -900 -750 -600 -450 -300 -150 0
W/m2
Surface latent heat flux
Peak
intensity
+48h
25 25.5 26 26.5 27 27.5 28 28.5 29
K
SST
+60h
Uncoupled
Partial
Full
Uncoupled
Partial
Full
Analysis
9 km
4.5 km

Ensemble experiments: 9 km

Example of the different SSTs and their impact on 10m wind speed and core pressure at msl (ensemble member 7) :

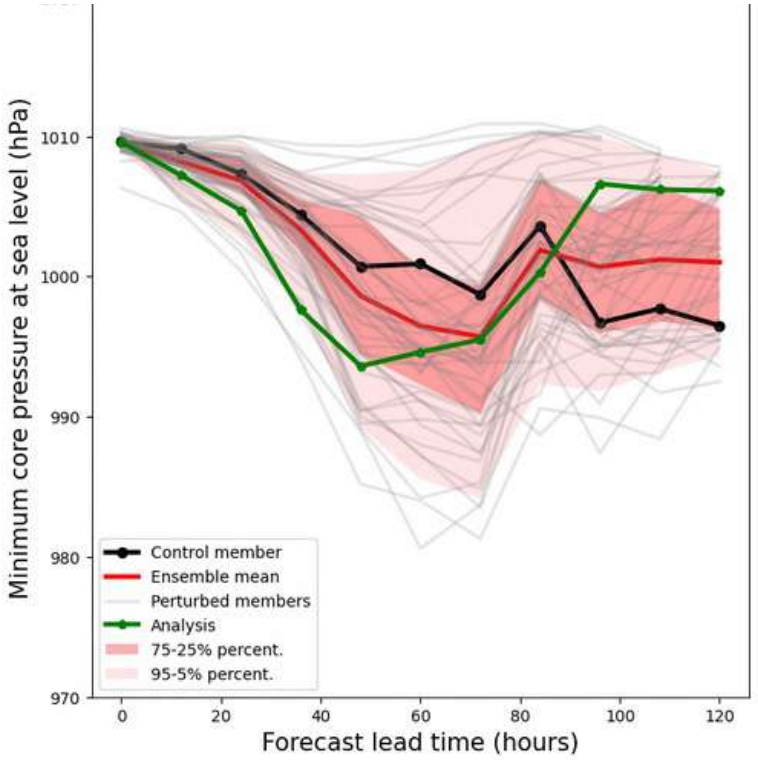


Ensemble experiments: 9 km

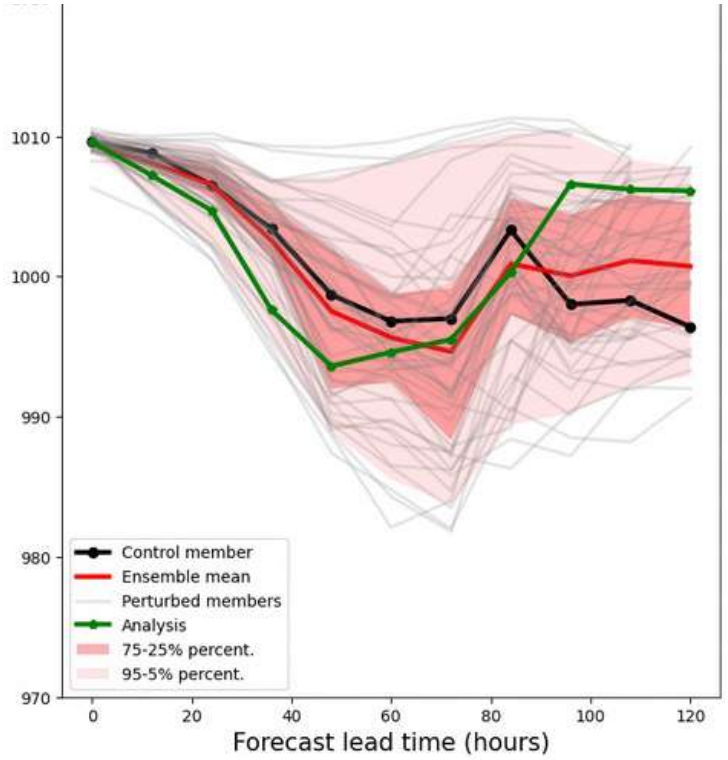
- In the ENS we don´t observe too many differences between **full** and **partial coupled** experiments (only control member slightly weaker in the full coupling).

- **Uncoupled** experiment shows much stronger intensification in the core pressure for some members, which leads to generally larger ensemble spread.

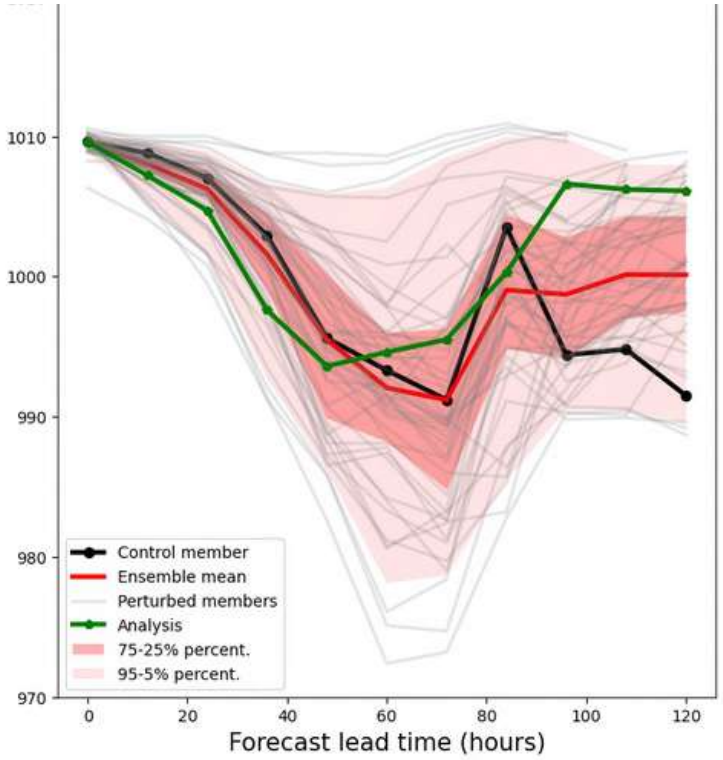
Initial perturbations + **full coupling**



Initial perturbations + **partial coupling**

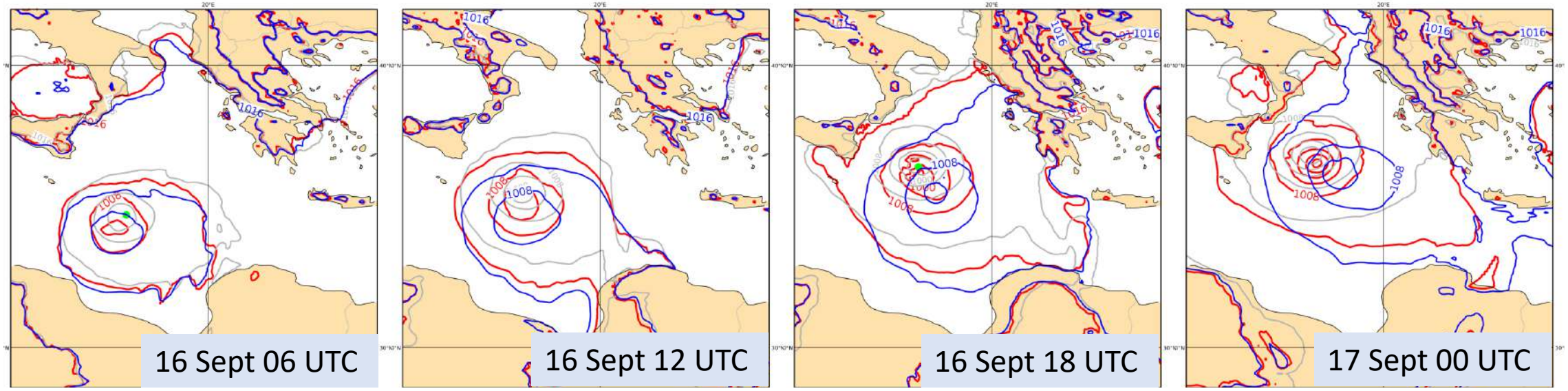


Initial perturbations + **uncoupled**

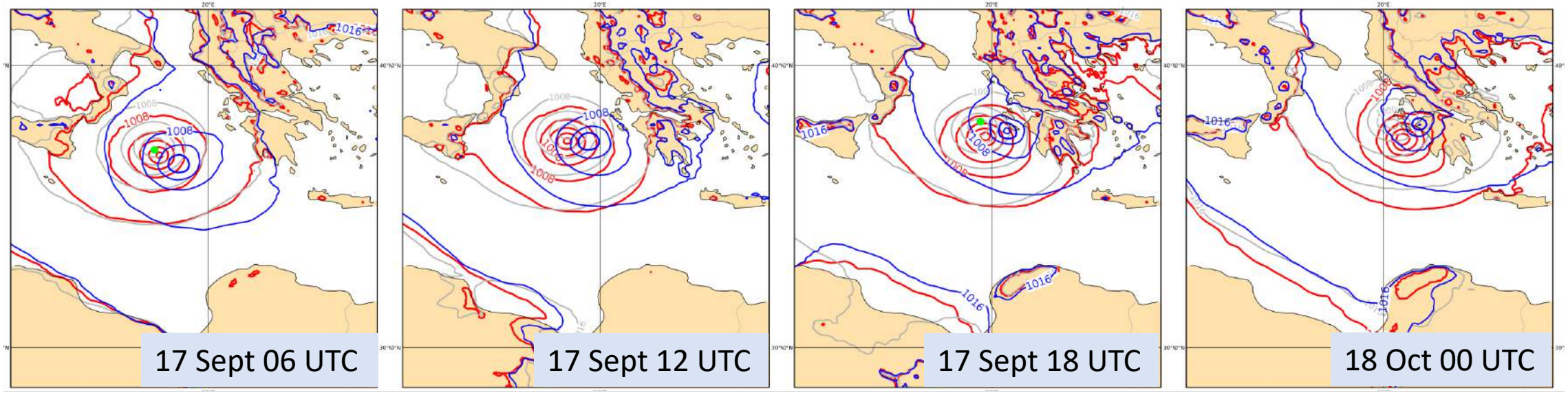


15 Sept 00 UTC. BLUE = 9 km RED = 4.5 km

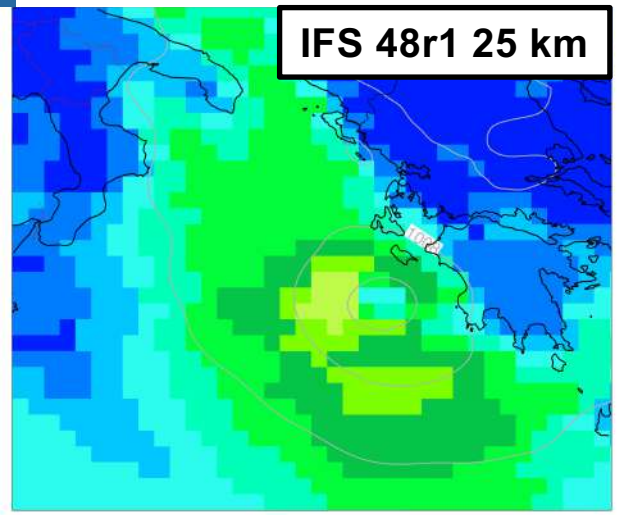
(However, not massive differences between 4.5 and 2.8 km)

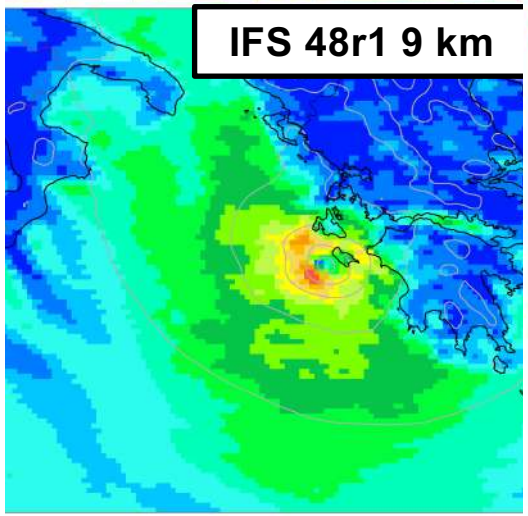


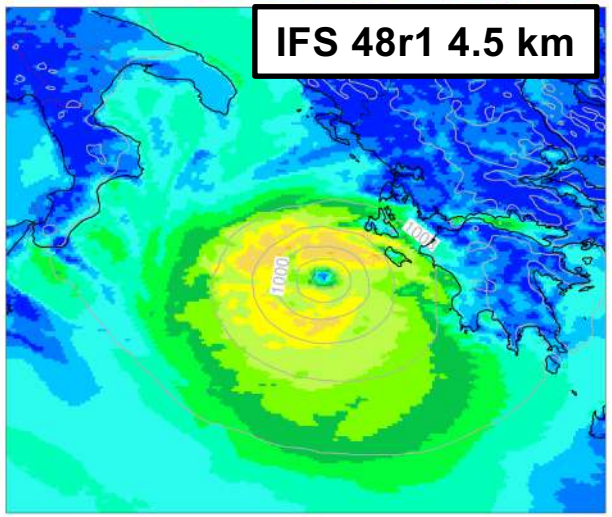
Comparison between horizontal resolutions with the **real SST** conditions for Ianos

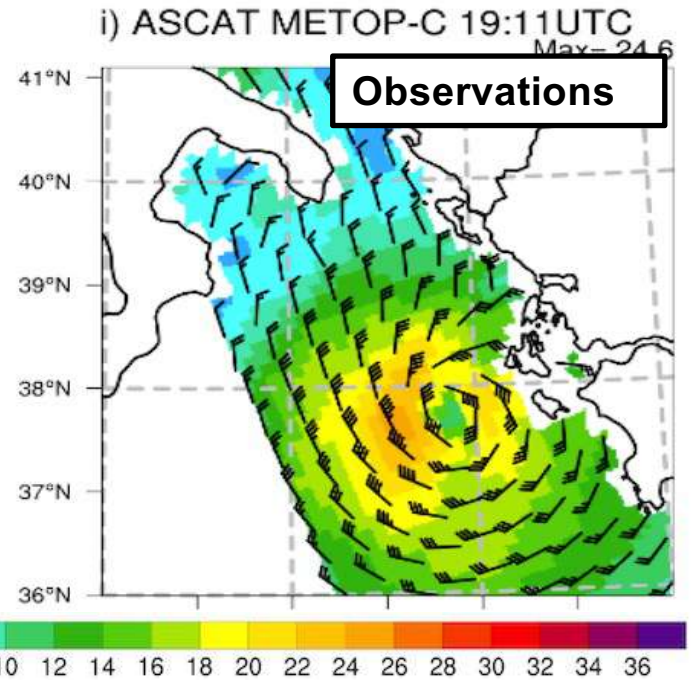


Surface wind speed (T+66h, m/s)

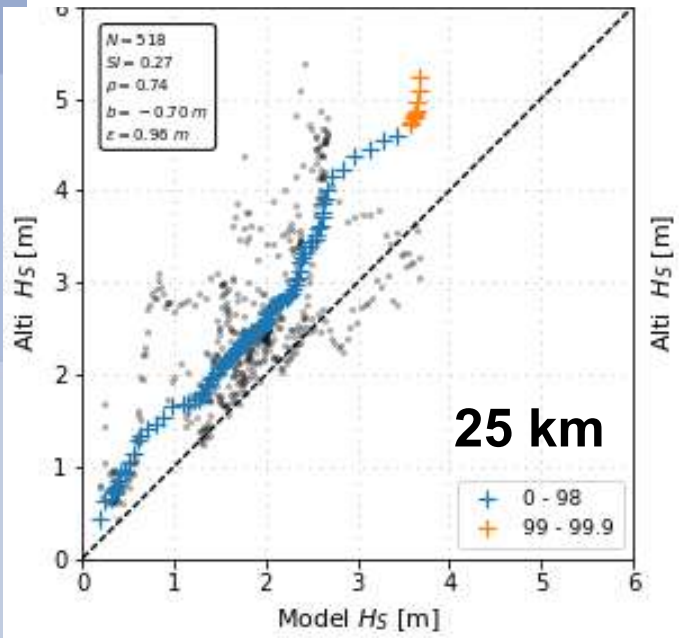


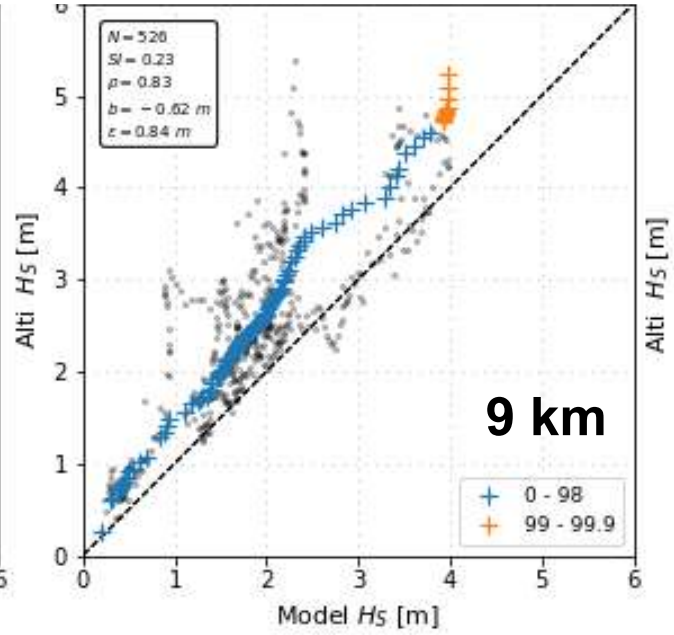


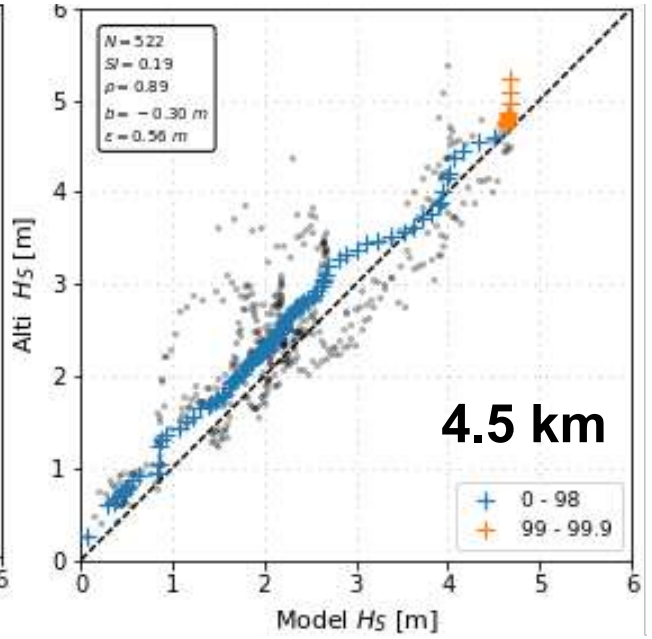




Waves (T+44h – T+84h) : Model vs. Observations (altimeter)

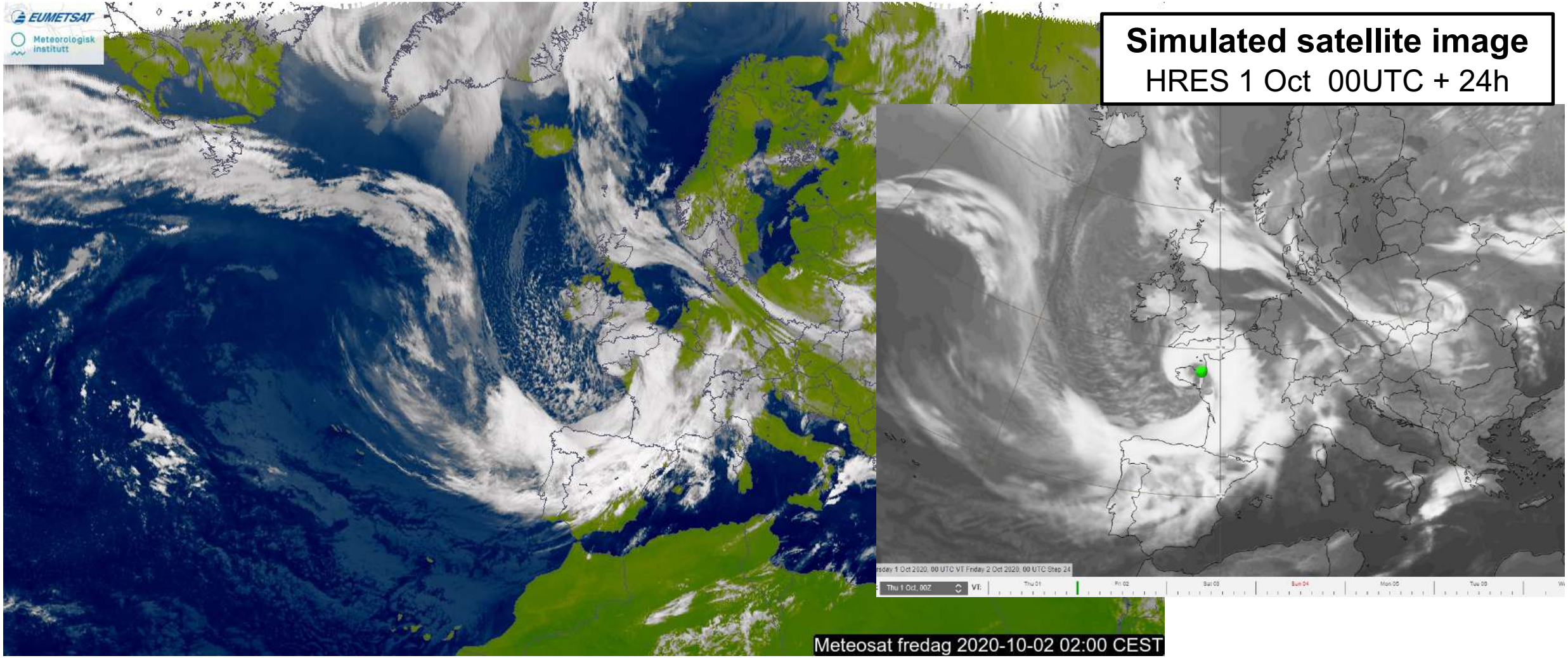






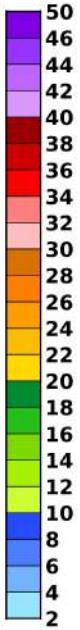
What about Ocean wind speed and ocean waves?

Storm Alex (Oct 2020)



48r1 25 km

48r1 9 km



Storm Alex

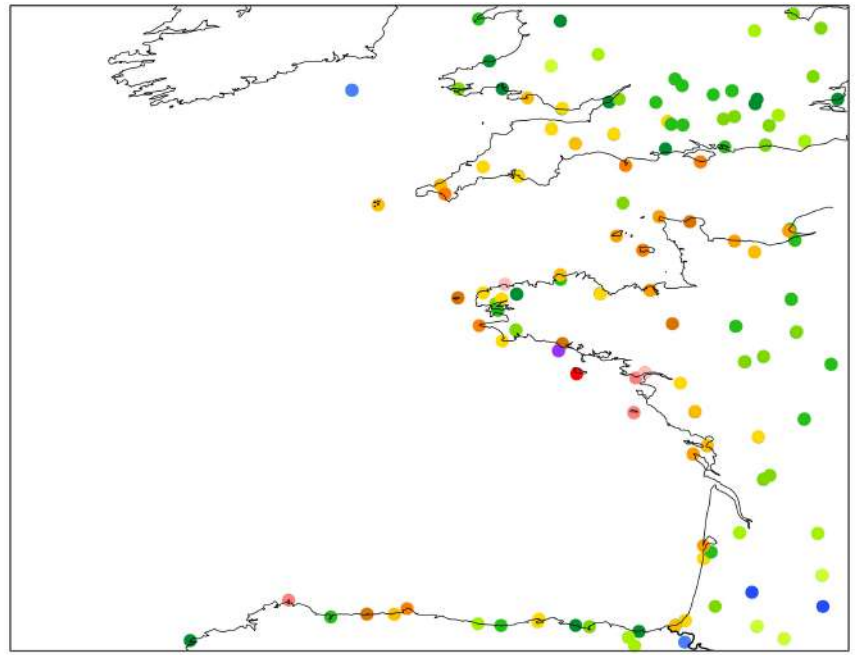
24h max wind gust (m/s)

Base time 01/10/2020 00 UTC
(T+12h - T+36h).

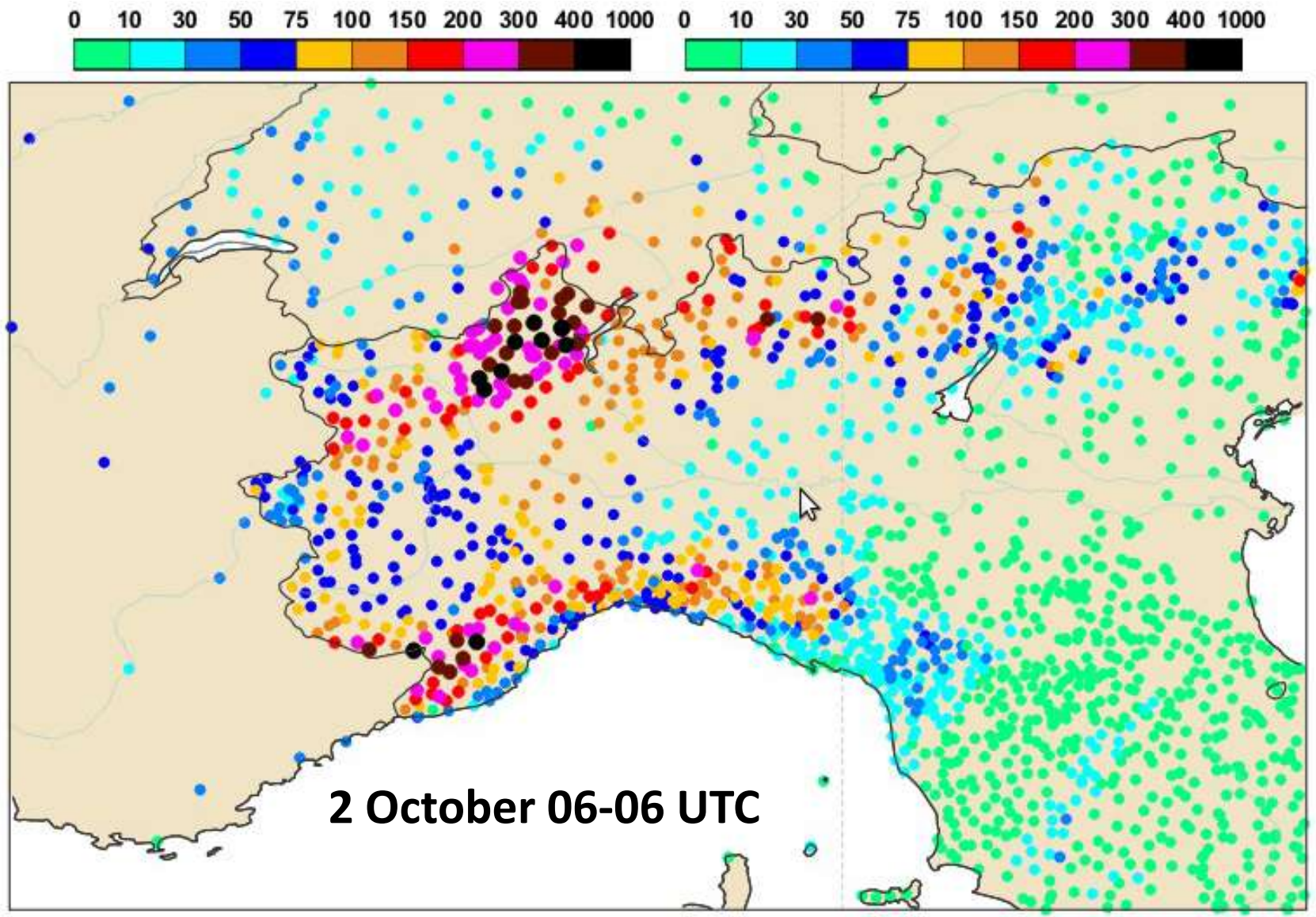
More observations are needed!

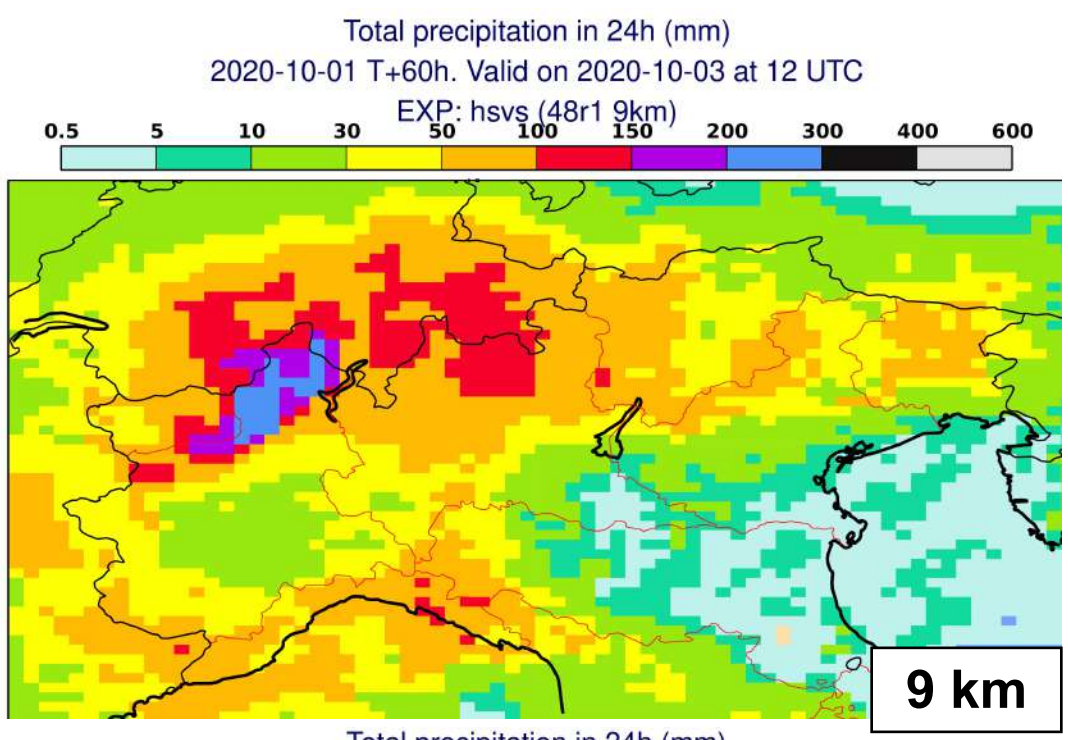
48r1 4.5 km

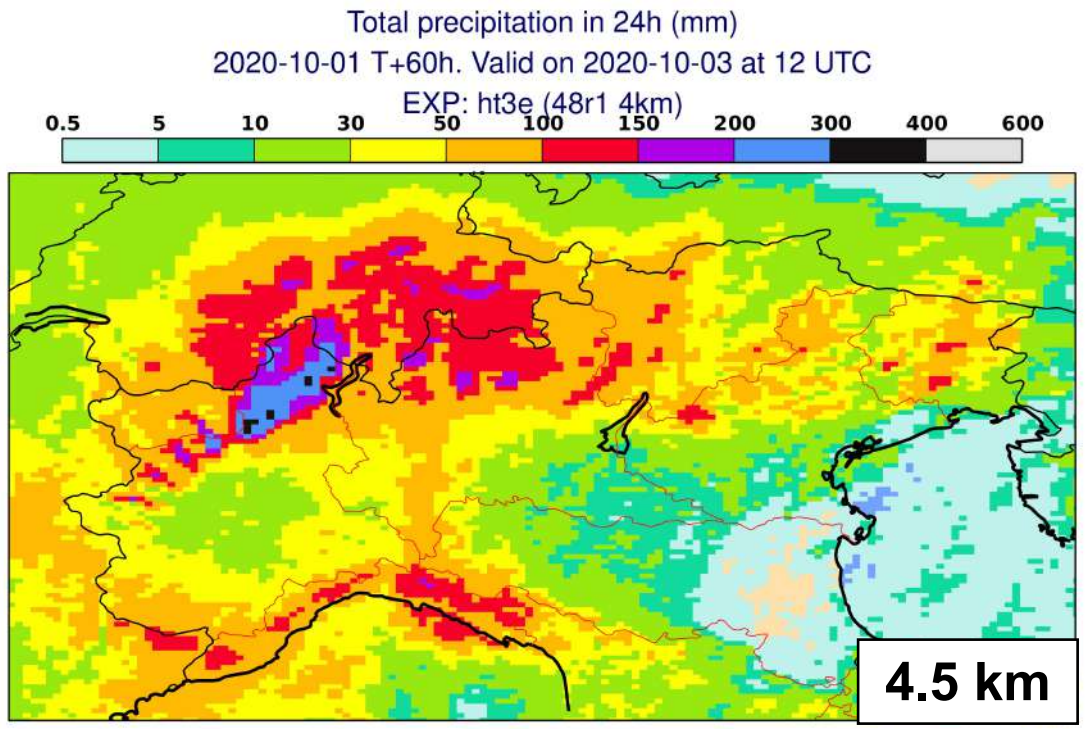
48r1 2.8 km

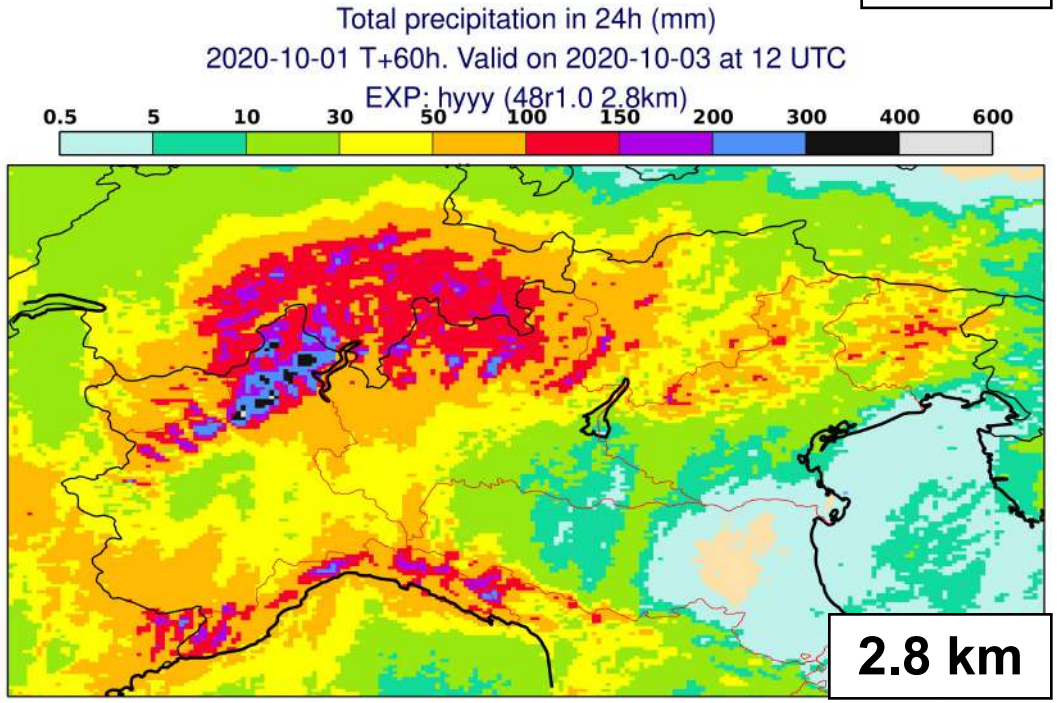


Very severe flash floods in Italy/France (2-3 Oct)

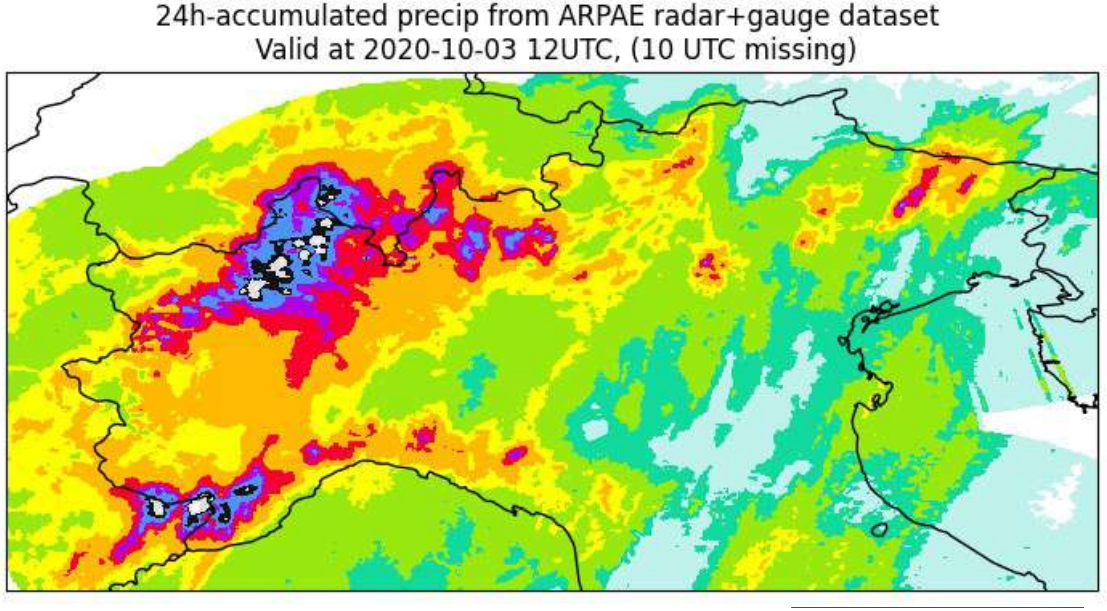




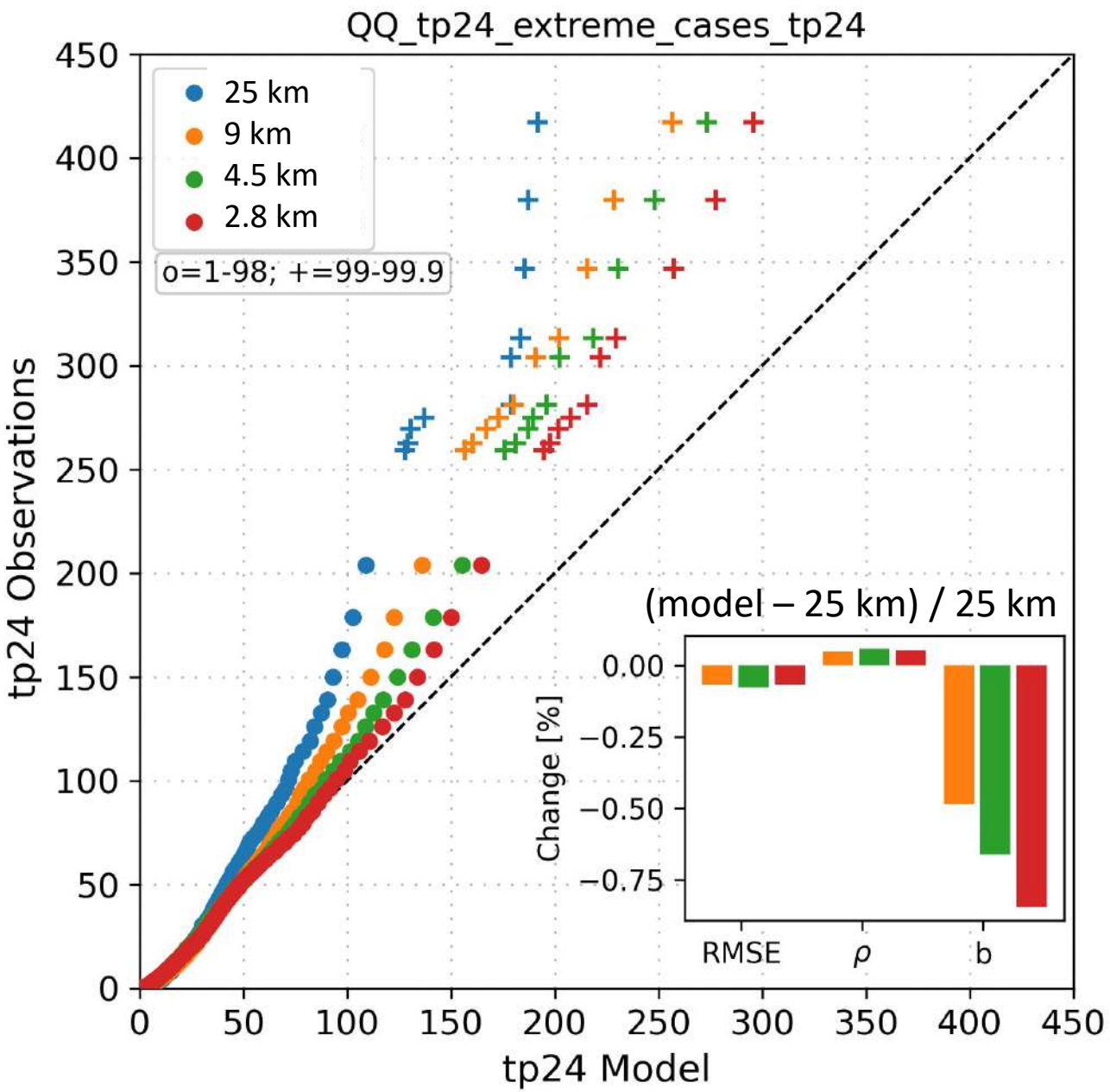




Base time 01/10/2020 00 UTC (T+36h-T+60h).

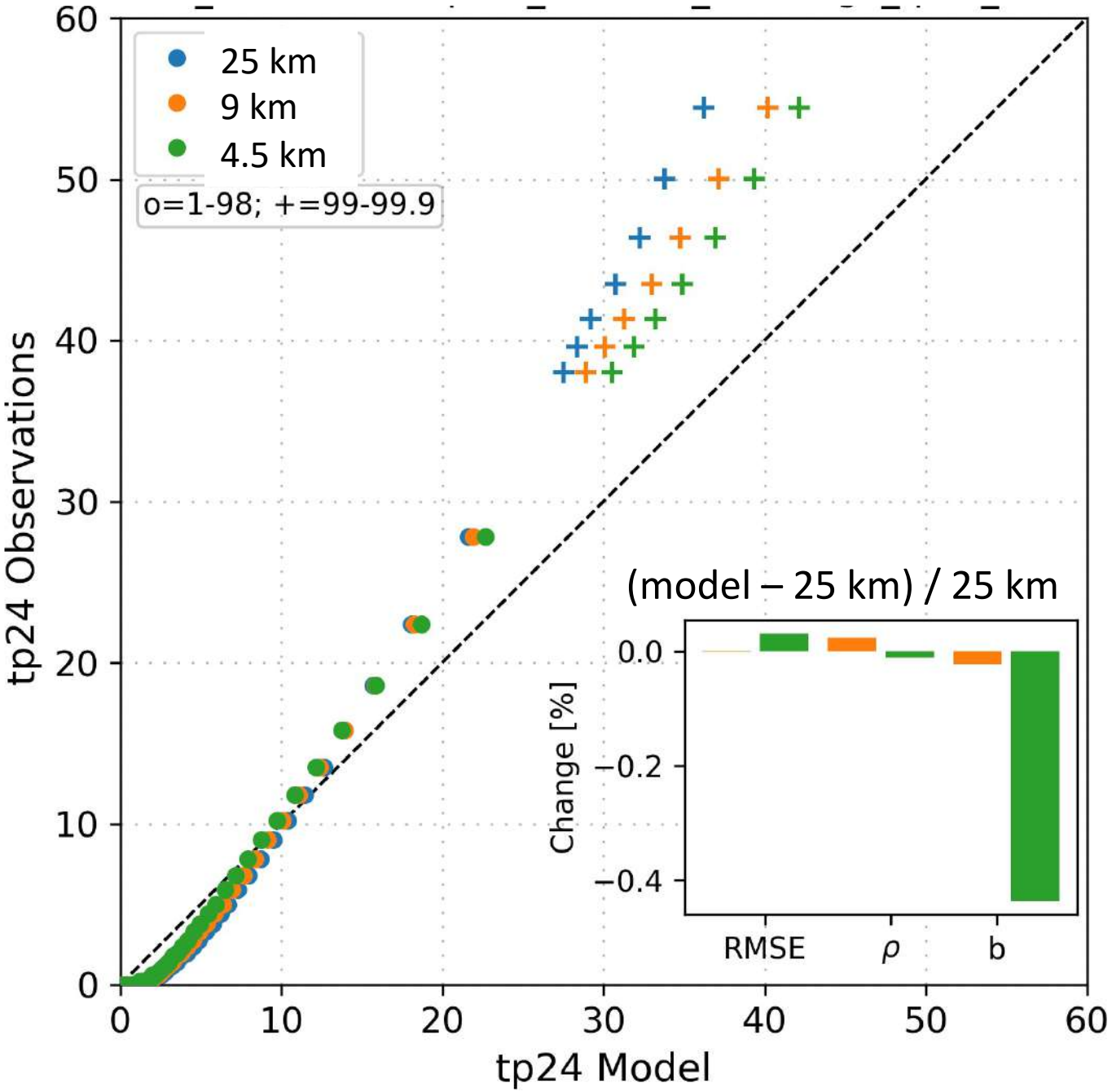


Q-Q for 24h accumulated precipitation (mm)



4 extreme precipitation events in North Italy:

- storm Adrian (Oct 2018)
- storm Alex (Oct 2020)
- floods in Po Valley (2 days, Nov 2019)



Q-Q for 24h accumulated precipitation (mm)

North Hemisphere extratropics
SUMMER (2 months). T+72h

CONCLUSIONS (from these case studies)

- The correct prediction of the intensity of Medicane Ianos in the IFS depends not only on the **horizontal resolution** but also on the role of the **ocean**. But more cases are needed.

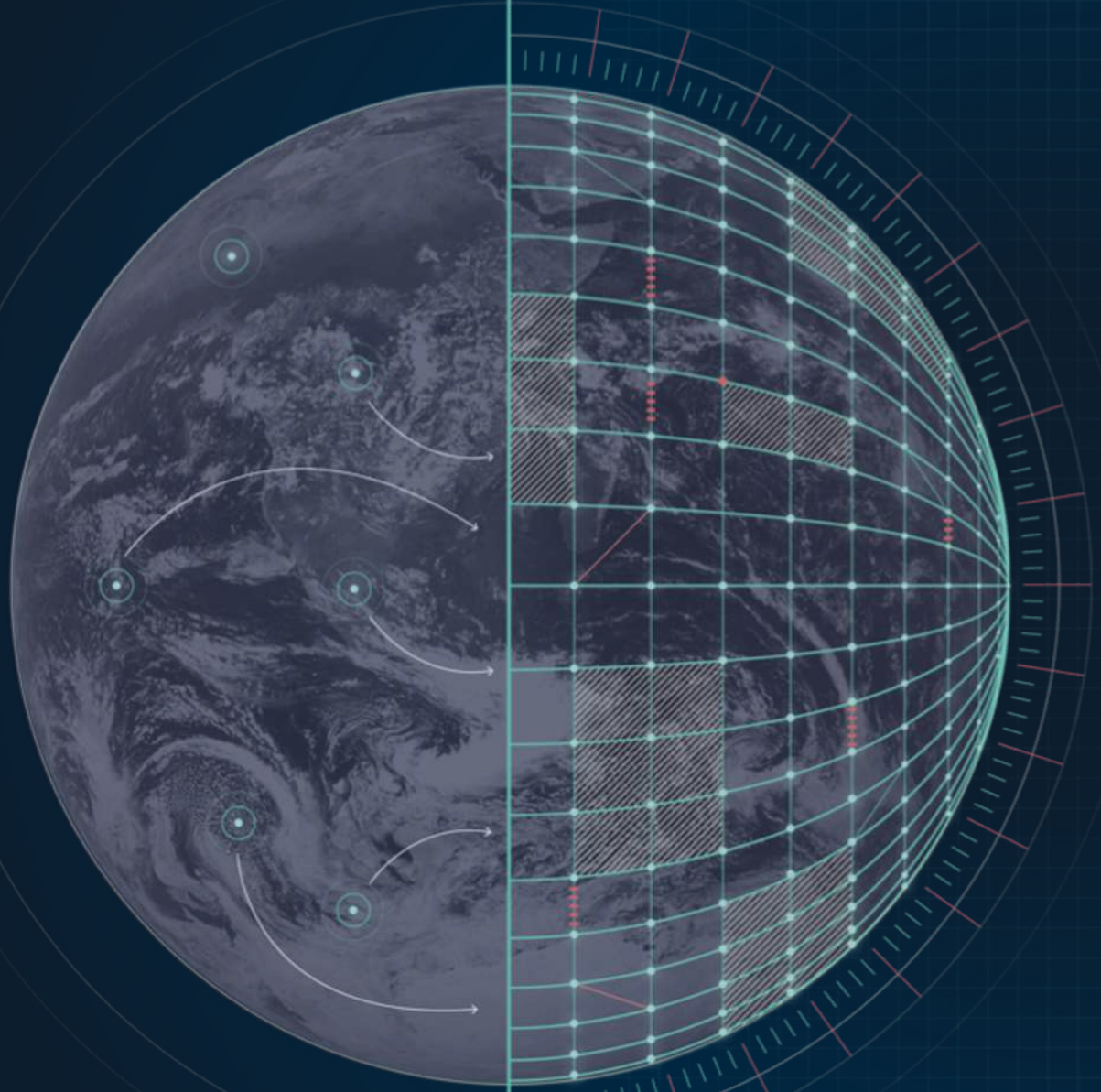
- **Warmer sea surface temperatures (SSTs)** contribute to the development and intensification of medicanes, leading to **stronger** storm systems.

- **Partial coupling** of the atmosphere-ocean system shows promising results in both deterministic and ensemble runs, with similar outcomes compared to full coupling in ensemble predictions. However, **uncoupled** experiments tend to **overestimate the strength and spread** of medicanes.

- Increasing the **horizontal resolution** improves the forecast accuracy of **precipitation**, particularly for extreme events in **mountainous** regions.

- Higher resolution simulations also yield improved predictions for wind gusts, wind speed, and waves, although **additional observations are required** for a correct evaluation.

DESTINATION EARTH



DIGITAL TWINS OF THE EARTH SYSTEM

Thanks for your attention!

Estíbaliz Gascón

estibaliz.gascon@ecmwf.int

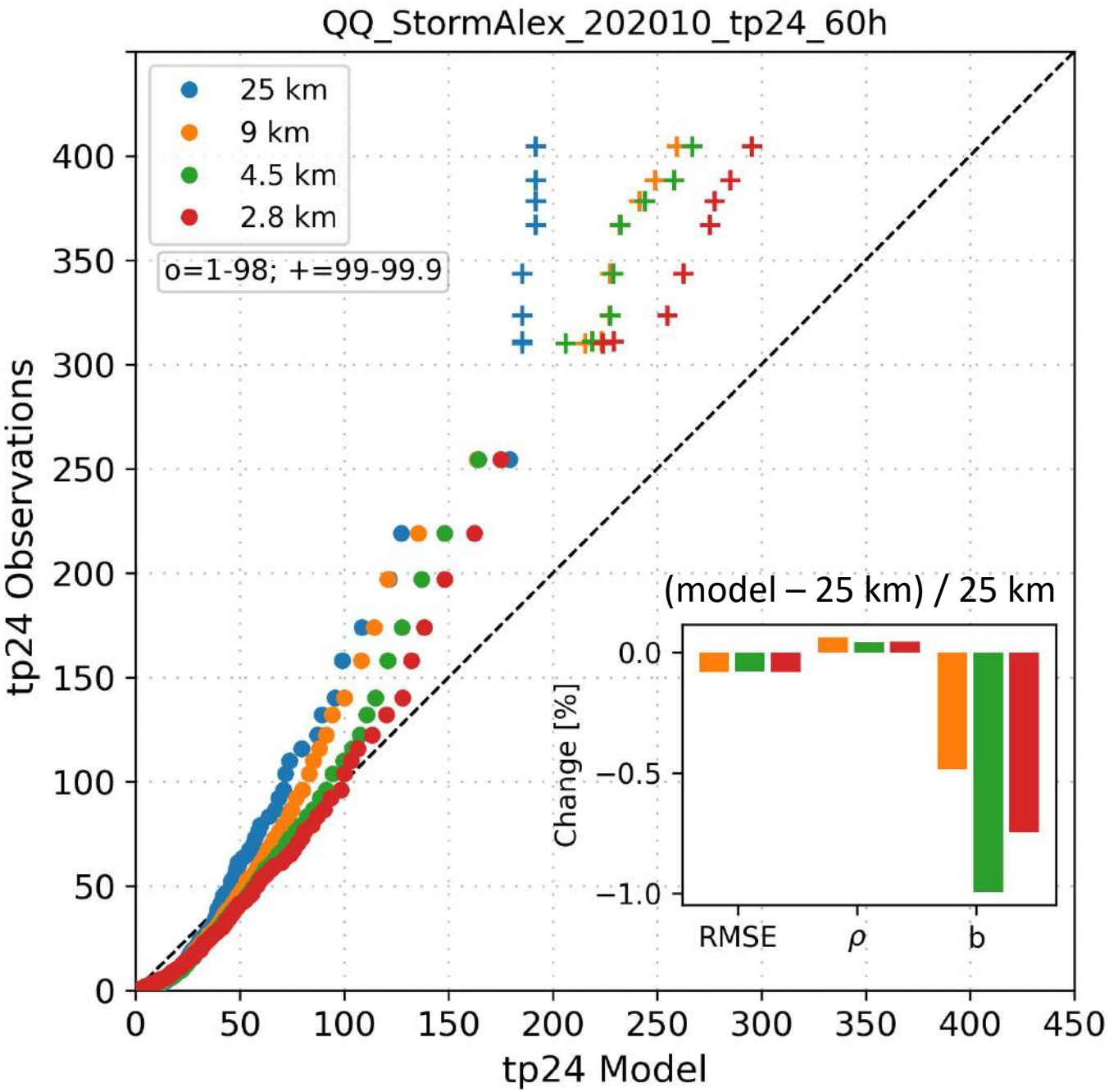
Funded by the European Union

ECMWF

Storm Alex (Oct 2020)

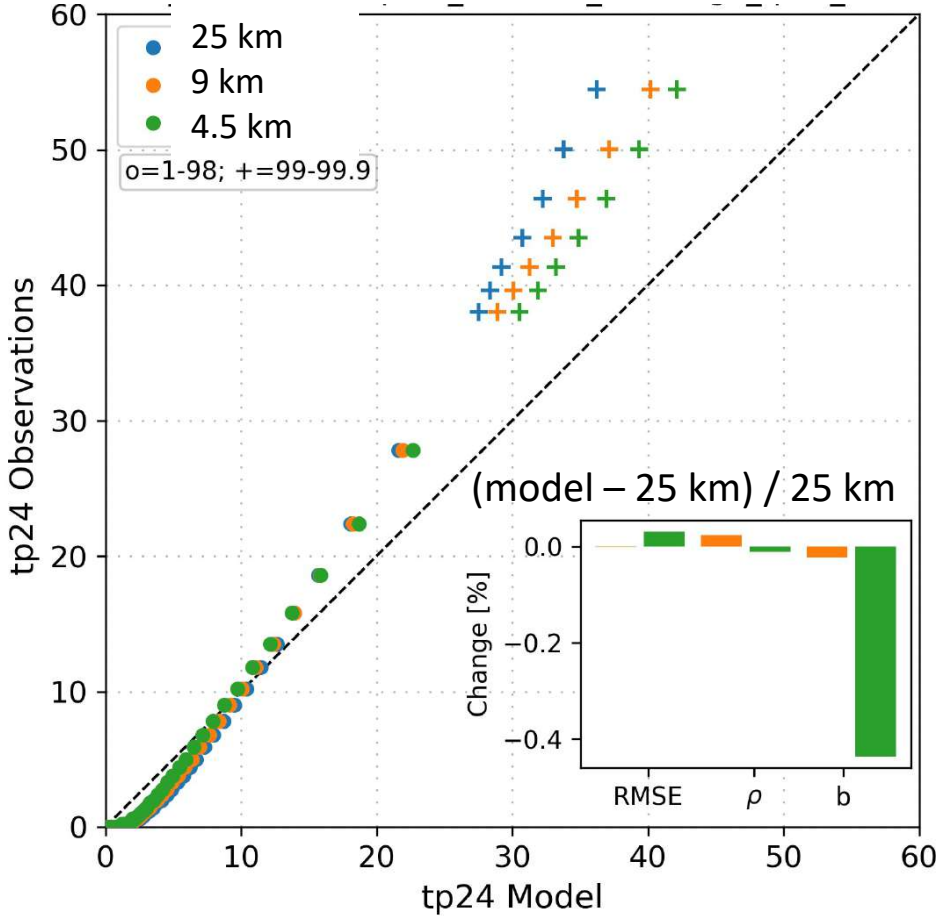
24h accumulated precipitation (mm)

T+36h - T+60h



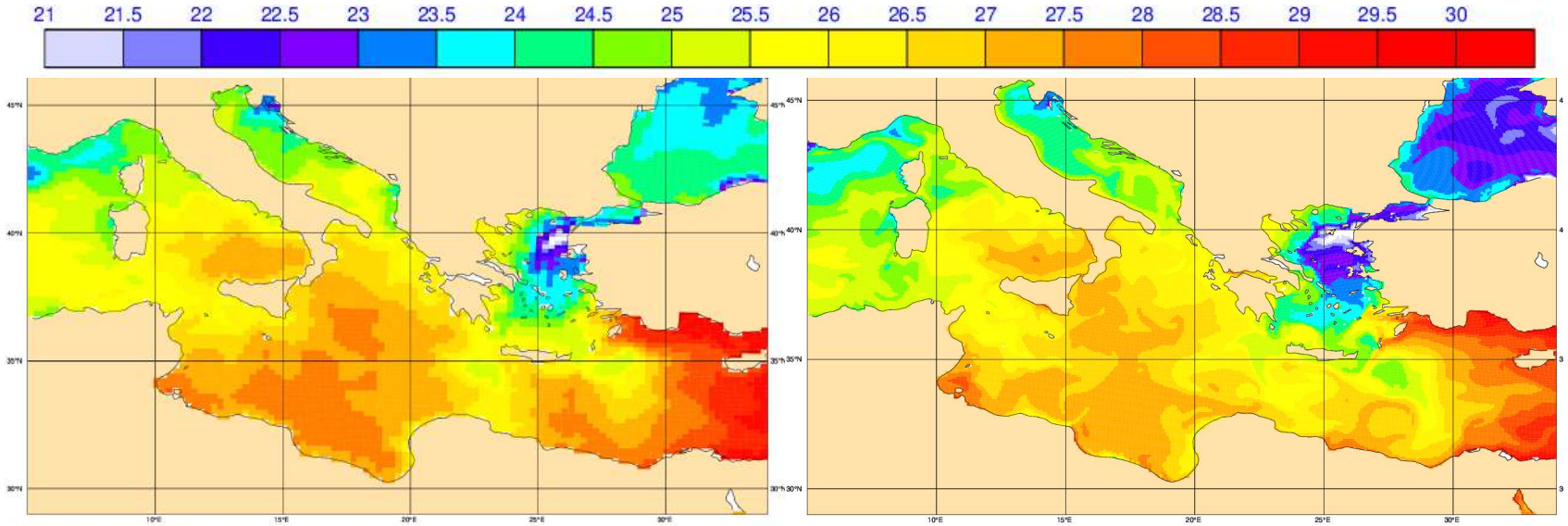
North Hemisphere extratropics

SUMMER (2 months). T+72h

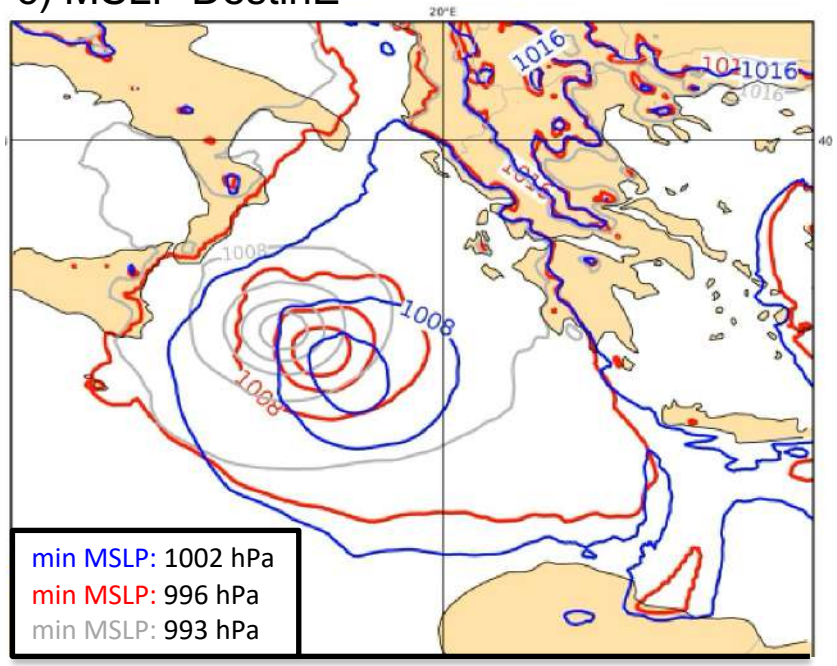


a) OCEAN5

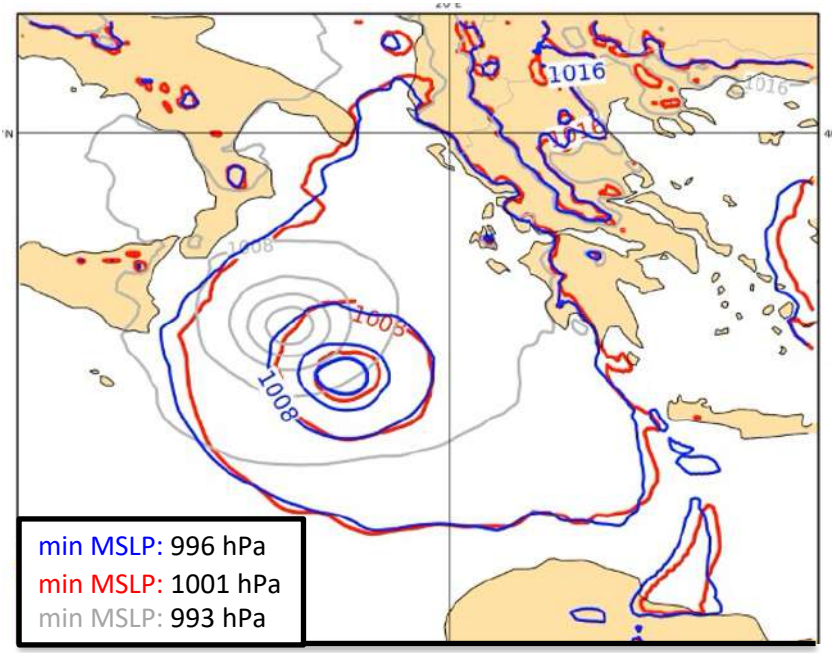
b) eORCA12



c) MSLP DestinE



d) MSLP INCITE



Why this study?

2 projects:
INCITE and DestinE

2 different results

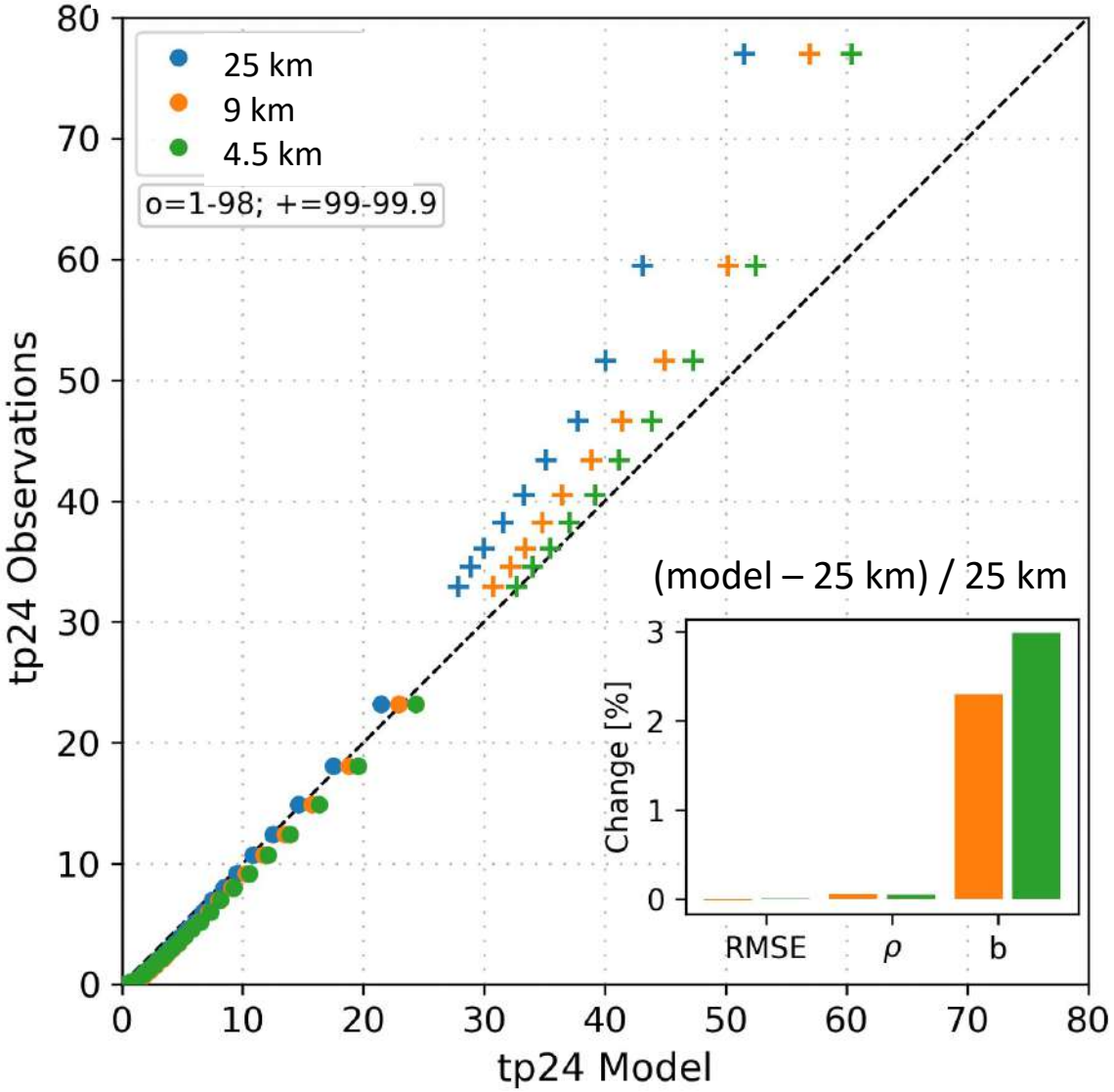
Is it a question of the differences in SST?

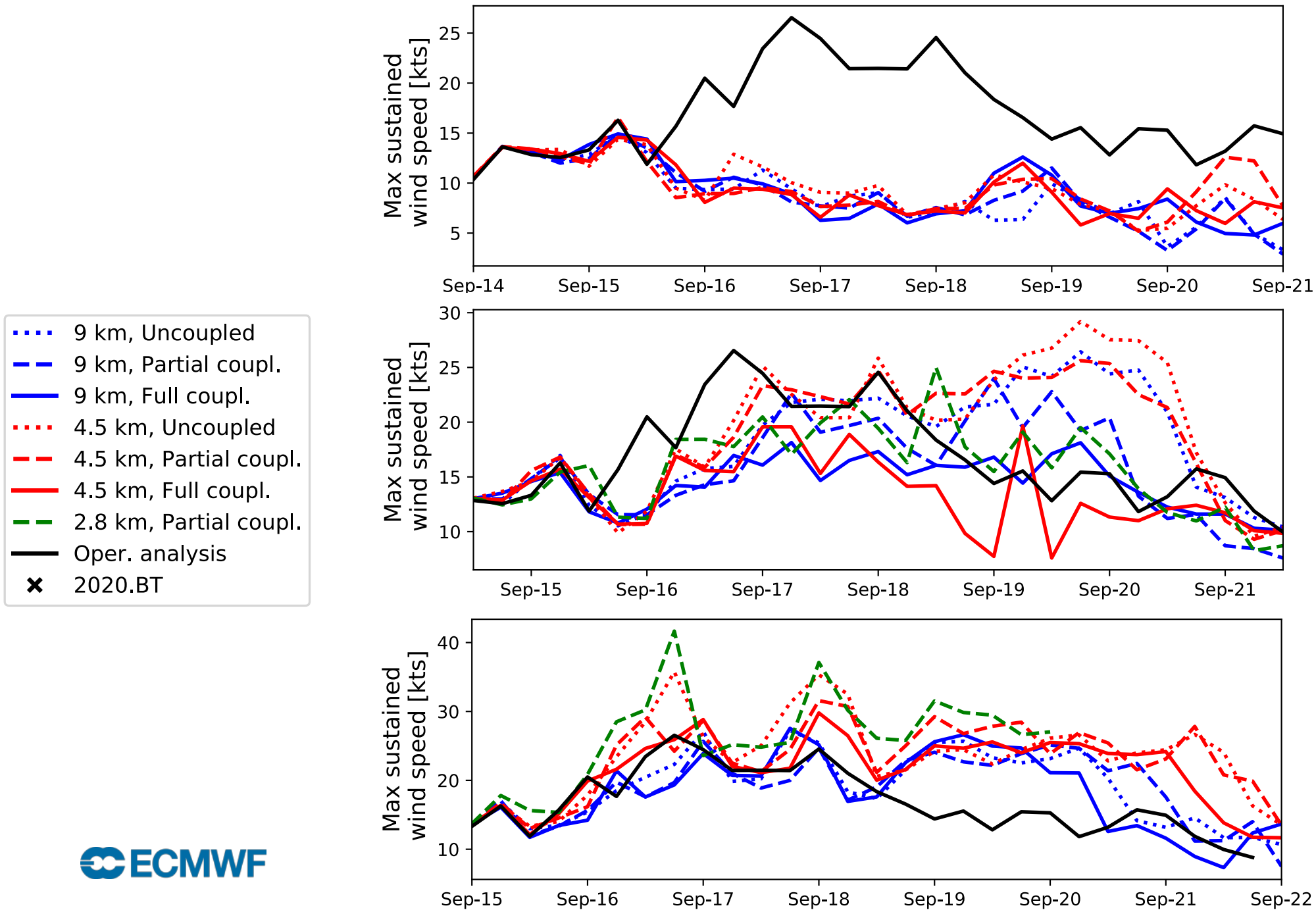
Blue – 9 km
Red – 4 km
Grey – analysis

North Hemisphere extratropics

WINTER (2 months)

T+72h




9 km, Uncoupled
9 km, Partial coupl.
9 km, Full coupl.
4.5 km, Uncoupled
4.5 km, Partial coupl.
4.5 km, Full coupl.
2.8 km, Partial coupl.
Oper. analysis
2020.BT
Max sustained wind speed [kts]
Sep-14
Sep-15
Sep-16
Sep-17
Sep-18
Sep-19
Sep-20
Sep-21
Sep-22
ECMWF

What about Ocean waves?

QQ plots: the higher the resolution, the better forecast for waves, specially regarding the extremes