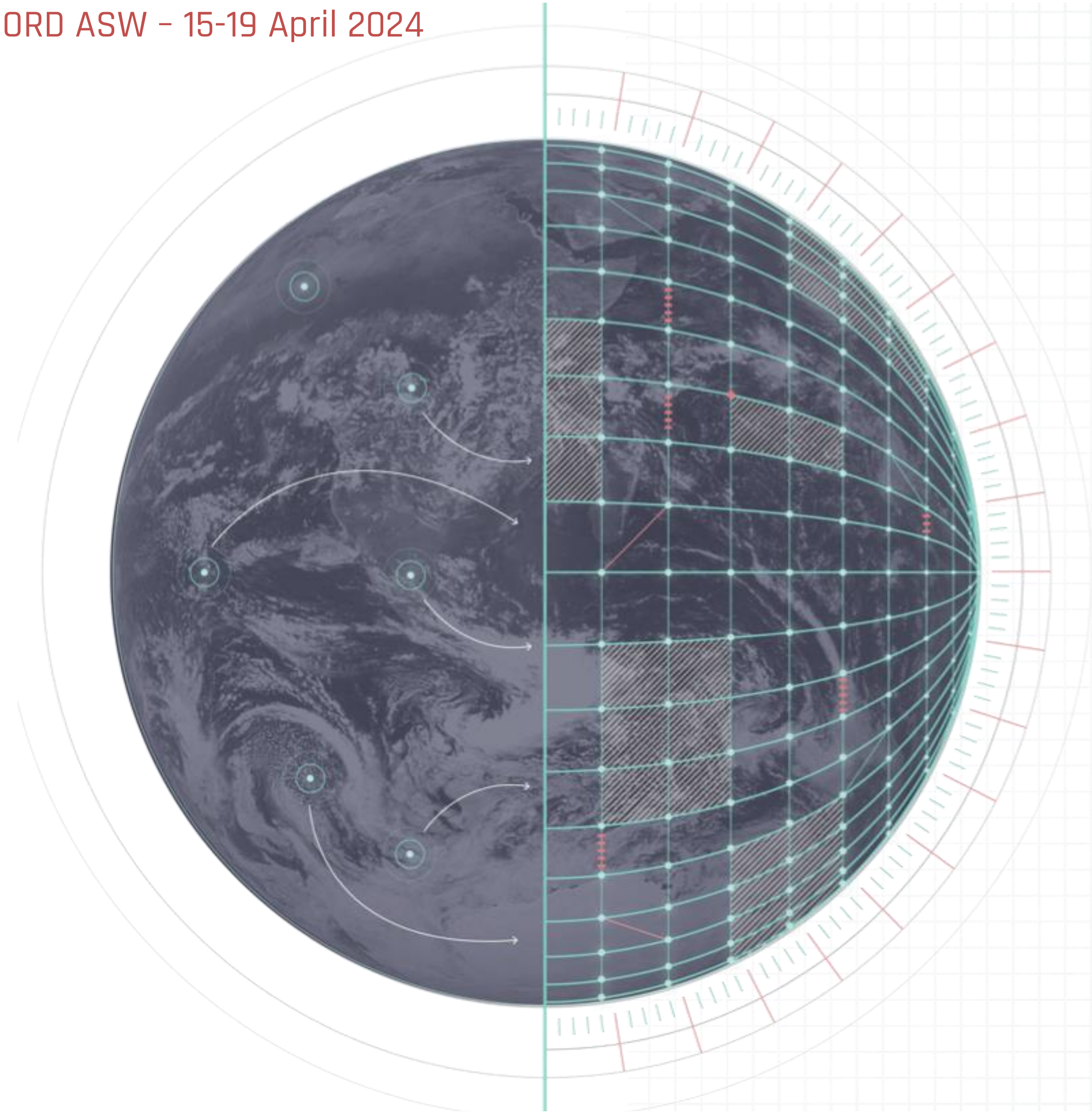


DESTINATION EARTH

Evaluating sub-km simulations for high-impact convective activity under DE On Demand Extremes

Juan Jesús González-Alemán,
Javier Calvo, Daniel Martín, Samuel Viana and Antonio Jiménez Garrote

AEMET Team

Funded by the European Union
Destination Earth implemented by ECMWF esa EUMETSAT

Case 1: MCS Valencia

- On 3 May 2022, a very high-impact static convective system (probably a mesoscale convective system; MCS) over south-east Spain led to heavy rainfall and flash-floods (>100 mm in 2 hours) in Valencia and its metropolitan area, beating rainfall records for May.
- This event had a very low predictability in high-resolution convective-allowing models.

- None of the national meteorological services' operational models (AROME – 1.3km, HARMONIE-AROME 2.5km, etc.) showed signals of convective system developed in the east of Spain.

- *Spain_2022* in dcmdb

LLUVIAS TORRENCIALES

Una fuerte tormenta estática bate el récord histórico de lluvia en Valencia en el mes de mayo

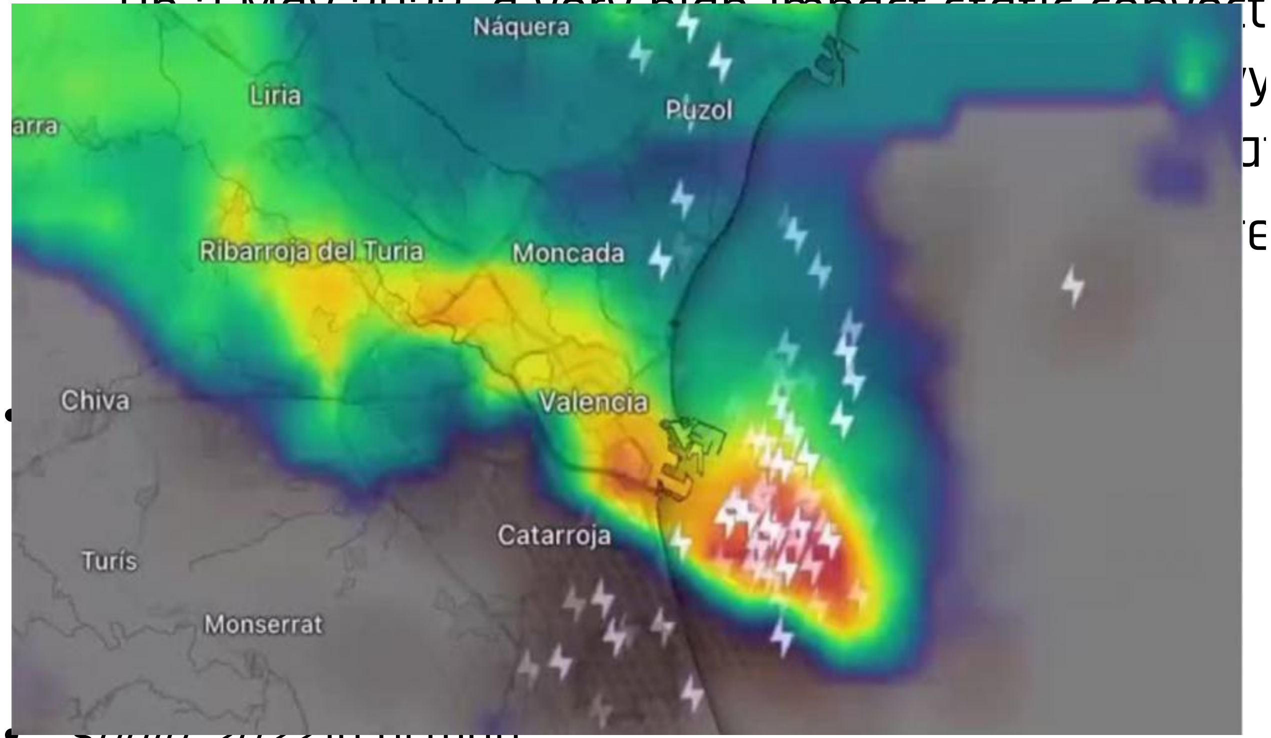
La persistente tromba corta túneles, calles y líneas de metro y anega bajos en los barrios marítimos. La Politécnica suspende las clases este miércoles

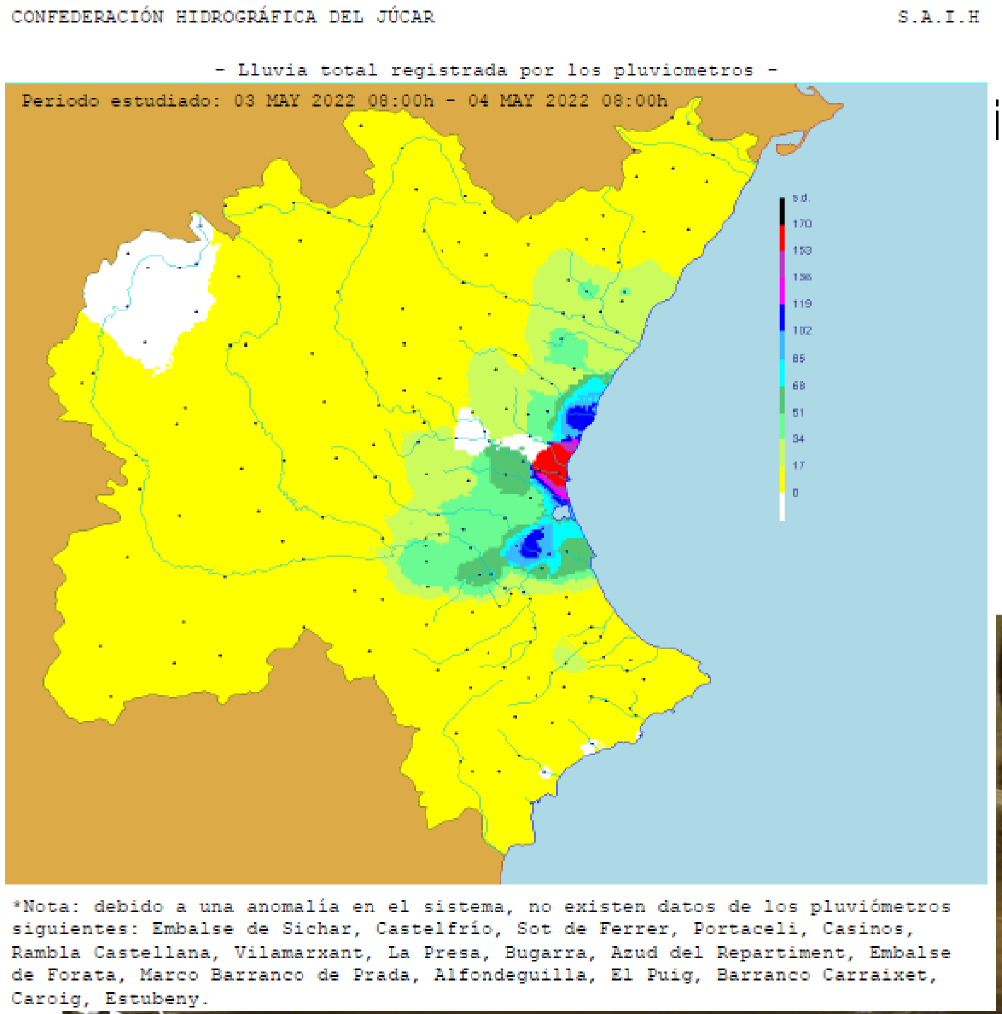
Un túnel anegado de Valencia por las lluvias torrenciales de este martes, en una imagen de la Policía Local. Video: EPV

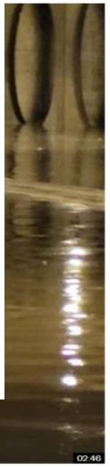
Case 1: MCS Valencia

On 3 May 2022, a very high-impact static convect… ive

- Spain_2022 in GitHub



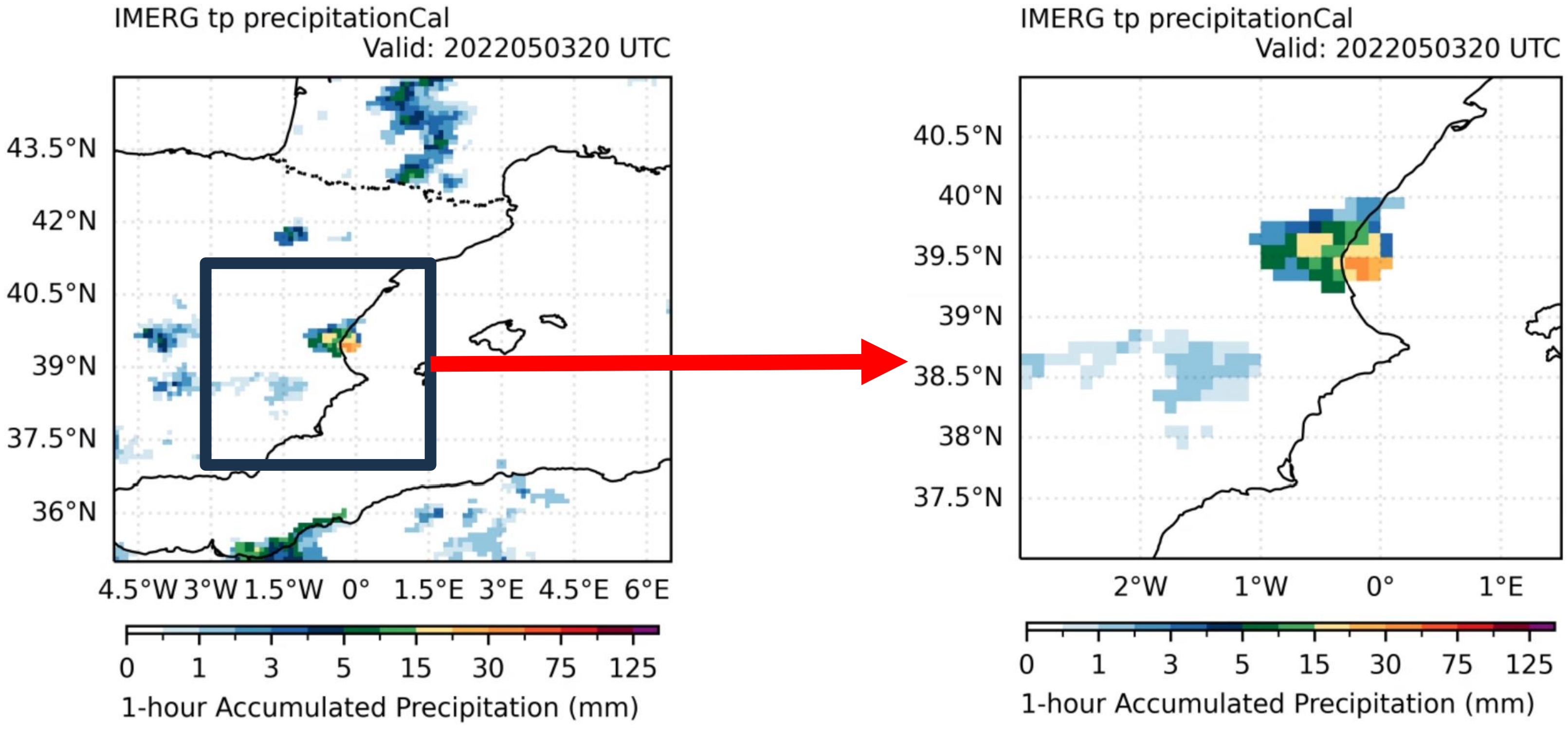




Un túnel anegado de Valencia por las lluvias torrenciales de este martes, en una imagen de la Policía Local.
Vídeo: EPV

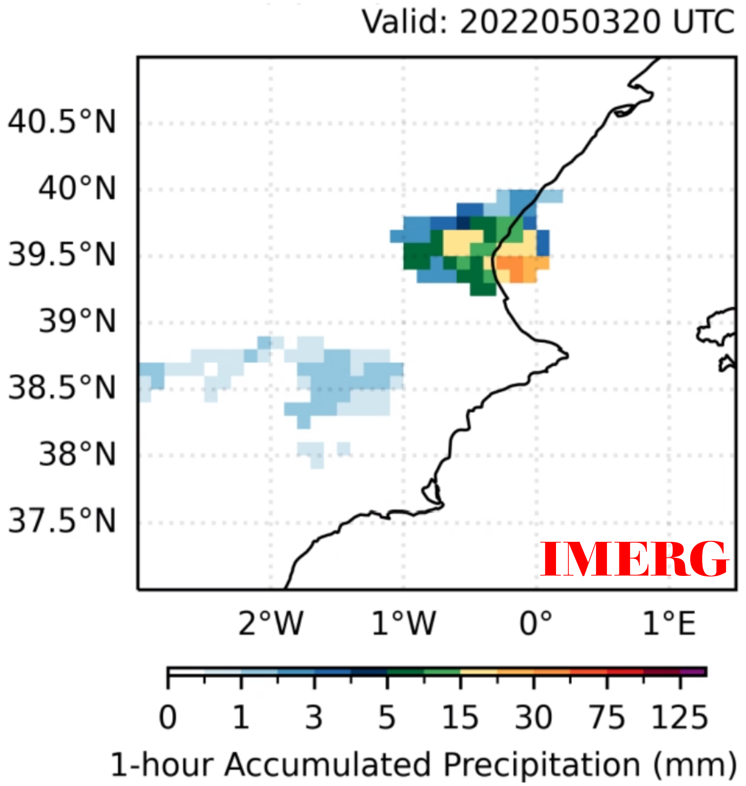
Case 1: MCS Valencia

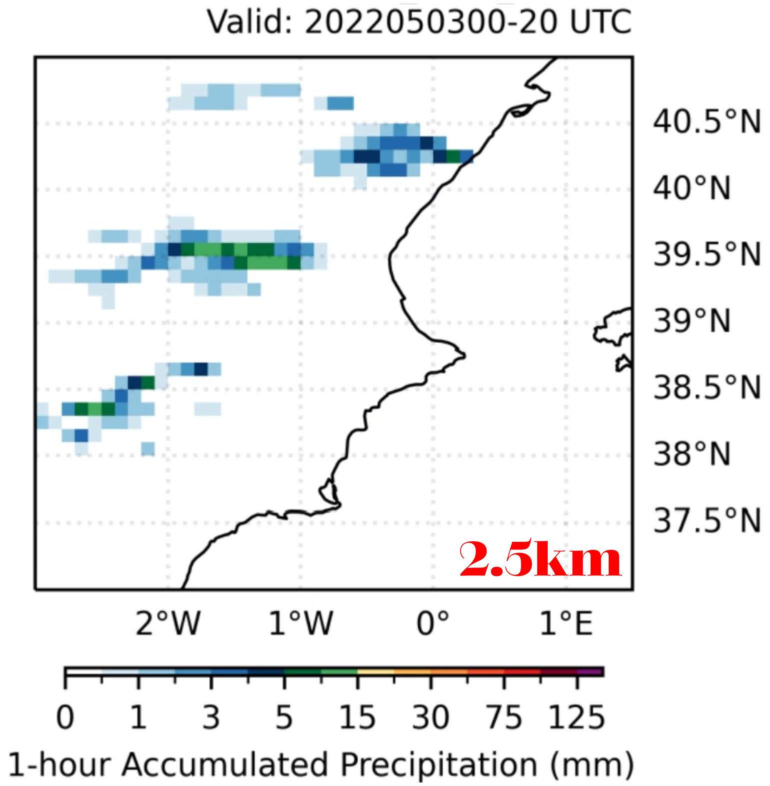
- Between 18z and 22z of day 3, there was a stationary precipitation band/patch over the coast of Valencia in the observations (IMERG-NASA precipitation), corresponding to this mesoscale convective system.
- We will use this observational dataset to compare against the model.



Case 1: MCS Valencia

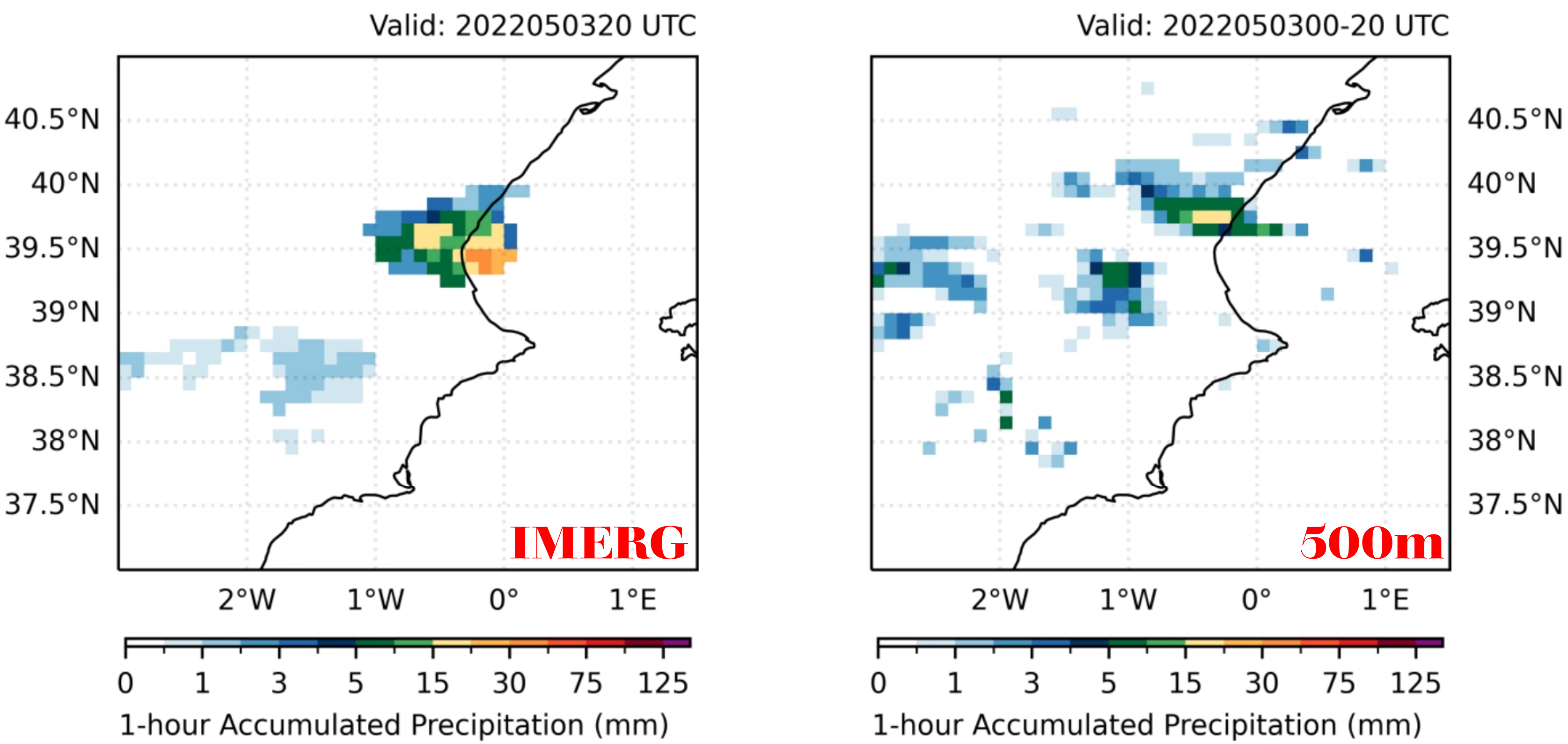
- This stationary precipitation band/patch over the coast of Valencia is not present in the operational 2.5 km run. The 2.5 km run only saw convective cells being advected westward by the flow, which also left strong precipitation but not in a stationary manner as in reality.





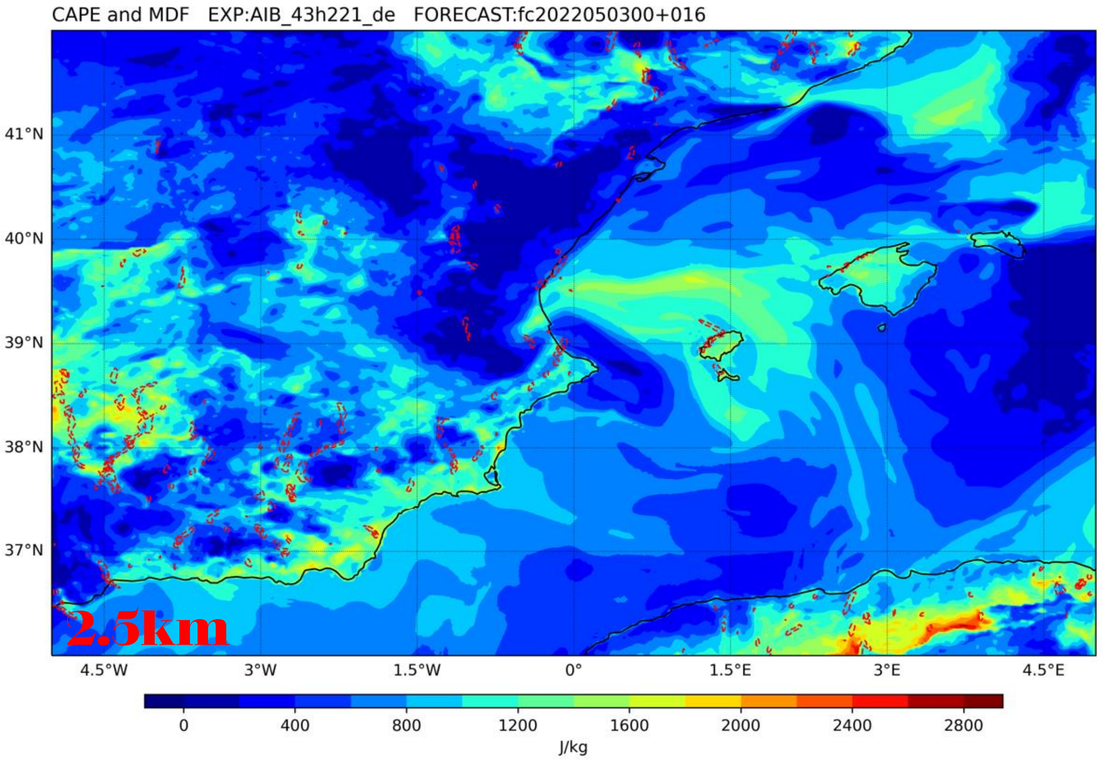
Case 1: MCS Valencia

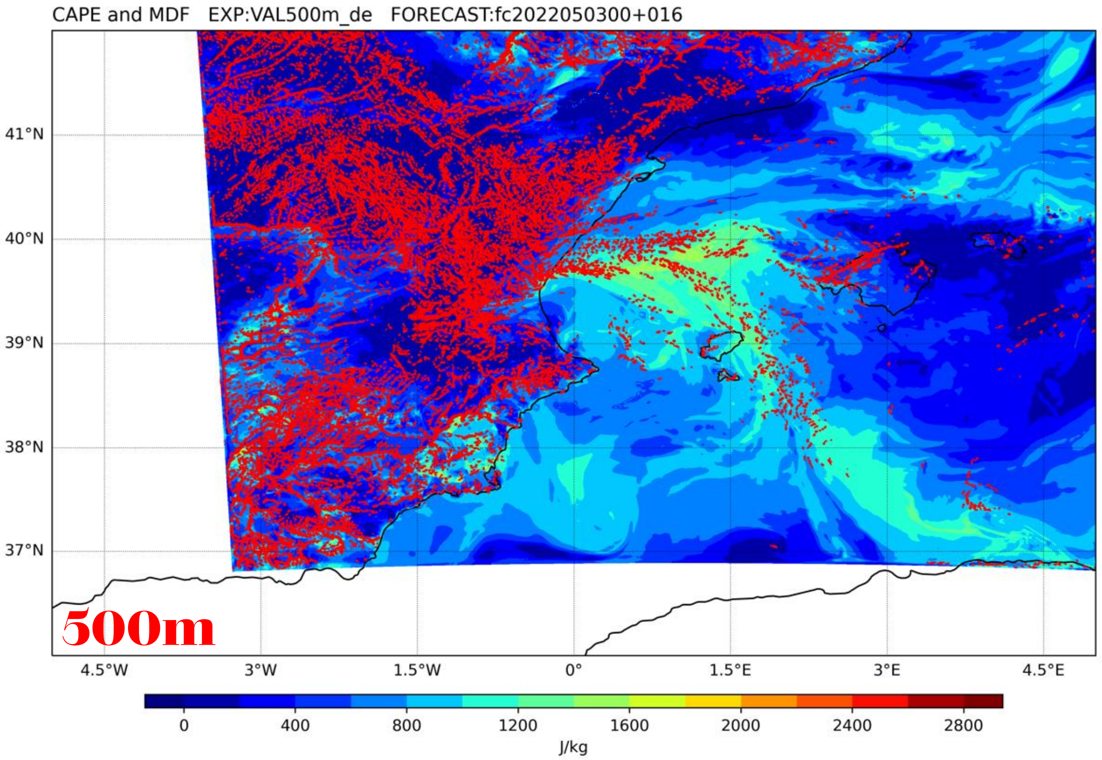
- The 500 m run start to see a stationary band of heavy rainfall, although a bit north and weaker than in the reality.



Case 1: MCS Valencia

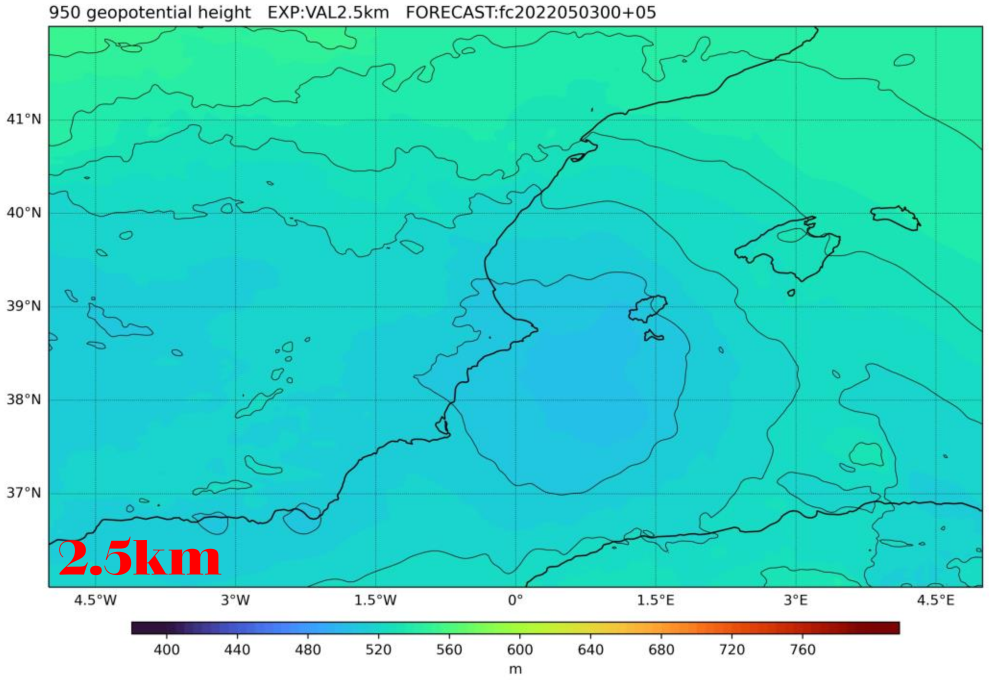
- This stationary precipitation band/patch in the 500 m. run was due to the presence of a moisture flux convergence (red) line in presence of high instability (CAPE; shaded). This convergence line was not present in 2.5 km.
- Instability (CAPE) seems to be similar in both runs, although in 500 m it gets further into the coast.

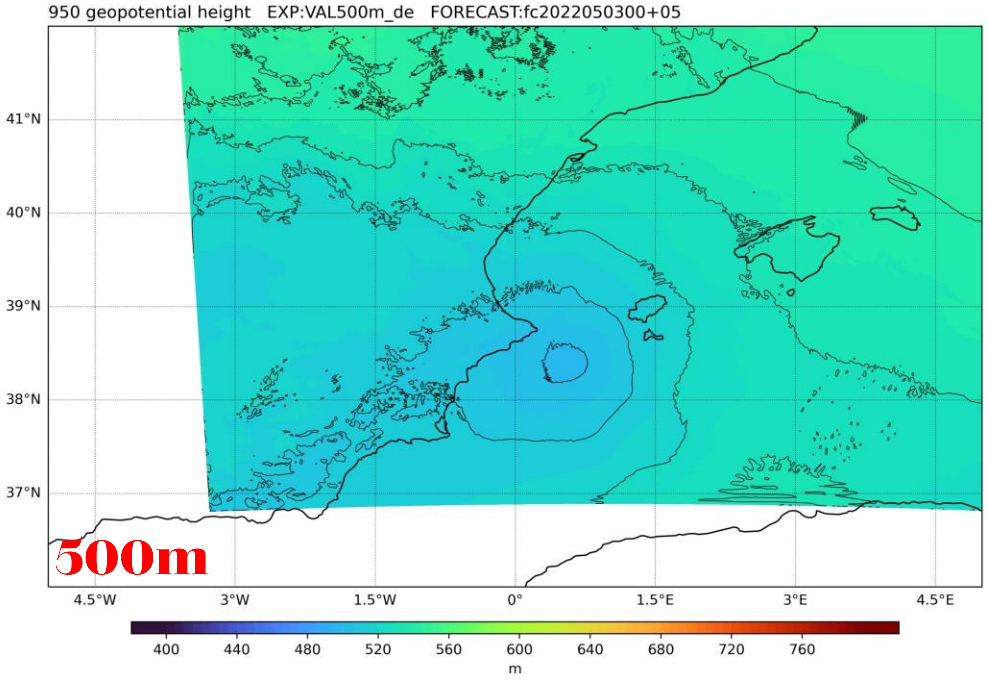




Case 1: MCS Valencia

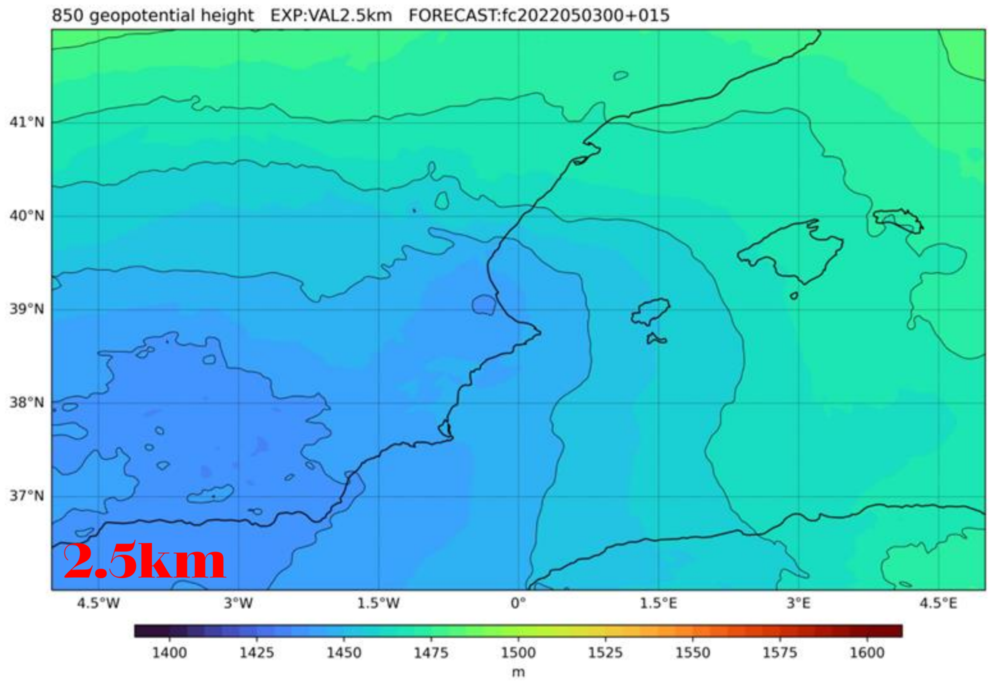
- Why 500 m is the one able to get a convergence line?
- Probably due to a better representation of the low and stronger pressure gradient with the anticyclonic region to the northeast, which promotes convergence?

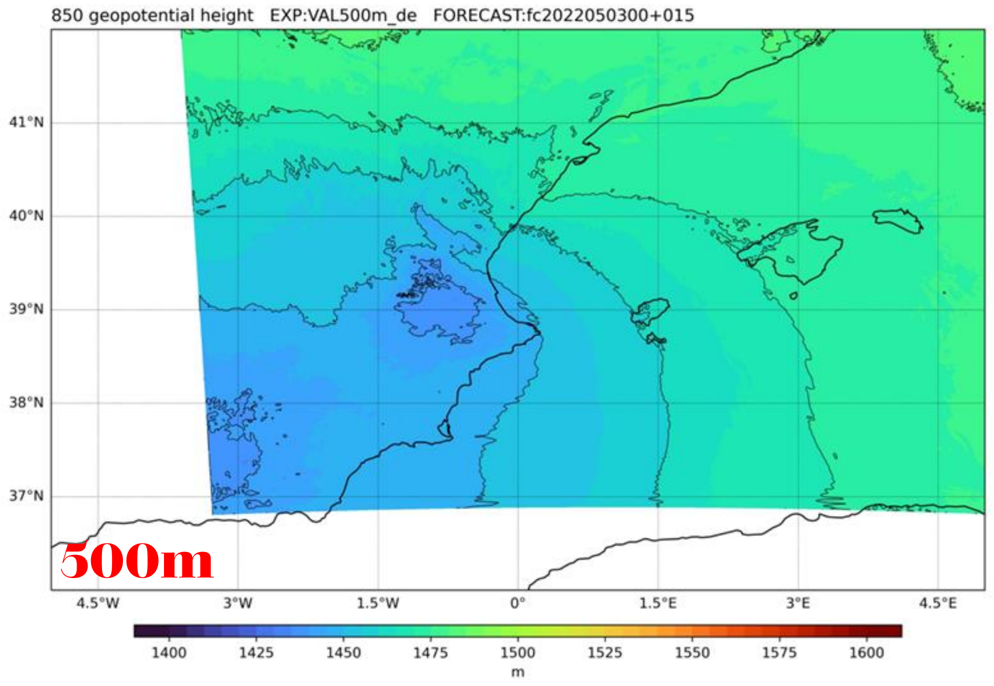




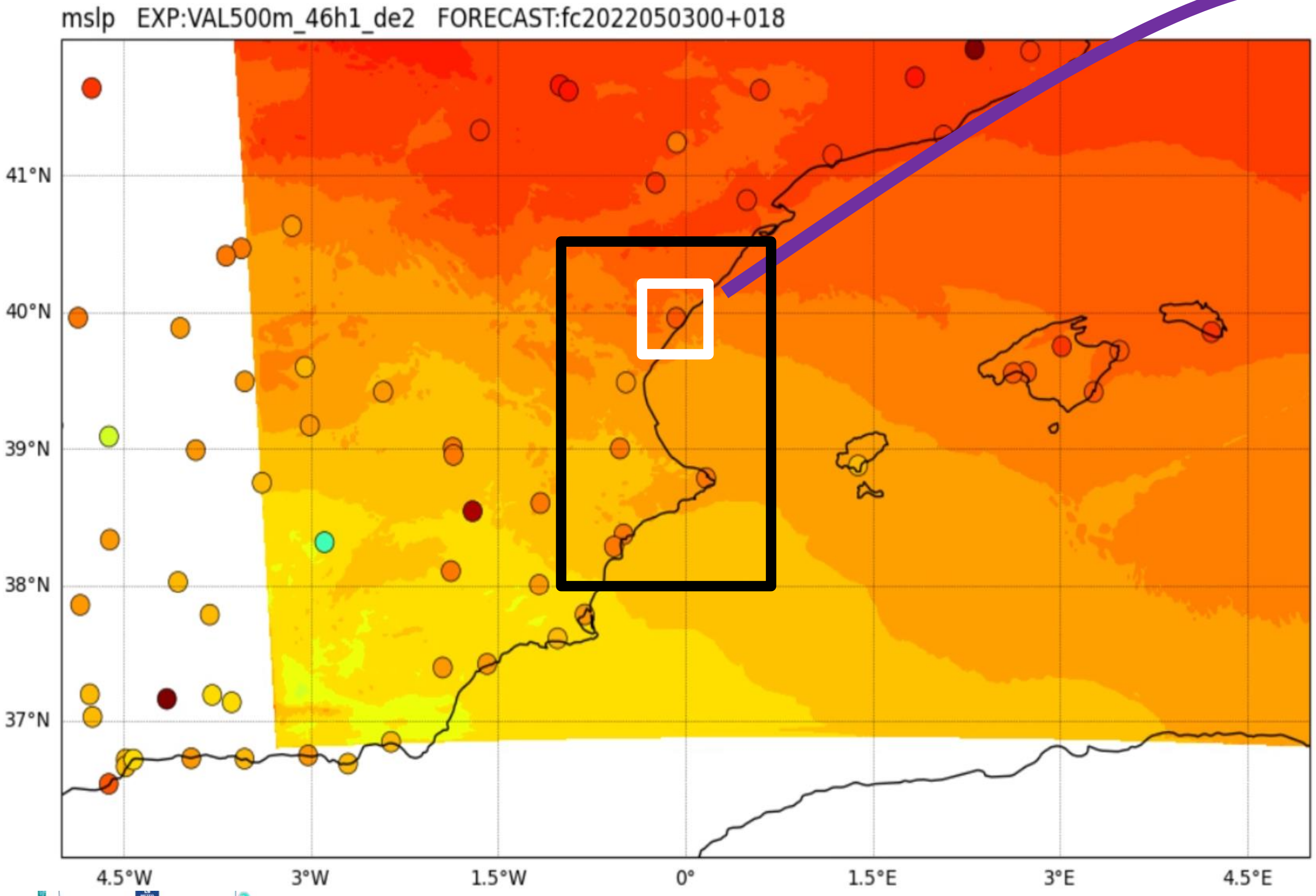
Case 1: MCS Valencia

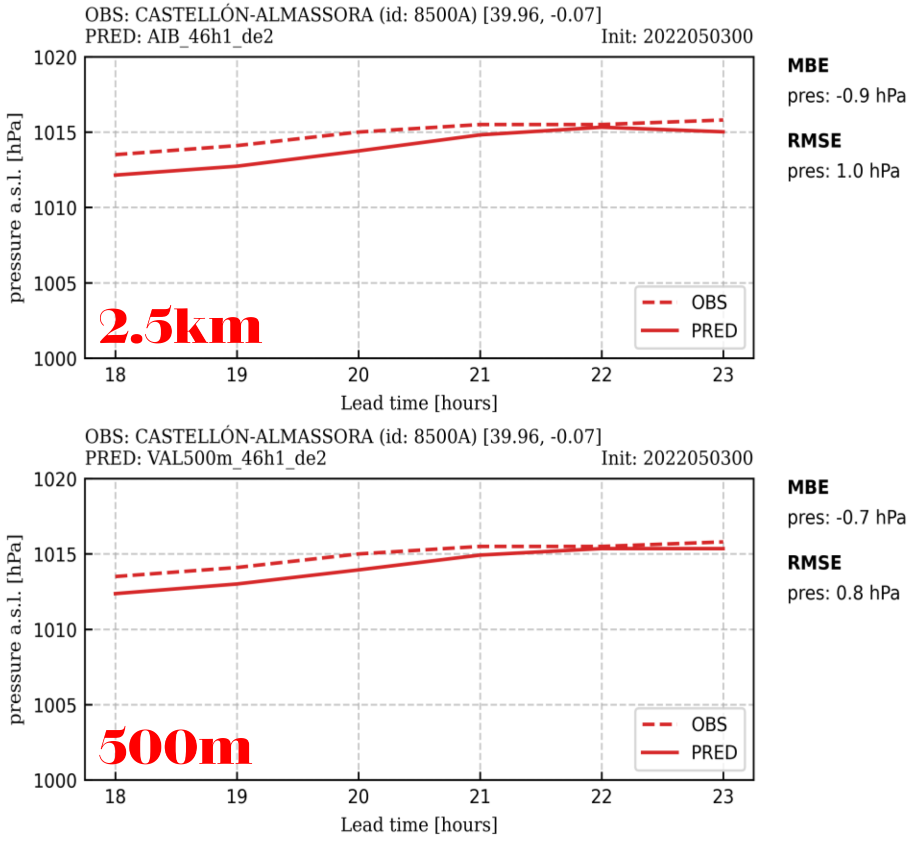
- Why 500 m is the one able to get a convergence line?
- Probably due to a better representation of the low and stronger pressure gradient with the anticyclonic region to the northeast, which promotes convergence?



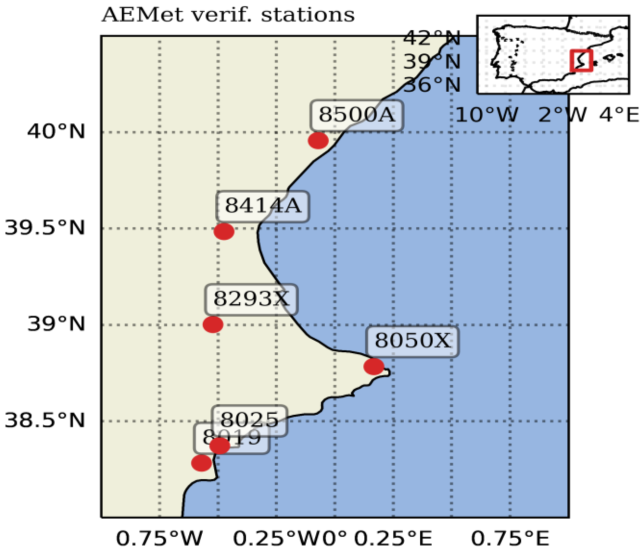


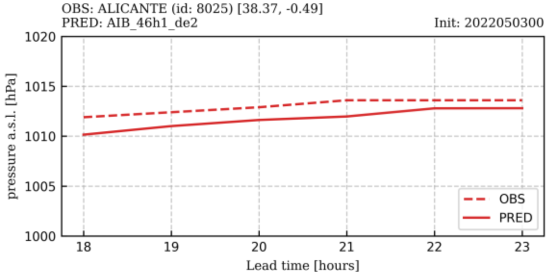
Case 1: MCS Valencia



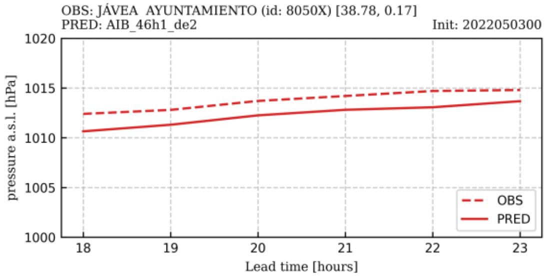


Case 1: MCS Valencia

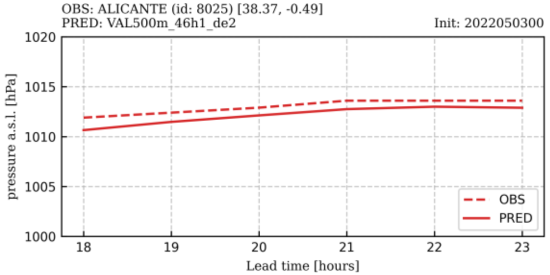




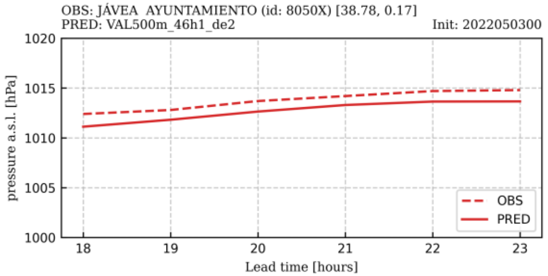
MBE
pres: -1.3 hPa
RMSE
pres: 1.3 hPa



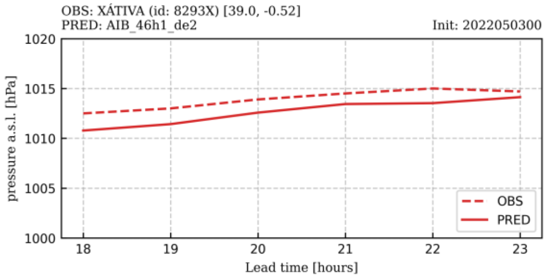
MBE
pres: -1.5 hPa
RMSE
pres: 1.5 hPa



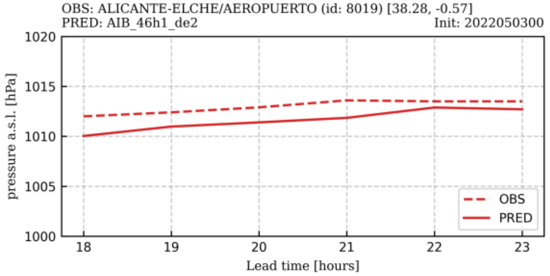
MBE
pres: -0.9 hPa
RMSE
pres: 0.9 hPa



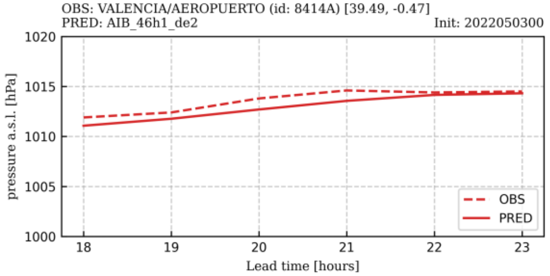
MBE
pres: -1.1 hPa
RMSE
pres: 1.1 hPa



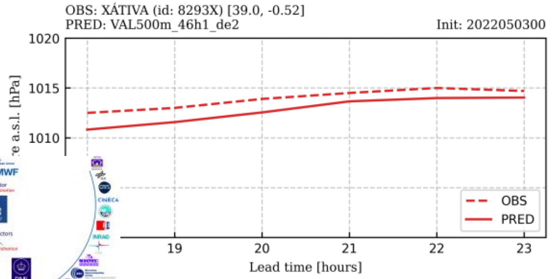
MBE
pres: -1.3 hPa
RMSE
pres: 1.3 hPa



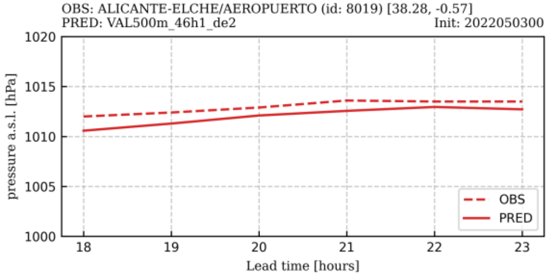
MBE
pres: -1.3 hPa
RMSE
pres: 1.4 hPa



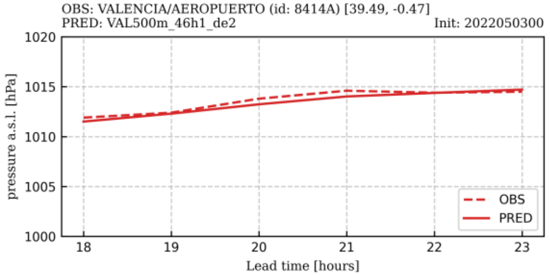
MBE
pres: -0.7 hPa
RMSE
pres: 0.8 hPa



MBE
pres: -1.2 hPa
RMSE
pres: 1.2 hPa



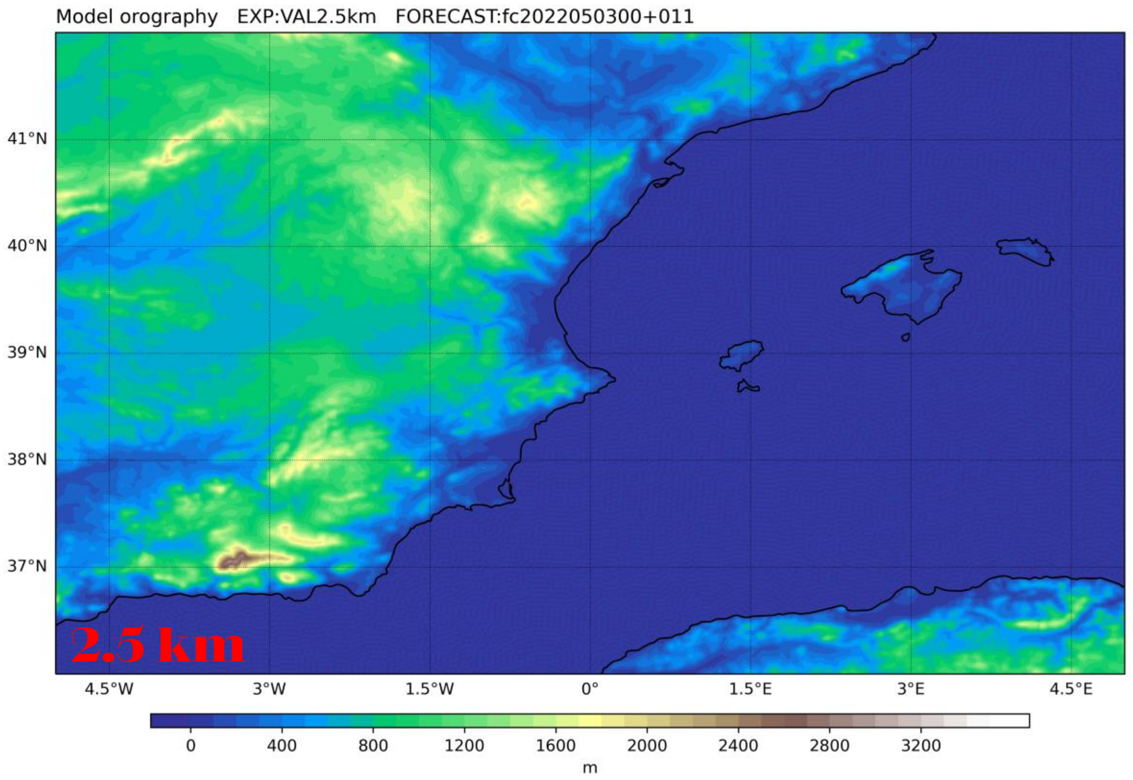
MBE
pres: -0.9 hPa
RMSE
pres: 1.0 hPa

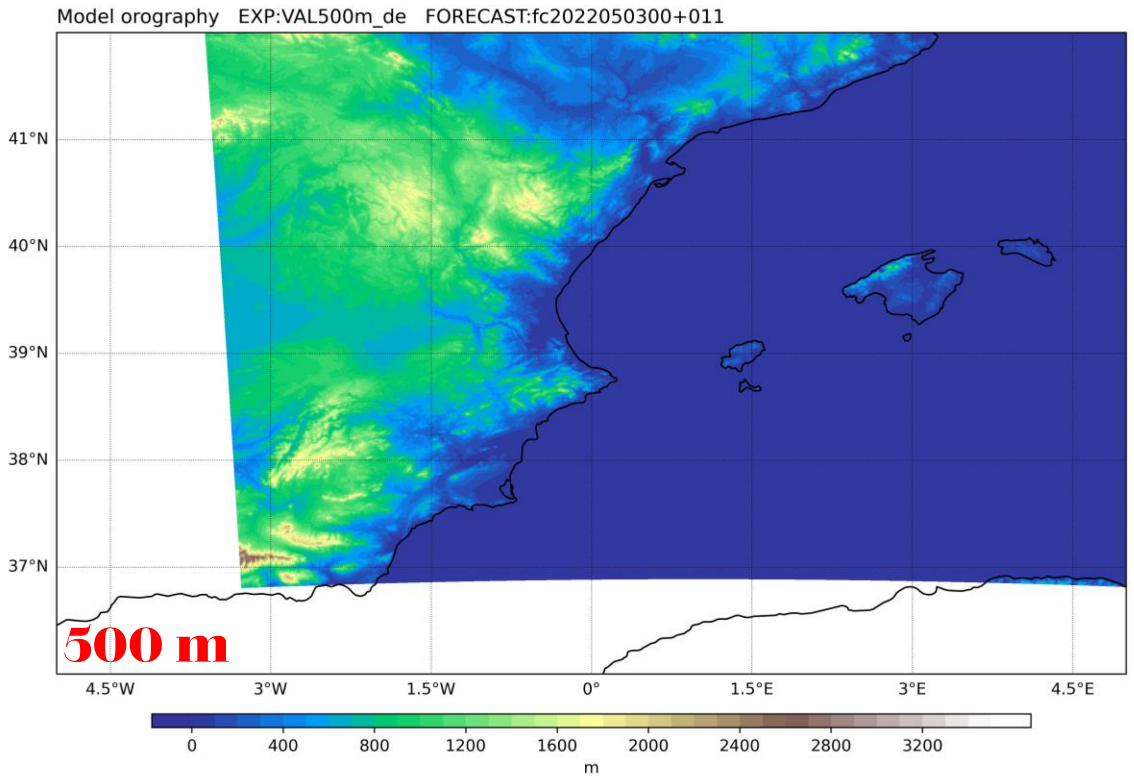


MBE
pres: -0.2 hPa
RMSE
pres: 0.4 hPa

Case 1: MCS Valencia

- Orography is not necessarily playing a crucial role, as the gradient is stronger not only because of the low and the anticyclone to the north. Although the low deepens further in 500 m once it enters the coast?





Case 1: MCS Valencia

Conclusions:

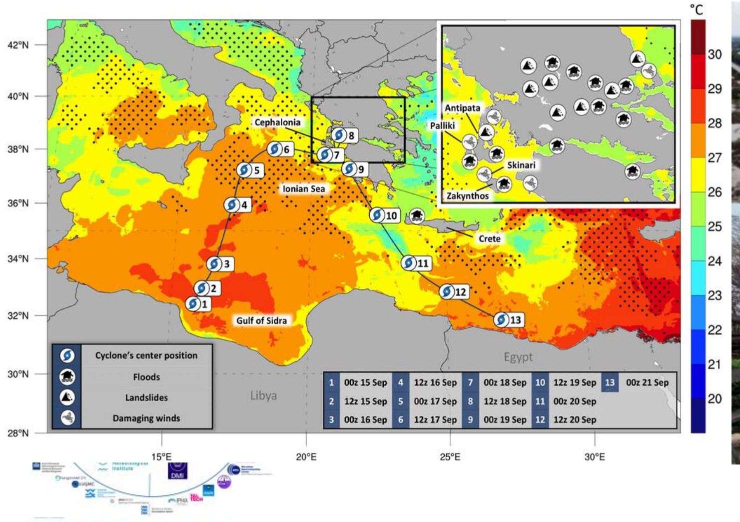
- Operational runs at 2.5 km were not able to simulate the deep convective system that left heavy rainfall over Valencia.
- Sub-kilometric resolution simulations are able to simulate the system, although it is not totally clear regarding the intensity and structure. Further analysis needed.
- The key differences are related to the well represented low-level moisture flux convergence line over the coast that does not occur in the reference run.

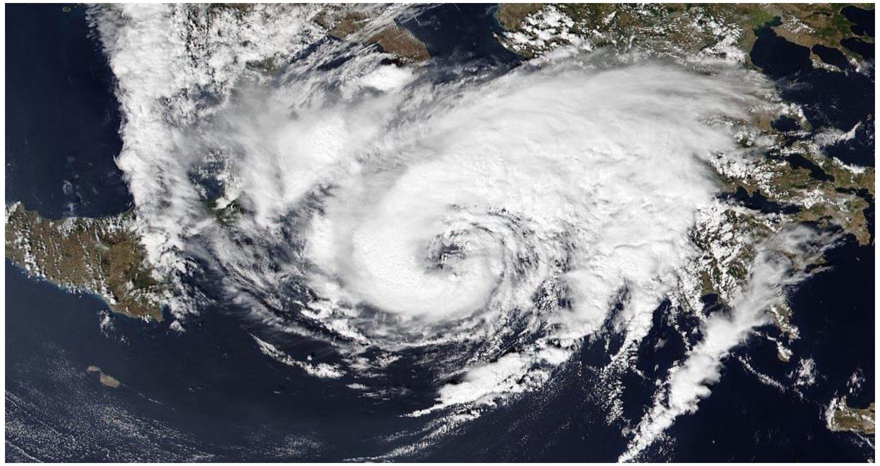
Next:

- Analysis of DEODE prototype runs (~500 m) and DT (IFS) global runs (~4 km).

Case 2: Medicane Ianos

- Ianos was one of the most intense Medicane ever recorded in the Mediterranean sea. Probably category 2 hurricane.
- It produced several environmental and socioeconomical impacts along a +1900 km path in the western and central parts of Greece.
- Mean sea level pressure down to 984 hPa and wind gusts were recorded up to 54 m/s.
- *Ianos_2020* in dcmdb

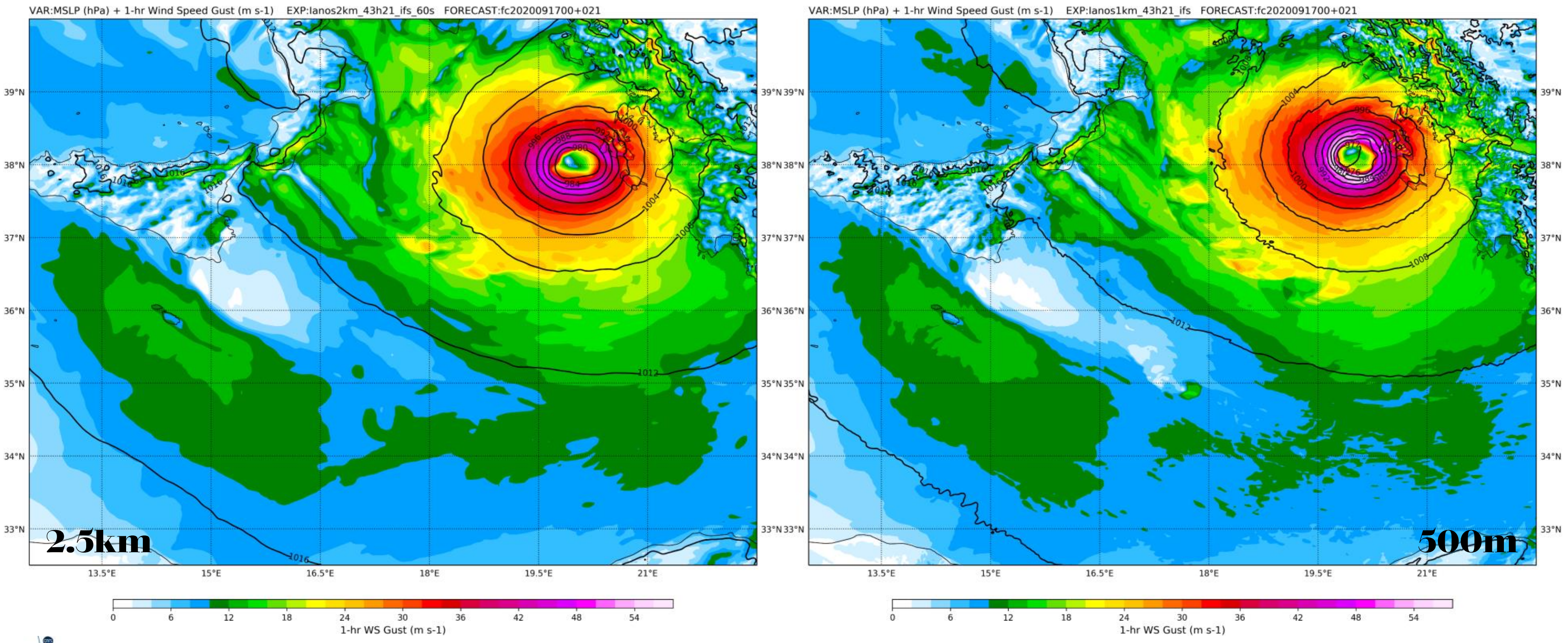




Case 2: Medicane Ianos

SUB-KM SIMULATIONS [500m] vs OPERATIONAL RESOLUTION [2.5 km]

- IANOS is seen stronger in the 500 m simulation vs. 2.5 km simulation.

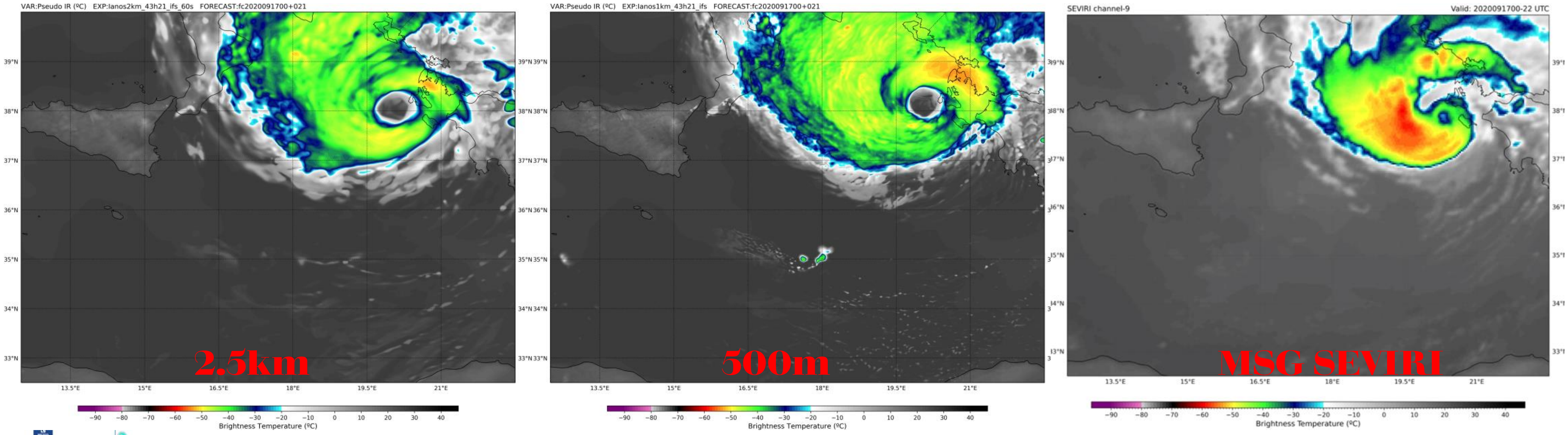


Surface (10-m) wind speed & mslp for HARMONIE-AROME at 2.5 km and 500 m

Case 2: Medicane Ianos

SUB-KM SIMULATIONS [500m] vs OPERATIONAL RESOLUTION [2.5 km]

- A hurricane structure is seen in the simulations, more robust in the 500 m resolution.
- This contrasts with a weaker tropical cyclone structure that was observed in SEVIRI, where no robust eye is developed.

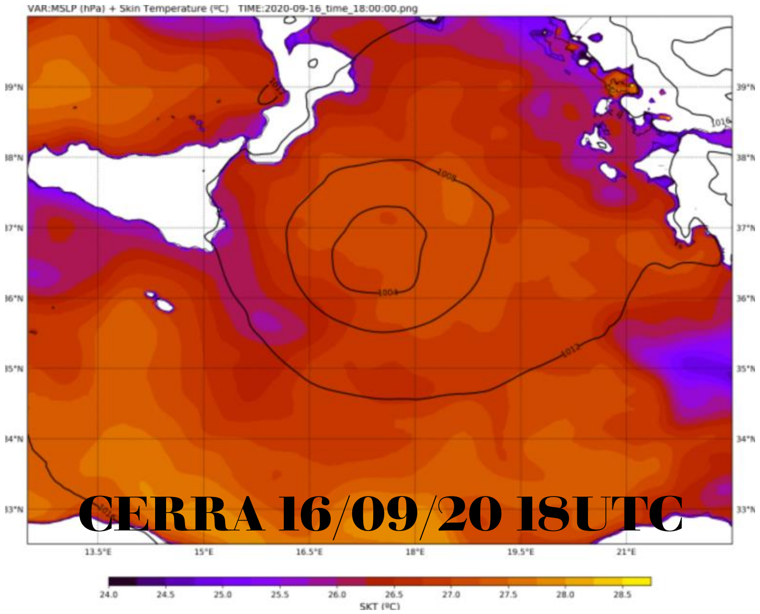


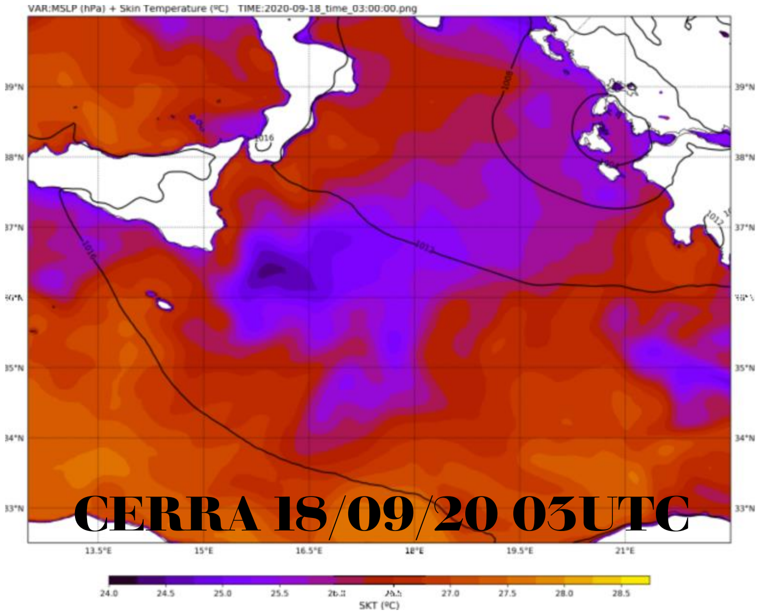
Simulated brightness temperature in HARMONIE-AROME | OBSERVED brightness temperature from MSG- SEVIRI channel 9

Case 2: Medicane Ianos

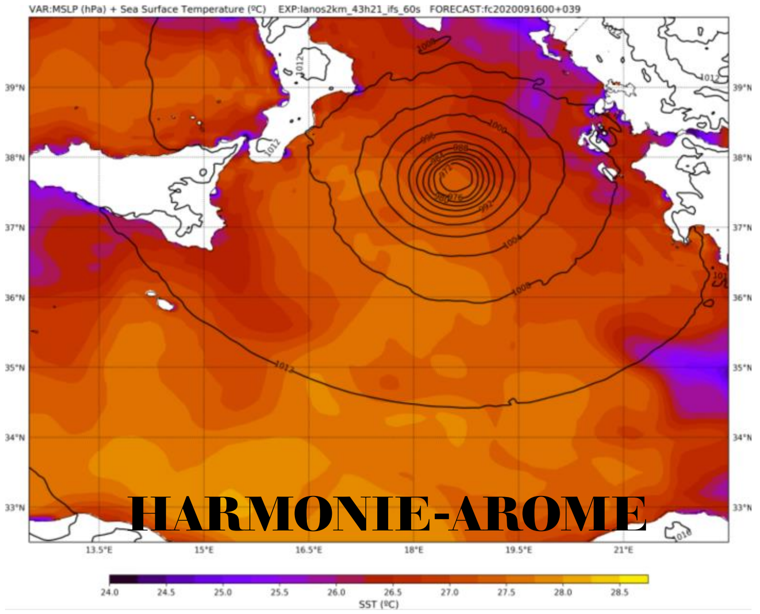
SUB-KM SIMULATIONS [500m] vs OPERATIONAL RESOLUTION [2.5 km]

OBSERVED sea surface temperature & mslp derived from CERRA reanalysis

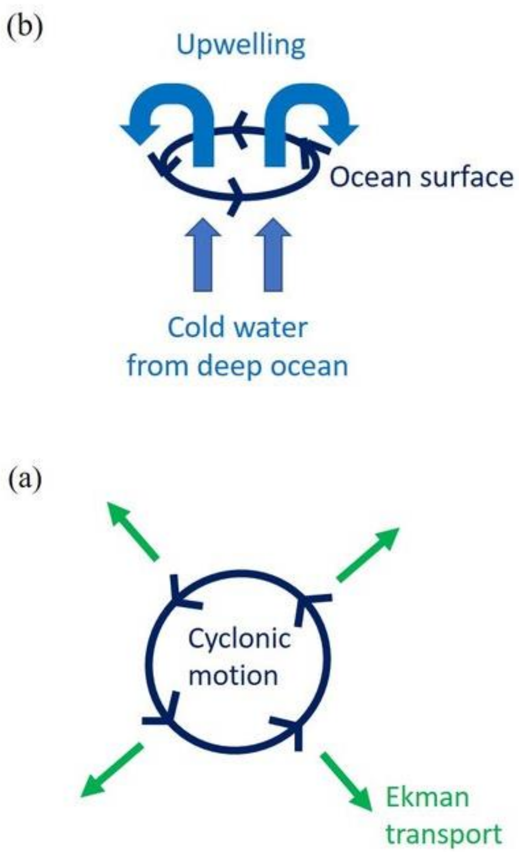


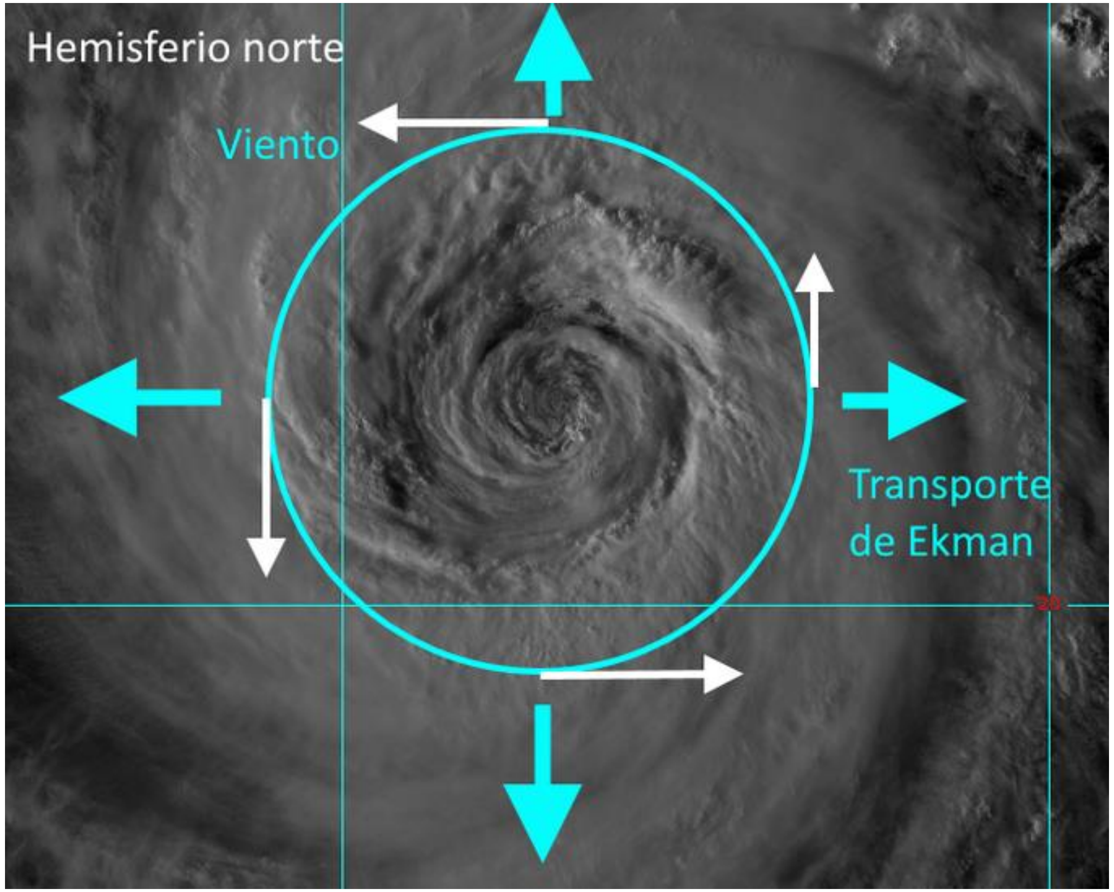


HARMONIE-AROME sea surface temperature & mslp



Case 2: Medicane Ianos





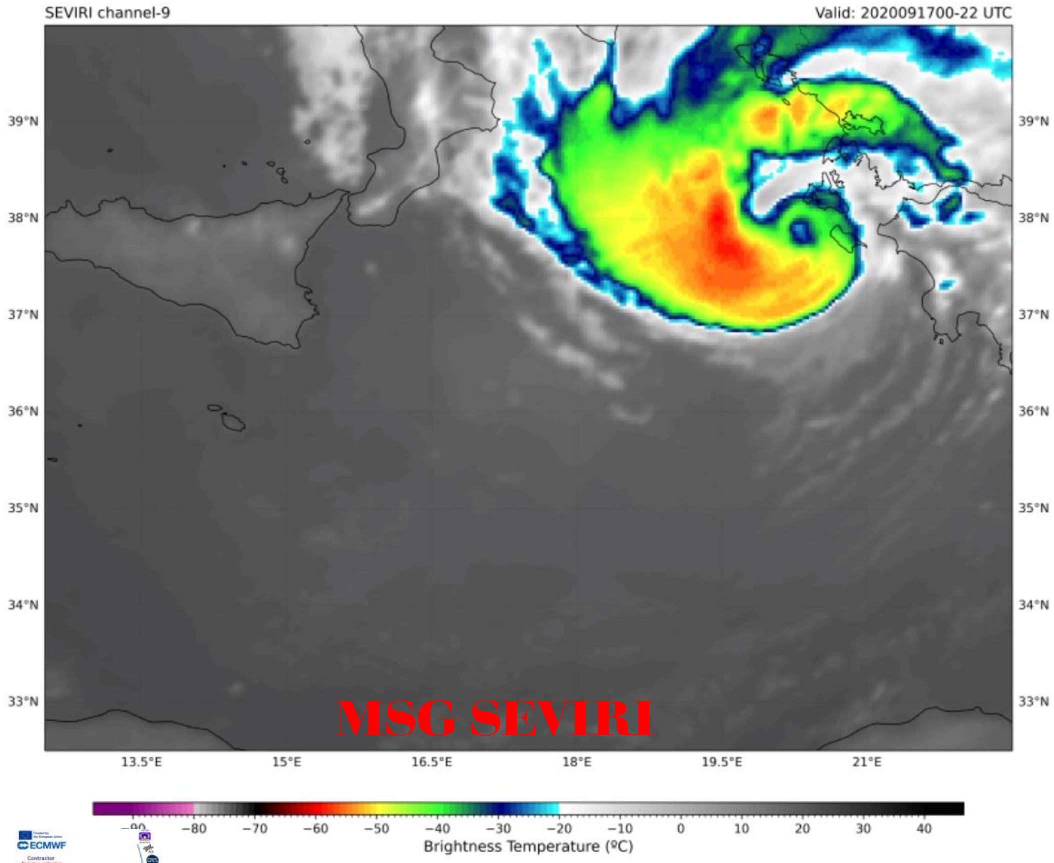
Upwelling in tropical cyclones

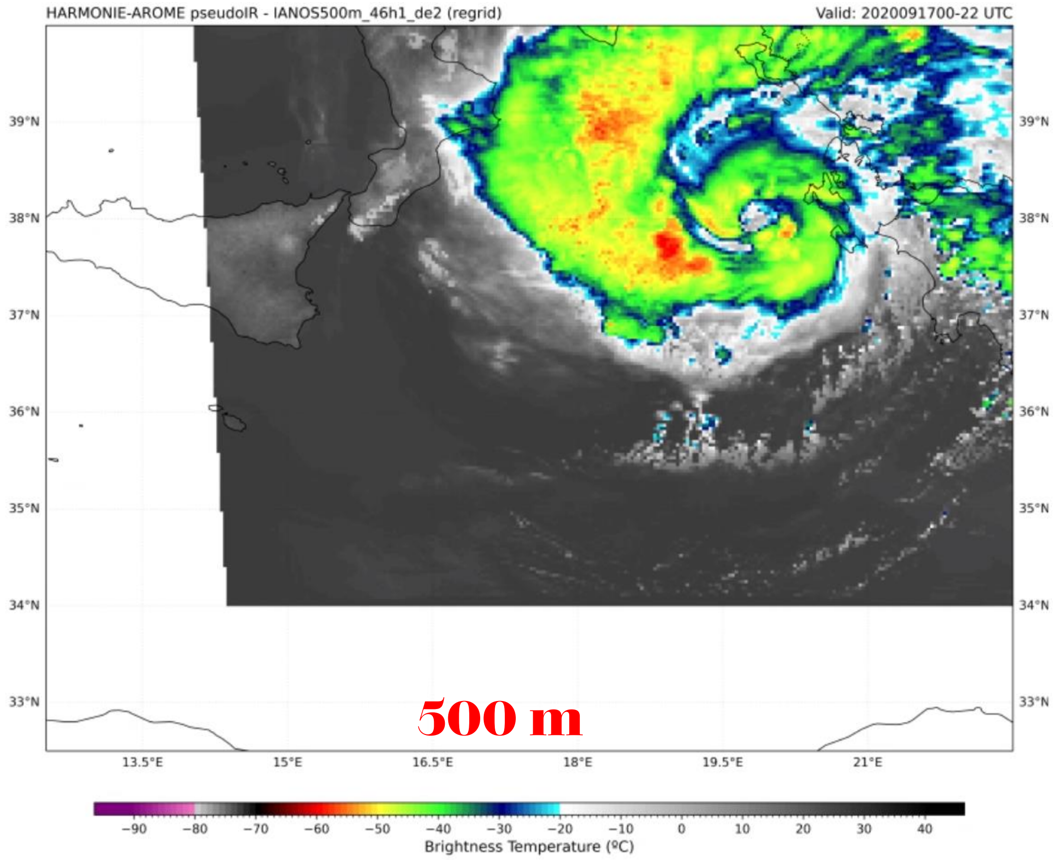
Funded by the European Union Destination Earth implemented by ECMWF esa EUMETSAT

Case 2: Medicane Ianos

Warm-up [10 days]:

Left: OBSERVED SEVIRI brightness temperature channel 9 (IR)
Right: Simulated brightness temperature in HARMONIE-AROME





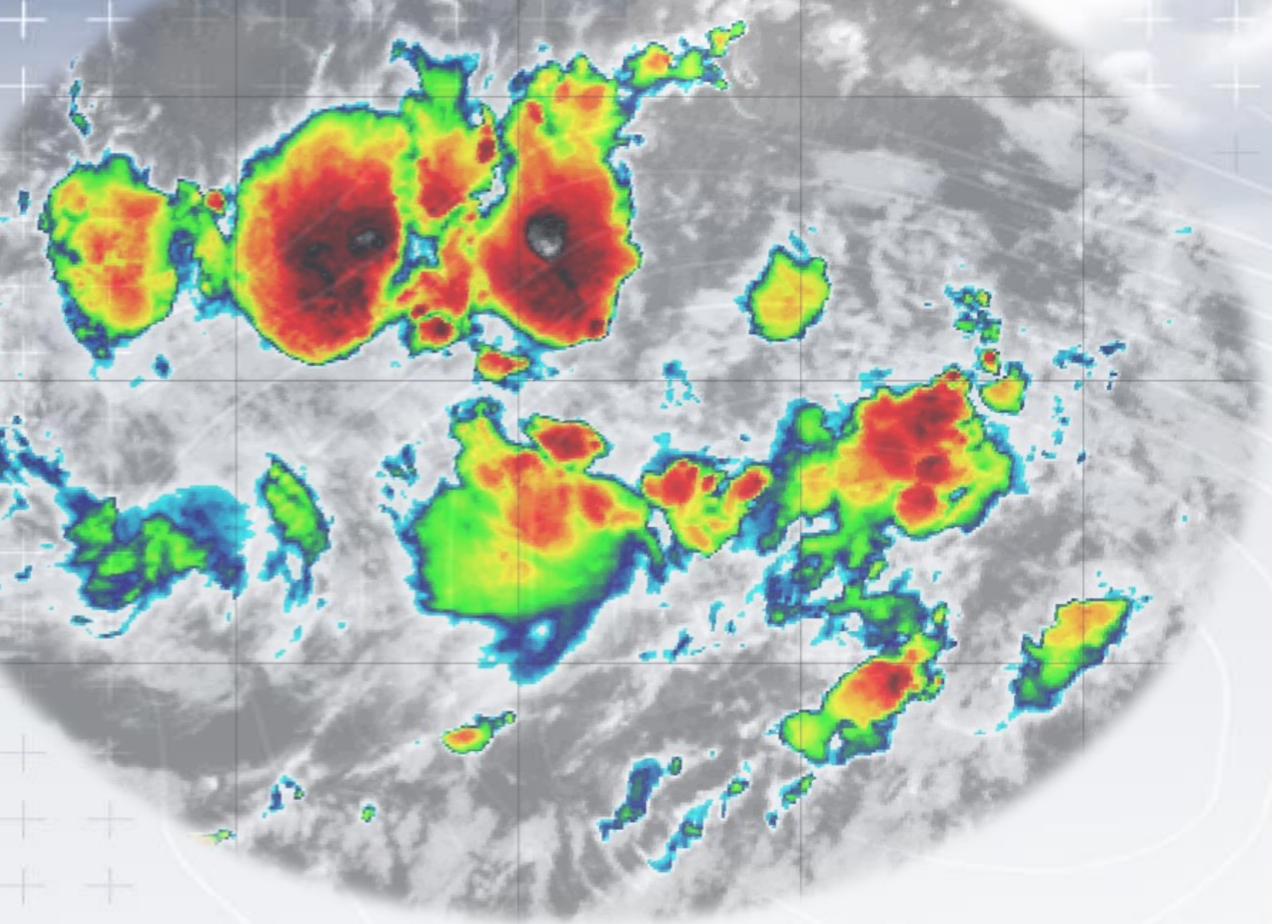
Case 2: Medicane Ianos

Conclusions:

- 2.5 km and 500 m resolution simulations over intensifies the cyclone. 500 m more.
- This is probably due to a lack of ocean-atmosphere coupling.
- Warm-up/spin-up tends to reduce the over intensification.

Next:

- Analysis of DEODE prototype runs (~500 m) and DT (IFS) global runs (~4 km).



GOBIERNO DE ESPAÑA
VICEPRESIDENCIA TERCERA DEL GOBIERNO
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO

AEMet
Agencia Estatal de Meteorología

Juan Jesús González Alemán

Numerical Weather Prediction Area,
Spanish State Meteorological Agency (AEMet)

Lagrangian spatial verification focused on convective activity in VHR

Lagrangian spatial verification focused on convective activity in VHR

- Thanks to the advent of VHR (sub-kilometric) NWP, we can start analysing specific convective activity features.
- At sub-kilometric resolutions, convective-related specific phenomena begin to be explicitly represented.
- Indeed, at VHR doubts arise regarding the use or not of shallow-convective squemes; a solution of scale-aware squeme has been proposed.
- Therefore, a window of opportunity for other kind of verification methods emerge --> Lagrangian's point of view.

Lagrangian spatial verification focused on convective activity in VHR

- It helps to:
  - Evaluate statistics of convective systems, the frequency, the number, the behaviour of their life cycle ,etc…
  - Verify NWP simulations with satellite data.
  - Convective storms.
  - Modes of convective storms:
    - Supercells, MCSs, MCCs, squall lines, Derechos.
    - Convective storms with high precipitation rate (BTs+precip).
    - Convective storms with high reflectivity (BTs+radar reflec).
    - Convective storms with high lightning activity (BTs+lightning).
  - **Convective initiation.**

Lagrangian spatial verification focused on convective activity in VHR

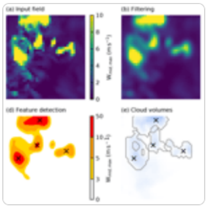
- Methods for cloud tracking are gaining importance in the analysis of model simulations.
- Here we use the TOBAC method --> Tracking and Object-Based Analysis of Clouds:

Geosci. Model Dev., 12, 4551–4570, 2019
https://doi.org/10.5194/gmd-12-4551-2019

Article | Assets | Peer review | Metrics | Related articles

Methods for assessment of models — 30 Oct 2019

tobac 1.2: towards a flexible framework for tracking and analysis of clouds in diverse datasets

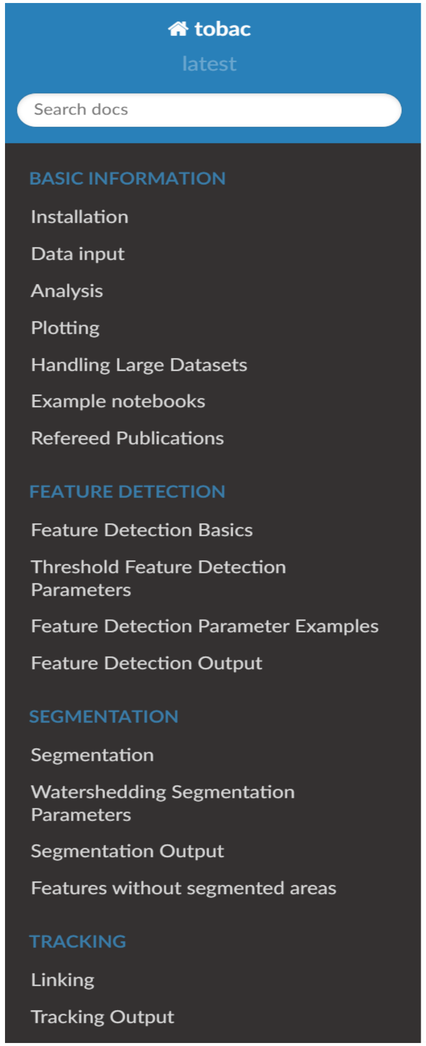


Max Heikenfeld[1], Peter J. Marinescu[2], Matthew Christensen[1], Duncan Watson-Parris[1], Fabian Senf[3], Susan C. van den Heever[2], and Philip Stier[1]
[1]Atmospheric, Oceanic & Planetary Physics, Department of Physics, University of Oxford, Oxford, UK
[2]Department of Atmospheric Sciences, Colorado State University, Fort Collins, USA
[3]Leibniz Institute for Tropospheric Research, Leipzig, Germany

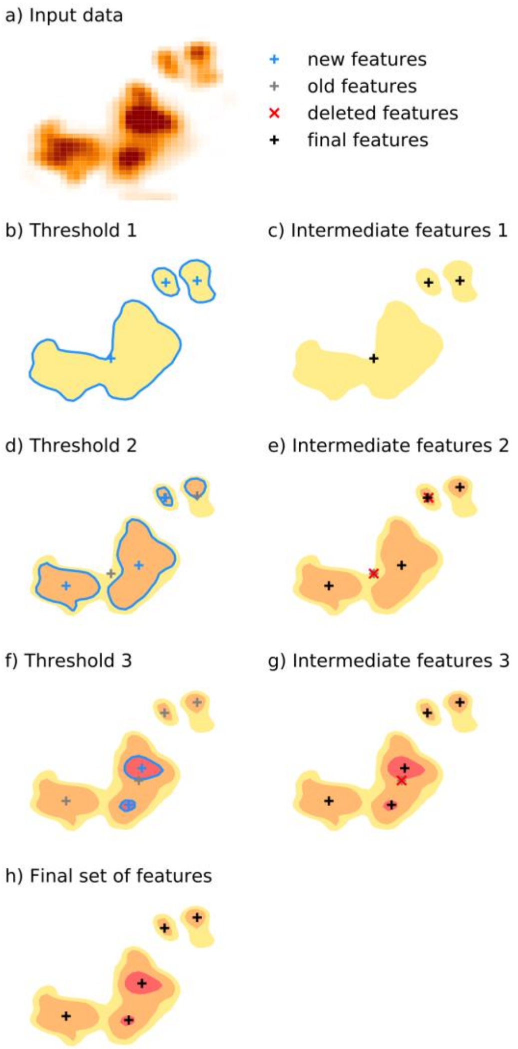
Correspondence: Philip Stier (philip.stier@physics.ox.ac.uk)

Received: 14 Apr 2019 – Discussion started: 24 May 2019 – Revised: 14 Sep 2019 – Accepted: 19 Sep 2019 – Published: 30 Oct 2019

Cloud tracking

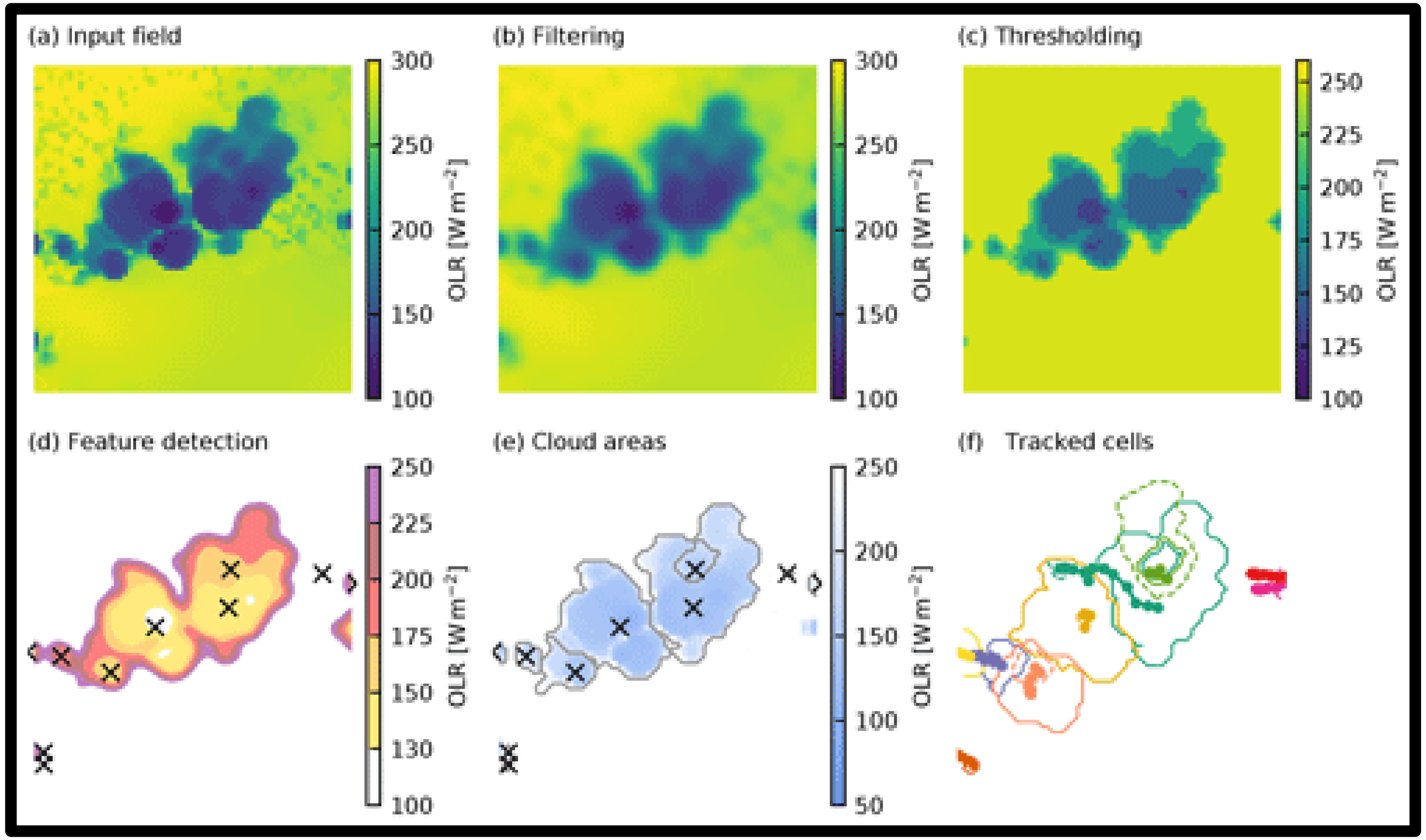


- tobac is a Python package to identify, track and analyze clouds in different types of gridded datasets, such as 3D model output from cloud-resolving model simulations or 2D data from satellite retrievals.
- The software is set up in a modular way to include different algorithms for feature identification, tracking, and analyses.
- tobac is also input variable agnostic and doesn't rely on specific input variables, nor a specific grid to work.
- In the current implementation, individual features are identified as either maxima or minima in a two-dimensional time-varying field (see Feature Detection Basics).
- An associated volume can then be determined using these features with a separate (or identical) time-varying 2D or 3D field and a threshold.
- The identified objects are linked into consistent trajectories representing the cloud over its lifecycle in the tracking step.
- Analysis and visualization methods provide a convenient way to use and display the tracking results.



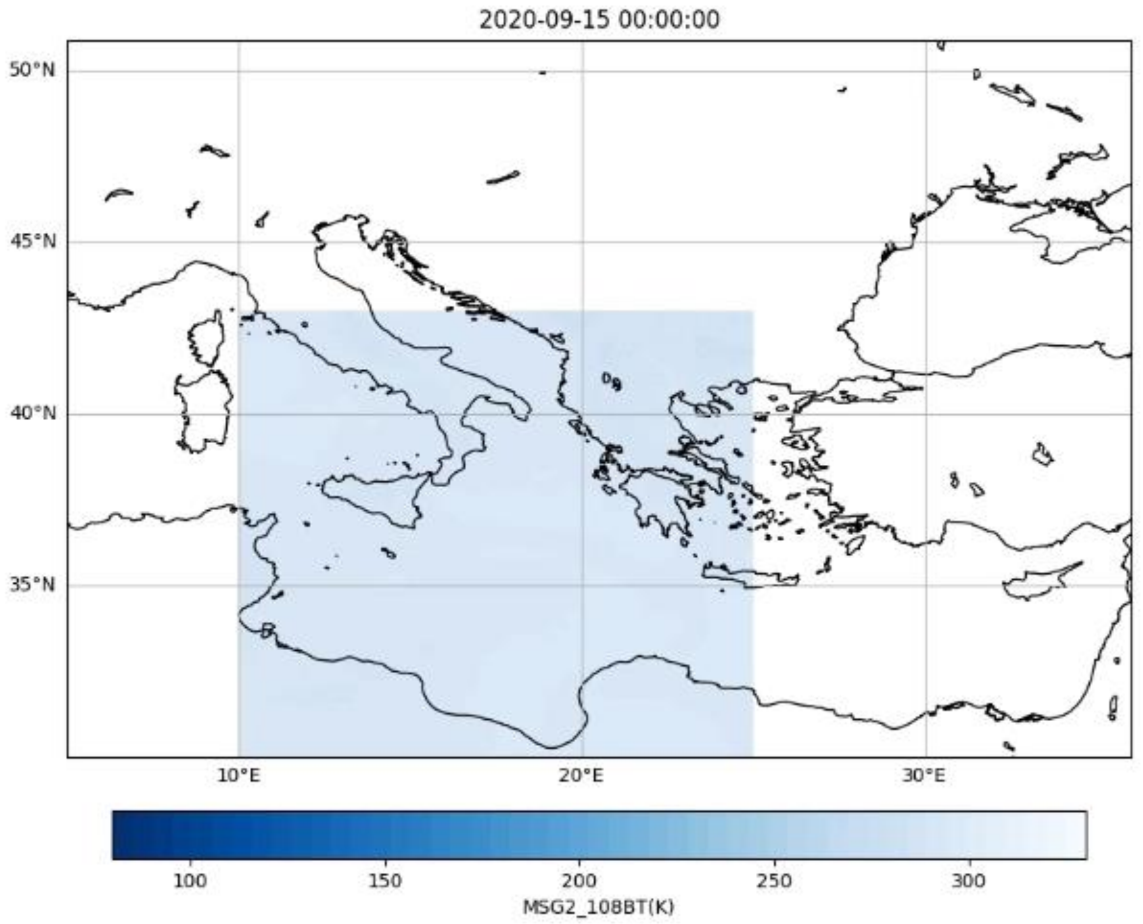
Cloud tracking

- tobac - Tracking and Object-Based Analysis of Clouds:



Cloud tracking

- tobac - Tracking and Object-Based Analysis of Clouds:



Cloud tracking – Convective Initiation

- Verification of convective initiation with satellite and reflectivity data:

Editorial Type: Article

Article Type: Research Article

Evaluating Convective Initiation in High-Resolution Numerical Weather Prediction Models Using *GOES-16* Infrared Brightness Temperatures

David S. Henderson, Jason A. Otkin, and John R. Mecikalski

Online Publication: 31 Mar 2021

Print Publication: 01 Apr 2021

DOI: https://doi.org/10.1175/MWR-D-20-0272.1

Page(s): 1153–1172

Article History | Download PDF | © Get Permissions

Cloud tracking – Convective Initiation

- Verification of convective initiation with satellite and reflectivity data:

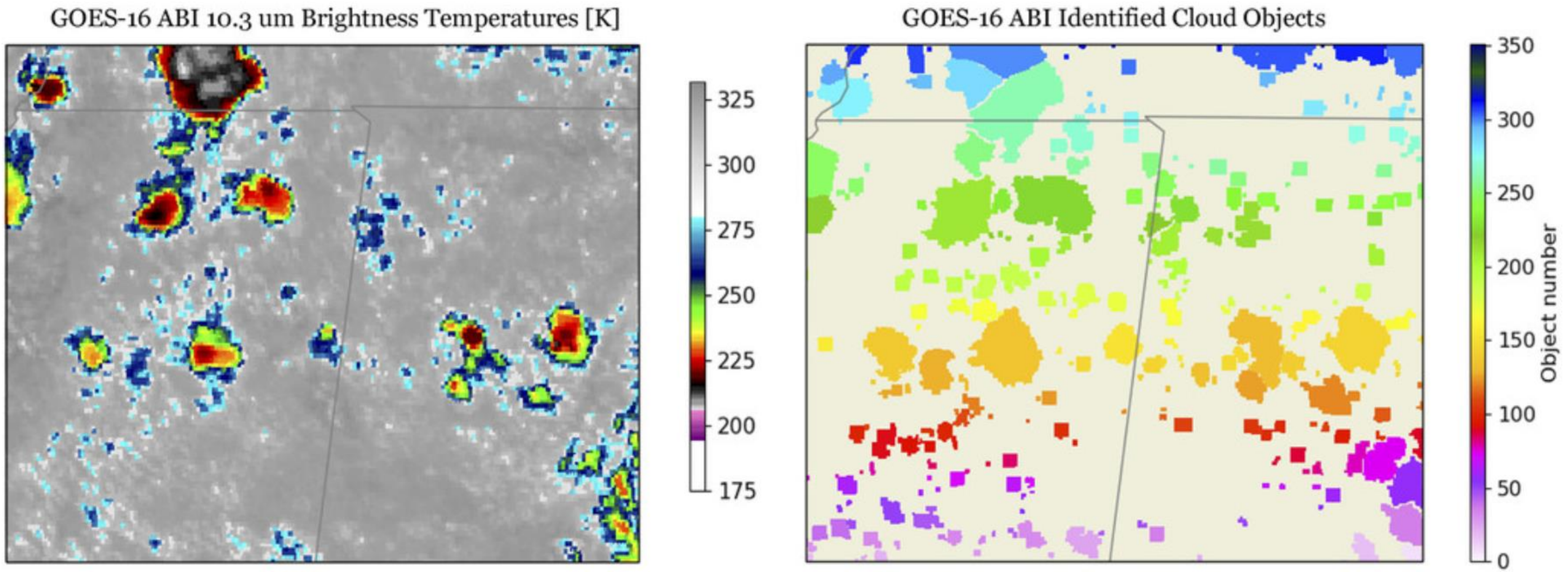


FIG. 2.

(left) An example of 1900 UTC *GOES-16 ABI* 10.35 μm brightness temperatures (K) within the inner domain region. (right) Derived cloud objects from this time step.

Case 2: Cloud tracking – Convective Initiation

- Verification of convective initiation with satellite and reflectivity data:

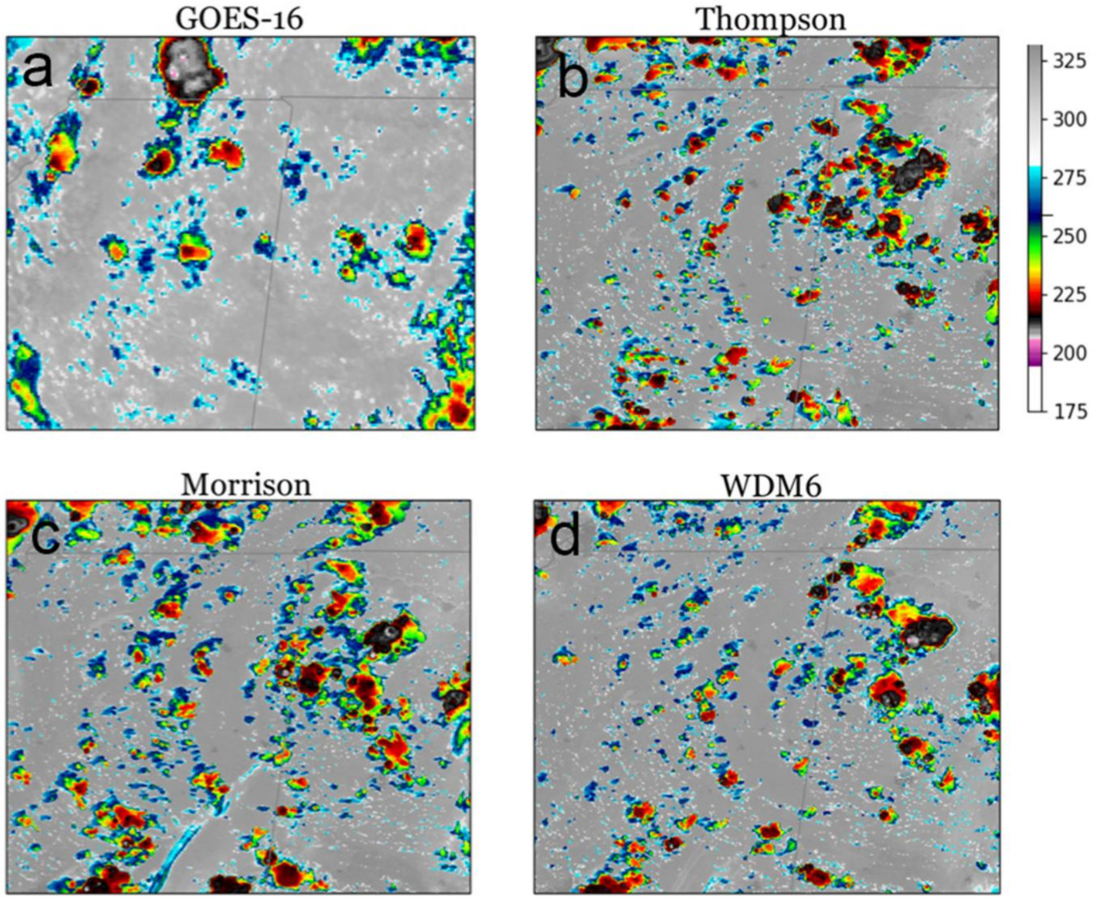


Fig. 5.

Observed and simulated ABI 10.35 μm brightness temperatures (K) at 1900 UTC for (a) *GOES-16*, (b) Thompson, (c) Morrison, and (d) WDM6.

Cloud tracking – Convective Initiation

- Verification of convective initiation with satellite and reflectivity data:

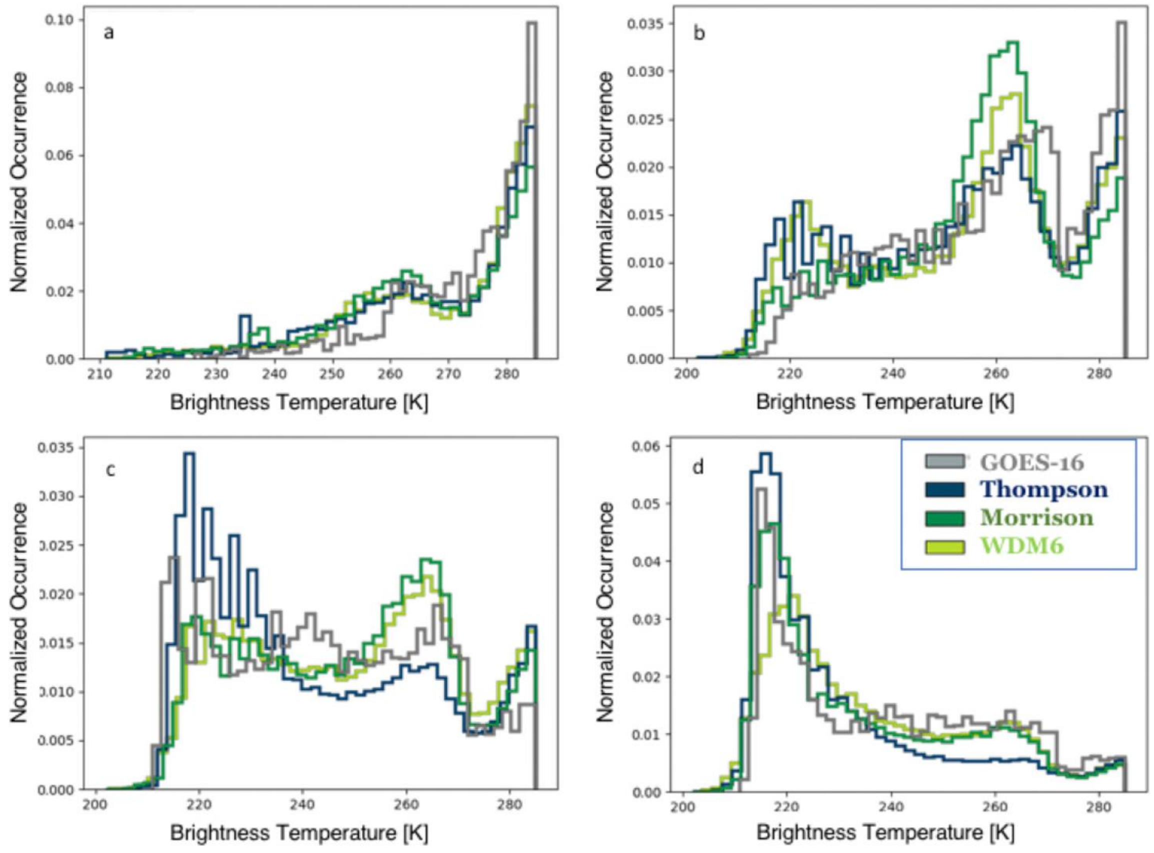


FIG. 4. Normalized ABI 10.35 μm brightness temperature probability density functions at (a) 1700, (b) 1800, (c) 1900, and (d) 2000 UTC. Brightness temperatures are binned every 2 K for *GOES-16* (gray) observations and Thompson (blue), Morrison (green), and WDM6 (light green) simulations.

Cloud tracking – Convective Initiation

- Verification of convective initiation with satellite and reflectivity data:

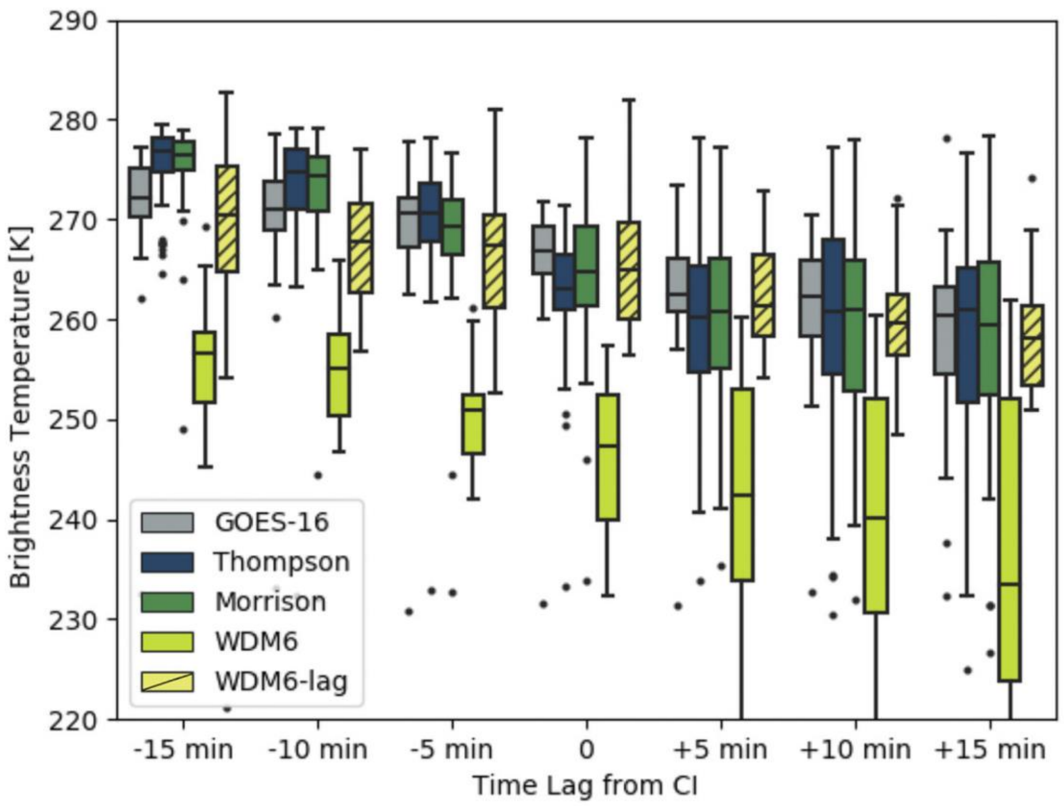
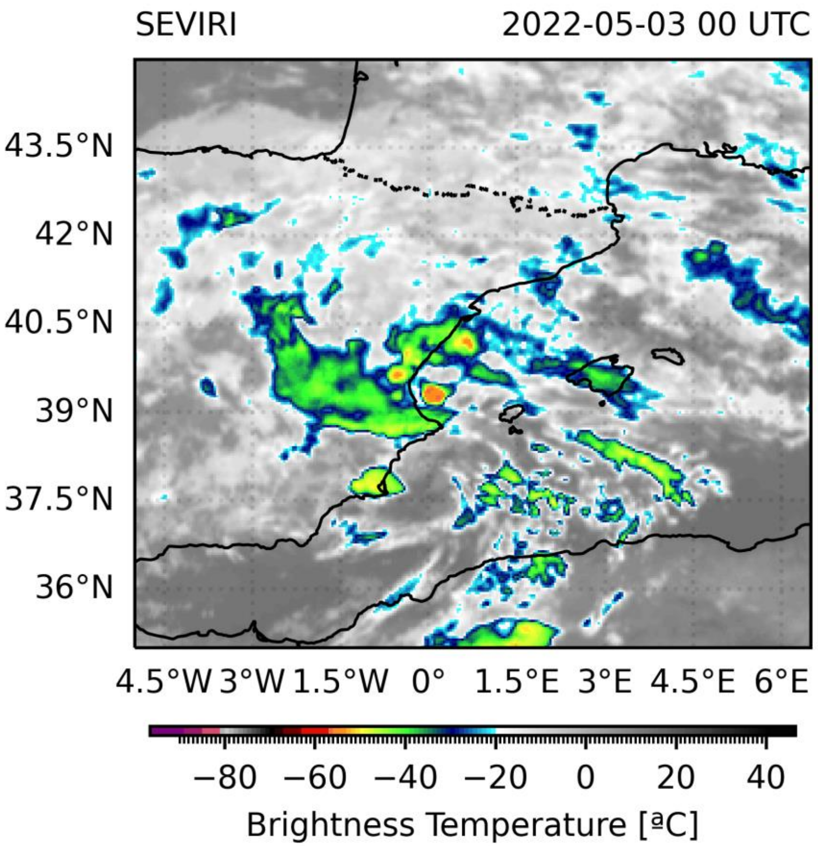


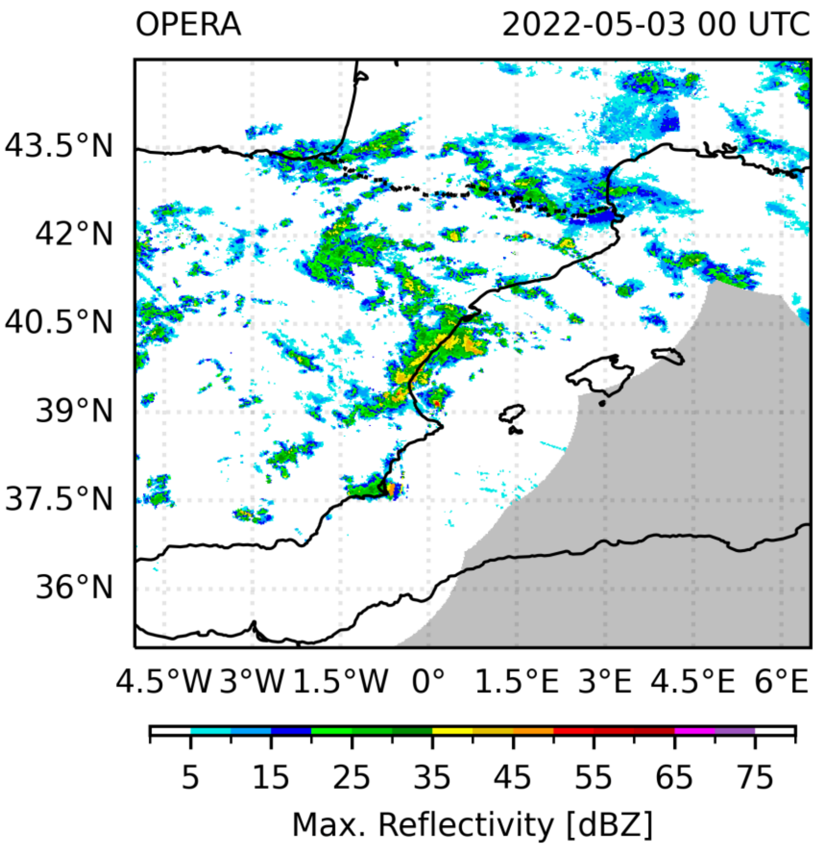
FIG. 6.

Box-and-whisker plots of ABI 10.35 μm brightness temperatures (K) for *GOES-16* (gray), Thompson (blue), Morrison (green), WDM6 (light green), and WDM6 lagged 30 min (hatched). Bars are spaced at 5-min intervals with time = 0 defined as the time CI was detected.

Cloud tracking – Convective Initiation

- Test example in Spain:



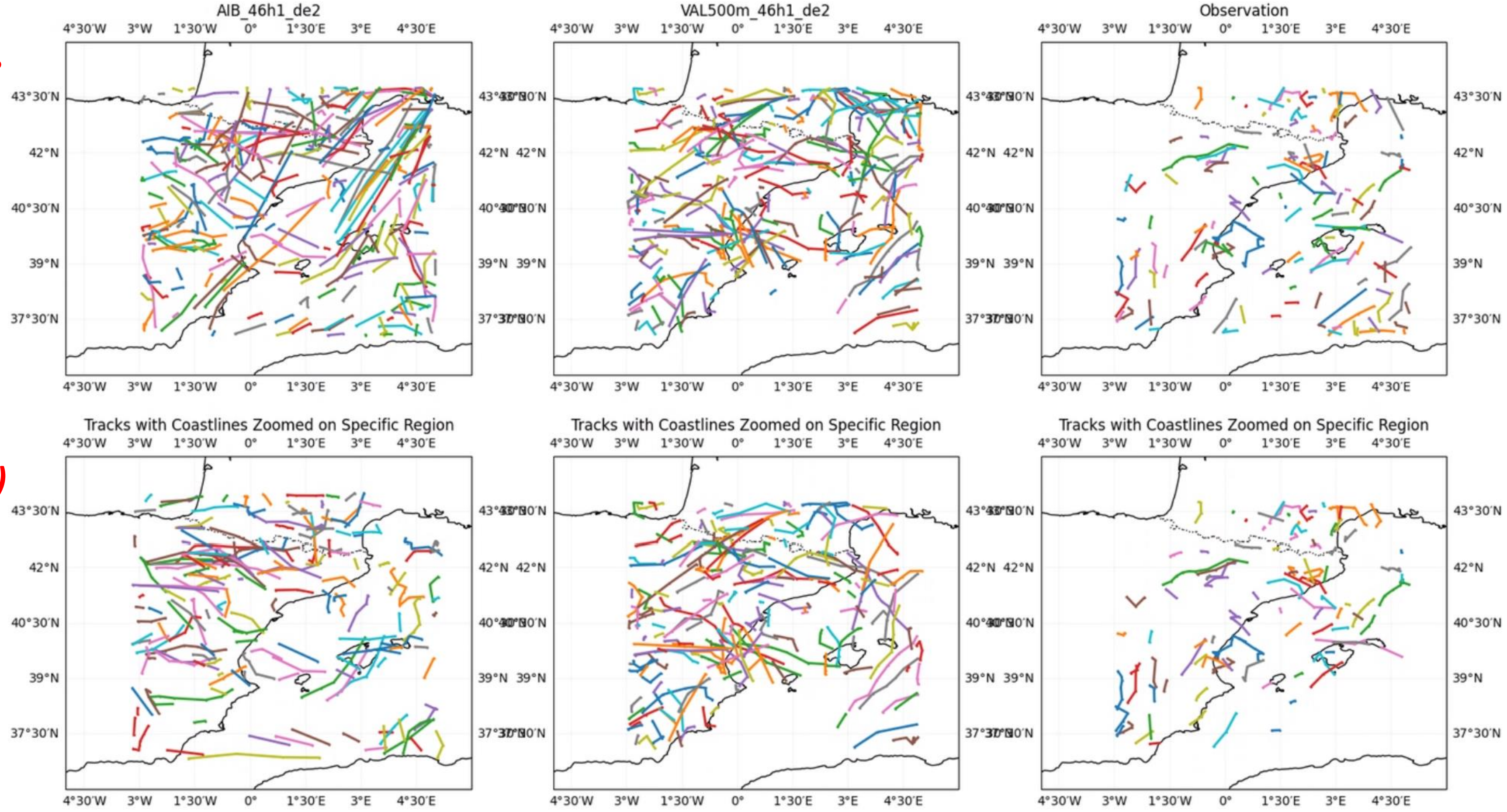


Cloud tracking – Convective Initiation

- Test example in Spain:

Satellite

Satellite + Radar (CI)



HARM 2.5 km | *HARM 0.5 km* | *Obs*

Visiting scientist stay at MetNorway

- Thanks to ACCORD, a stay with Andrew Singleton is planned to further develop, improve and integrate this methodology in HARP.