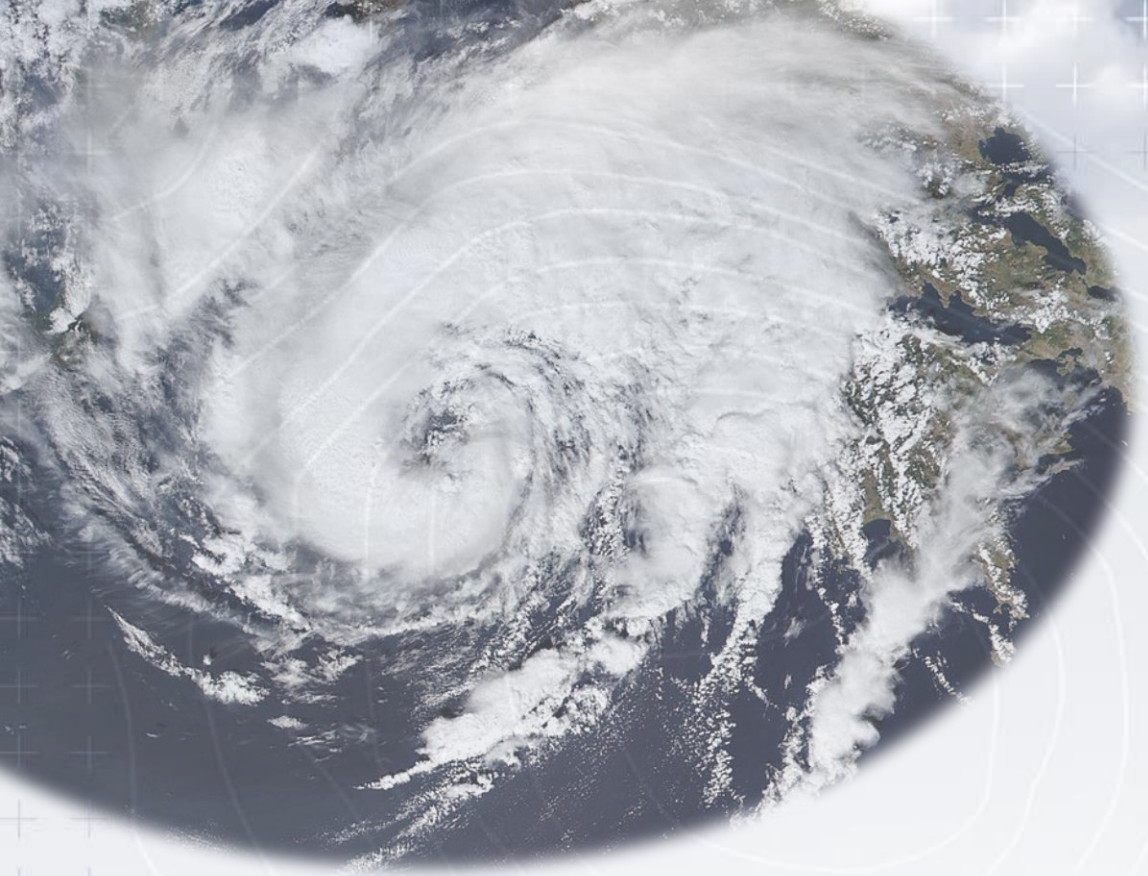


Juan Jesús González-Alemán (1)
Samuel Viana (1)
Javier Calvo (1)
Carlos Calvo-Sancho (2)

1 *Spanish State Meteorological Agency (AEMet)*
2 *University of Valladolid/Complutense University of Madrid*

Testing very high-resolution simulations in HARMONIE-AROME

44th EWGLAM and 29th SRNWP Meeting, 26-29 Sept 2022, Brussels

- Introduction:
  - Very high-resolution/sub-kilometric simulations (VHR) are becoming more and more frequent thanks to the increase of modelling knowledge and computational resources.
  - Due to this fast progress, it then becomes essential to verify these simulations in the representation of high impact weather.
  - In this work, we try to test this kind of simulations on two specific problems which are highly sensible to increasing resolution:
    - Convective activity induced by complex terrain, through atmosphere-orography interactions.
    - A tropical-like cyclone/hurricane (Medicane Ianos, 2020) over the Mediterranean Sea.

- Introduction – Case 1:
  - The thunderstorm developed in the Canary Islands was not “seen” by the operational HARMONIE-AROME run but parallel testing VHR runs could simulate it.

- Introduction – Case 2:
  - Ianos was a anomalous Medicane that impacted the eastern Mediterranean in September 2020, especially Greece, leaving severe damage.
  - The first medicane to robustly show tropical characteristics and the strongest on record (~984 hPa, ~44 m/s, ~644 mm).
  - Operational forecasts of Ianos were not highly valuable due to its peculiarities: very intense and small scale.
  - Motivation for Ianos case study:
    - It hasn't been done before for a medicane
    - ECMWF Severe Weather Event Catalogue
    - Participation Medcyclone EU COST Action (model intercomparison)
    - Climate change impact on medicanes

Convective activity in the Canary Islands

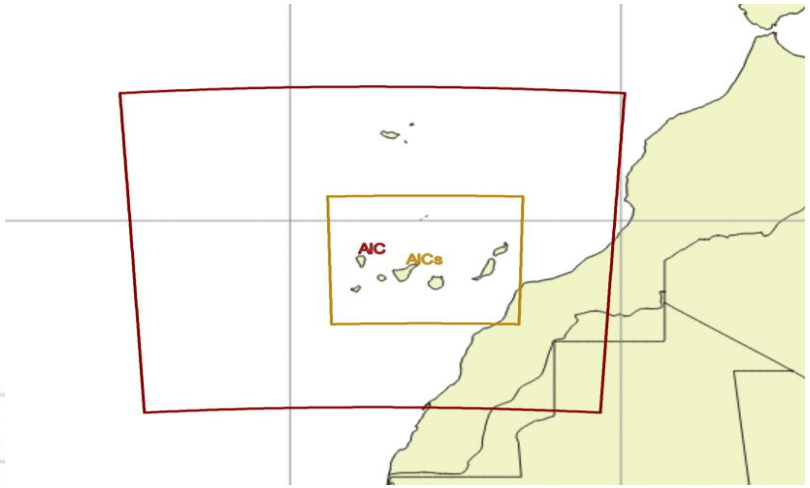
- Methodology:
  - VHR experimental runs (1.25km, 1km and 500m) vs operational run (2.5km) in the Canary Islands:
    - **AIC: Op**

    Assimilation | Res: 2.5km | Nlatlon: 576x480 | Tstep: 75| Grid: Linear
    - **AIC125: Exp**

    Assimilation | Res: 1.25km| Nlatlon: 1152x960 | Tstep: 45 | Grid: Linear
    - **AICs1km: Exp**

    Dynamical adaptation from IFS | Res: 1km | Nlatlon: 576x480 | Tstep: 30| Grid: Linear
    - **AICs500m: Exp**

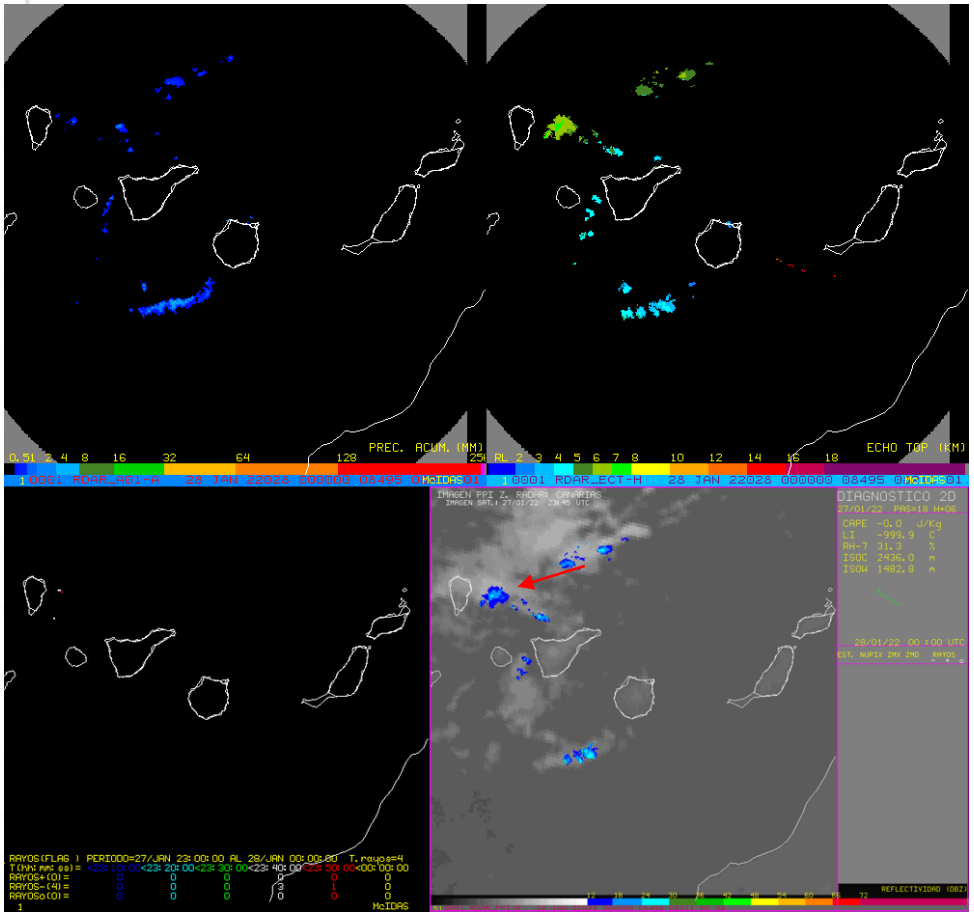
    Dynamical adaptation from AIC | Res: 500m | Nlatlon: 1152x960 | Tstep: 15 | Grid: Cuadratic



Convective activity in the Canary Islands

- Observations:

28 JAN 00z



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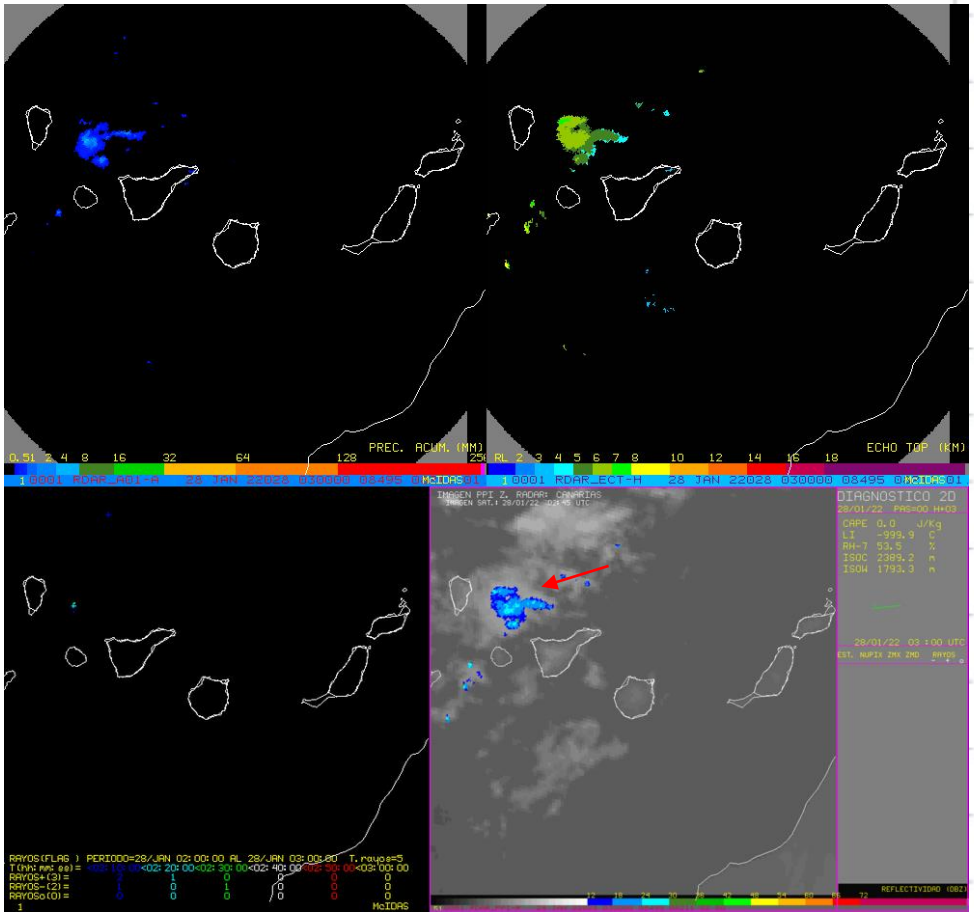
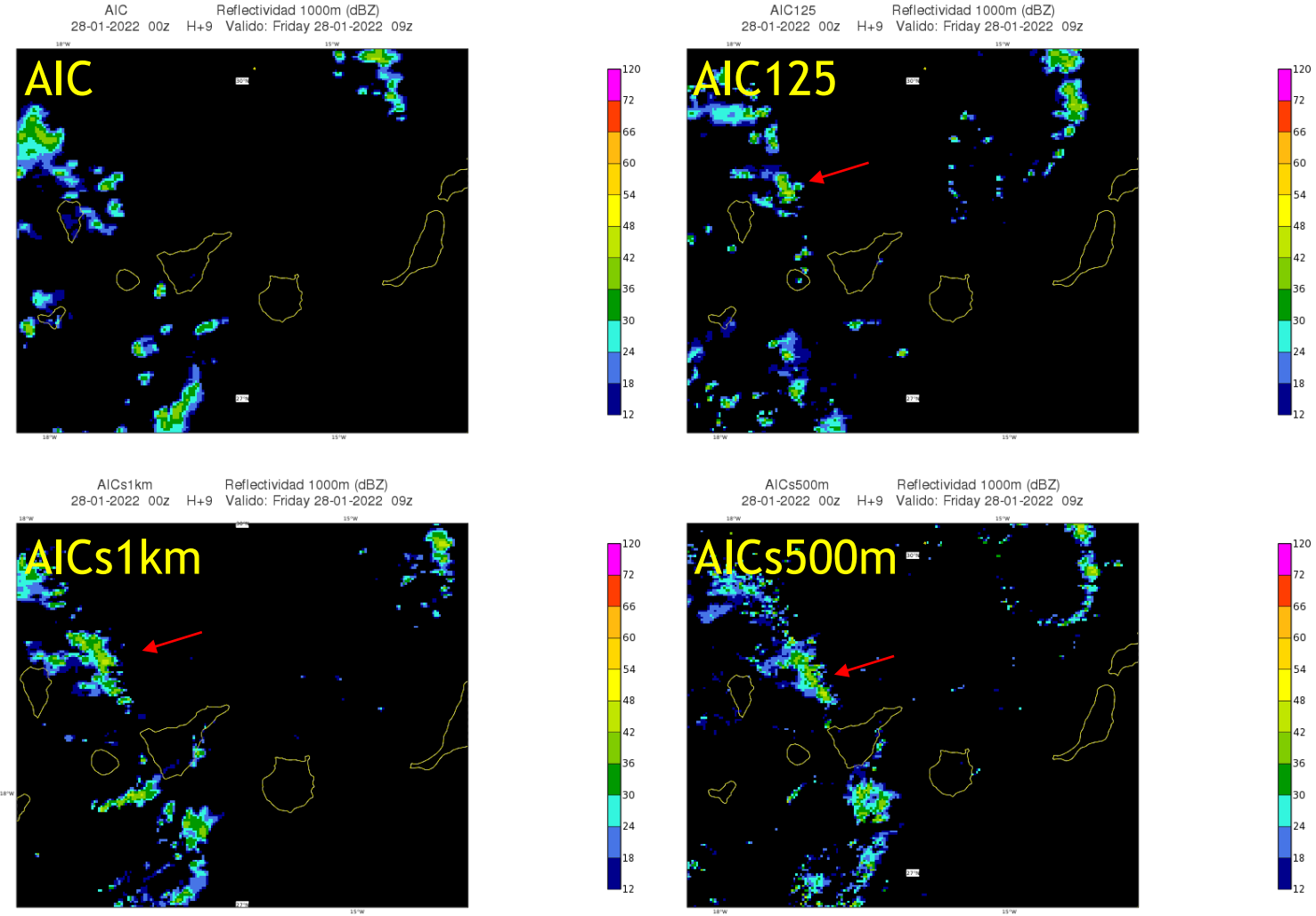


Convective activity in the Canary Islands

- Models:

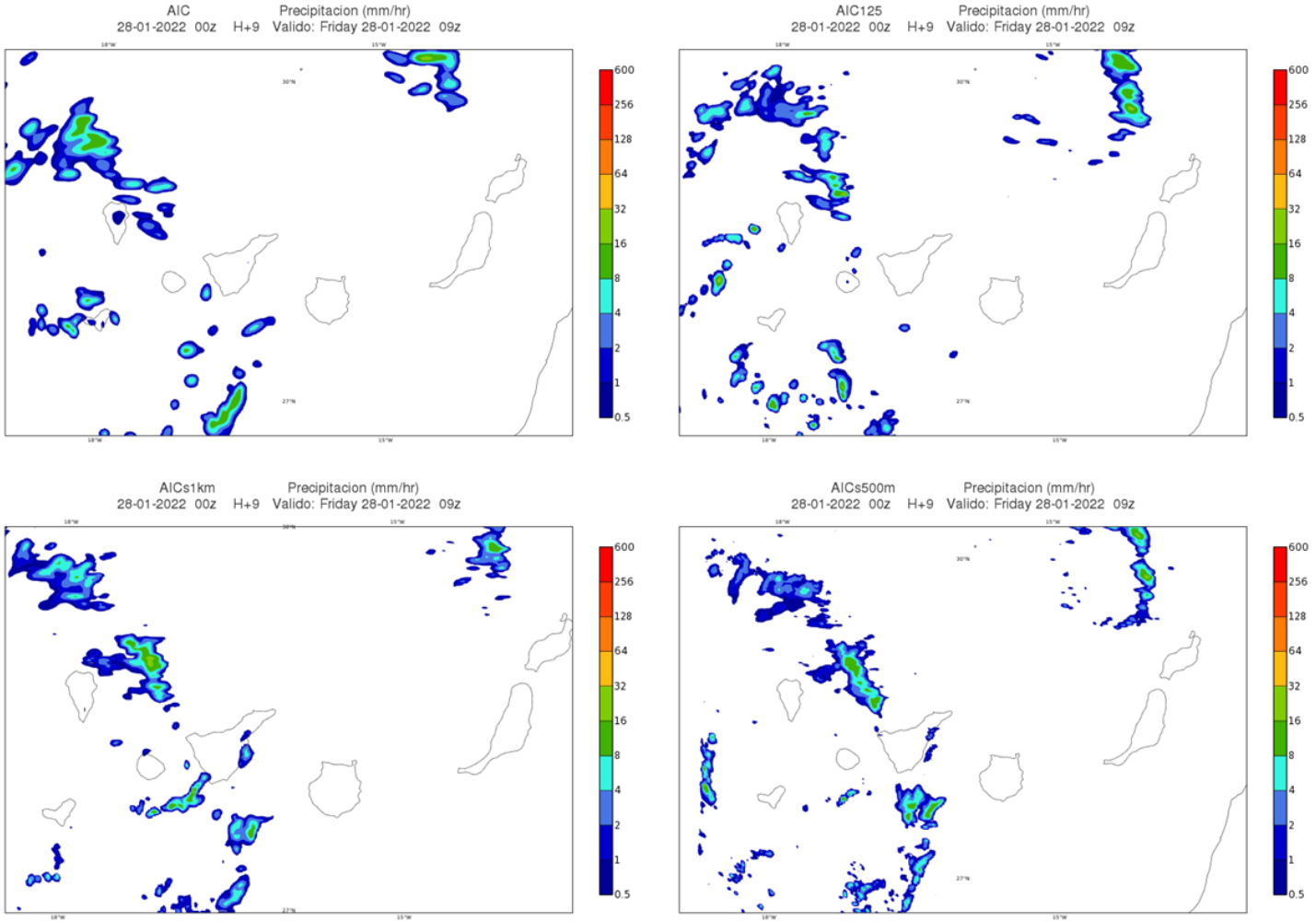
28 JAN 09z



Convective activity in the Canary Islands

- Models:

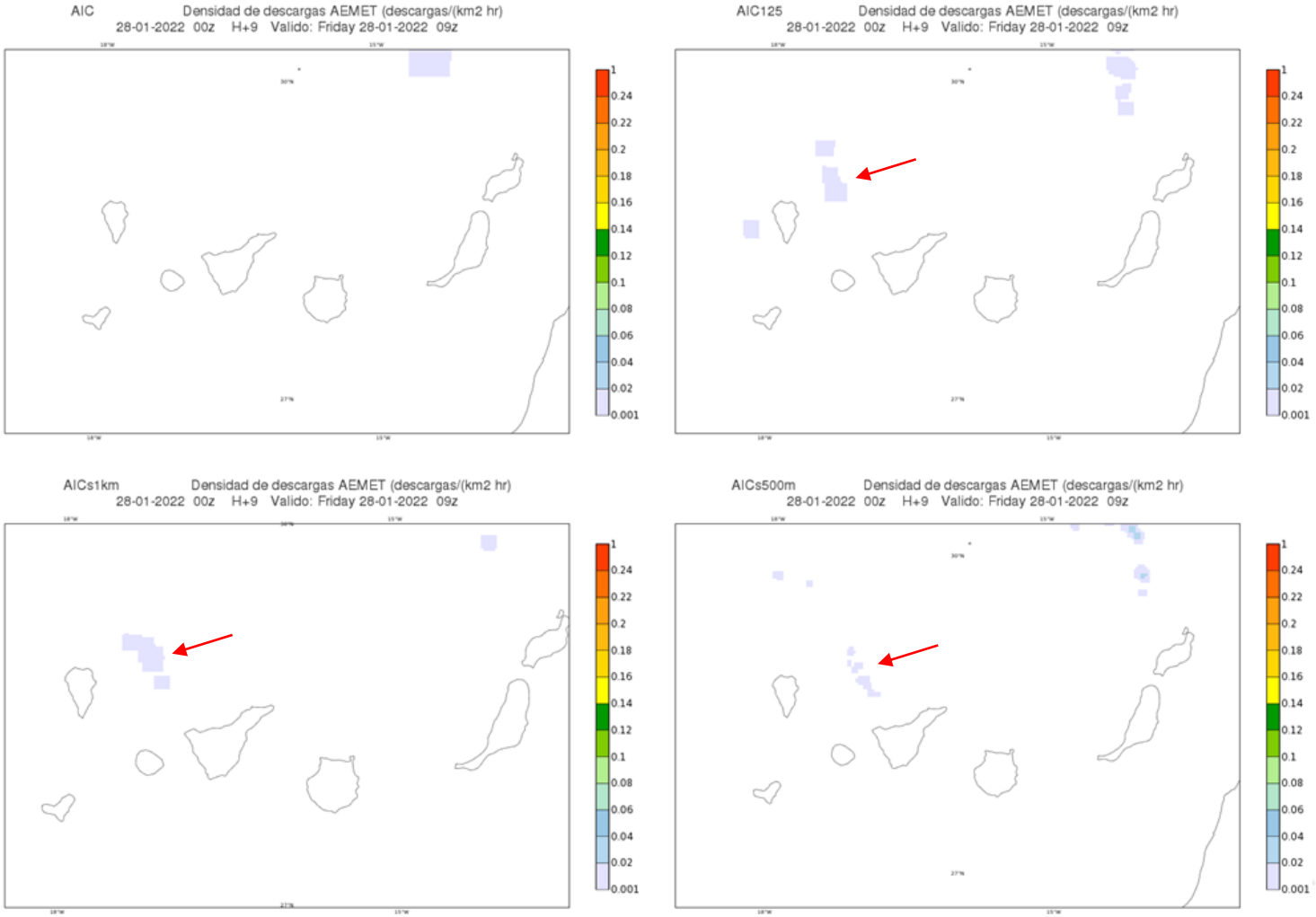
28 JAN 09z



Convective activity in the Canary Islands

- Models:

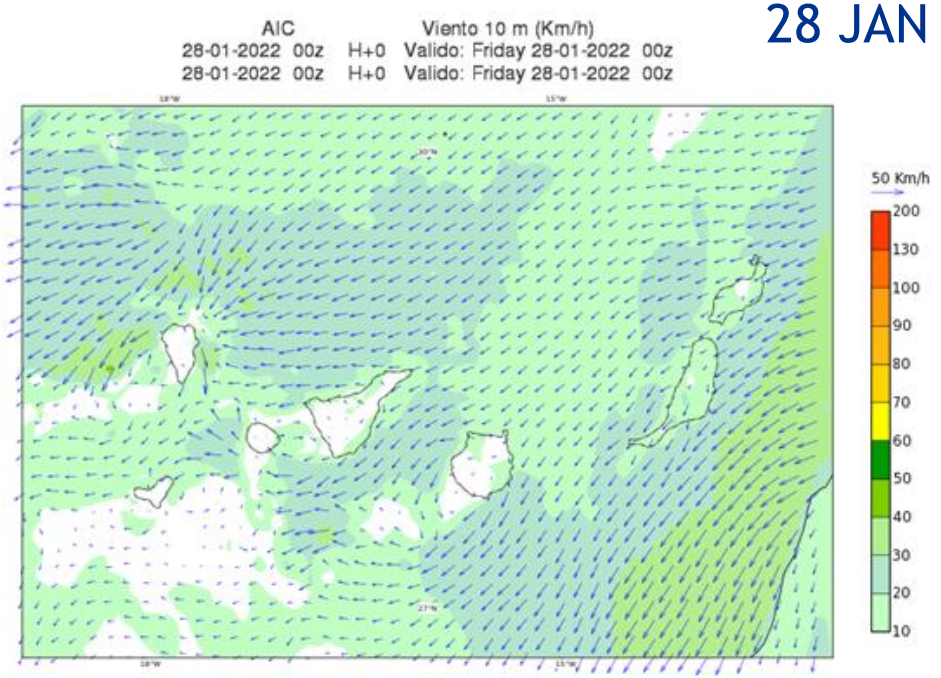
28 JAN 09z

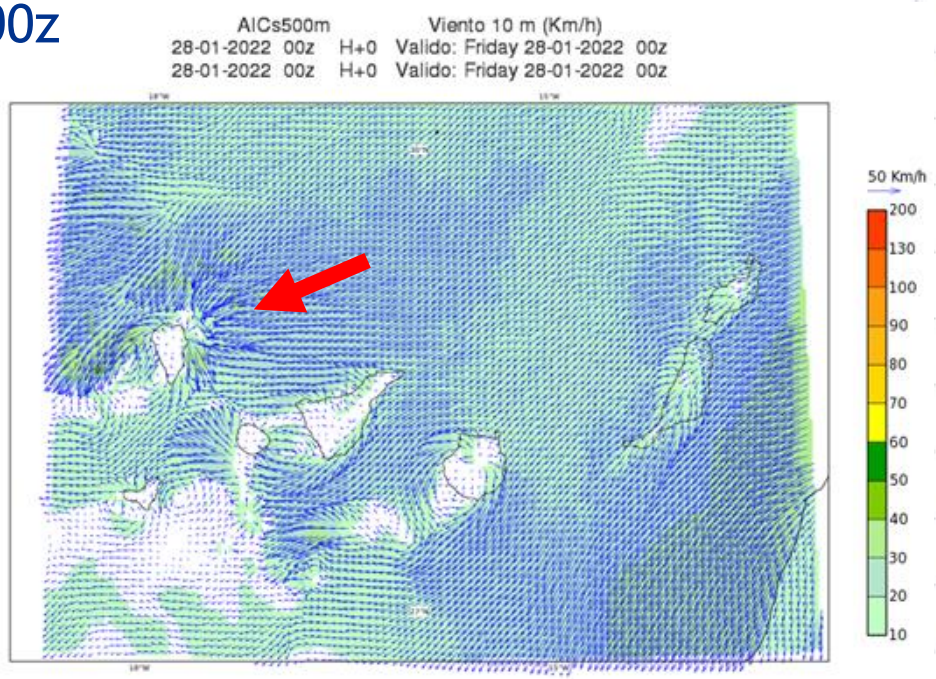


Convective activity in the Canary Islands

- Models:

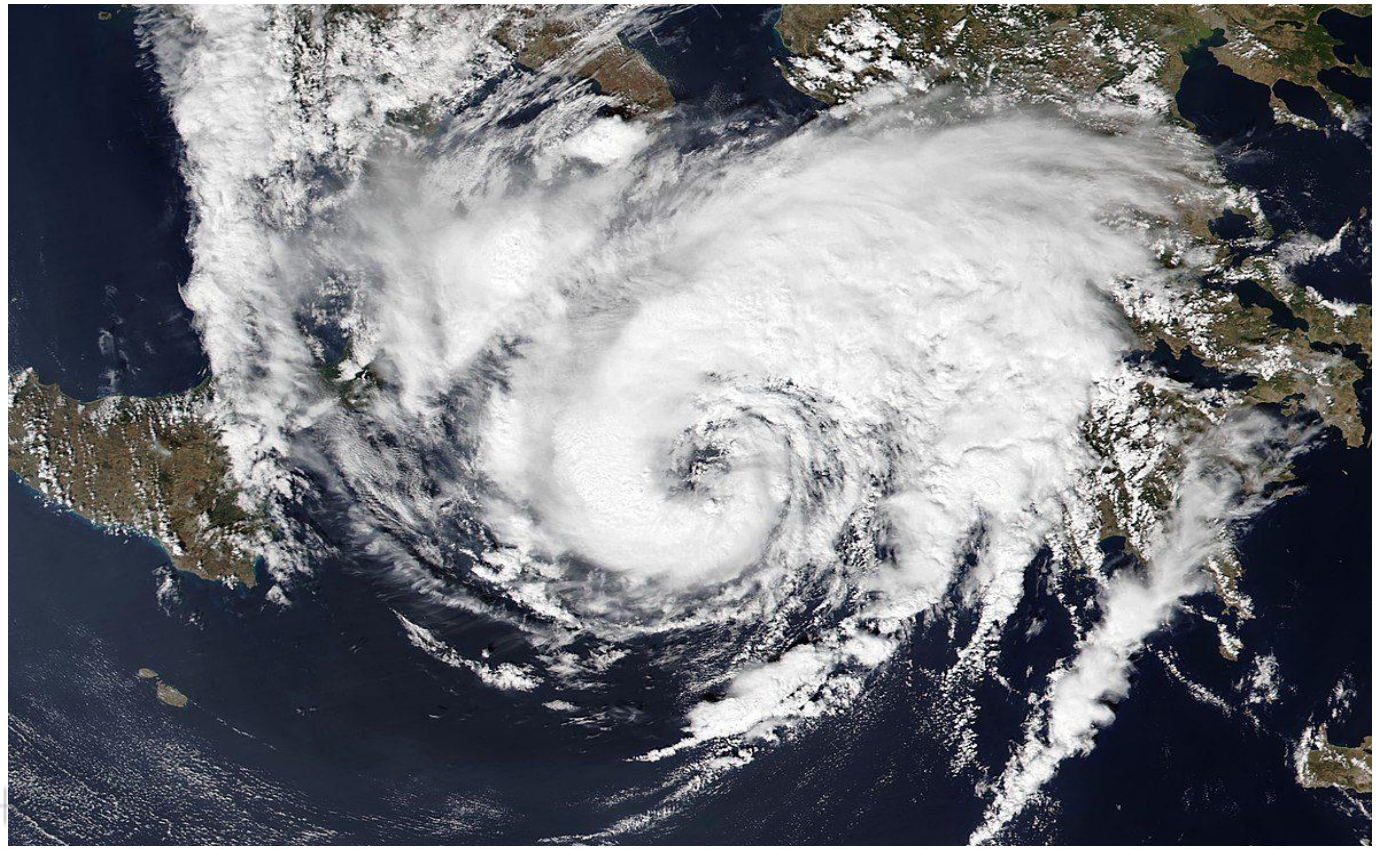
28 JAN 00z





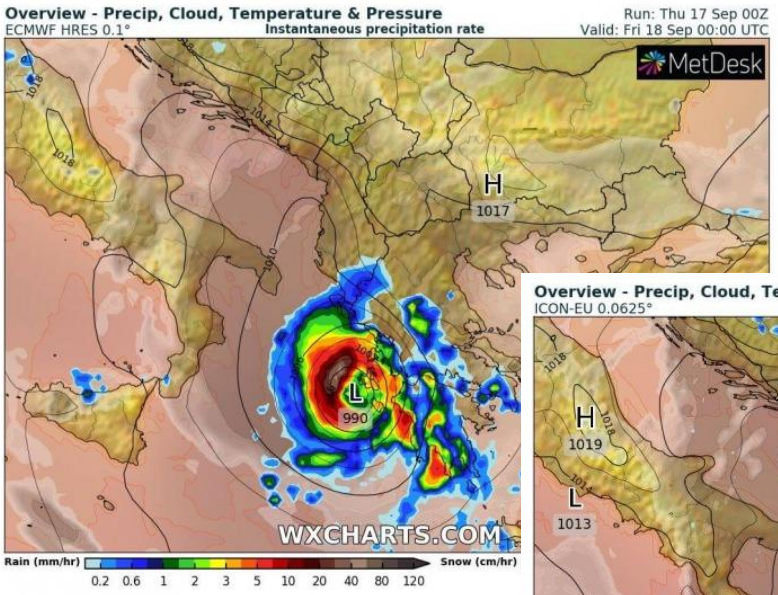
Medicane Ianos

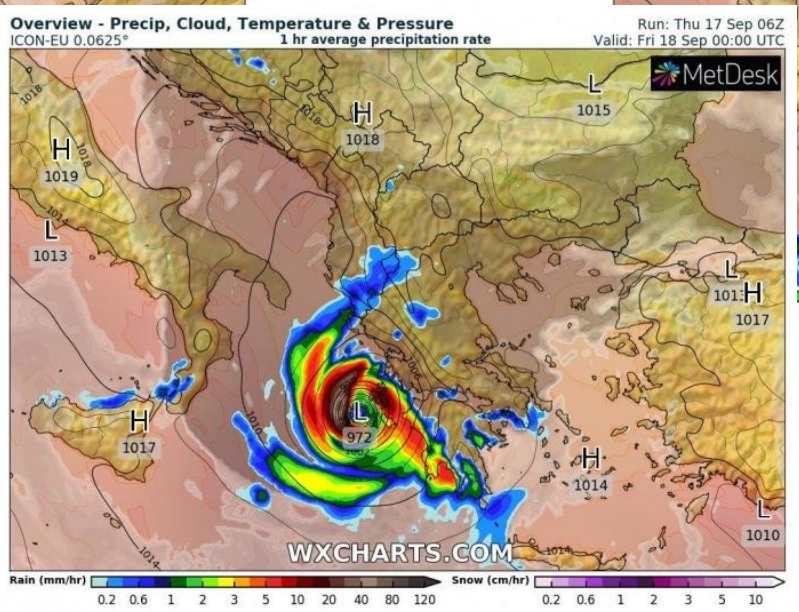
- Introduction:
  - Testing BCs, domain and resolution in simulations for Medicane/Hurricane Ianos.

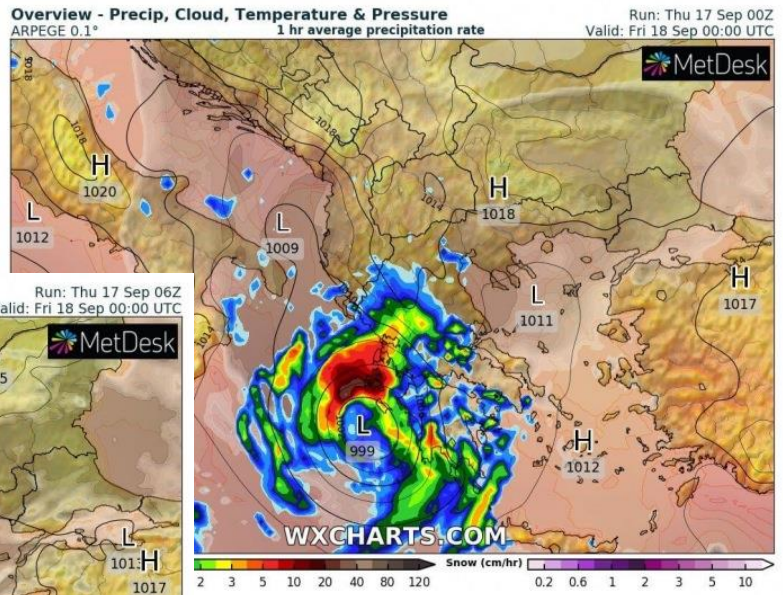


Medicane Ianos

- Introduction:
  - Forecast for Ianos where quite variable, from LAM models predicting a very intense cyclone and global models a more weak cyclone.







Medicane Ianos

SEVERE WEATHER EUROPE

New model data suggests an extremely dangerous medicane Ianos will strike into Greece on Friday

By: Marko Korosec

Published: 17/09/2020

Mesoscale Discussion Archives

Model guidance is now calling medicane Ianos could become one of the strongest Mediterranean tropical-like cyclones on record. The minimum central pressure is expected to drop to near 980 mbar, with sustained winds reaching hurricane-force Category 1 strength. Peak gusts could exceed 200 km/h, therefore, a severe impact is likely for western Greece tonight through Friday morning. Huge amounts of rainfall will lead to dangerous flash floods.

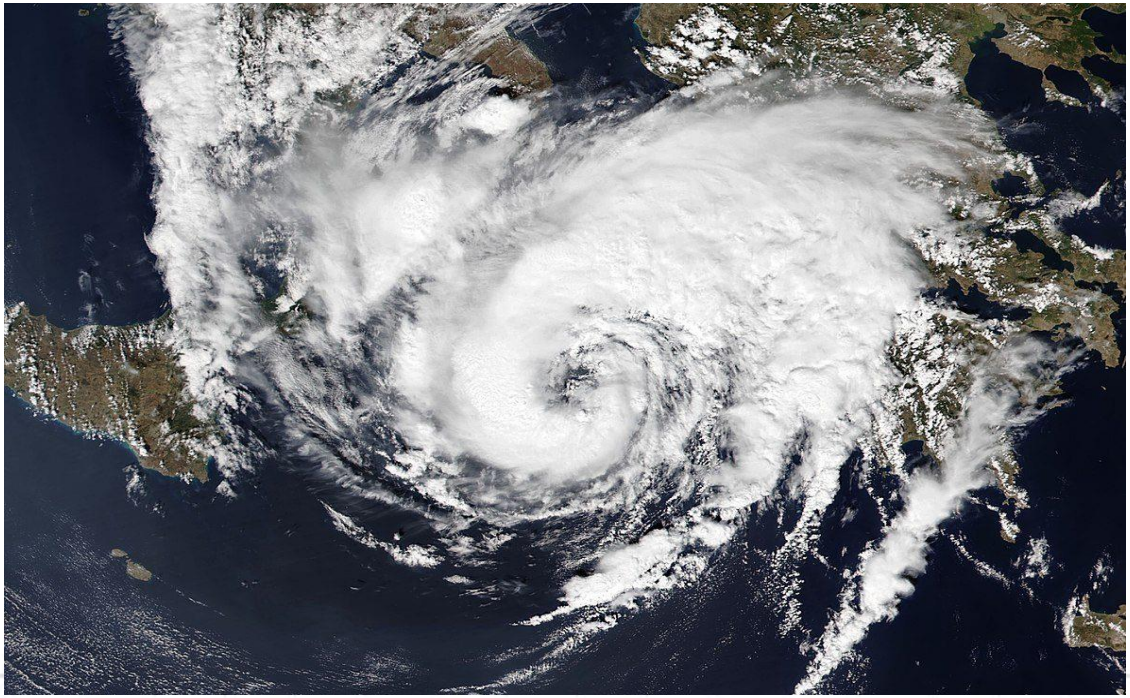
Key messages

Medicane Ianos

- Introduction:
  - Impact of Ianos

Medicane Ianos

- MEDIterranean hurriCANES (medicanes) are intense cyclones that acquire tropical characteristics, associated with extreme winds and rainfall, thus posing a serious natural hazard to populated areas along Mediterranean coasts.
- Understanding how medicanes will change with global warming is essential given the increase in sea surface temperatures expected over the Mediterranean Sea.



Medicane Ianos

- Why important to investigate NWP behaviour?

AGU100 ADVANCING EARTH AND SPACE SCIENCE

Geophysical Research Letters

RESEARCH LETTER
10.1029/2018GL081253

Key Points:

- A recently developed high-resolution climate model is the first global coupled model to realistically simulate Mediterranean hurricanes
- Mediterranean hurricanes potentially become more hazardous due to increasing wind, duration and rainfall
- Changes mainly occur in autumn and are associated with a more robust hurricane-like structure

Potential Increase in Hazard From Mediterranean Hurricane Activity With Global Warming

Juan J. González-Alemán[1], Salvatore Pascale[2,3], Jesús Gutierrez-Fernandez[1], Hiroyuki Murakami[3,4], Miguel A. Gaertner[5], and Gabriel A. Vecchi[6,7]

[1]Environmental Sciences Institute, University of Castilla-La Mancha, Toledo, Spain, [2]Atmospheric and Oceanic Sciences Program, Princeton University, Princeton, NJ, USA, [3]Geophysical Fluid Dynamics Laboratory/NOAA, Princeton, NJ, USA, [4]Cooperative Programs for the Advancement of Earth System Science, University Corporation for Atmospheric Research, Boulder, CO, USA, [5]Environmental Sciences Faculty, University of Castilla-La Mancha, Toledo, Spain, [6]Department of Geosciences, Princeton University, Princeton, NJ, USA, [7]Princeton Environmental Institute, Princeton University, Princeton, NJ, USA

Medicane Ianos

- Why important to investigate NWP behaviour?
  - We found that despite a decrease in frequency, Medicanes potentially become more hazardous with global warming, lasting longer and producing stronger winds and rainfall.
  - These changes are associated with a more robust hurricane-like (possibly cat 2) structure and are mainly confined to autumn.
  - Thus, continued anthropogenic warming will increase the risks associated with medicanes even in an intermediate scenario (RCP4.5), with potential natural and socioeconomic consequences.

Medicane Ianos

BAMS Article

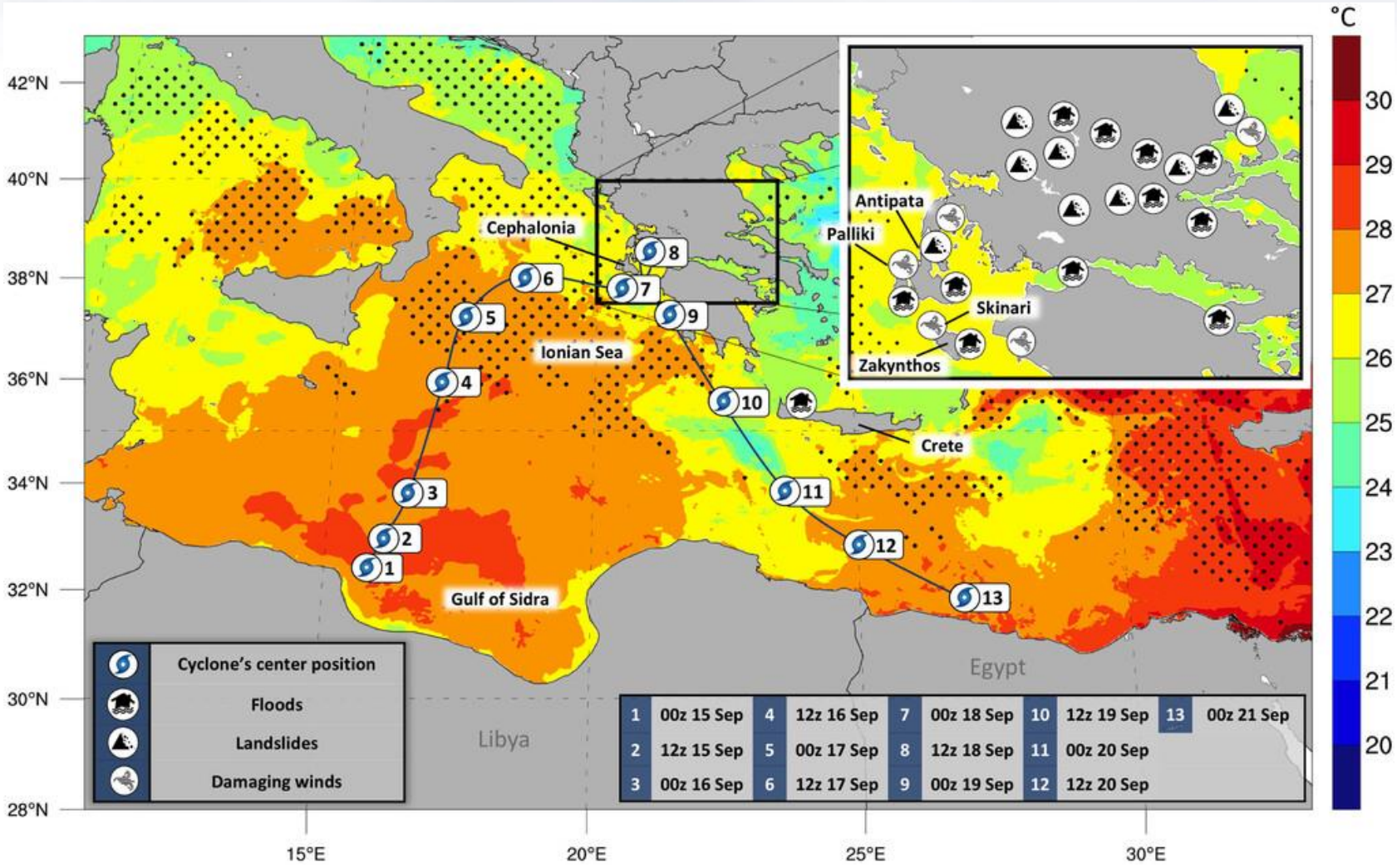
Ianos—A Hurricane in the Mediterranean

K. Lagouvardos, A. Karagiannidis, S. Dafis, A. Kalimeris, and V. Kotroni

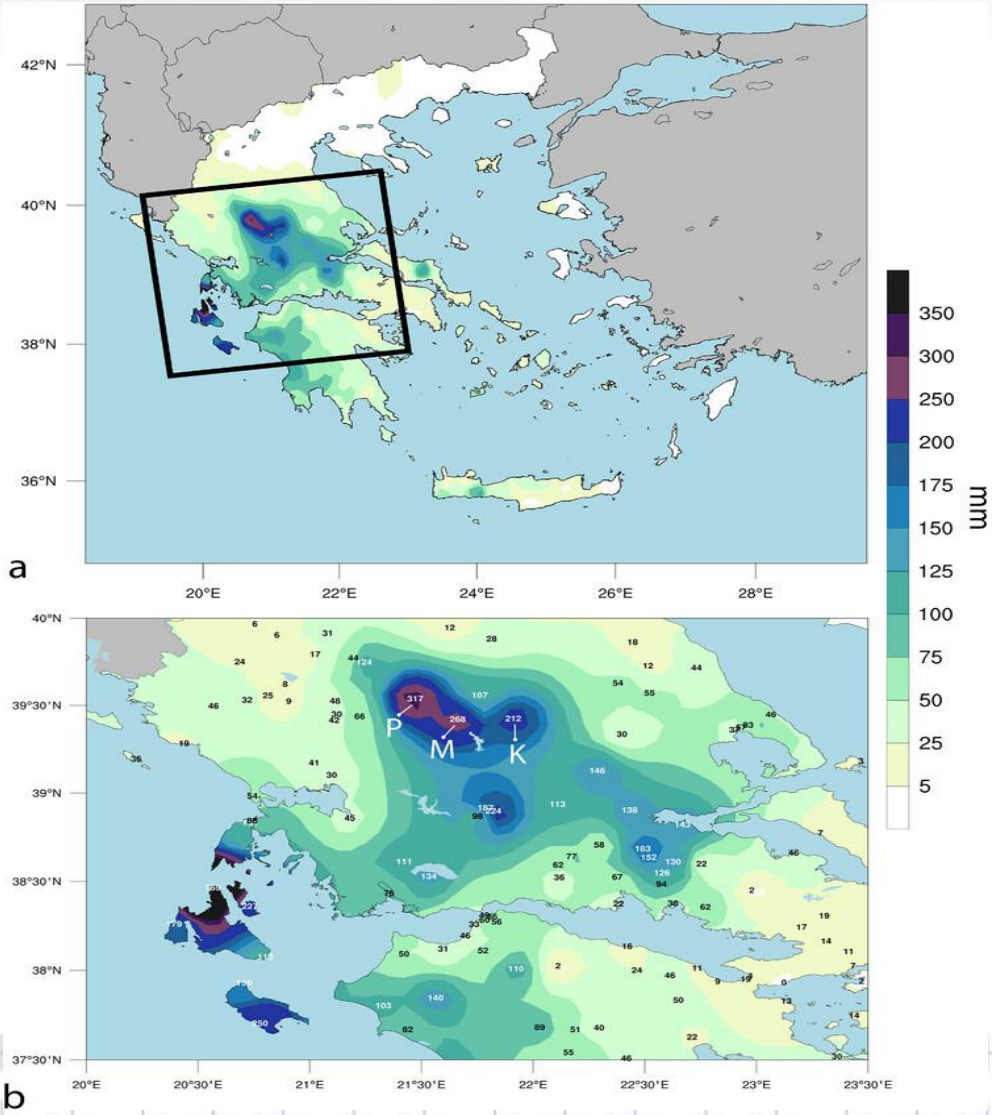
ABSTRACT: During 15–21 September 2020, an intense medicane, named Ianos, formed over the warm Mediterranean Sea. Following a path of approximately 1,900 km, Medicane Ianos affected Greece resulting in four casualties and devastating damage in the western and central parts of Greece. Persistent gale force 1-min winds up to 44 m s^{-1} and wind gusts up to 54 m s^{-1} were recorded in Cephalonia Island (Ionian Sea), while record-breaking amounts of accumulated rainfall have been recorded in several Ionian islands, as well as in parts of central Greece. Analysis of the available observations showed that Ianos was the most intense medicane ever recorded in the Mediterranean. This paper aims at investigating the genesis and evolution of the medicane, based on in situ observations, satellite measurements, and model analyses. Toward that objective, Meteosat Second Generation (MSG) SEVIRI imagery, combined with lightning data permitted to follow the evolution of convective activity during the various phases of Ianos. This investigation is complemented with upper-air model analyses in order to evaluate the synoptic environment within which Ianos had formed and was sustained over 7 days. Finally, the Global Precipitation Measurement *Core Observatory* (GPM *CO*) satellite overpasses over Medicane Ianos provided invaluable information about its 3D structure, especially during its most intense phase.

KEYWORDS: Cyclogenesis/cyclolysis; Dynamics; Hurricanes/typhoons; Extreme events

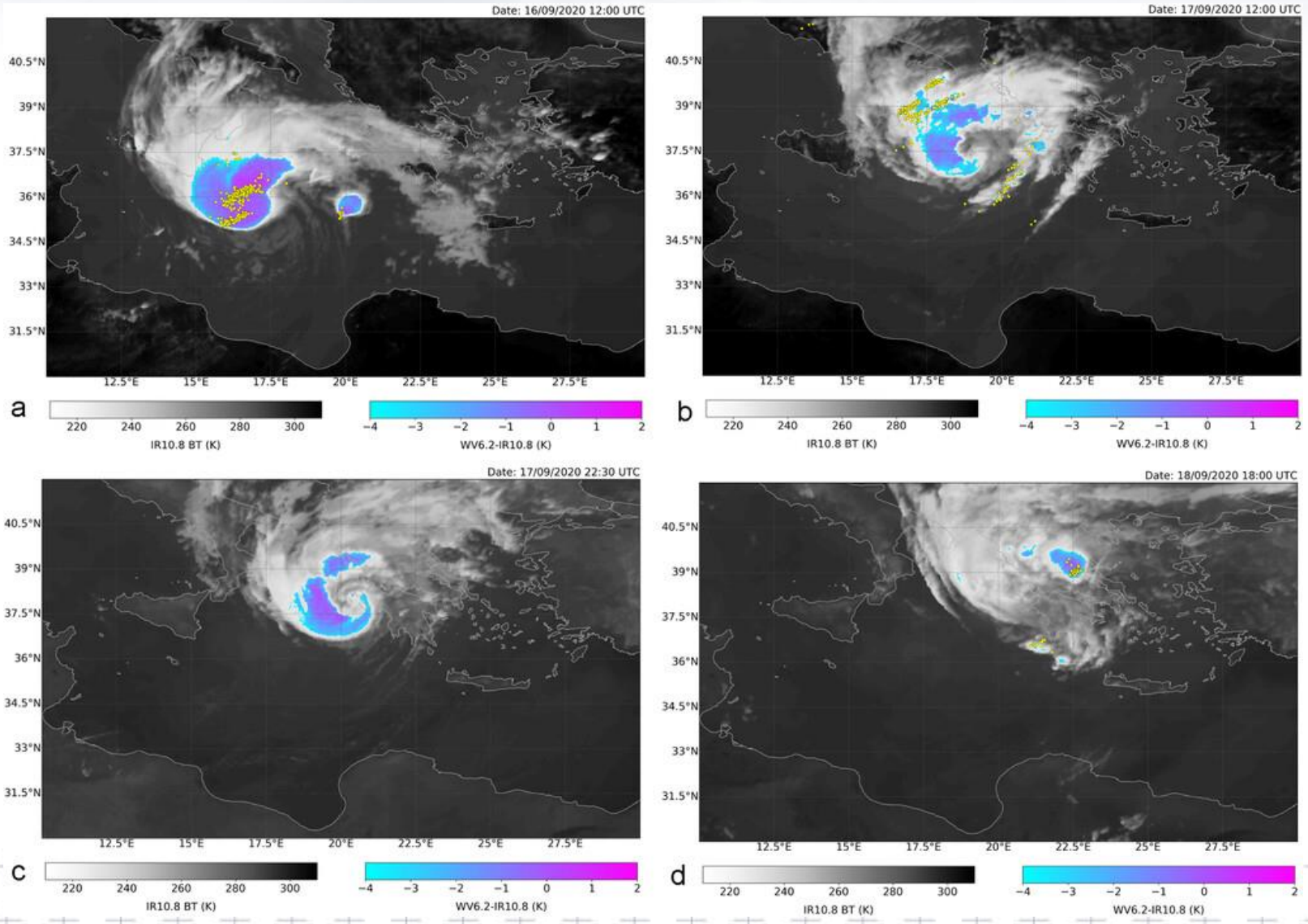
Medicane Ianos



Medicane Ianos

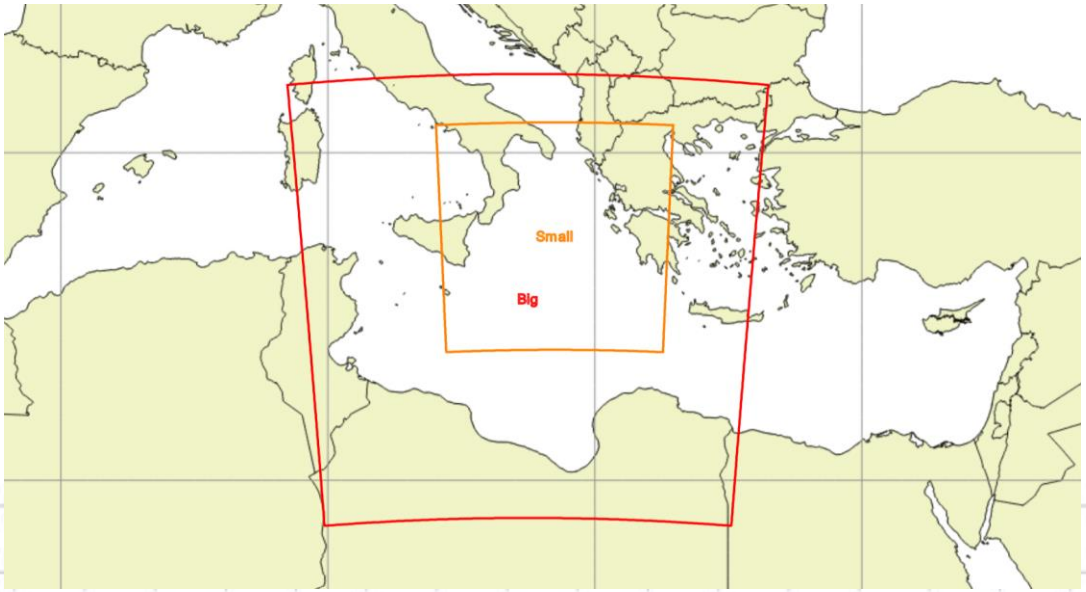


Medicane Ianos

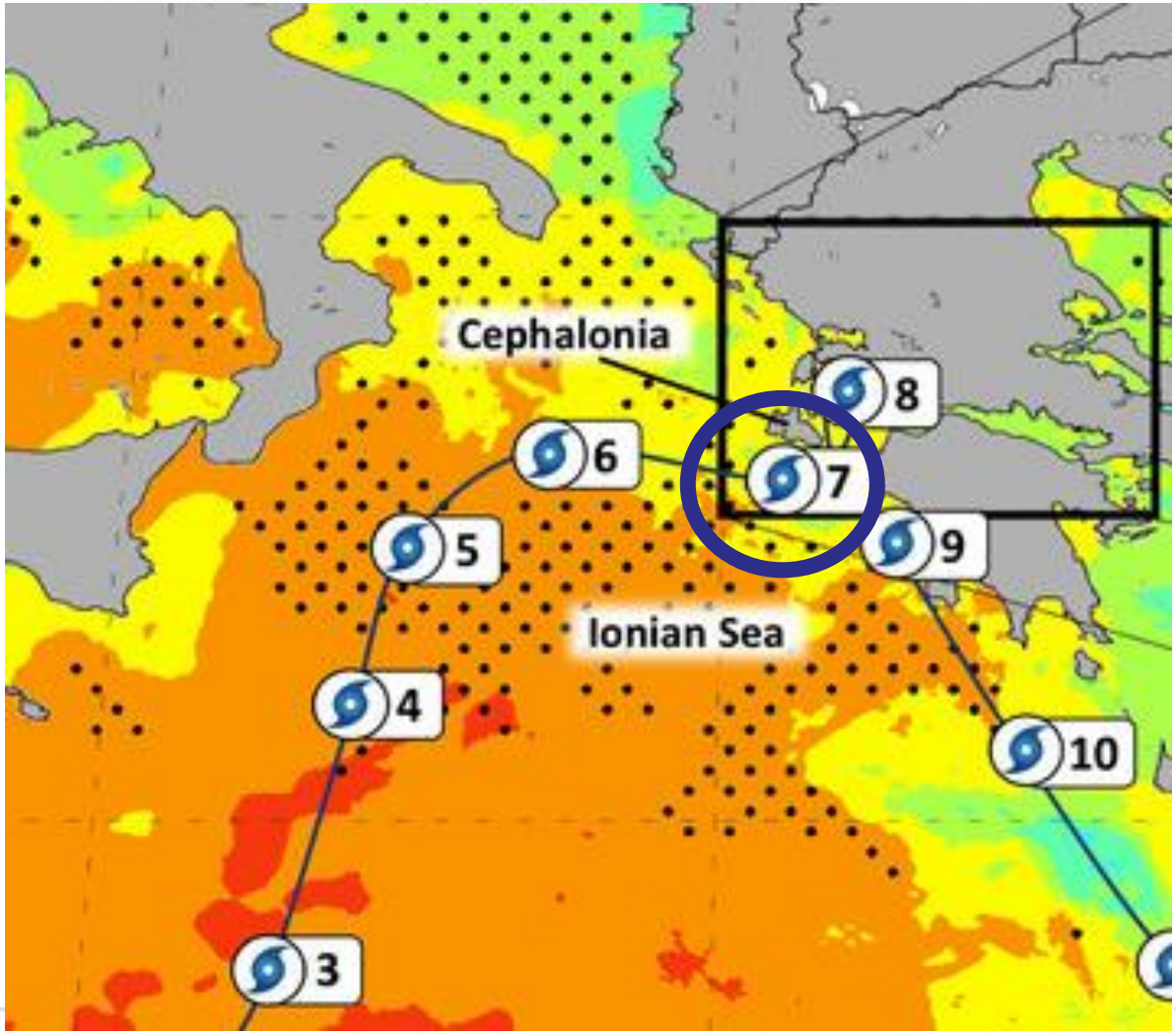


Medicane Ianos

- Methodology:
  - Dynamical adaptation (from IFS analysis)
  - 24 hours of forecasts from 17/09 00z
  - Resolution1: IFS+HARM 2km Big vs IFS+HARM 1km Big
  - Resolution2: HARM2km+HARM 1km Small vs HARM2km+HARM 500m Small
  - BCs: IFS+HARM 1km Small vs HARM2km+HARM 1km Small
  - Domain size: IFS+HARM 1km Small vs IFS+HARM 1km Big

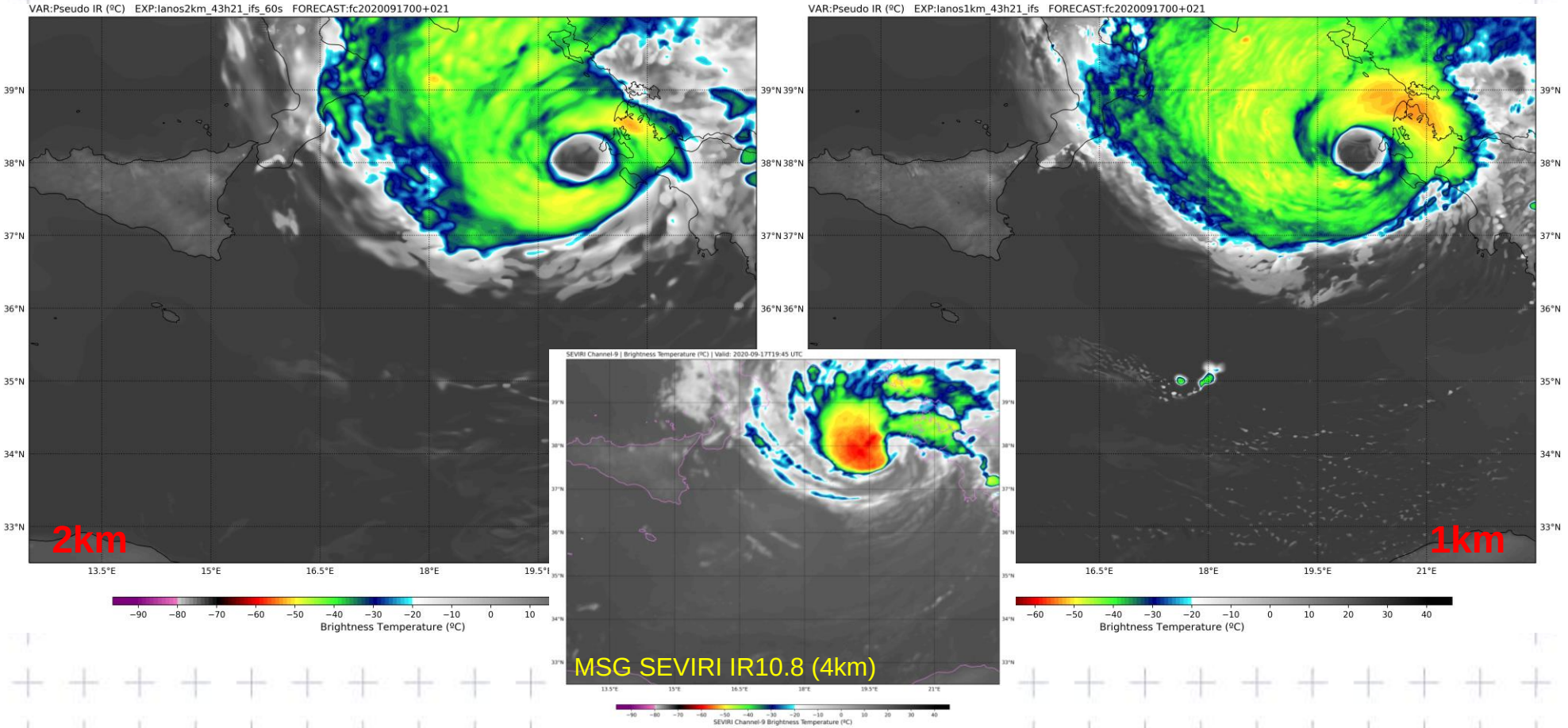


Medicane Ianos



Medicane Ianos

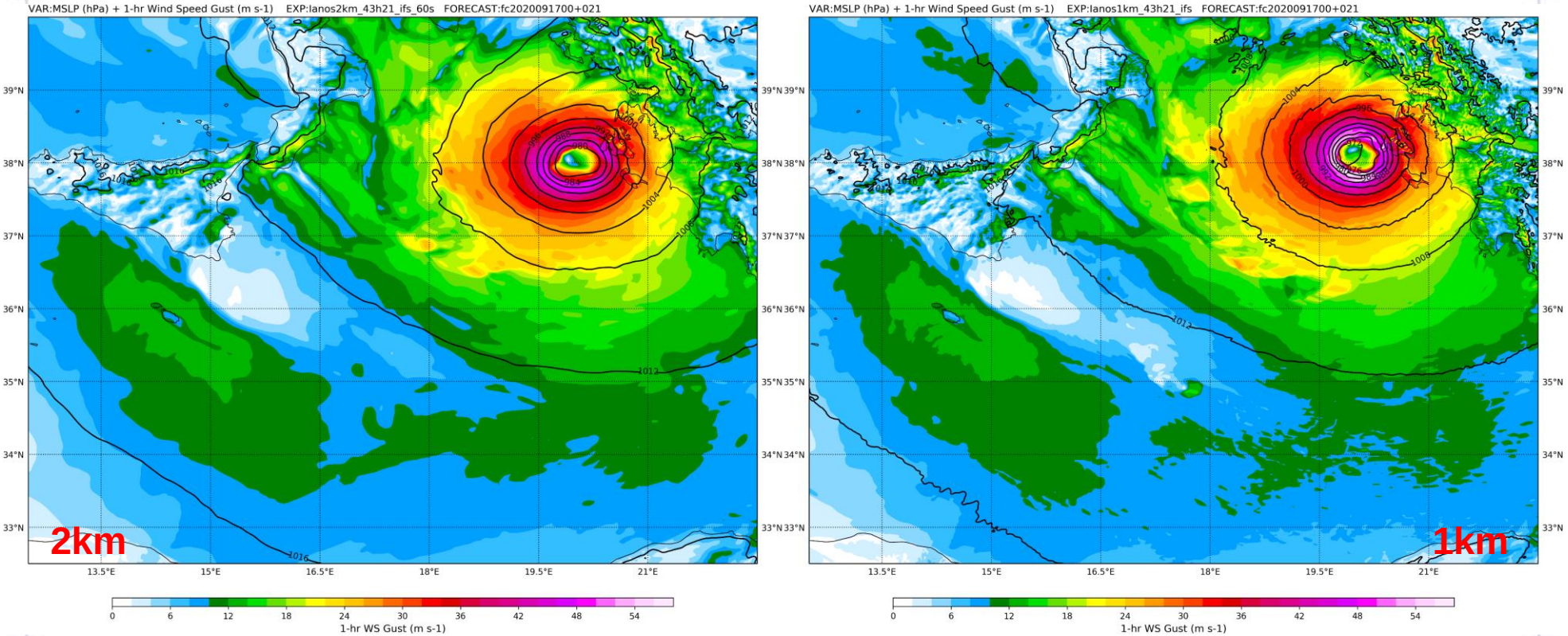
- Results – pseudo BTs:
  - Influence of resolution (2km vs 1km)



1700 + 21h

Medicane Ianos

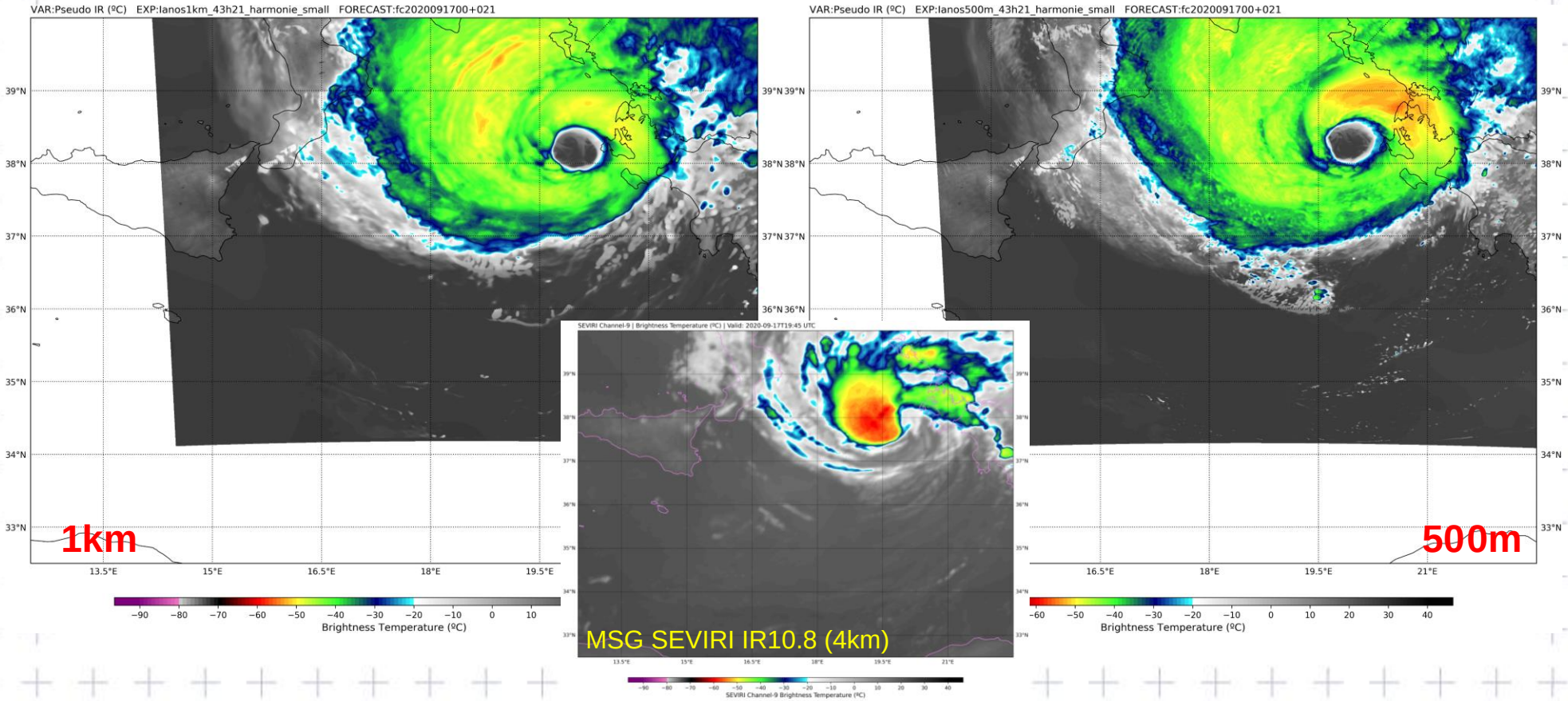
- Results – MSLP+Wind:
  - Influence of resolution (2km vs 1km)



1700 + 21h

Medicane Ianos

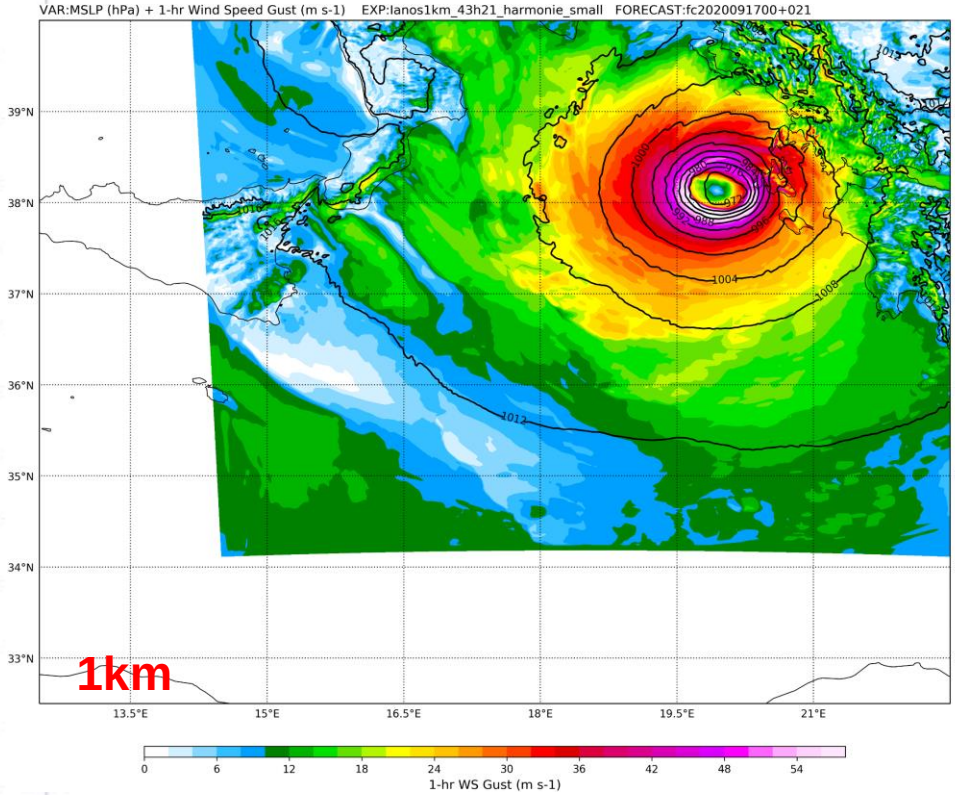
- Results – pseudo BTs:
  - Influence of resolution (1km vs 500m)

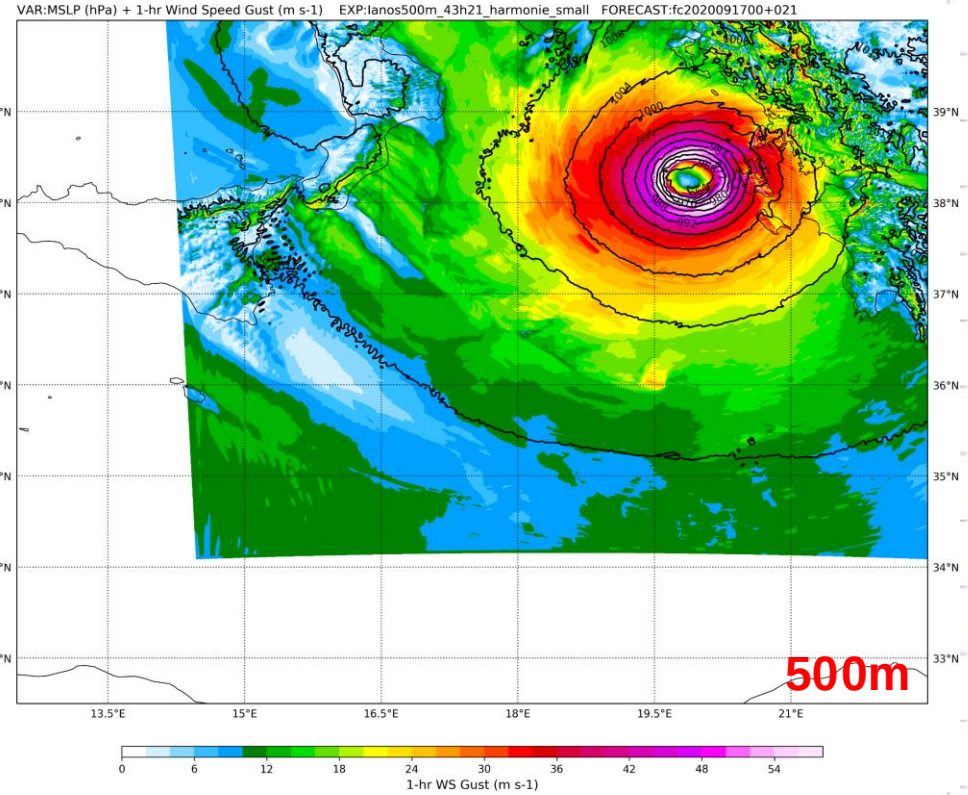


1700 + 21h

Medicane Ianos

- Results – MSLP+Wind:
  - Influence of resolution (1km vs 500m)

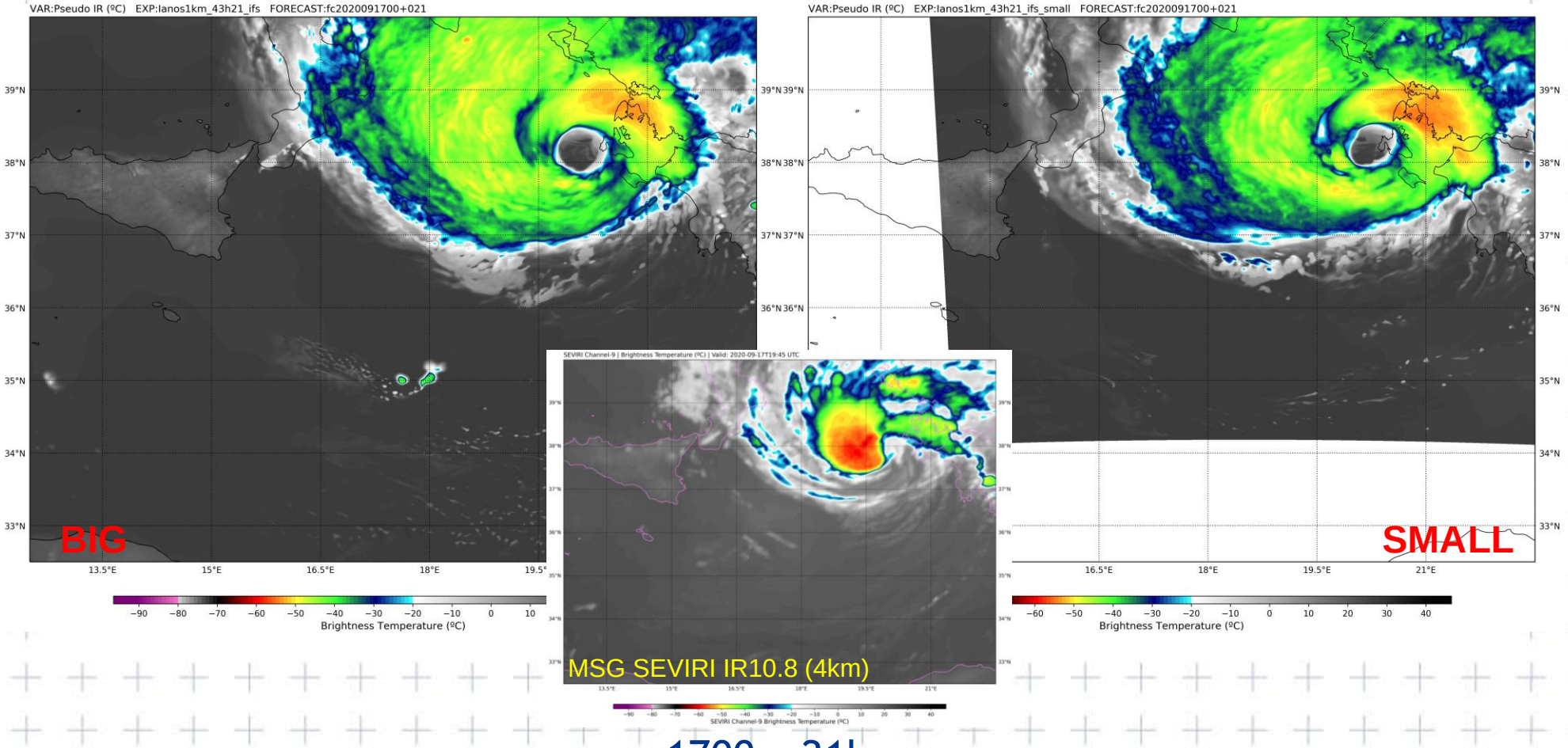




1700 + 21h

Medicane Ianos

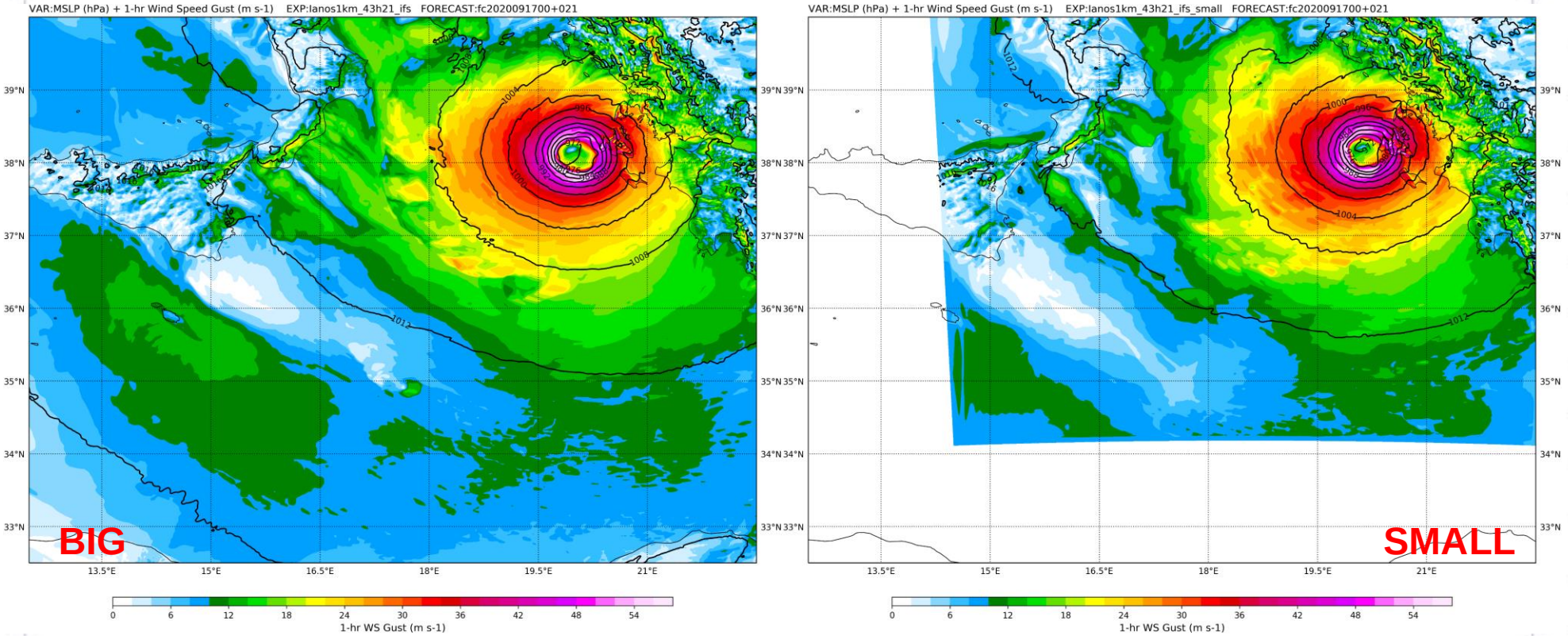
- Results – pseudo BTs:
  - Influence of domain (Big vs Small 1km)



1700 + 21h

Medicane Ianos

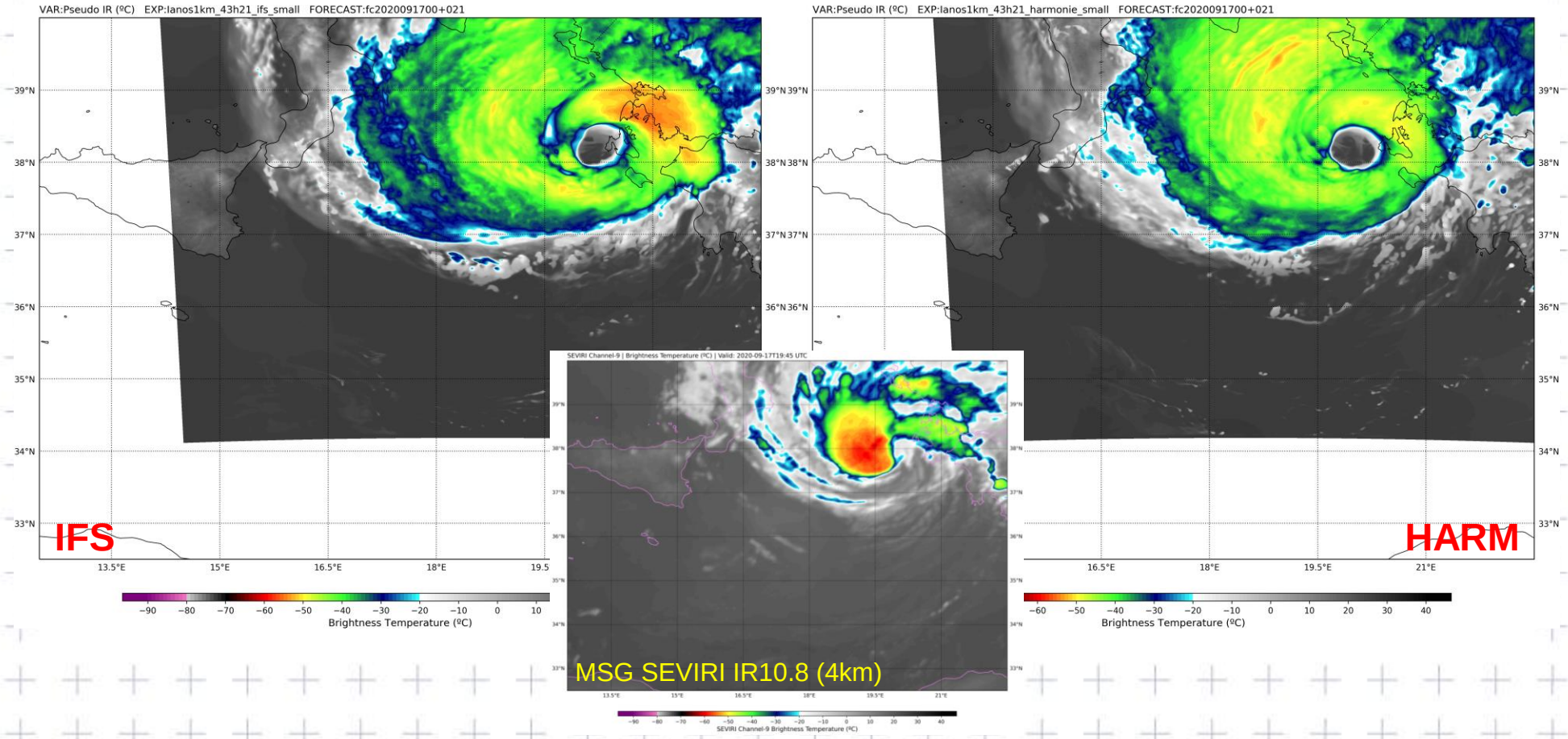
- Results – MSLP+Wind:
  - Influence of domain (Big vs Small 1km)



1700 + 21h

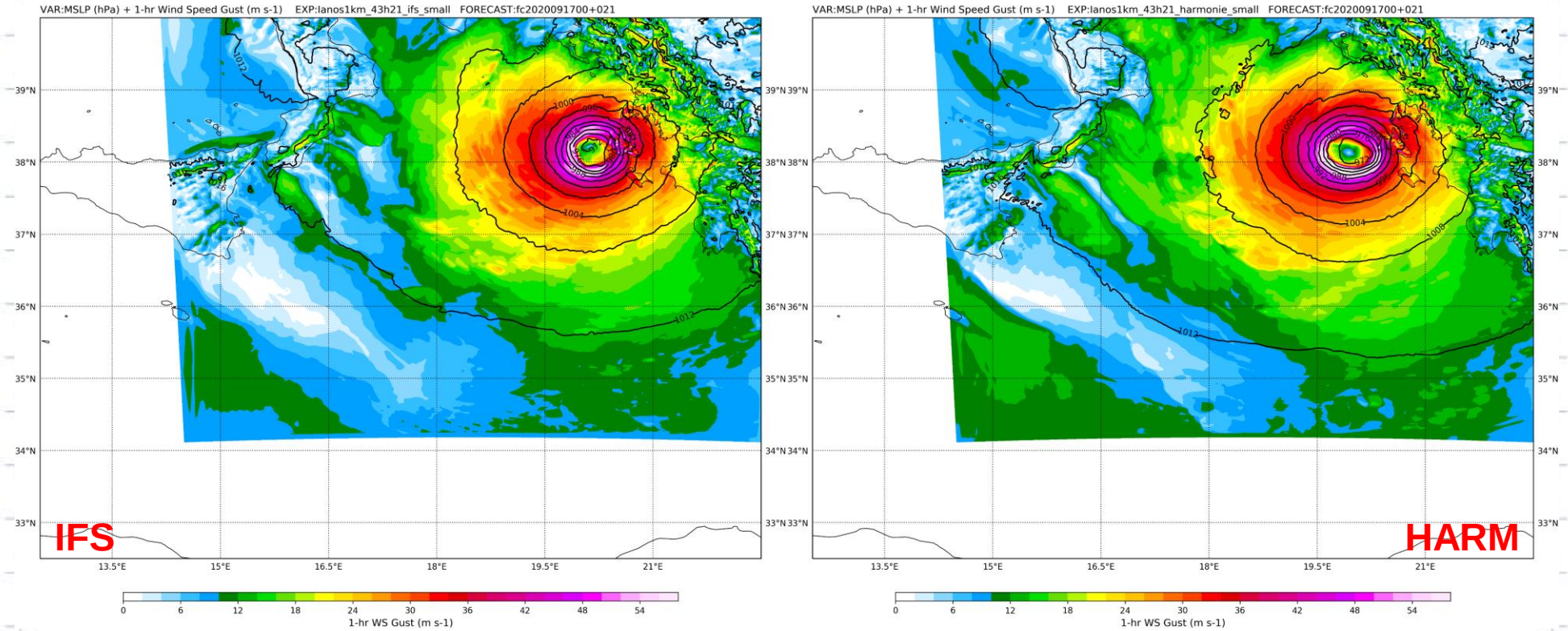
Medicane Ianos

- Results – pseudo IR10.8 Brightness Temperature:
  - Influence of BCs (IFS vs HARM 1km)



Medicane Ianos

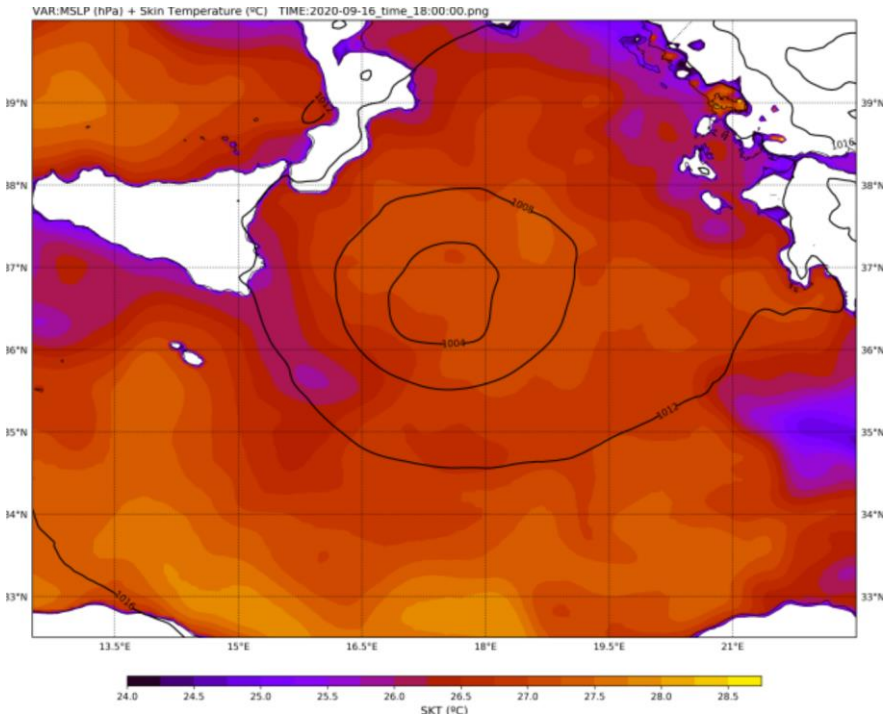
- Results – MSLP+Wind:
  - Influence of BCs (IFS vs HARM 1km)



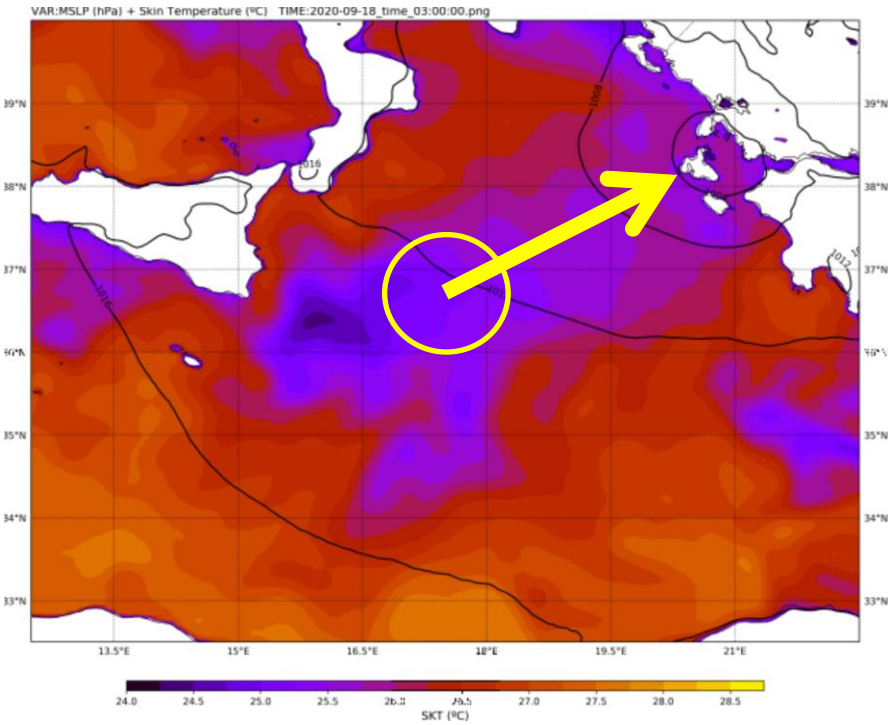
1700 + 21h

Medicane Ianos

- Results - Influence of SSTs:
  - CERRA (5.5km) reanalysis



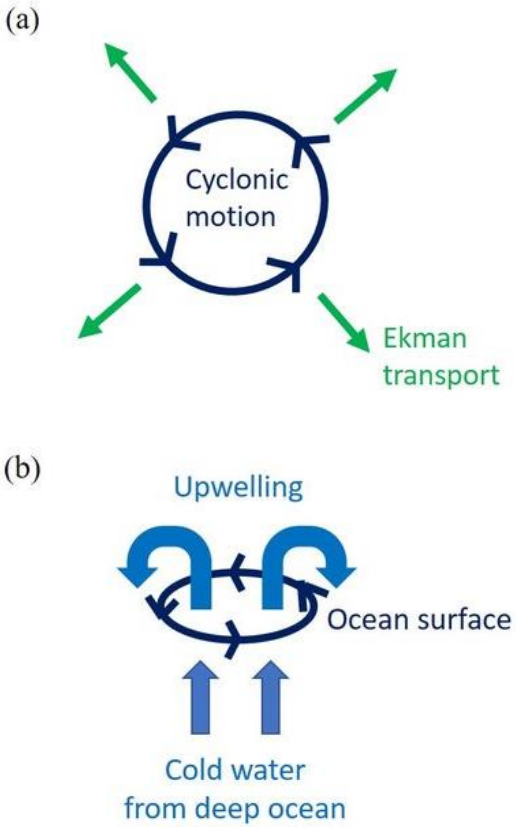
16/09 18z

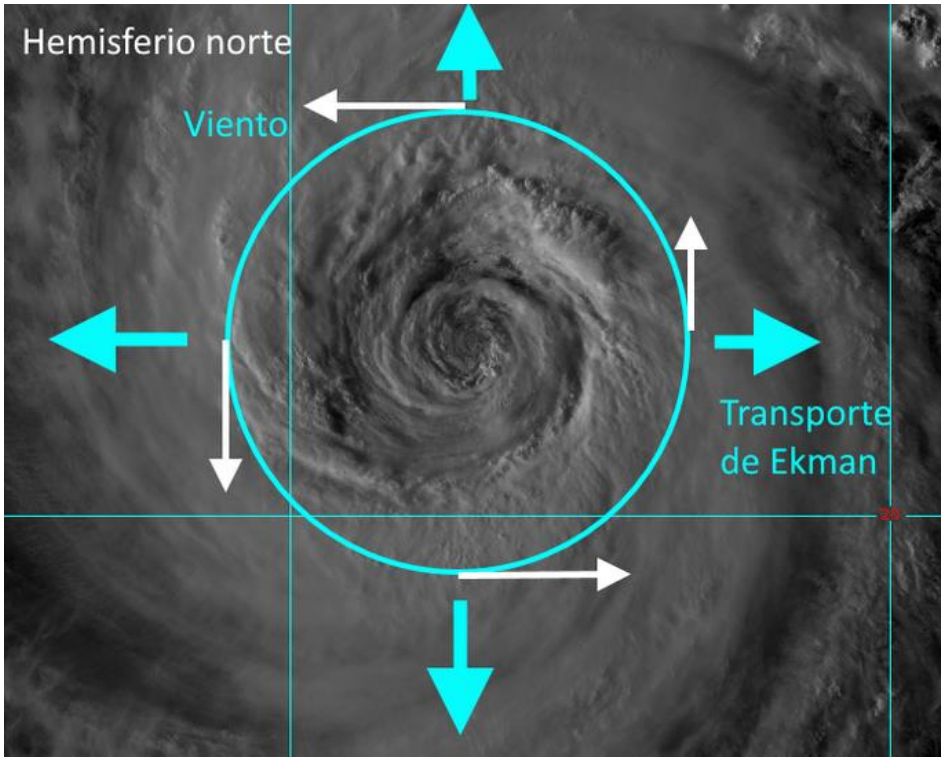


18/09 03z

Medicane Ianos

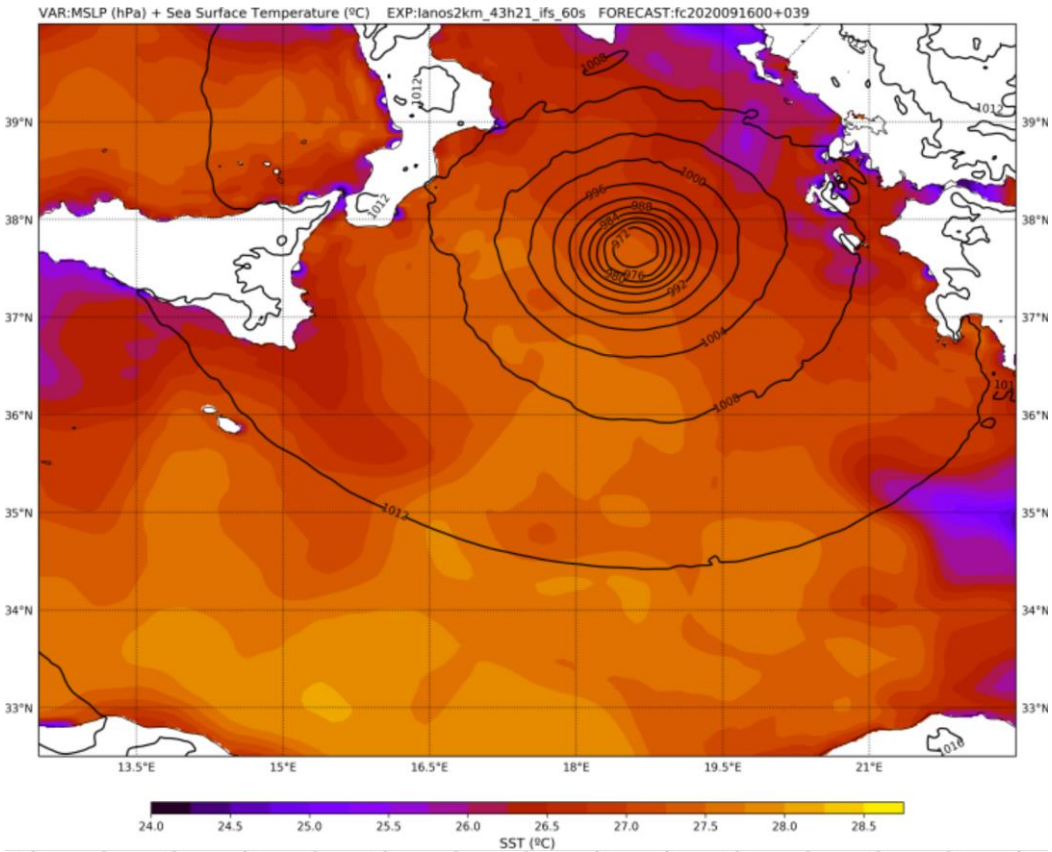
- Results:
  - Influence of TCs on SSTs





Medicane Ianos

- Results - Influence of SSTs:
  - HARMONIE-AROME (fixed SSTs)

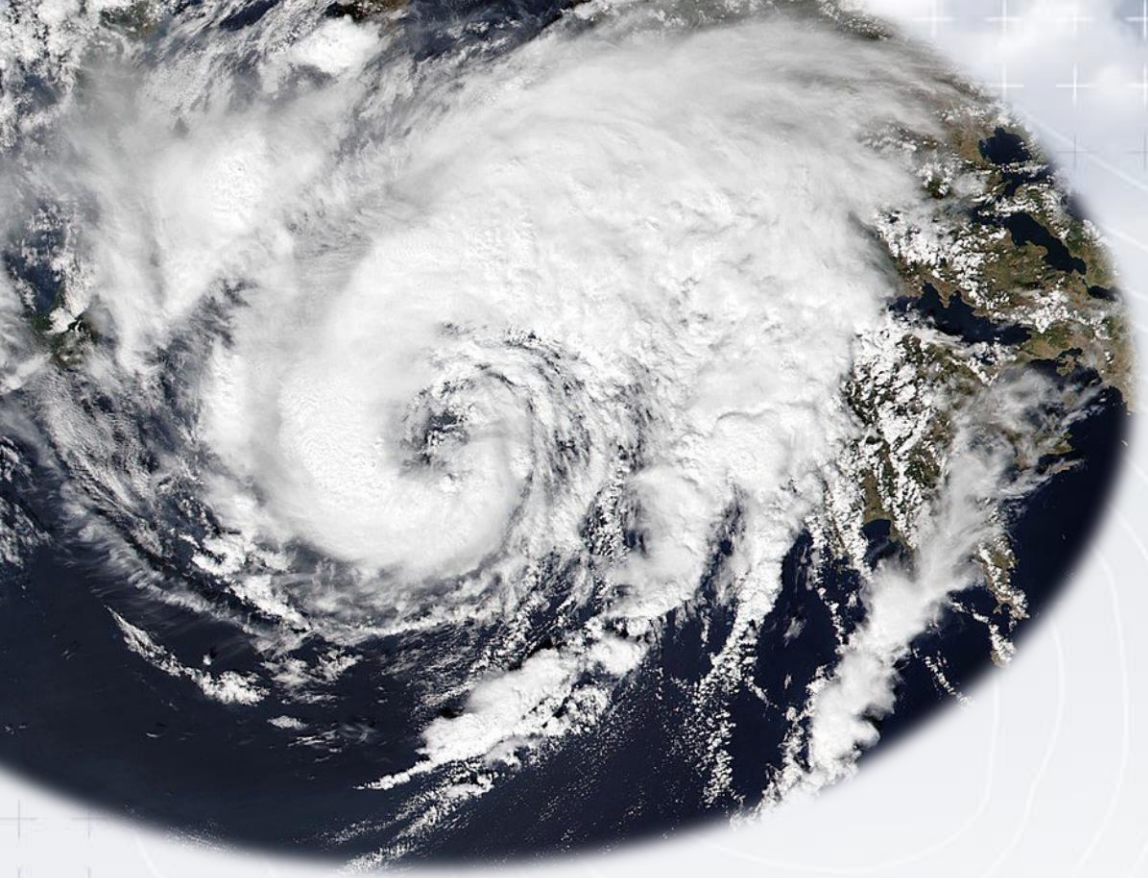


Conclusions

- VHR simulations improved the forecast of a T-storm resulted from atmospheric flow mesoscale interactions with the orography.
- Medicane/Hurricane Ianos is not affected much -in track- by domain, BCs and resolution changes.
- Most of the differences are found in the intensity: 2km runs simulates “better” cyclone. VHR over-intensifies the cyclone.
- It could be more important to simulate atmosphere-ocean interactions within the cyclone structure. Ianos could be the first medicane to produce upwelling.

Future outlook

- Verify these simulations with other data sources and local data, implementing also the spatial verification of convective activity (in HARP).
- Use of simulated BTs from RTTOV model.
- Testing coupled atmosphere-ocean simulations. Investigation of upwelling.
- Use of data assimilation.



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VICEPRESIDENCIA TERCERA DEL GOBIERNO
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO
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Thanks for your attention! Questions?