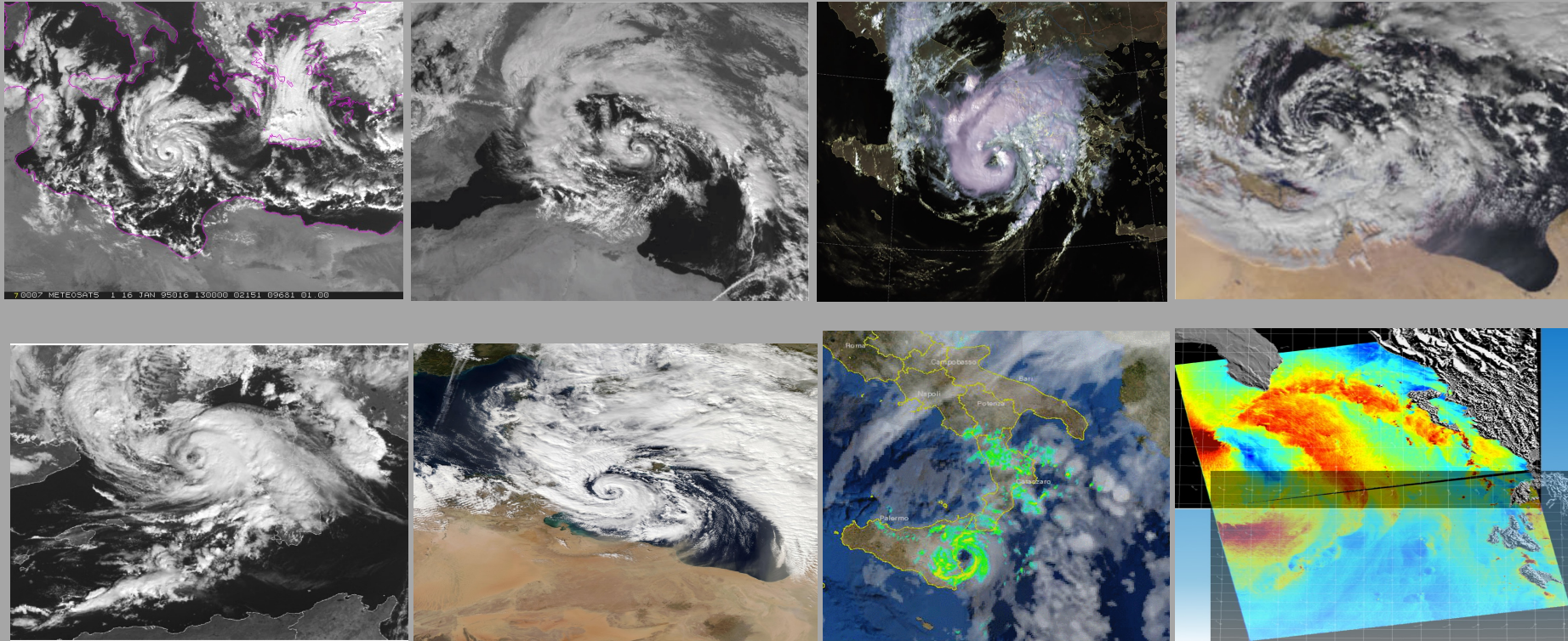


Numerical modeling of medicanes: challenges and future perspectives



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UNIVERSITÀ
DEGLI STUDI
DI PADOVA



DEPARTMENT OF
GEOSCIENCES

OUTLINE

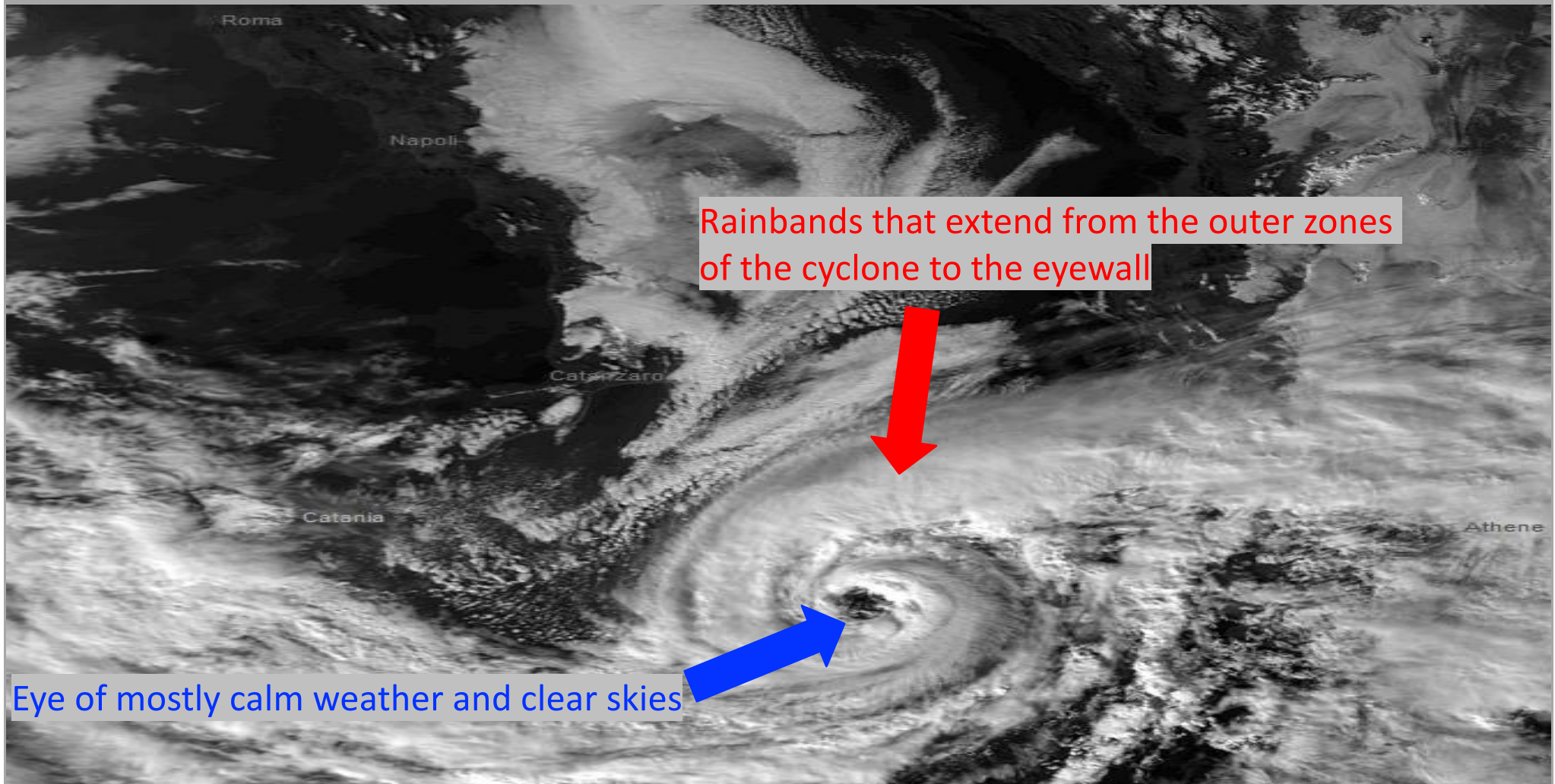
1. INTRODUCTION

2. DYNAMICAL FEATURES

3. DEFINITION OF «MEDICANE»

4. PREDICTABILITY AND COUPLED RUNS

Since satellite images became available, it has been possible to identify vortices in the Mediterranean basin whose characteristics are similar to those of Tropical Cyclones.

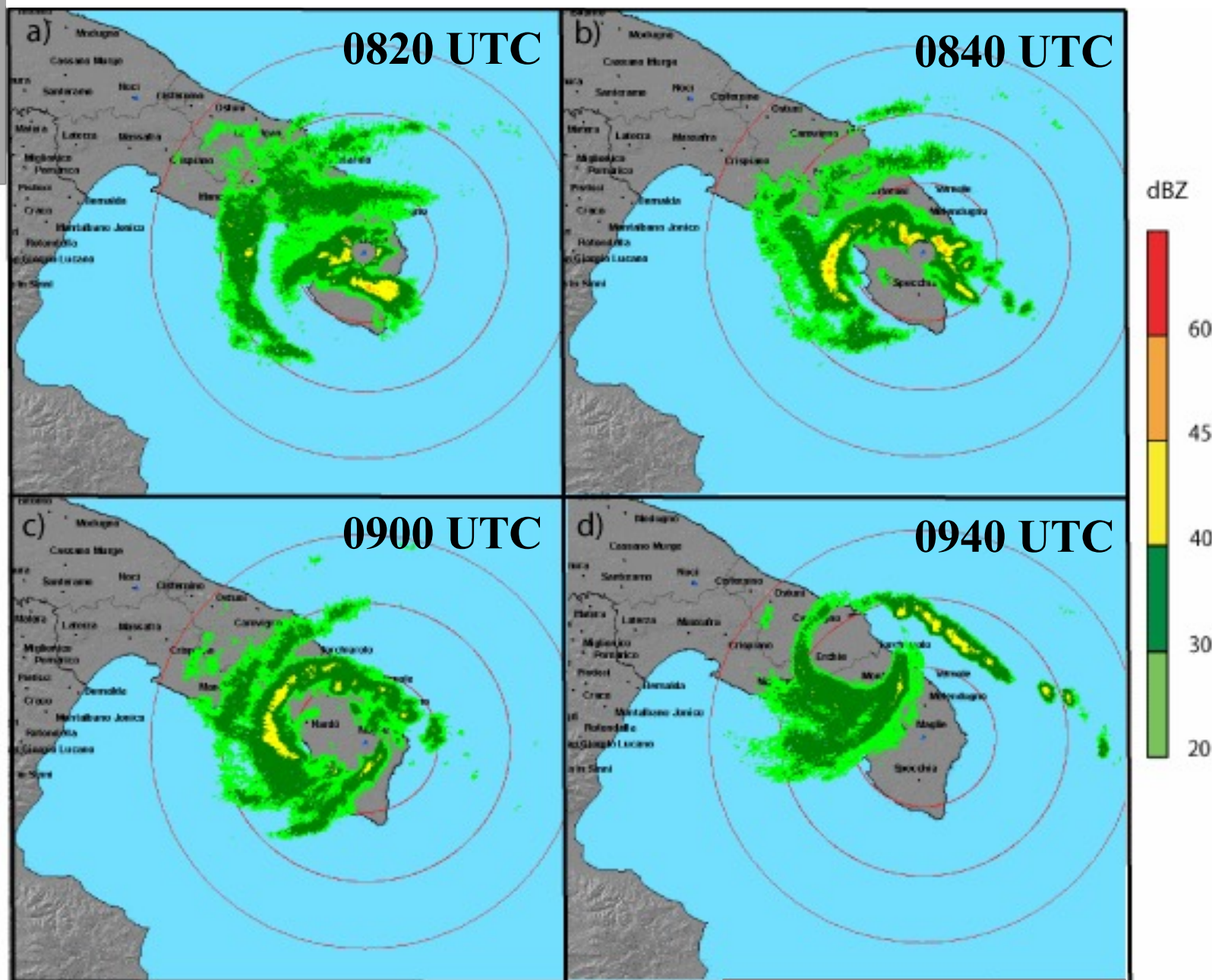


Rainbands that extend from the outer zones of the cyclone to the eyewall

Eye of mostly calm weather and clear skies

LEUCOSIA (26-27 JAN 1982)

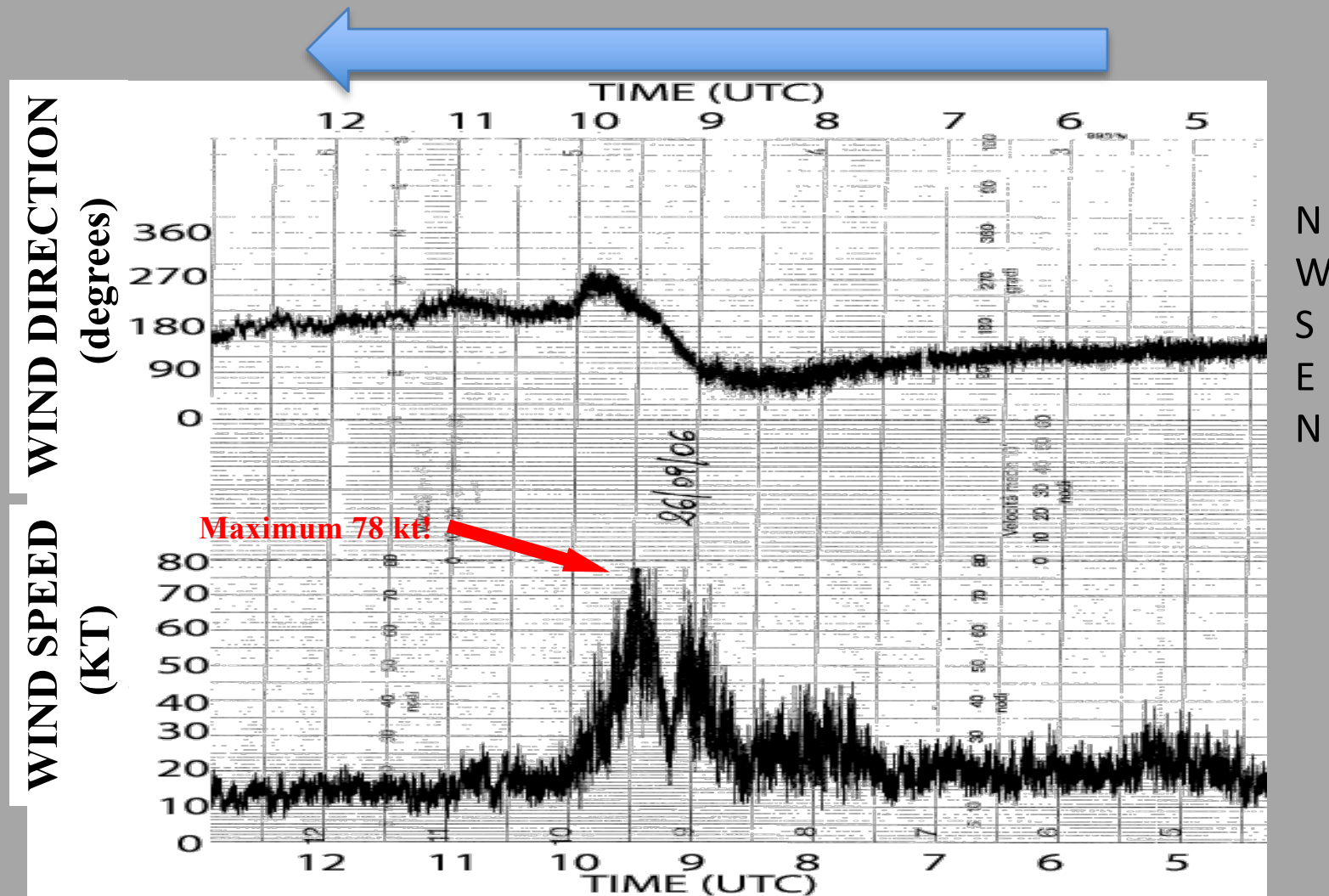
RADAR REFLECTIVITY (dBZ)



MARIA (26/09/2006)

Moscatello et al. (2008a)

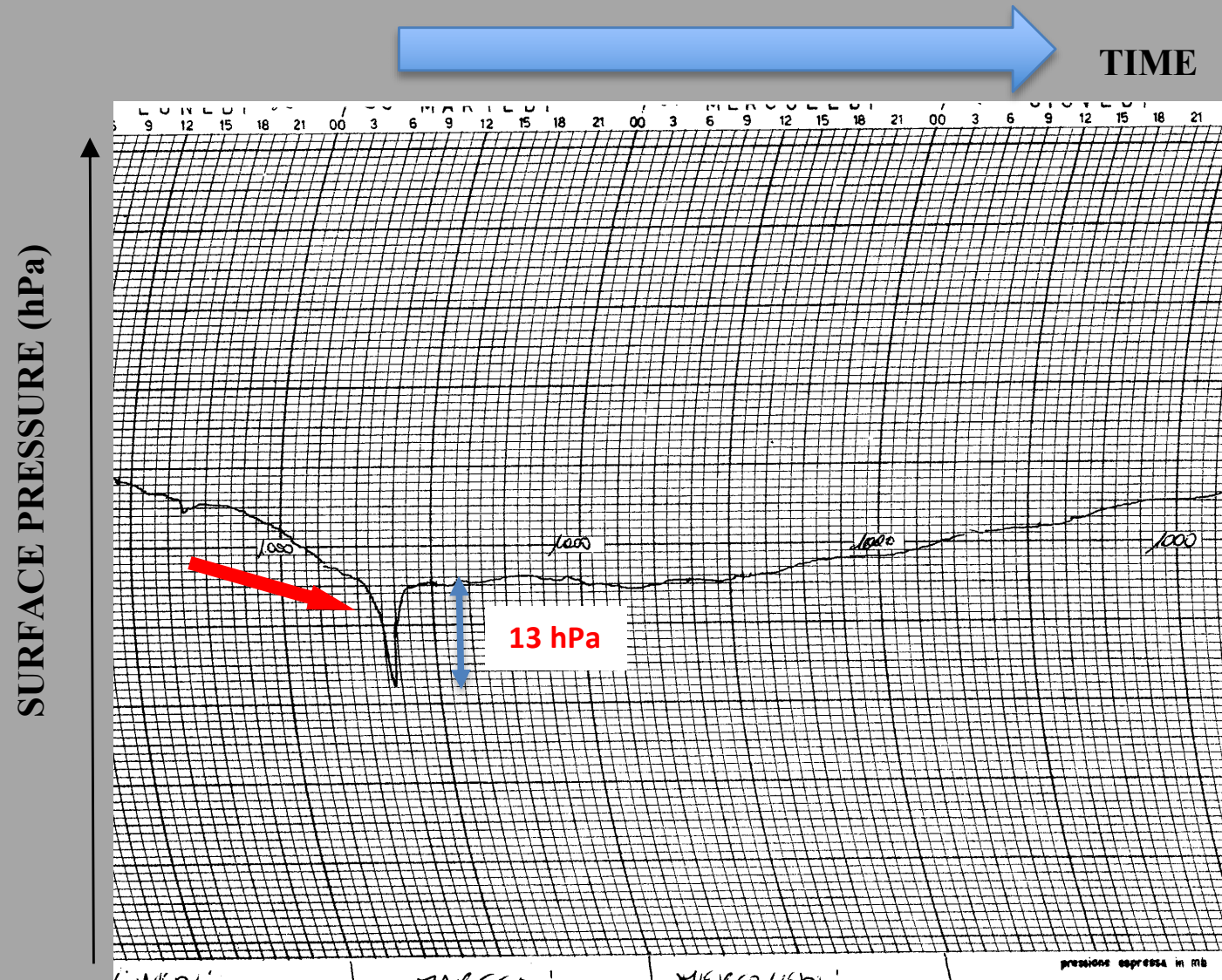
GALATINA AIRPORT



MARIA (26/09/2006)

Moscatello et al. (2008a)

GALATINA AIRPORT



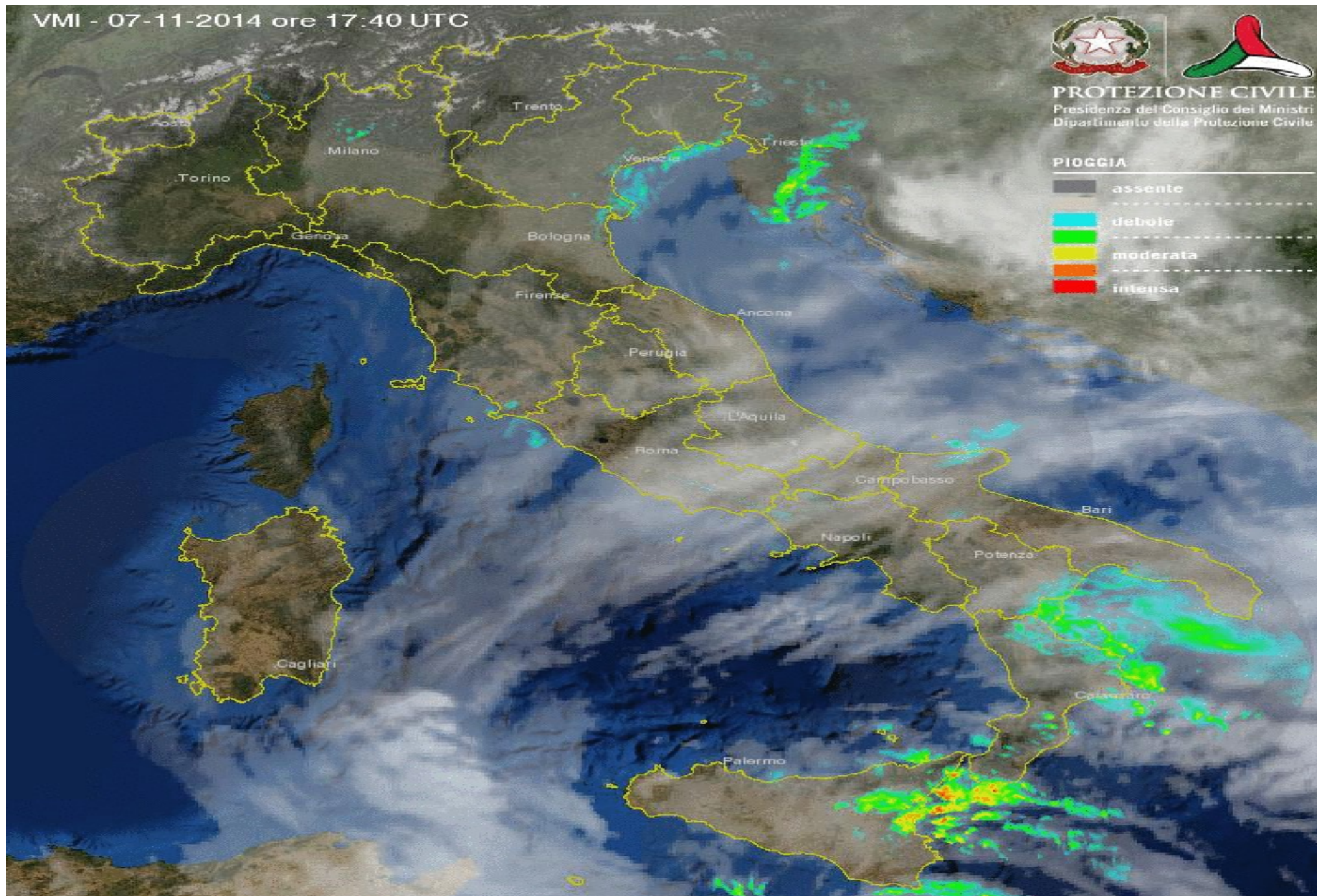
MARIA (26/09/2006)

VMI - 07-11-2014 ore 17:40 UTC



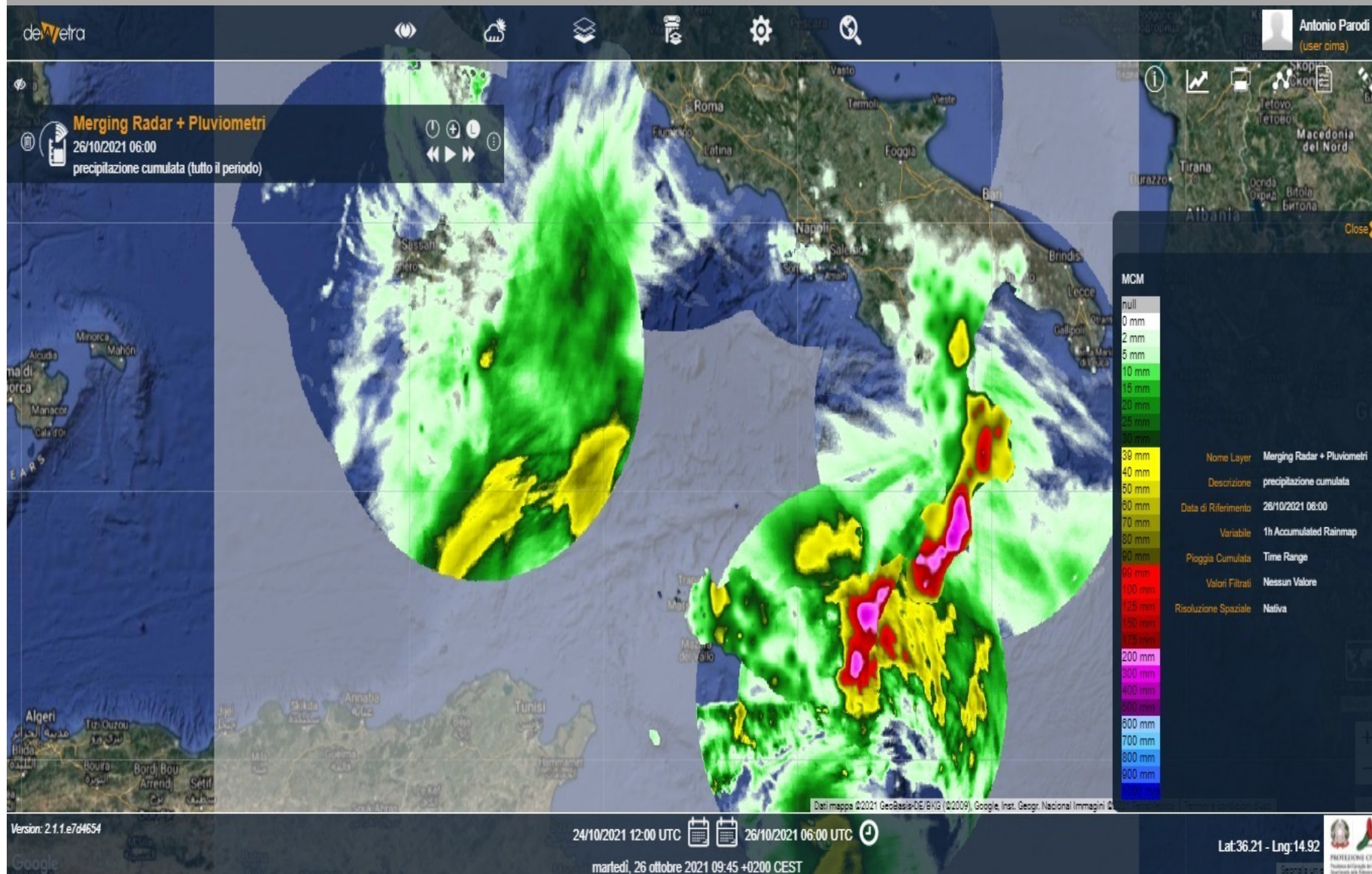
PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

PIOGGIA



QENDRESA (07/11/2014)

CUMULATED RAINFALL



APOLLO 24-28/10/2021

OUTLINE

1. INTRODUCTION

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Mediterranean (medicane)

Tropical-like

cyclones

Generally, cyclones with characteristics similar to TC for part of their lifetime are possible in the Mediterranean (e.g., presence of a central “eye”, warm core, symmetric structure)

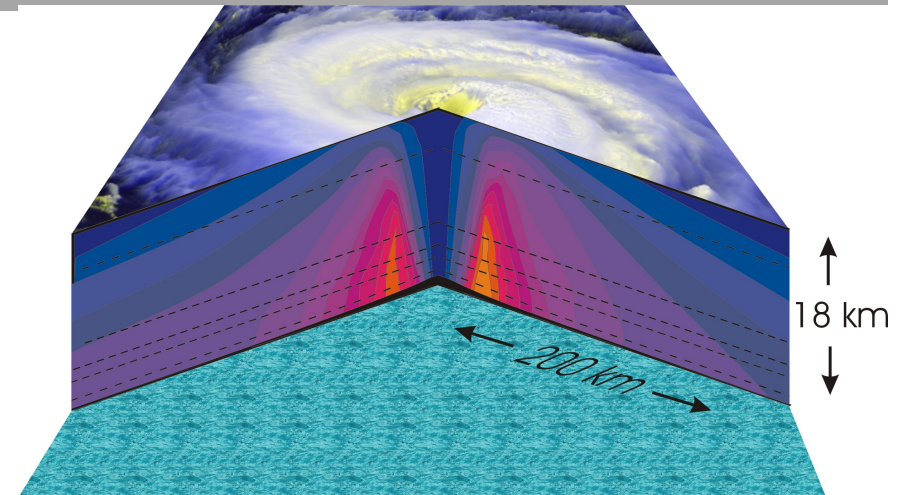
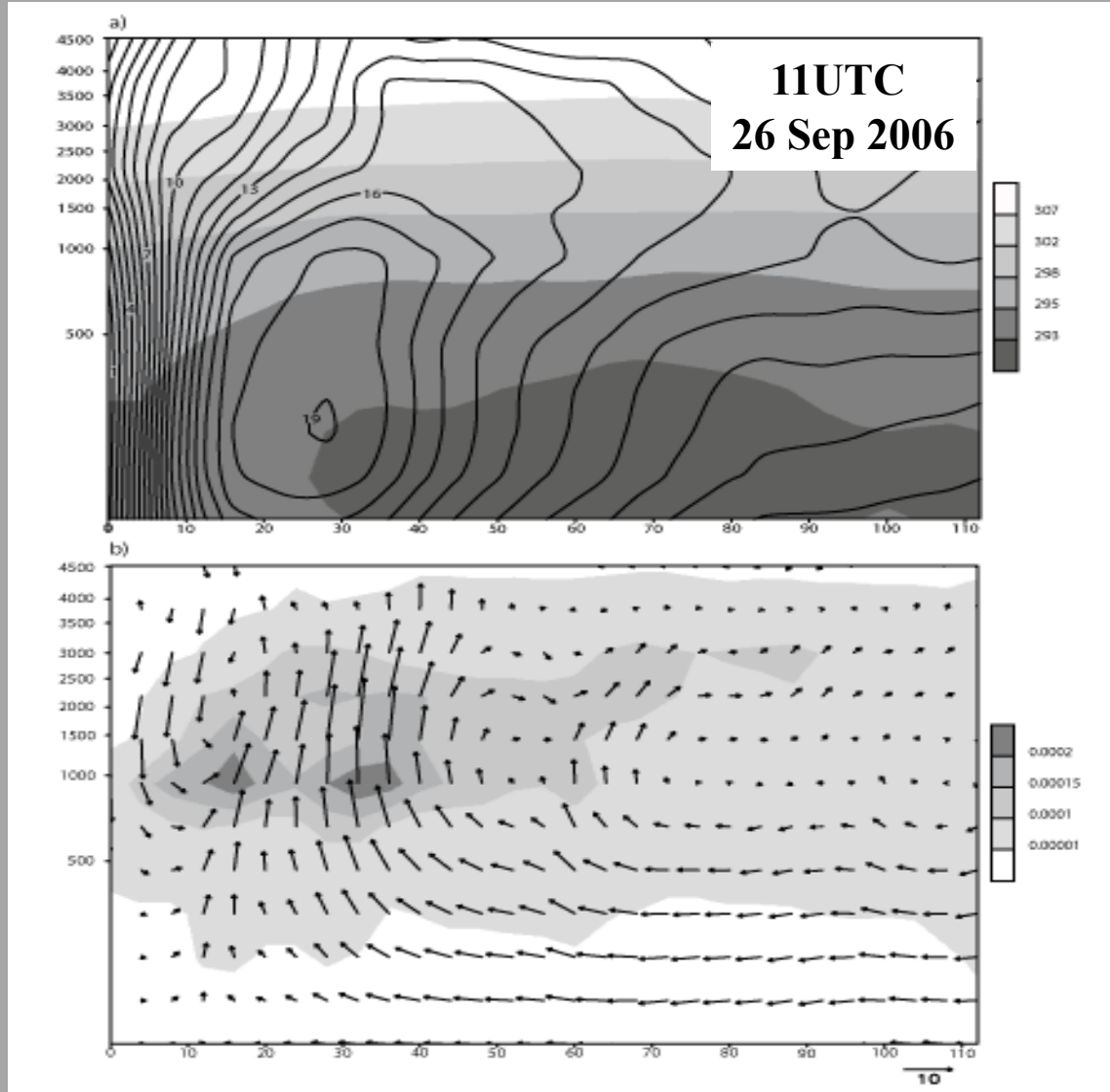
They are less intense and smaller than TC (they can rarely reach level 1 of the Saffir-Simpson scale)

They are rare (0-3 per year)

Some analogies and differences with TC can be identified

1. WIND STRUCTURE

Coordinate system origin in the pressure minimum



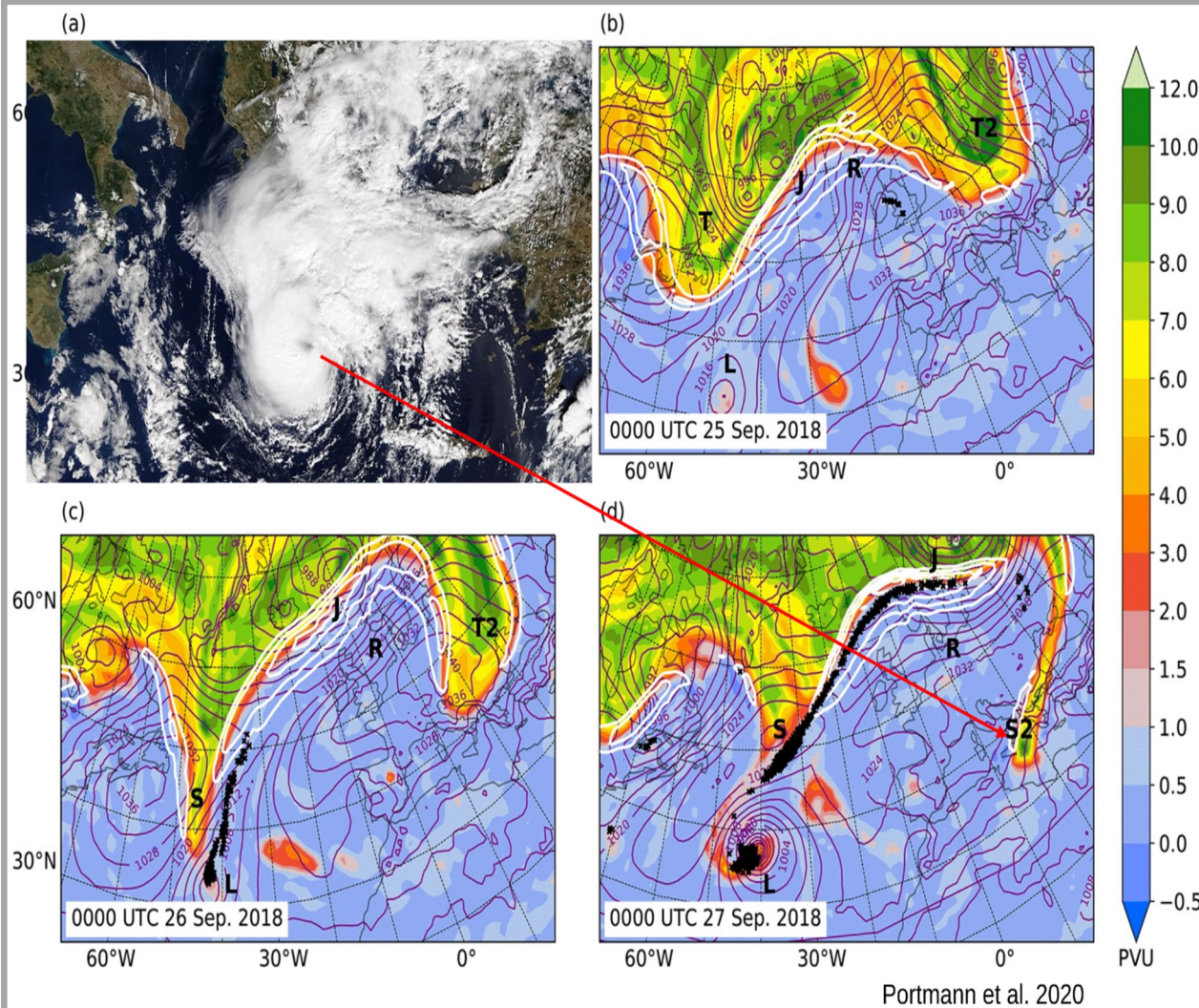
Azimuthal wind component
(m/s, contours)
Theta (K, grey scale)

Radial wind + w (arrows)
 q_c (g/kg, grey scale)

No scale contraction for all cyclones (ERA5)

Moscatello et al. (2008b)
Gutierrez-Fernandez et al. (2024)

2. PV STREAMERS (GENESIS)



PV at 325 K (shaded, in PVU) and mslp (contours)

1. Rossby wave breaking leads to..
2. ... southern deviations of PV streamer over the Mediterranean where...
3. ... baroclinic instability leads to initial intensification

*Common mechanism for **almost all intense Mediterranean cyclones!***

ZORBAS (27 SEP -2 OCT 2018)

2. PV STREAMERS (GENESIS)

Predictability: How an uncertain short-wave perturbation on the North Atlantic wave guide affects the forecast of an intense Mediterranean cyclone (Medicane Zorbas)

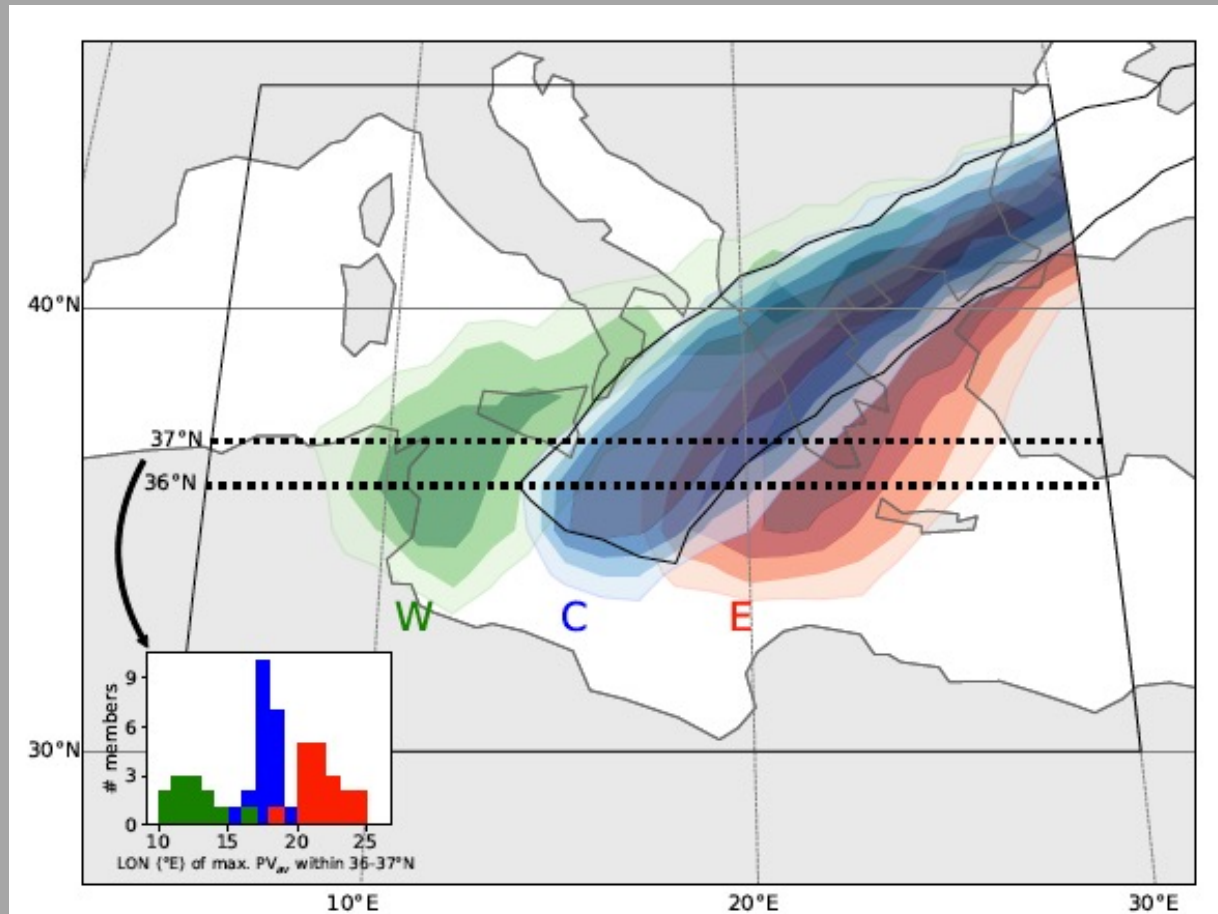


Figure 7. Clustering of ensemble members (initialized at 0000 UTC 24 Sep 2018) according to the position of the upper-level PV streamer in the Mediterranean at 0000 UTC 27 Sep 2018. Colors show frequencies of $PV_{av} \geq 2$ PVU (shading, every 20%,) for each cluster (blue: cluster C, green: cluster W, red: cluster E) and the black line the contour where $PV_{av} = 2$ PVU in the operational analysis. The region considered for the clustering is shown by the black box. PV_{av} denotes vertically averaged PV between 320 and 330 K with PV values below 2 PVU set to zero (see text for details).

2. PV STREAMERS (INTENSIFICATION)

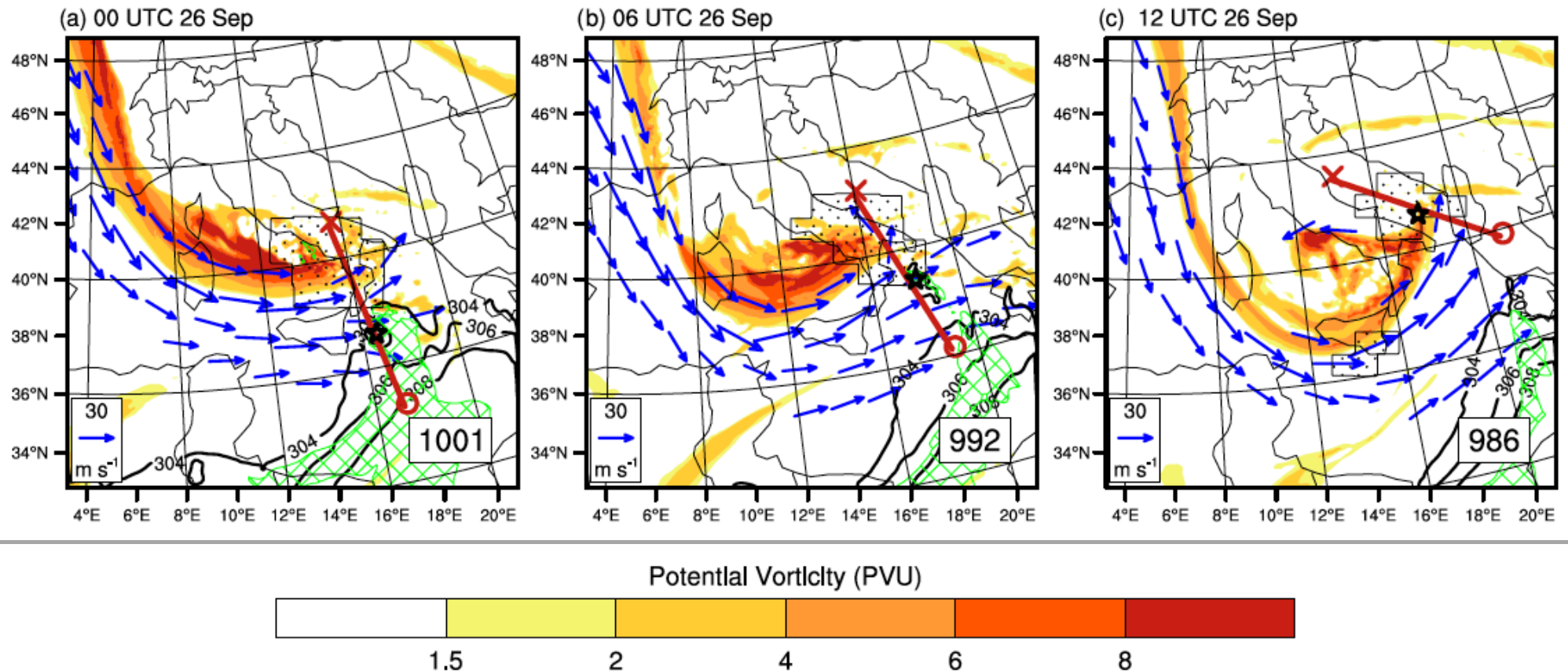
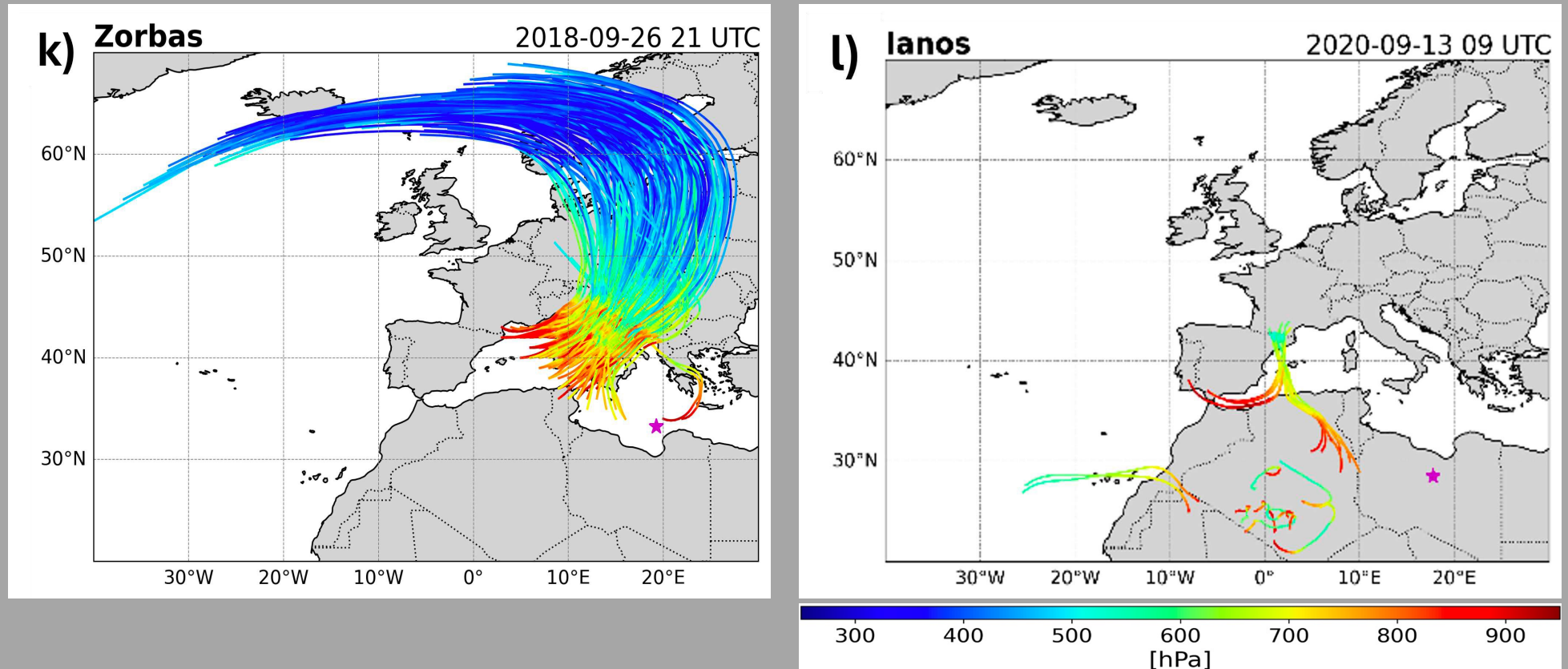


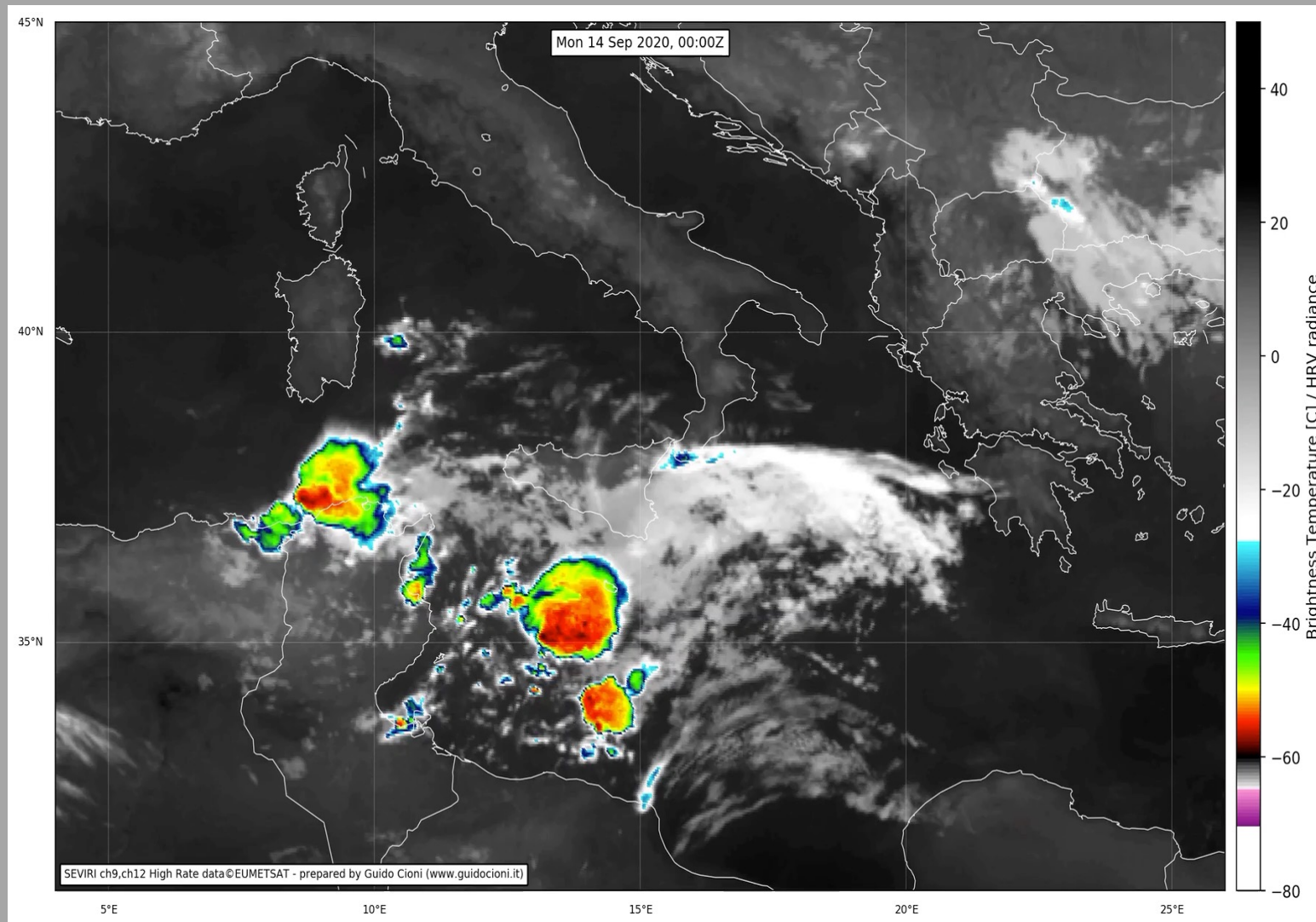
Figure 12. Results for ECMA at 0000, 0600, and 1200 UTC on 26 September 2006. Top: potential vorticity at 300 hPa (shaded, PVU), wind speed at 300 hPa over 30 m s⁻¹ (vector), ω_{dyn} at 400 hPa less than -0.4 Pa s⁻¹ (dotted) and CAPE larger than 1500 J kg⁻¹ (hatched). The star and the figure in the white box give the position and MSLP minimum, respectively, of the mesocyclone. Bottom: vertical cross-section of potential vorticity (shaded,

3. DIFFERENT PATHWAYS TO MEDICANE FORMATION



Nigro et al. (2026)

IANOS – HRV and Cloud Temperature top

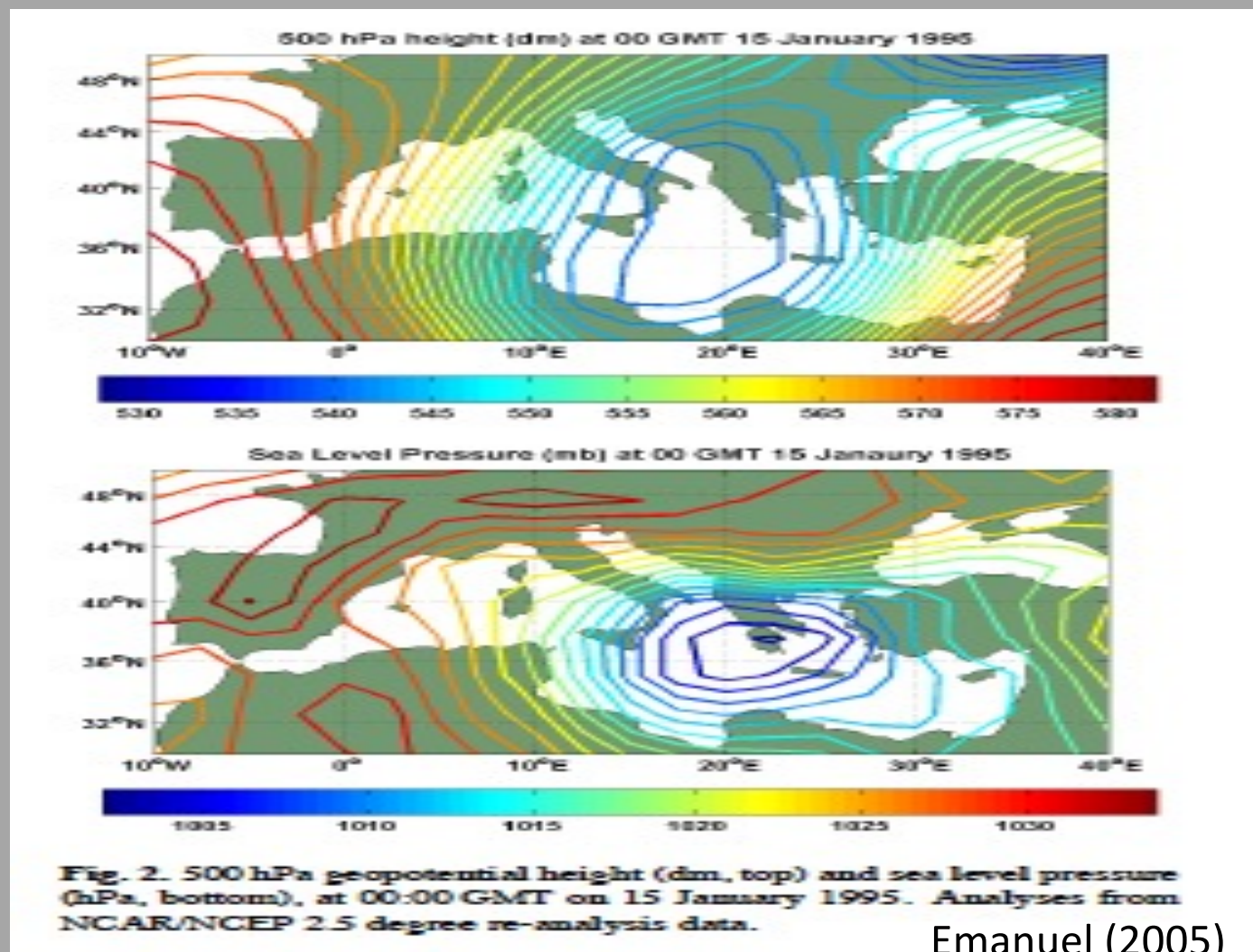


Medicane Ianos struck Greece causing four victims and massive damage in the western and central part. Wind gusts of up to 54 m/s and 645 mm/24 h of rain have been recorded on the island of Kefalonia

IANOS 17-18/09/2020

Sanchez et al. (2024)

4. MECHANISM OF DEVELOPMENT



Mediterranean hurricanes usually, and perhaps always, generate directly underneath an unusually deep, cut-off low at upper levels, in regions of large air-sea **thermodynamic disequilibrium** due to unusually **deep, cold air associated with a trough**
BUT NOT ALL MEDICANES DEVELOP ONLY THROUGH AIR-SEA INTERACTION

The Tropical Transition of the October 1996 Medicane in the Western Mediterranean Sea: A Warm Seclusion Event

EDOARDO MAZZA AND UWE ULBRICH

Institute of Meteorology, Freie Universität, Berlin, Germany

RUPERT KLEIN

Institute of Mathematics, Freie Universität, Berlin, Germany

(Manuscript received 15 December 2016, in final form 8 March 2017)

Quarterly Journal of the
Royal Meteorological Society



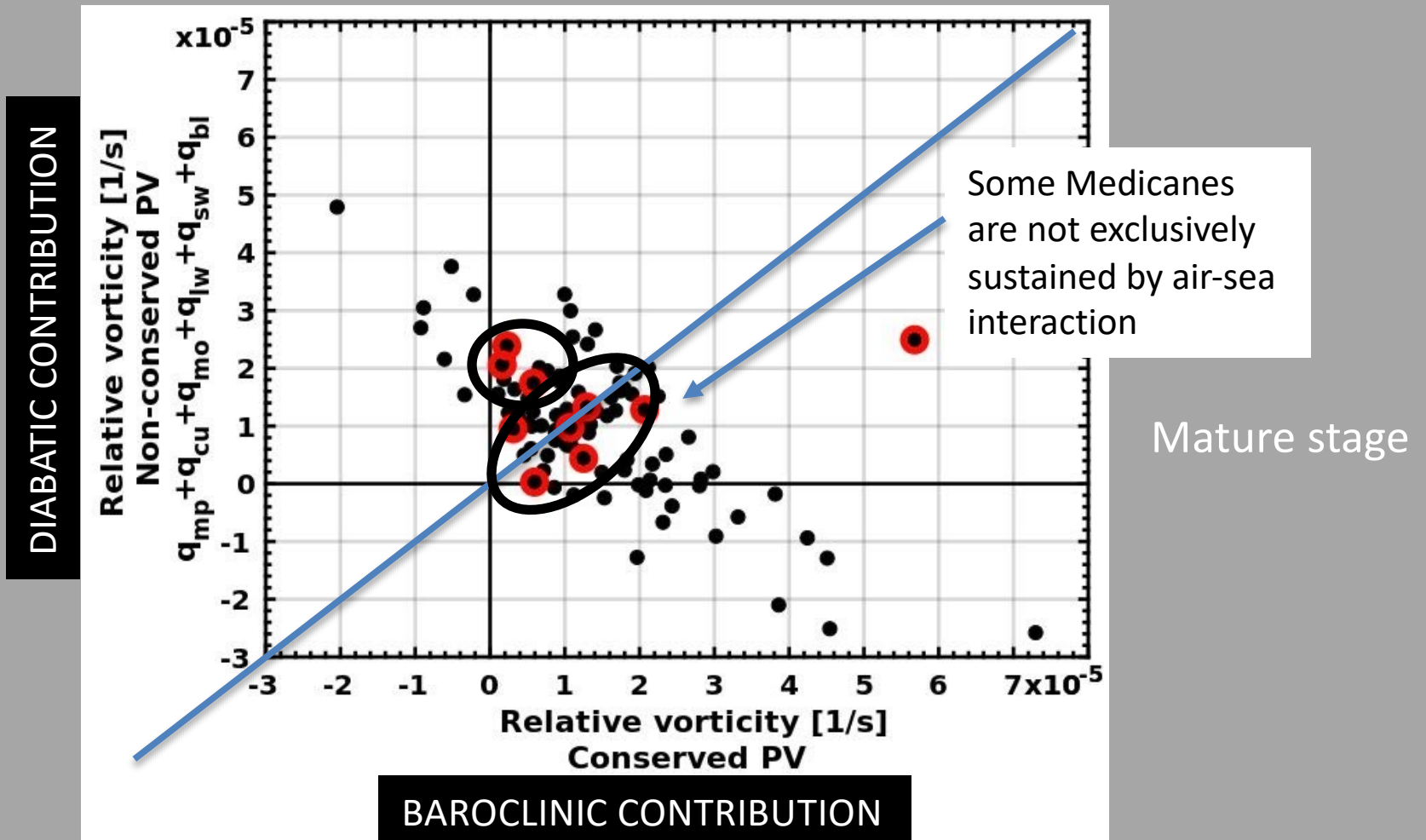
RESEARCH ARTICLE

Medicanes as subtropical cyclones: the December 2005 case from the perspective of surface pressure tendency diagnostics and atmospheric water budget

Lluís Fita , Emmanouil Flaounas

First published: 26 February 2018 | <https://doi.org/10.1002/qj.3273> | Citations: 56

Contribution of baroclinic vs diabatic processes to 850 hPa relative vorticity



Contribution to 850 hPa relative vorticity, in the centre of 100 cyclones: conserved, adiabatically transported PV (x-axis) and non-conserved, diabatically-produced PV (y-axis).

Medicanes (red) do not concentrate in a region of the parameter space -> **We cannot apply a pure air-sea interaction model.** Flaounas et al. (2020)

OUTLINE

1. INTRODUCTION

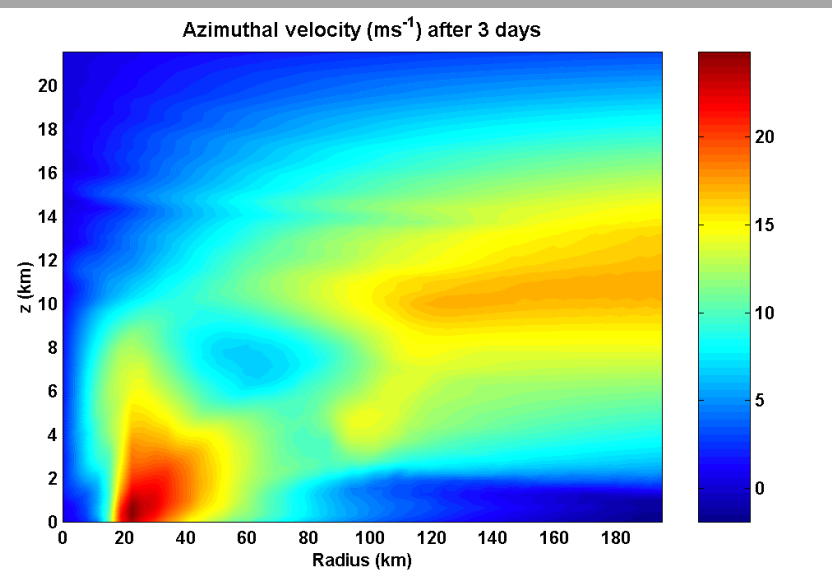
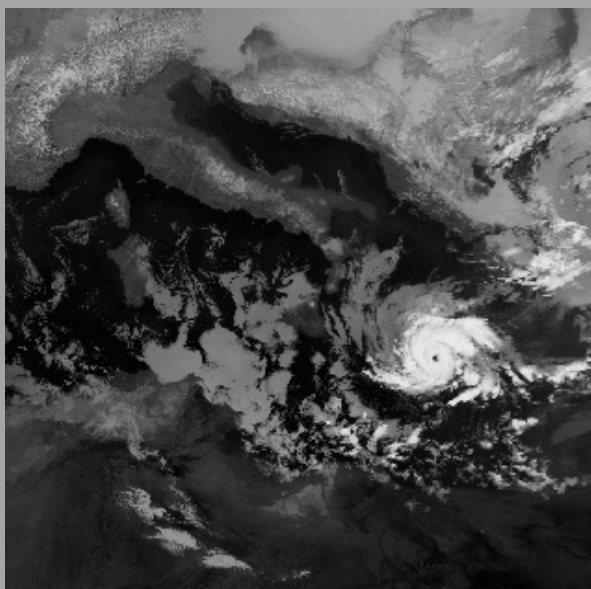
2. DYNAMICAL FEATURES

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A. KERRY EMANUEL'S PERSPECTIVE

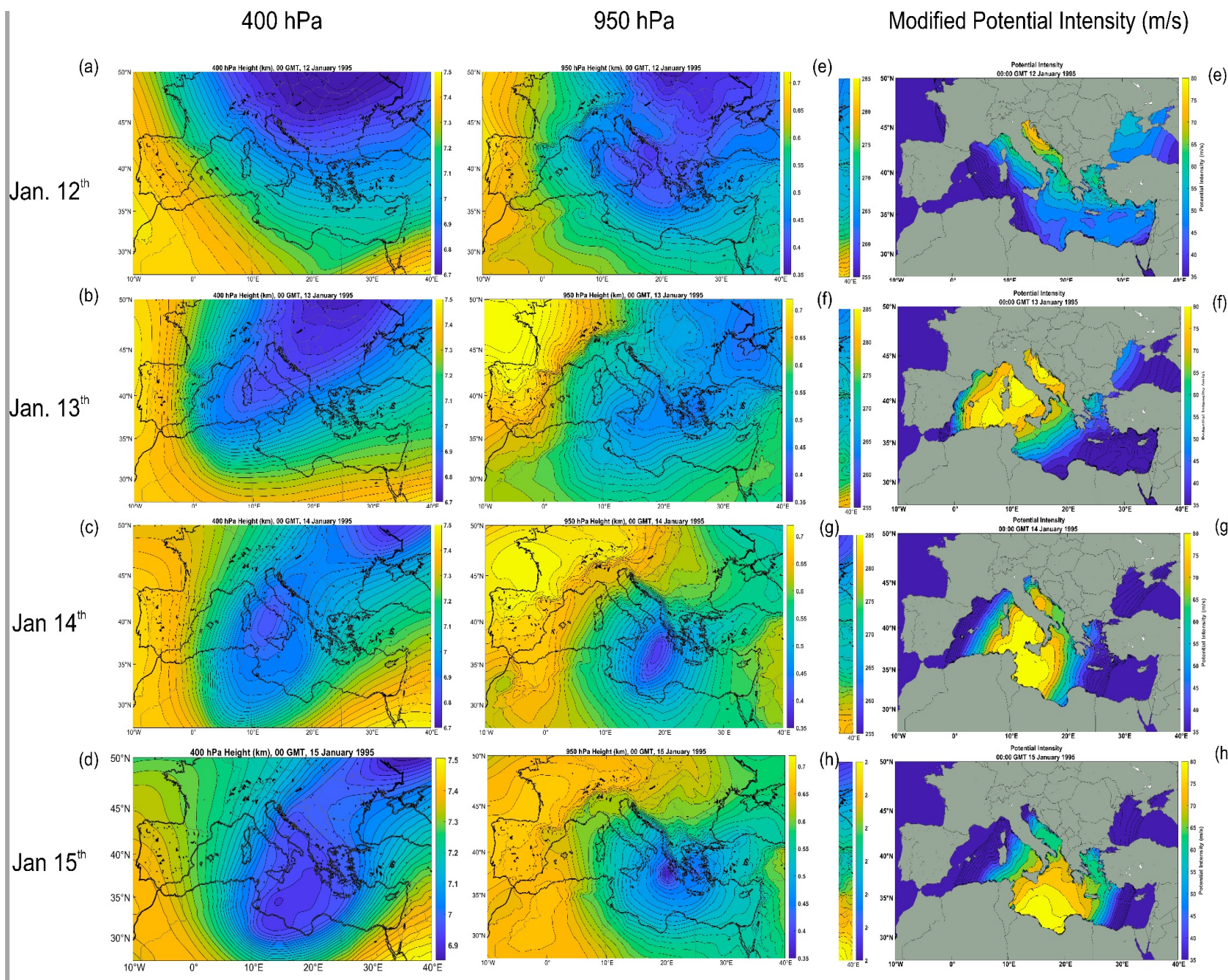
Genesis and maintenance of “Mediterranean hurricanes”
(Emanuel, 2005)



An **axisymmetric, cloud-resolving model** -in which any development may occur only due to the **feedback between surface enthalpy fluxes and wind** – was applied to show that a **cold, upper low** can produce high potential intensity (PI) in an Ionian cyclone (Jan 1995)

CELENO (15-17/01/1995)

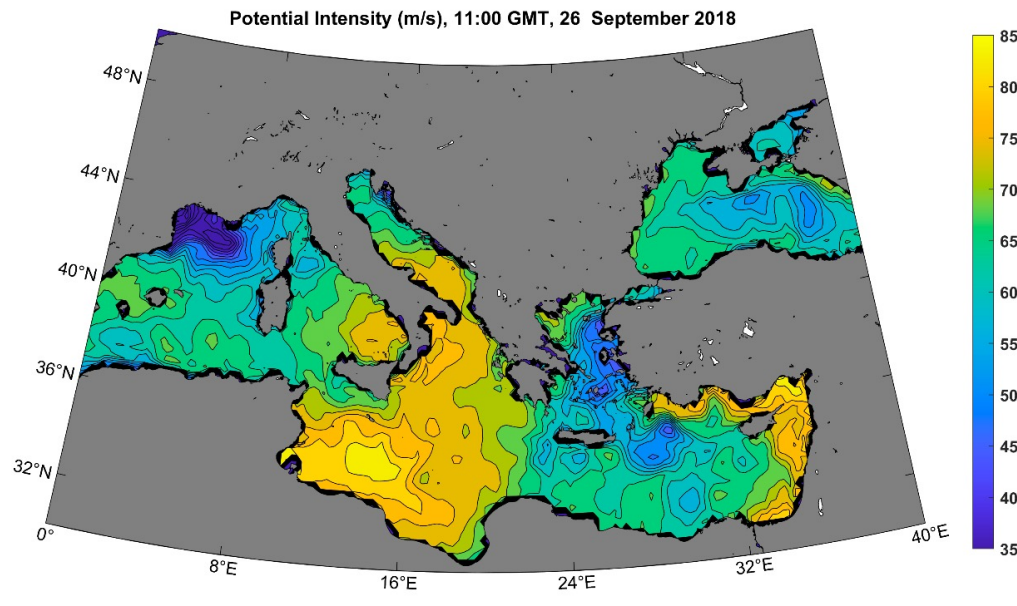
Emanuel (2005)



CELENO

The cold air aloft strongly enhanced PI -> **CYCLOPs (CYC clones from Locally Originating Potential intensity)** Emanuel et al. (2025)

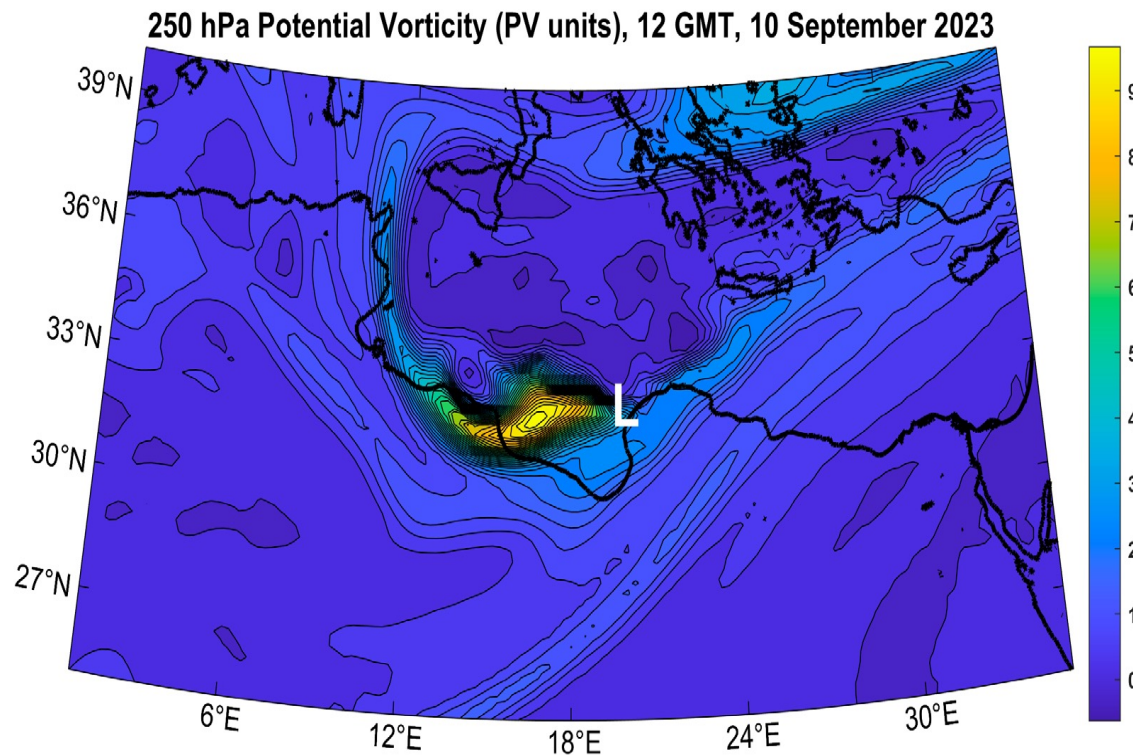
ZORBAS



Potential intensity (PI) distribution in the Mediterranean and Black Seas, 11 GMT on 26 September 2018

In much of the Mediterranean, PI was typical of tropical warm pools with values approaching 80 m/s before the cyclogenesis. The cold air aloft did little to enhance PI -> **tropical transition** (Bosart and Bartlo 1991; Davis and Bosart 2003, 2004); however, it almost certainly humidified the middle troposphere, making genesis somewhat more likely

Medicane Daniel



Potential vorticity (PV units, $10^{-6} \text{ K kg}^{-1} \text{ m}^2 \text{ s}^{-1}$) at 250 hPa at 12 GMT on 10 September, 2023. The white “L” marks the approximate surface center of Daniel at this time

Tropical transition as Zorbas, BUT as it approached the Libyan coast around Sep 10, it came under the influence of a mesoscale “satellite” PV mass rotating around the principal upper-level cutoff cyclone.

The superposition of the **high-level PV anomaly** with the surface-based warm core probably contributed to Daniel’s intensification which, remarkably for a surface flux-driven cyclone, continued after landfall (Hewson et al., 2024).

Emanuel et al. (2025)

B. European perspective

DIFFERENT CATEGORIES OF MEDICANES

The Tropical Transition of the October 1996 Medicane in the Western Mediterranean Sea: A Warm Seclusion Event

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RESEARCH ARTICLE

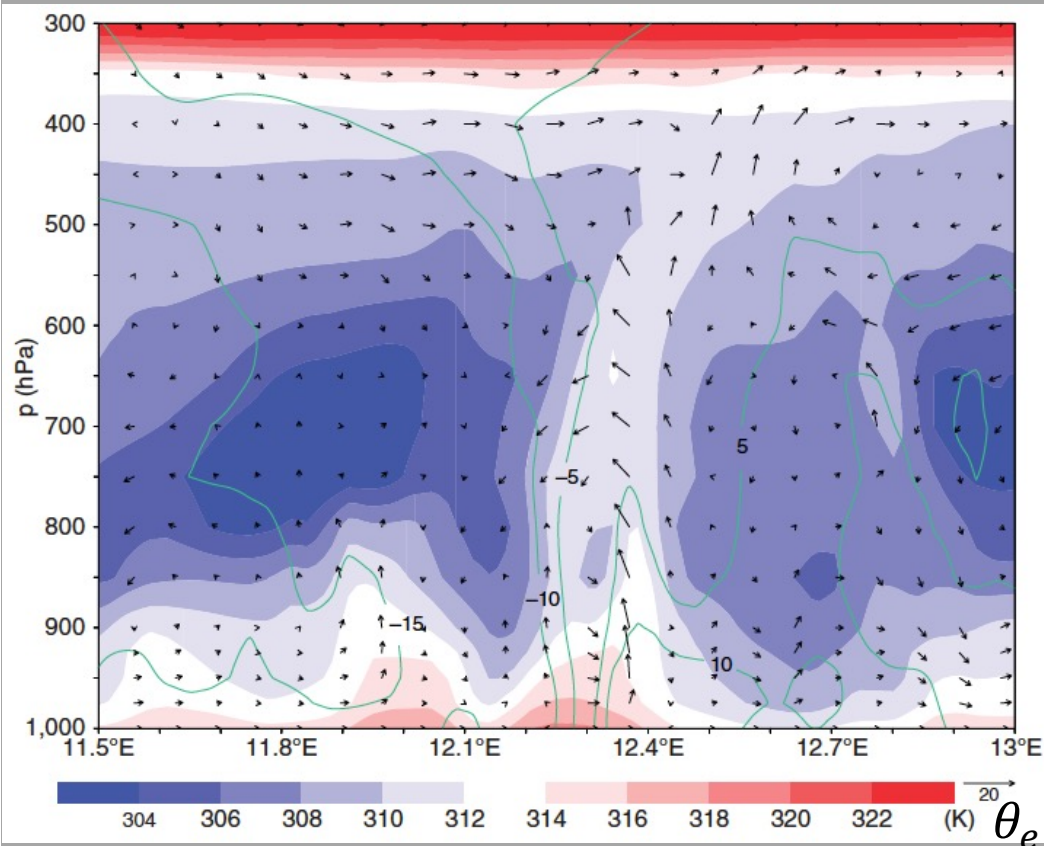
Medicanes as subtropical cyclones: the December 2005 case from the perspective of surface pressure tendency diagnostics and atmospheric water budget

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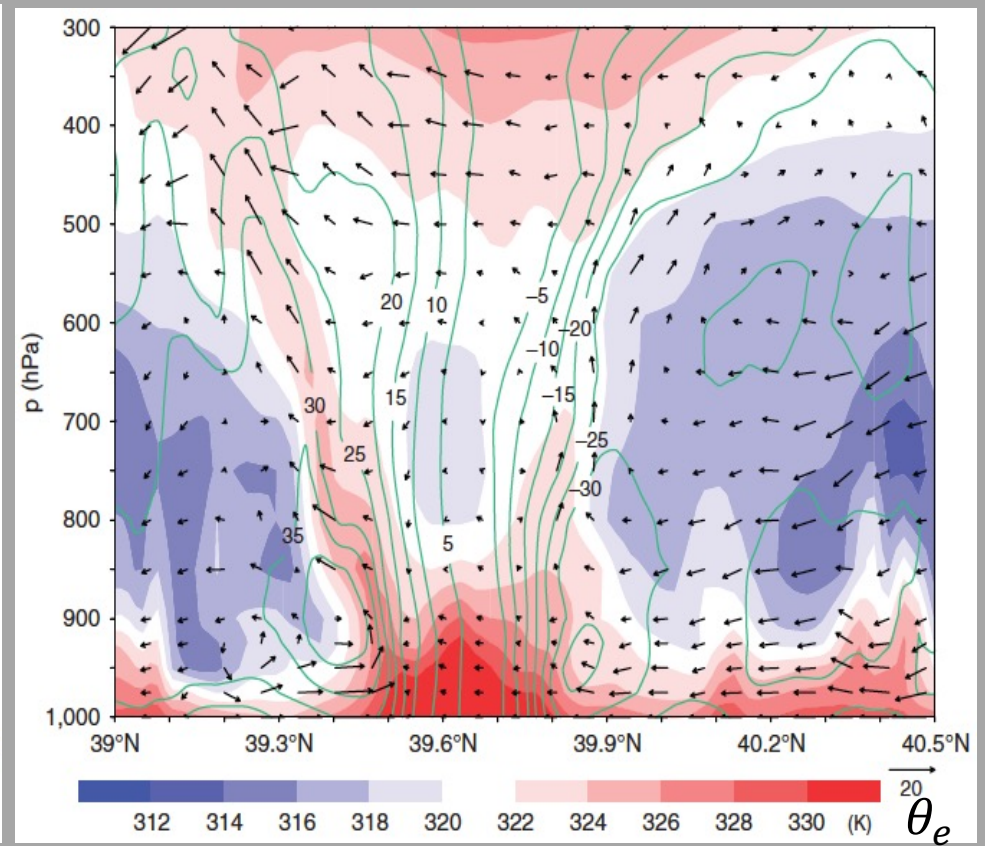
First published: 26 February 2018 | <https://doi.org/10.1002/qj.3273> | Citations: 56

CROSS SECTION ALONG THE CYCLONE CENTER

Symmetric, deep warm core structures but only the second one shows the upward transport of warm/moist air typical of TC -> Different contribution of baroclinic versus diabatic processes



ZEO (DECEMBER 2005)



CORNELIA (OCTOBER 1996)

Vertical cross-section of θ_e (colours), storm-relative winds (vectors), absolute momentum (lines, contour interval=5m/s; zero not shown) near the cyclone centre

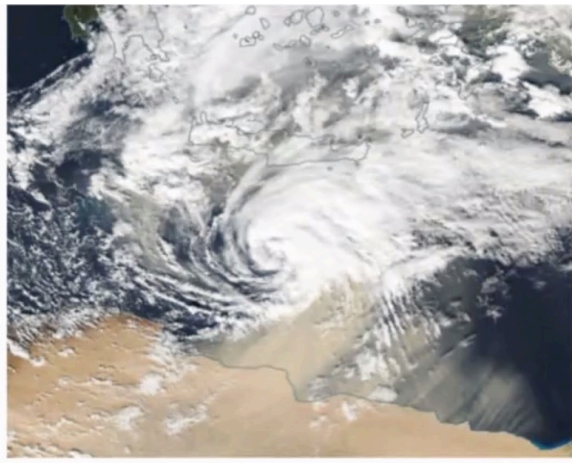
Miglietta and Rotunno (2019)

The term “medicane” has been used to cover a wide range of the continuum existing between ECs and TCs. Distinct categories can be identified, depending on the dominant process in the mature stage.

(**TYPE A: subtropical cyclone or warm seclusion; TYPE B: tropical transition**).

Type A

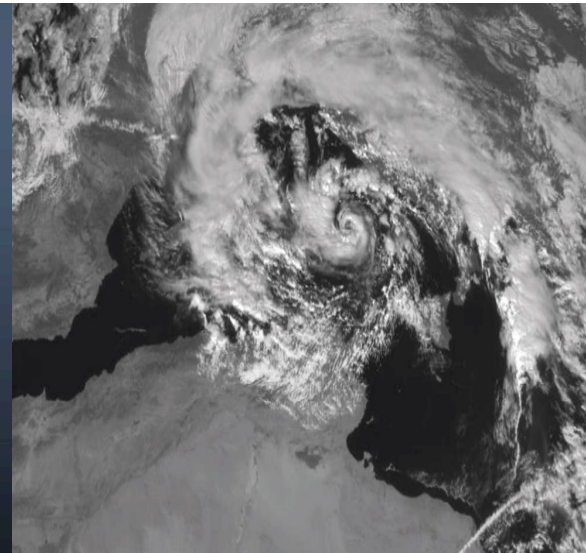
(Shallow) warm core cyclones mostly driven by baroclinicity and weak diabatic processes (no deep convection in the mature stage)



Hybrid characteristics

Type B

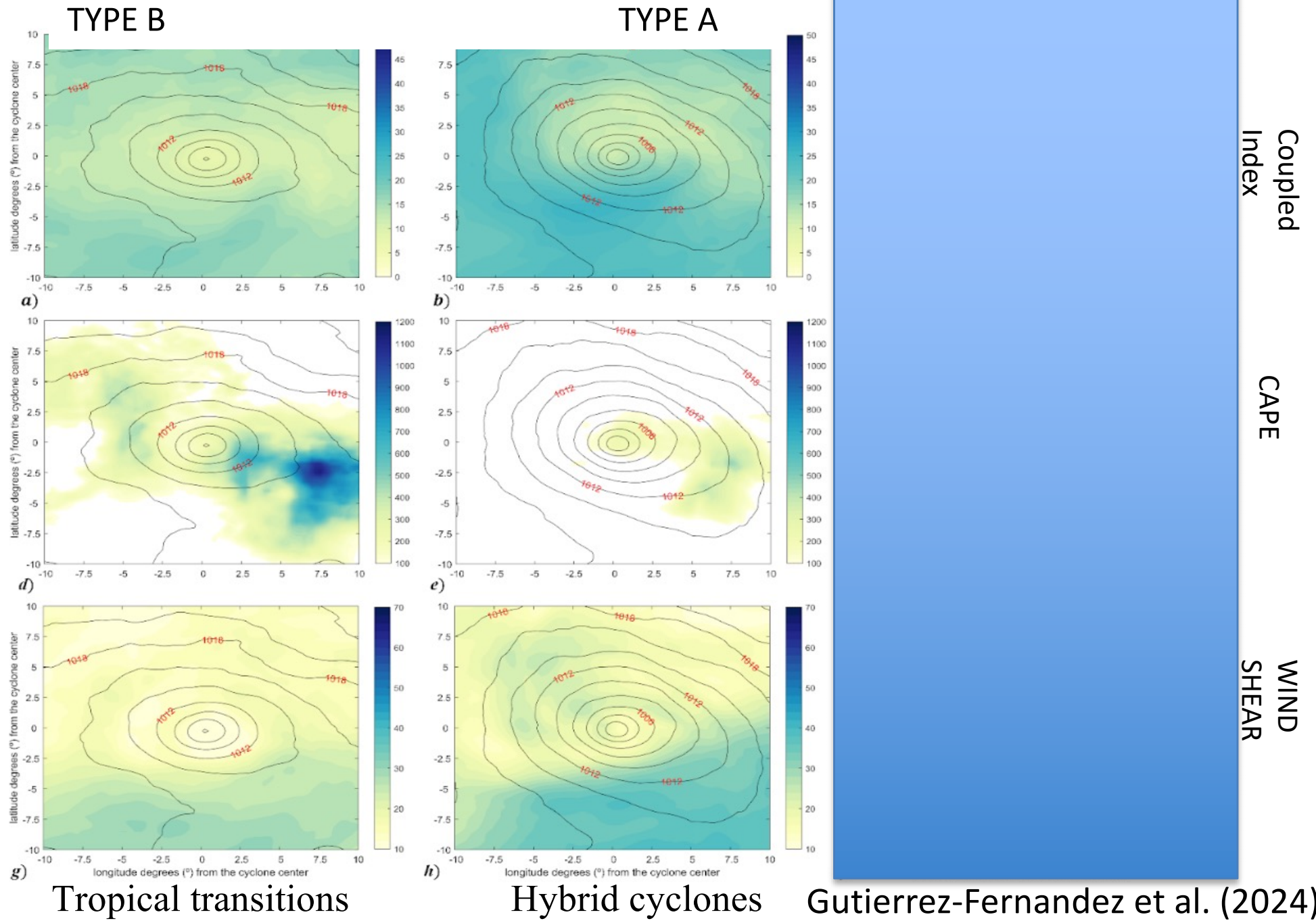
Deep warm core cyclones mostly driven by strong diabatic processes and weak baroclinic instability



Characteristics similar to TC for short periods

Miglietta and Rotunno (2019); Dafis et al. (2020)

COMPOSITE AT MATURE STAGE BASED ON SCALE CONTRACTION



C. ABSENCE OF AN OFFICIAL DEFINITION OF «MEDICANE»

Different Criteria to address medicanes as weather systems of tropical characteristics:

i. Phenomenological: empirical, rather arbitrary definition

ii. Structural: based on structural characteristics (symmetric, warm core) and arbitrary thresholds applied to atmospheric variables of model outputs

iii. Development mechanism: focusing only on key mechanism of intensification

Leading to:

- Confusion within the scientific community (different criteria to physically define medicanes in model and observation datasets).
- Confusion among weather services for the purposes of issuing warnings of imminent high-impact weather.

i. Phenomenological criteria



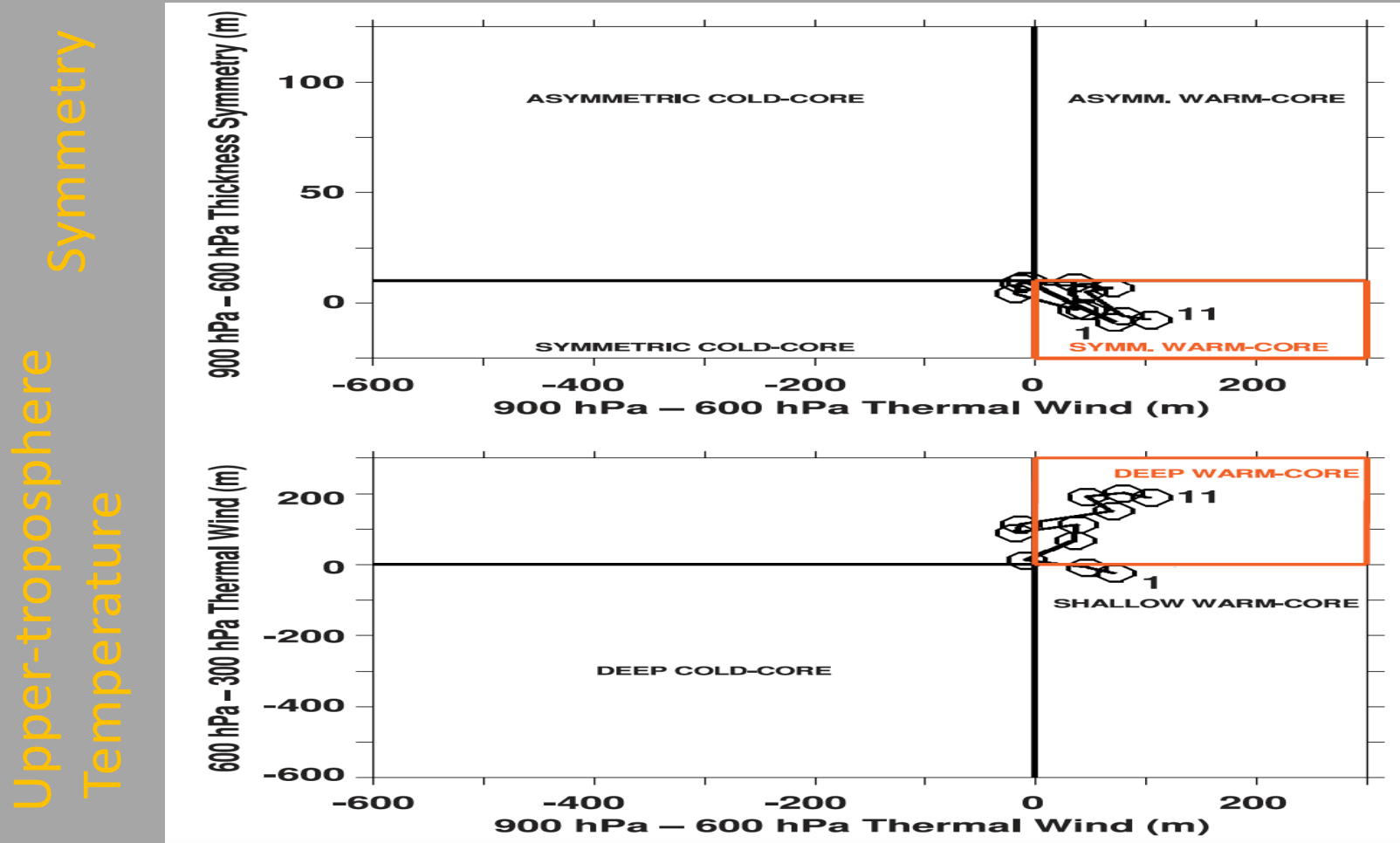
Figure 2. Large and highly symmetric baroclinic cyclone on 11 April 2005 at 2330 UTC (IR image of Meteosat).

ii. Structural criteria

Discriminate symmetric, deep warm core cyclones.

Do not discriminate the development mechanism.

CYCLONE PHASE SPACE (HART) DIAGRAM



Lower-troposphere Temperature

Gaertner et al. (2007)

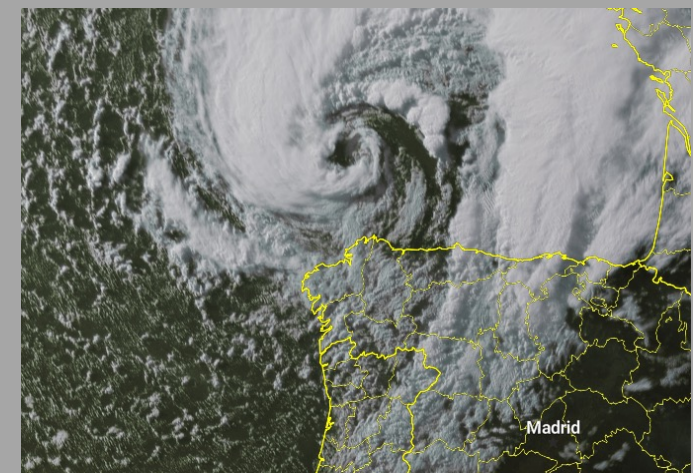
iii. Development mechanism

Can we define some **tools** to distinguish in the Mediterranean in near real-time:

- tropical transitions (type A),
- warm seclusions (type B)
- Subtropical cyclones (type B)
- Winter cyclones (“polar lows” type)?



Ianos medicane (2020)

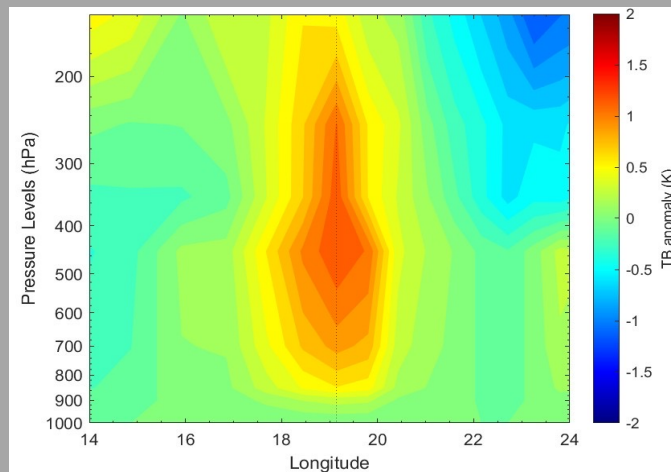


warm seclusion (2018)

Phenomenological/structural definition of medicane

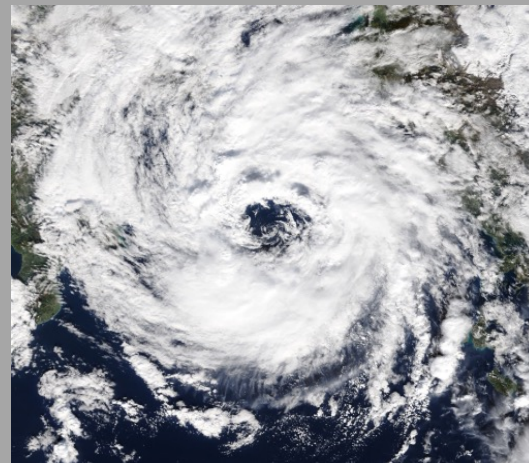
A medicane is a mesoscale cyclone that develops over the Mediterranean Sea and displays tropical-like cyclone characteristics:

A warm core extending into the upper troposphere



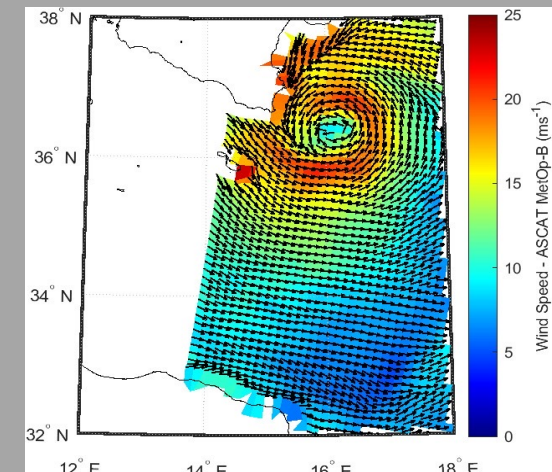
MW vertical cross-section of Brightness Temperature anomaly for medicane Zorbas, 29 Oct. 2018.

An eye-like feature in its center with spiral cloud bands around



Medicane "Numa" MODIS Terra VIS image, 18 Nov. 2017

An almost windless center surrounded by nearly-symmetric sea-surface wind circulation with maximum wind speed within a few tens of km from the center



Medicane "Apollo" ASCAT wind field 29 Oct. 2021

Miglietta et al. (2025)

<https://glossary.ametsoc.org/wiki/medicane/>

ADVANTAGES OF THE DEFINITION

- Based on Earth observations
- Simple enough to aid weather services in identification and communication
- Consistent with previous studies either using phenomenological or structural criteria
- Recognizes the existence of a deep warm-core induced by different mechanisms, following the indications from early studies that air-sea interaction is not expected to contribute exclusively to the development of a medicane

Miglietta M. M., Flaounas E., González-Alemán J. J., Panegrossi G., Gaertner M. A., Pantillon F., Pasquero C., Schultz D. M., D'Adderio L. P., Dafis S., Husson R., Ricchi A., Carrió D. S., Davolio S., Fita L., Picornell M. A., Pytharoulis I., Raveh-Rubin S., Scoccimarro E., Bernini L., Cavicchia L., Conte D., Ferretti R., Flocas H., Gutiérrez-Fernández J., Hatzaki M., Homar Santaner V., Jansà A., Patlakas P., Defining Medicanes: Bridging the Knowledge Gap Between Tropical and Extratropical Cyclones in the Mediterranean, BAMS, 106, E1955–E1971, <https://doi.org/10.1175/BAMS-D-24-0289.1>

OUTLINE

1. INTRODUCTION

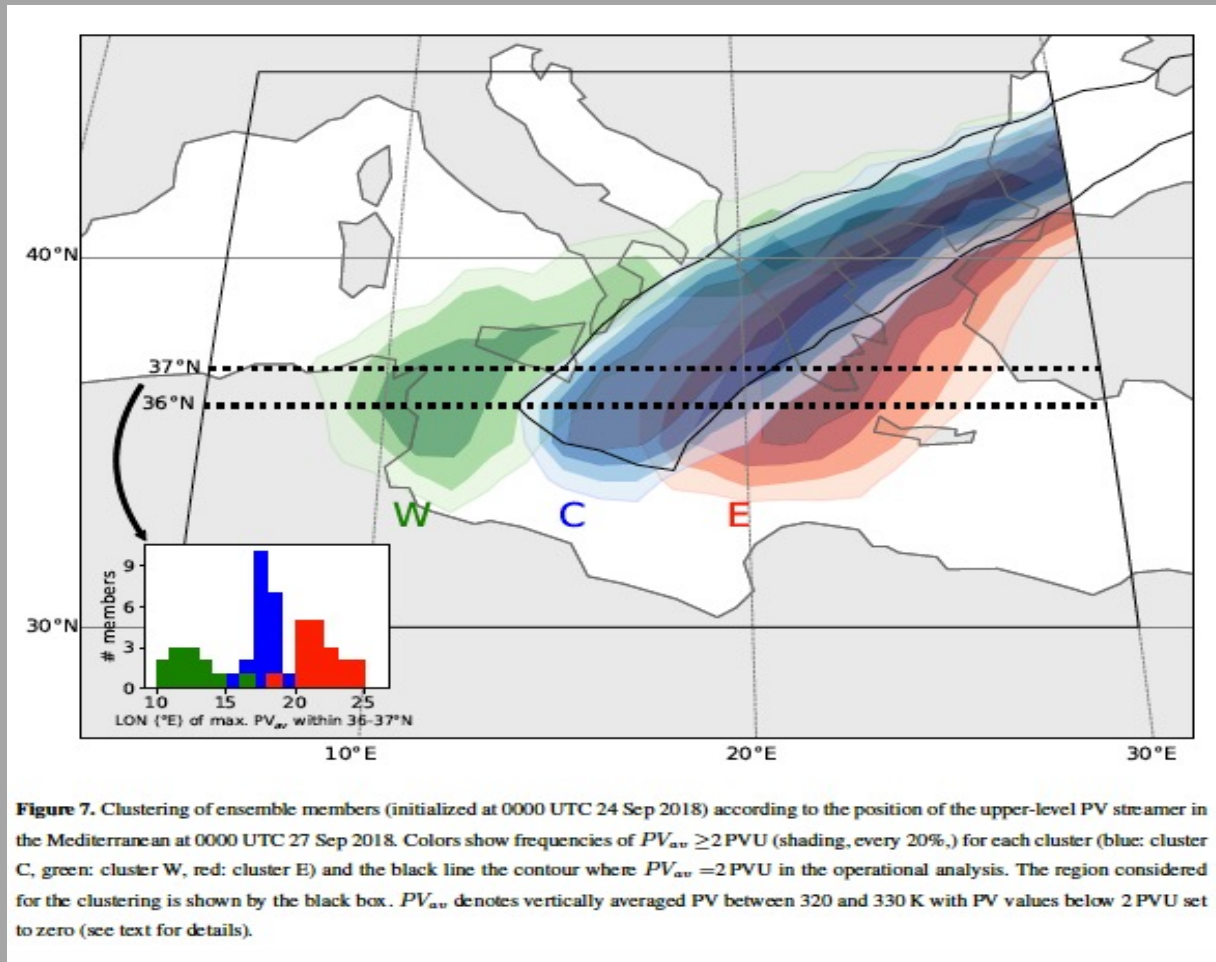
2. DYNAMICAL FEATURES

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PREDICTABILITY

How an uncertain short-wave perturbation on the North Atlantic wave guide affects the forecast of an intense Mediterranean cyclone (Medicane Zorbas)



Portmann et al. (2020)

Role of Upper-Level Dynamics: The accuracy of medium-range forecasts heavily relies on how well models simulate upstream short-wave disturbances and potential vorticity (PV) anomalies.

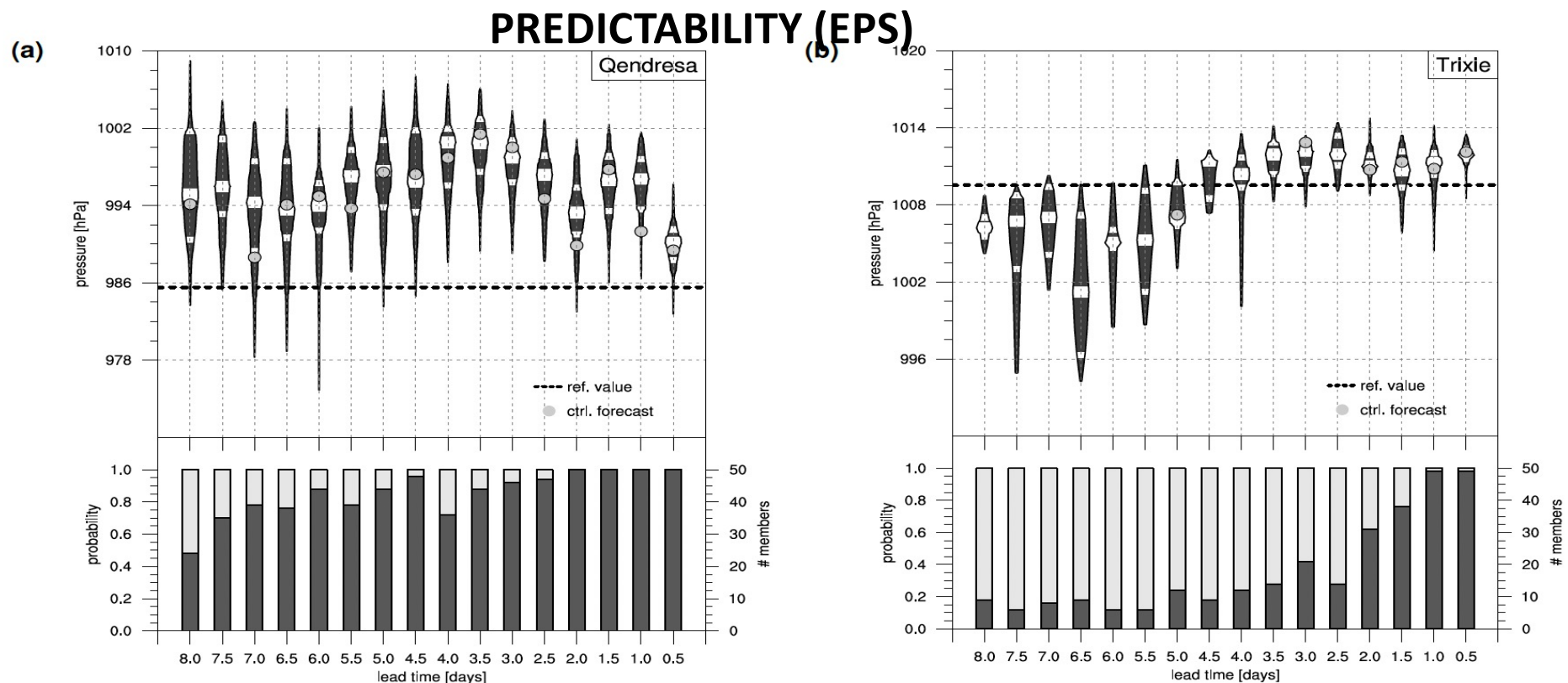
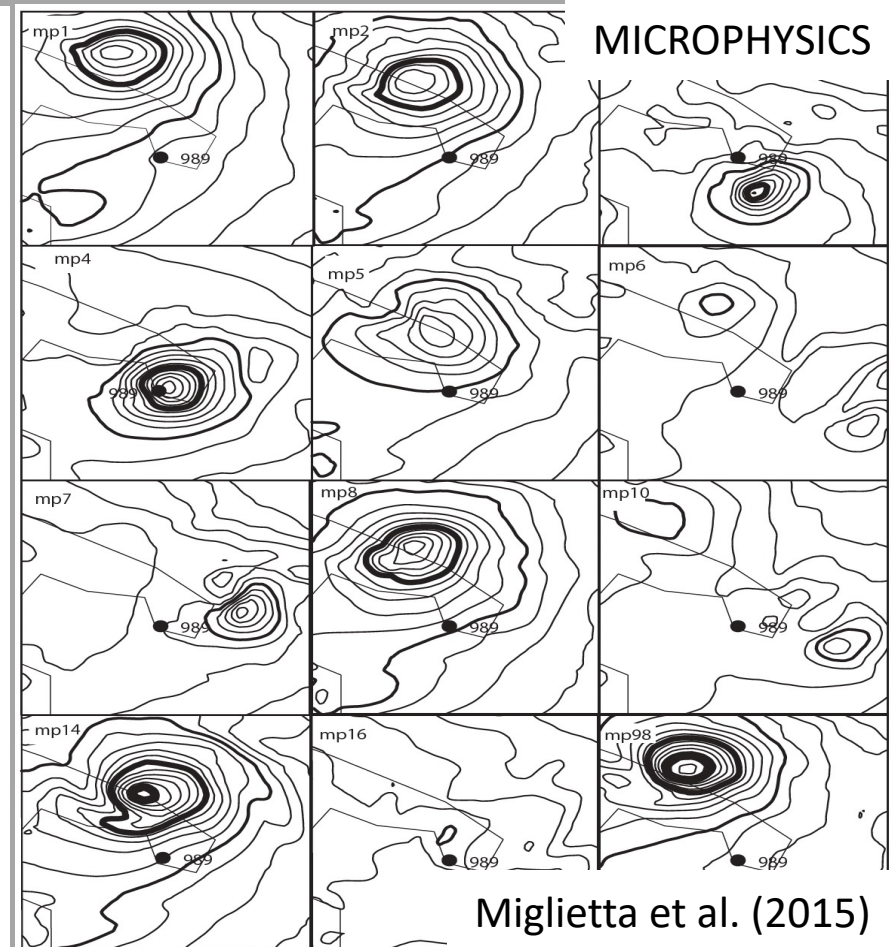
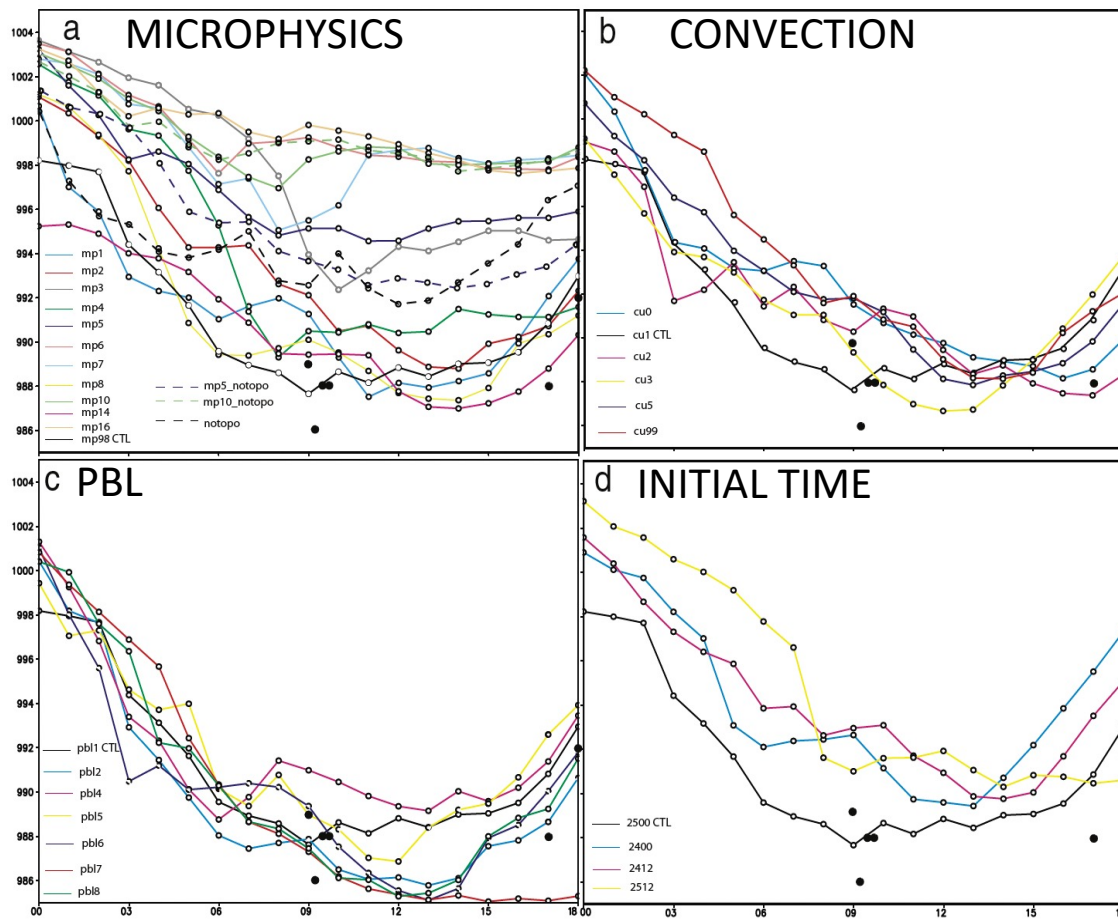


FIGURE 4 Ensemble forecasts of MSLP for storms Qendresa (left) and Trixie (right). Upper panels: box-percentile plots, with white stripes marking the 25th, 50th (median) and 75th percentiles; the yellow circle shows the control forecast value (provided it has the cyclone); the dashed line is the operational analysis value. Lower panels: number of members having the cyclone (no cyclone) are represented by blue (gray) bars. Di Muzio et al. (2019)

- **Predictability Horizon:** generally 5 - 7 days.
- **Predictability Barrier:** Non-gradual *jump* rather than a progressive convergence as lead times shorten.
- **Initial Conditions Sensitivity:** Forecasts initialized *after* the cyclone has formed are more accurate than earlier forecasts (initialized before cyclogenesis)

SENSITIVITY TO PARAMETERIZATIONS (WRF)



Microphysics: largest impact on structure, intensity, and warm-core evolution. Almost all tested schemes successfully captured the tropical transition.

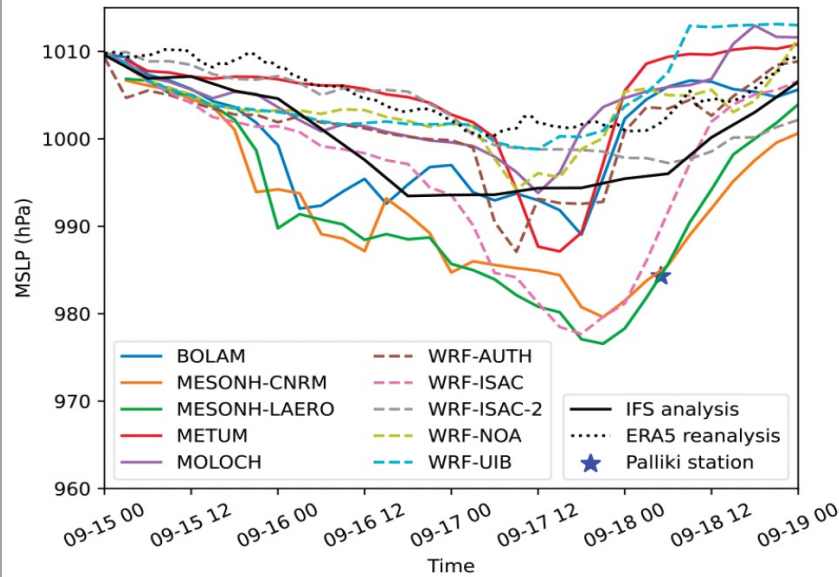
Cumulus Parameterization: secondary, but still important, role (spacing: 7.5 km)

Time-lagged ensemble: spread in the cyclone depth and track smaller/comparable with that from microphysics.

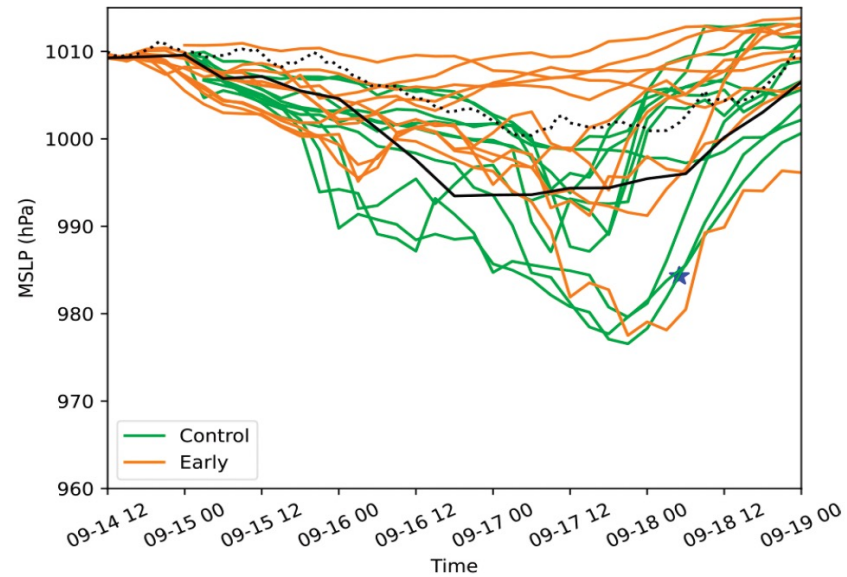
Qendresa: intensity mainly influenced by PBL/surface layer: results are case dependent (Pytharoulis et al., 2018).

SENSITIVITY TO MODEL, INITIAL CONDITION, RESOLUTION

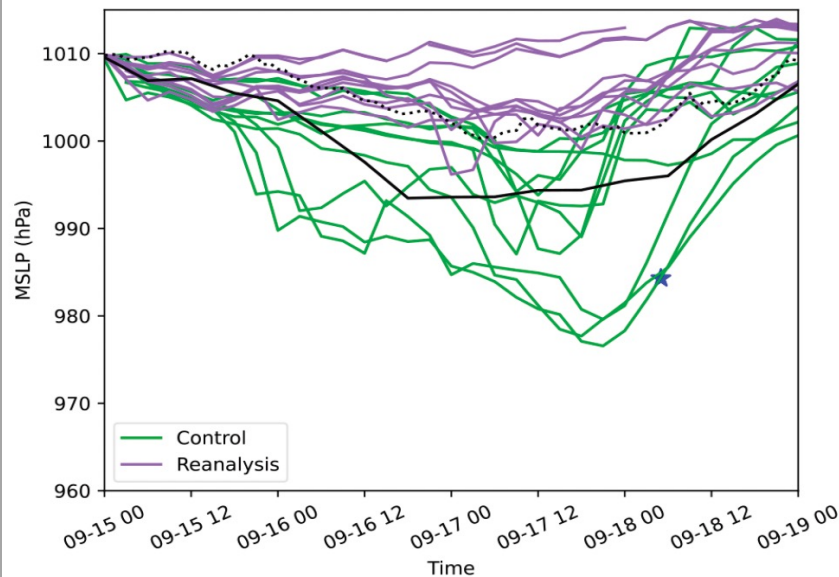
(a) Control runs



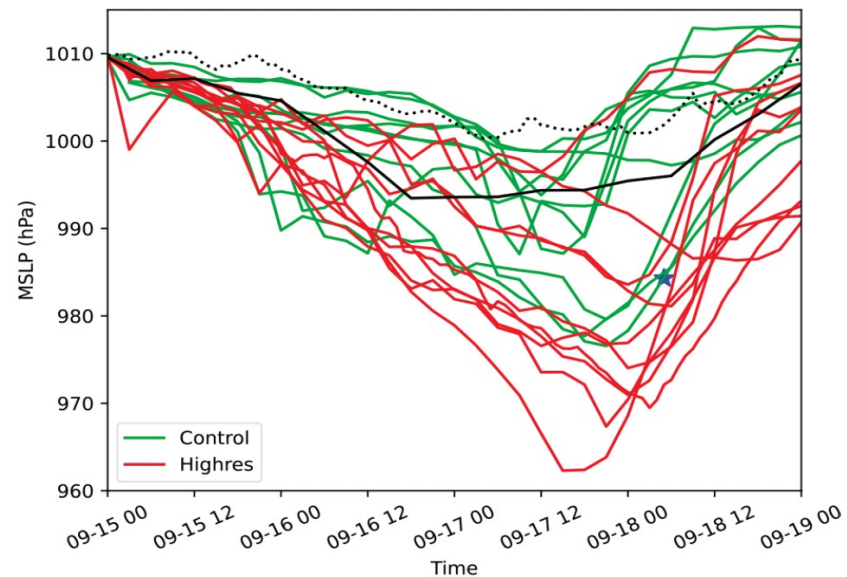
(b) Sensitivity to initial time



(c) Sensitivity to initial data



(d) Sensitivity to horizontal resolution



Key results: accurately representing deep convection at high resolutions is vital for correctly forecasting the track/intensity of lanos

Pantillon et al. (2024)

COUPLING WITH CHEMISTRY-MODELS (OFFLINE)

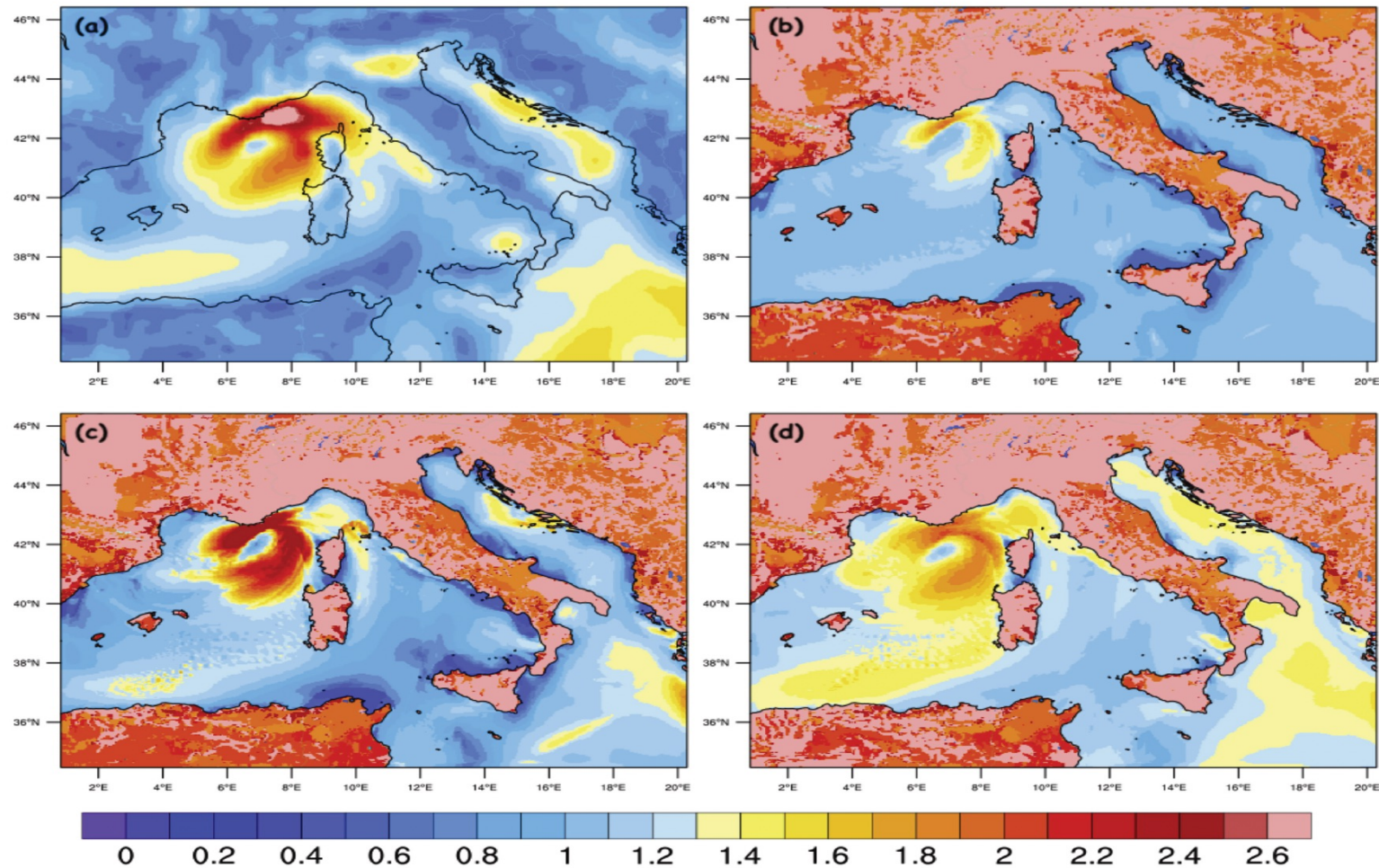
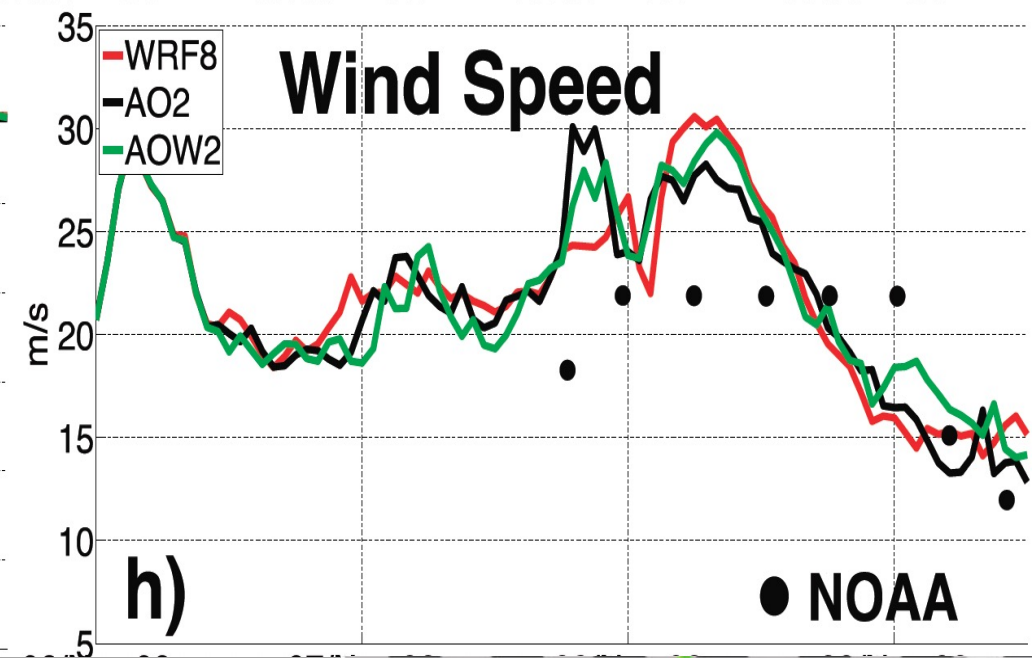
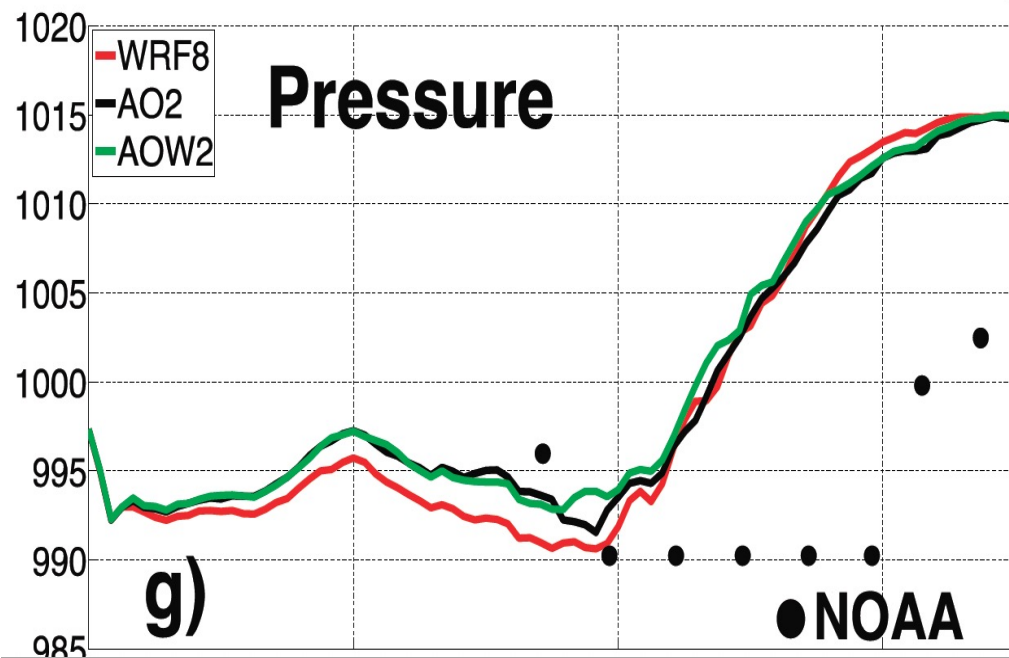


Fig. 15. Drag coefficient for momentum ($10^{-3} C_D$) on November 08, 2011 at 1800 UTC, from (a) ERA5 reanalysis; (b) CNTL run; (c) L12 run; (d) K12 run.

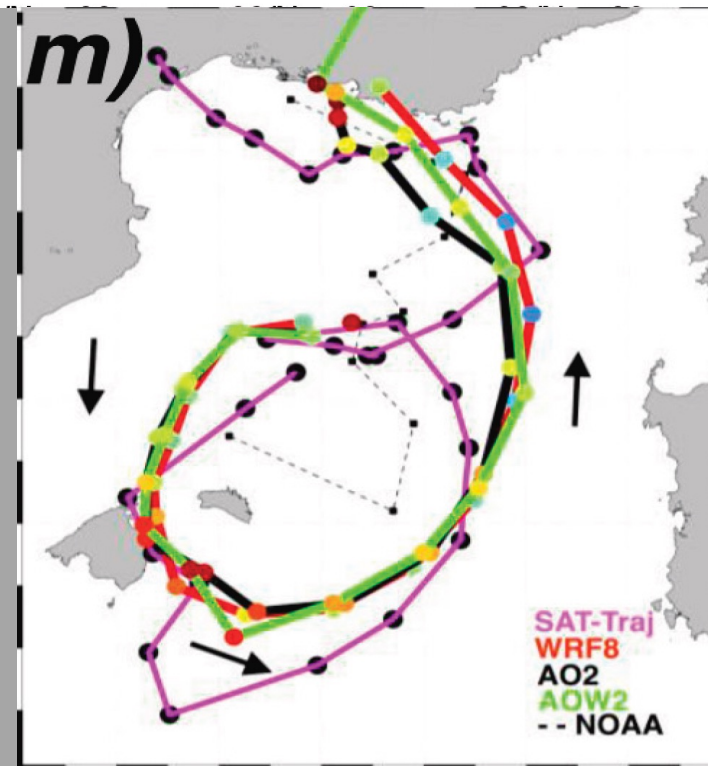
Wave peak frequency passed from WWIII to WRF-Chem (with GOCART aerosol package) allows to calculate *wave-age* (altering *sea surface roughness* and *aerodynamic drag*) and *sea spray source functions* (modifying *surface heat/moisture fluxes* under high wind conditions), which are critical for accurately calculating *air-sea momentum/heat fluxes* during medicanes. Two surface roughness parameterizations (L12 and K12) are tested.

Rizza et al. (2021) (see also Pravia-Sarabia et al., 2021)

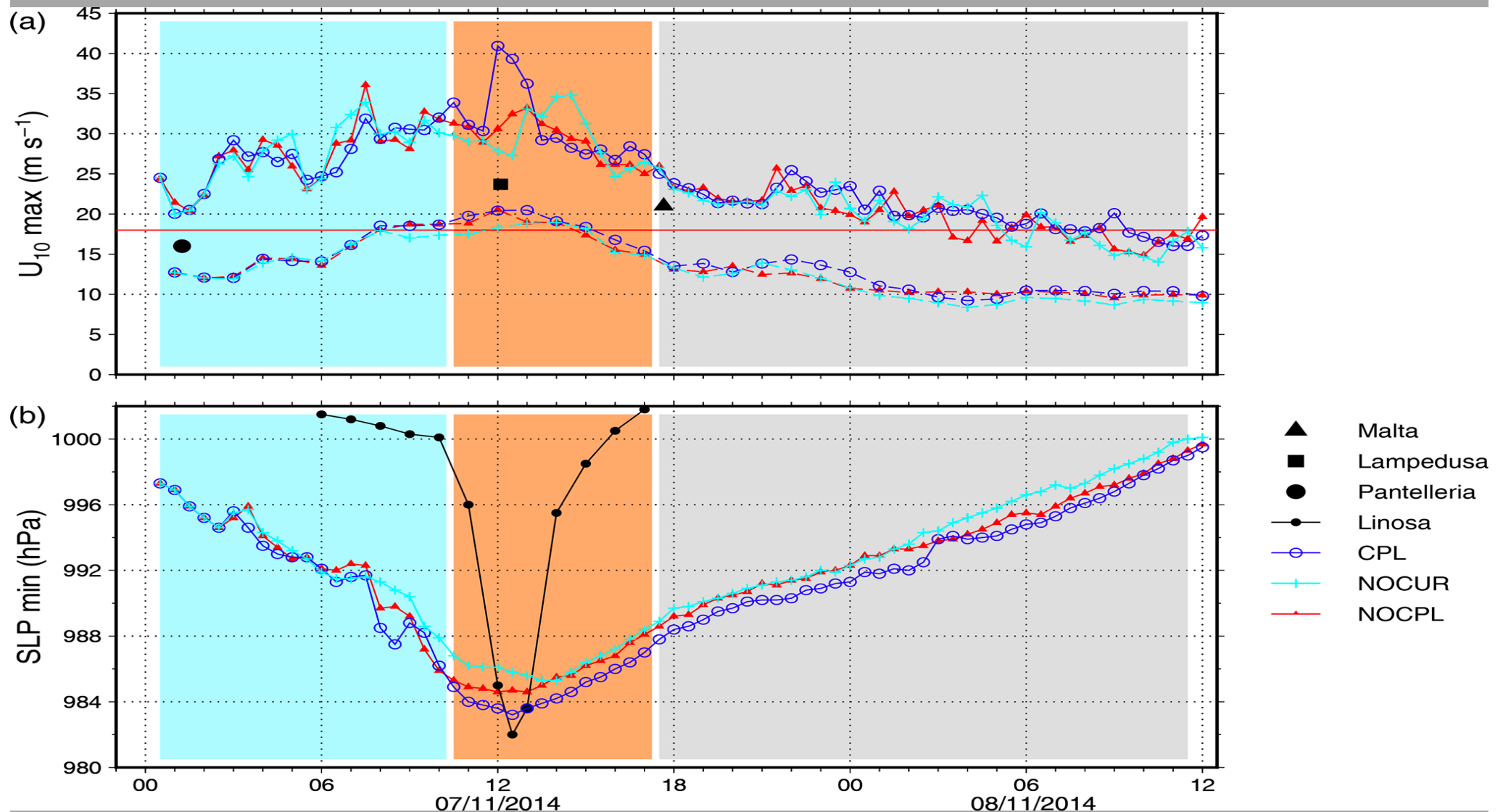
COUPLING WITH OCEAN AND WAVE MODELS (WRF+ROMS+SWAN; 5 km spacing).



ROLF: coupled modeling approaches do not significantly change the track or intensity compared to a standalone atmospheric run (Ricchi et al., 2017).

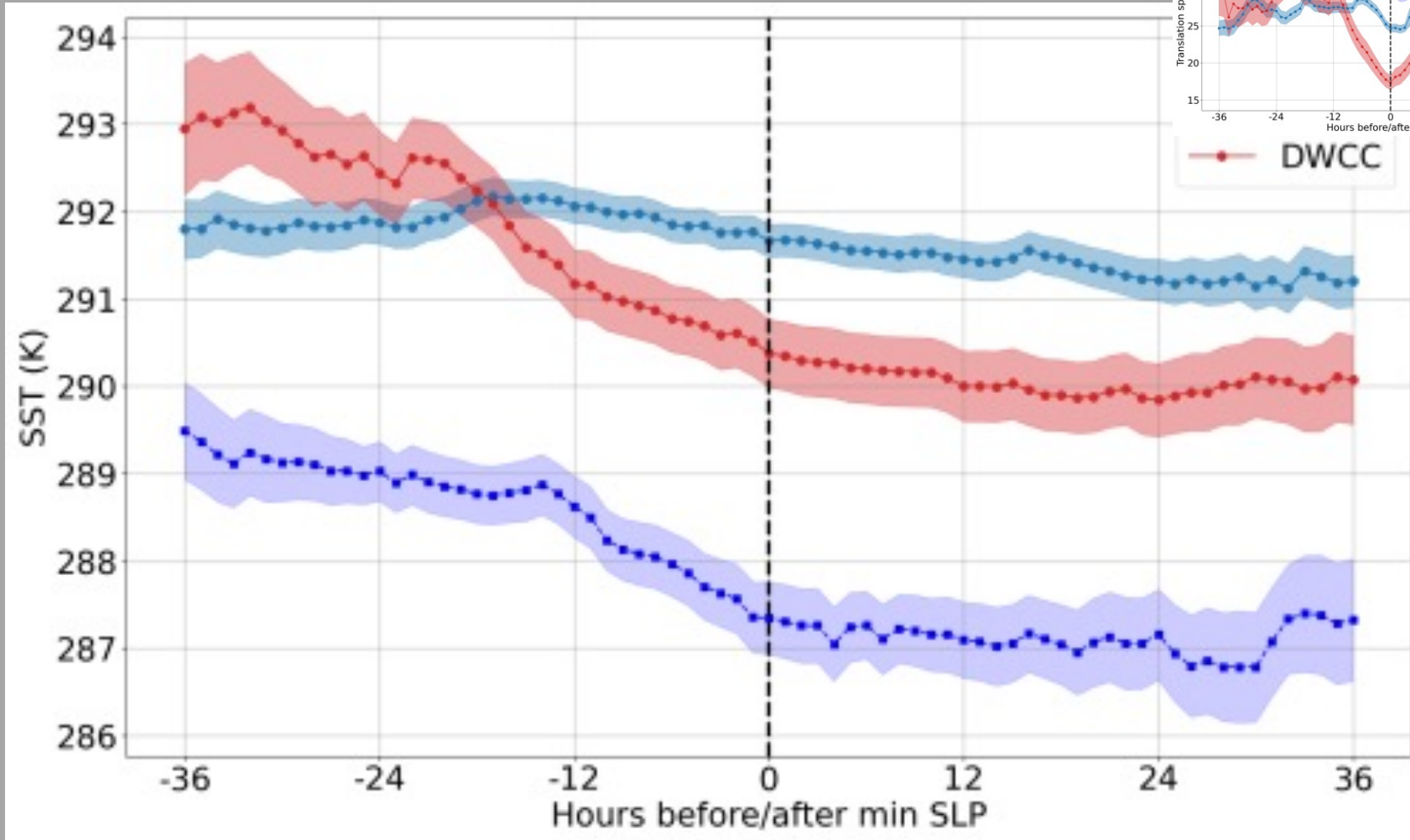


COUPLING WITH OCEAN MODELS (MESO-NH+NEMO; 1.33 km spacing)



QENDRESA: the impact of coupling is very weak, due to a cold wake (for medicanes mostly due to *heat extraction by surface fluxes*) much weaker than for TC (mostly due to *turbulent mixing* of the subsurface ocean layer), despite comparable wind speed...

SST COOLING IN ERA-5 REANALYSIS

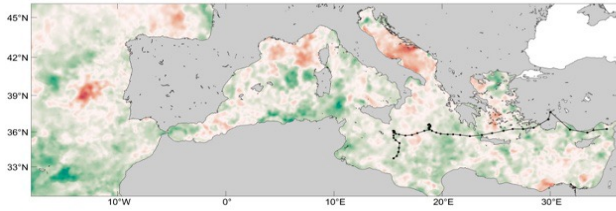


... BUT Qendresa is a fast-moving cyclone.

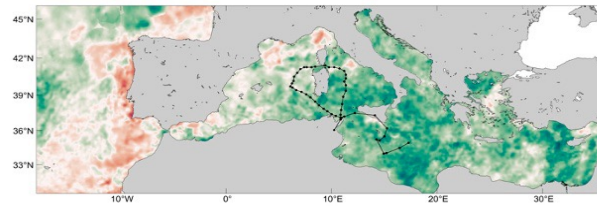
In a climatological study, Bernini et al. (2026) found that *slow translation speeds* may cause a colder SST anomaly (the cyclone spends more time over cool water). The composite SST reduction of 3K is strong, compared to TC, and can be related to the *shallow MLD* in the Mediterranean (typically 15-30 m in October).

SST COOLING IN OBSERVATIONS (FROM -5 to +5 days)

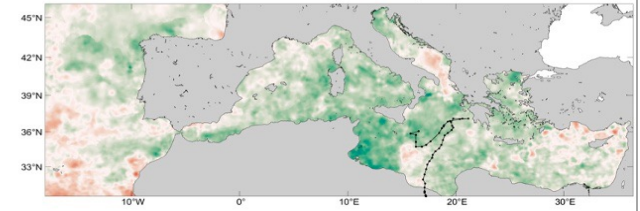
Leucosia (1982)



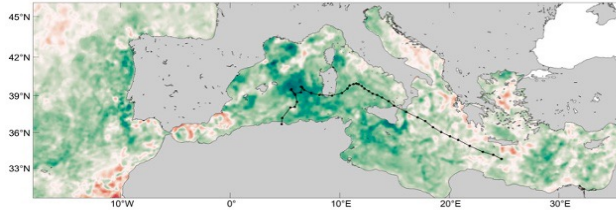
Callisto (1983)



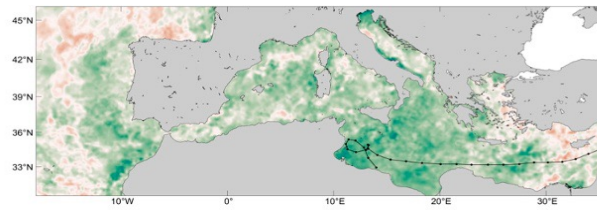
Celeno (1995)



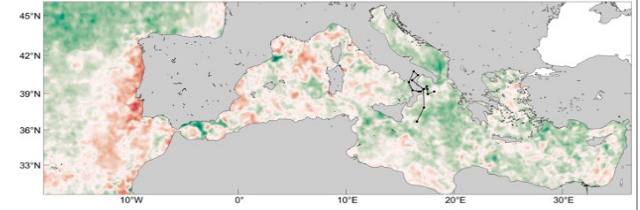
Cornelia (1996)



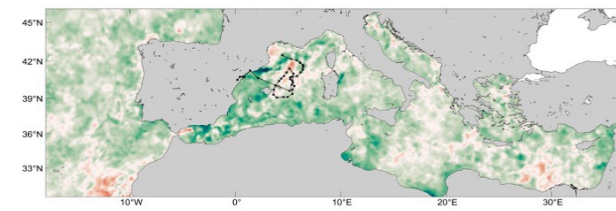
Zeo (2005)



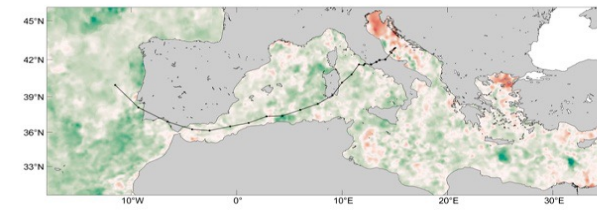
Querida (2006)



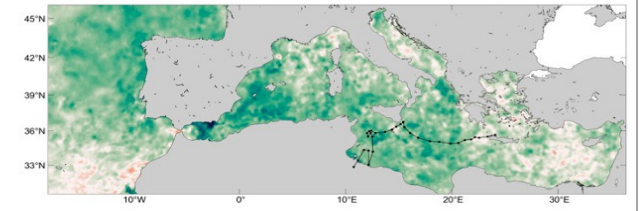
Rolf (2011)



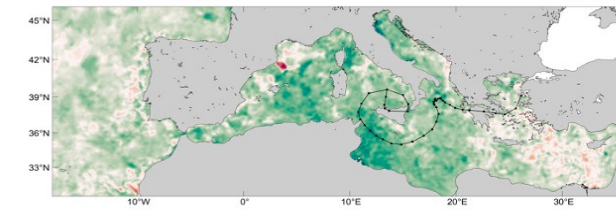
Ilona (2014)



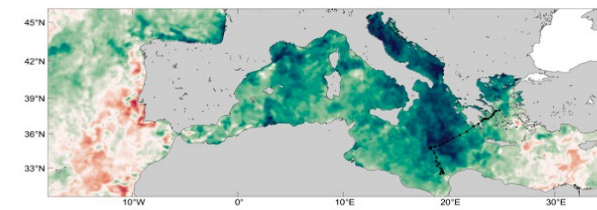
Qendresa (2014)



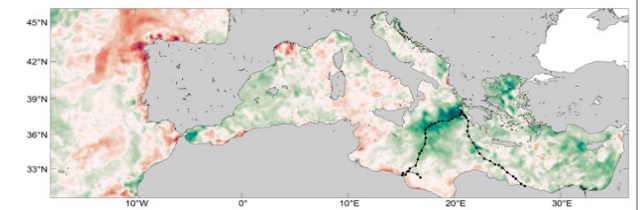
Numa (2017)



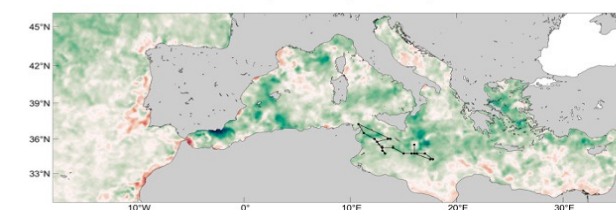
Zorbas (2018)



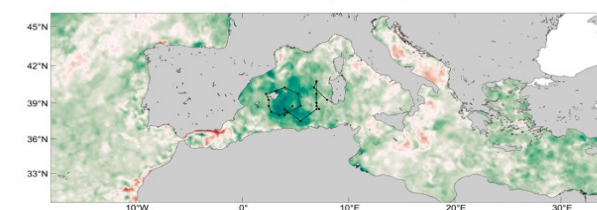
Ianos (2020)



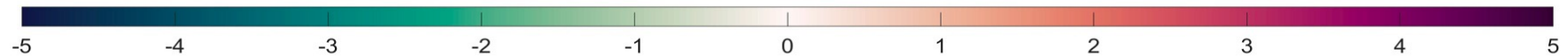
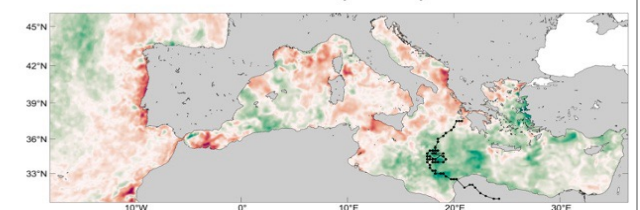
Apollo (2021)



Blas (2021)

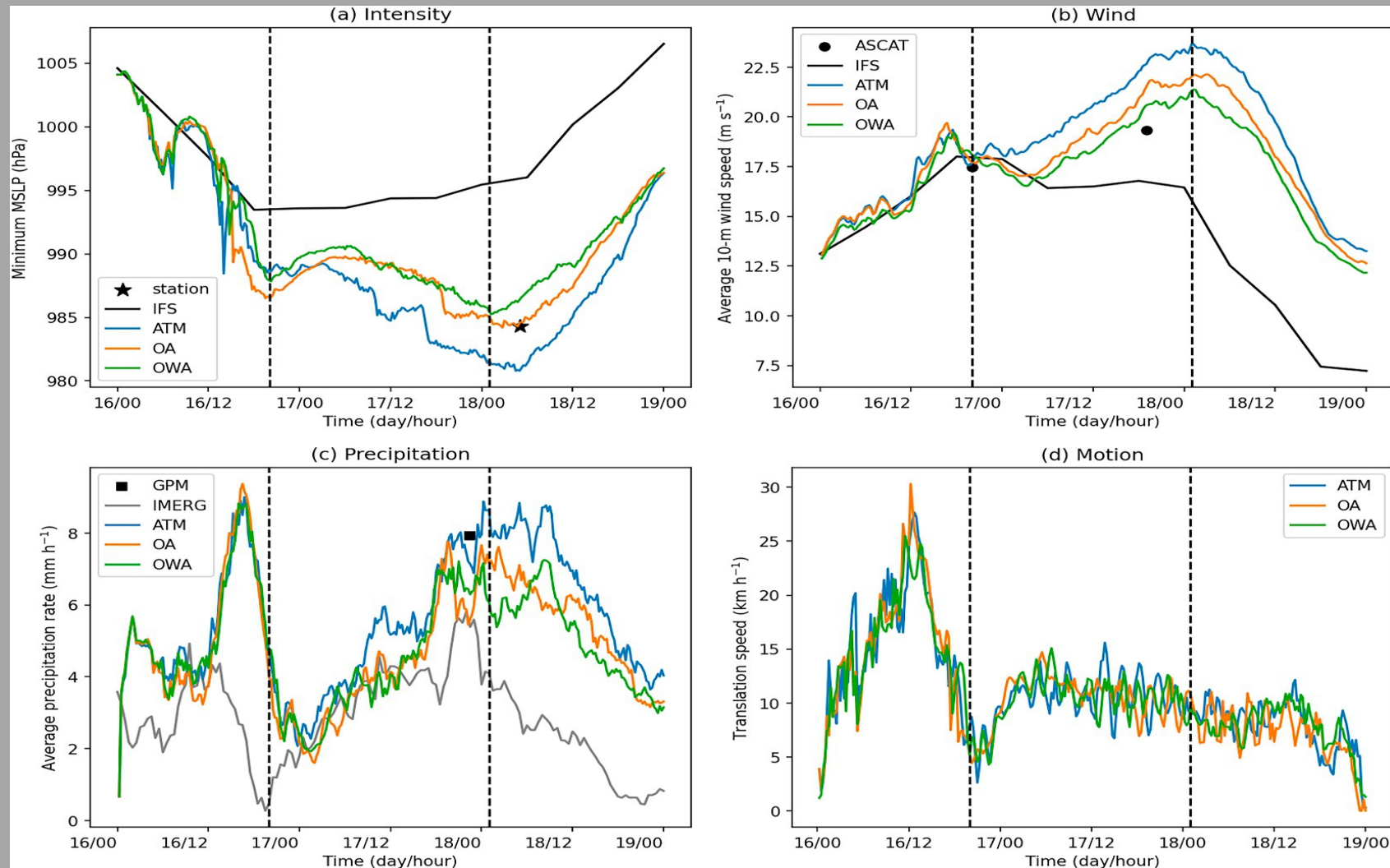


Daniel (2023)



Change (from -0.3°C to -3.1°C) depending on the case (Avolio et al., 2024)

COUPLING WITH OCEAN AND WAVE MODELS MESONH-CROCO-WWIII; 1.8 km spacing)



IANOS: Realistic numerical simulations require a convection-permitting and fully coupled modeling system, which capture well the evolution of the SST and of OML. The cold wake locally exceeds 3°C and is not driven by surface fluxes but rather by turbulent mixing at the base of OML—as in TC of category 2 or more.

Conclusions and Future steps

- The definition clarifies what is a medicane but does not allow us to discriminate among cyclones with different development mechanisms: can we differentiate them in real time?
- Atmosphere-ocean-wave coupling necessary for intense cases (tropical transitions); atmosphere-chemistry coupling should be better explored (e.g., role of aerosol size and distribution?).
- Systematic studies relative to the predictability of the cyclones as a function of resolution and parameterization (e.g., spectral bin microphysics) are needed.

Acknowledgements

- COST action CA19109 - MEDCYCLONES “European network for Mediterranean cyclones in weather and climate”
- COST action CA22162 - FUTUREMED “A transdisciplinary network to bridge climate science and impacts on society”
- “Earth Observations as a cornerstone to the understanding and prediction of tropical like cyclone risk in the Mediterranean (MEDICANES)”, ESA Contract No. 4000144111/23/I-KE, In response to: ESA CfP/5-50033/23/I-KE

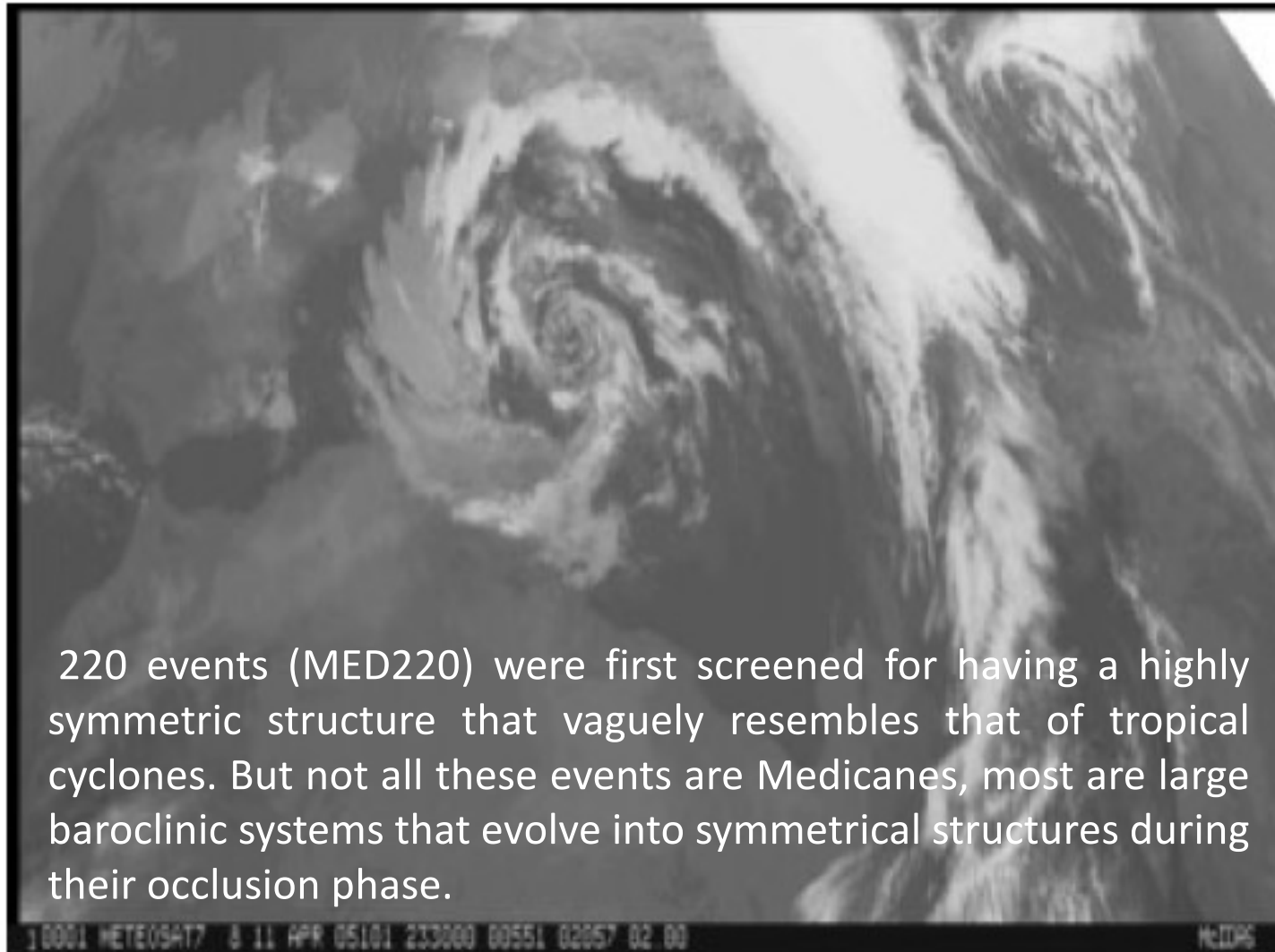
OUTLINE

1. INTRODUCTION

2. DYNAMICAL FEATURES

3. DEFINITION OF «MEDICANE»

4. CLIMATOLOGY AND CLIMATE CHANGE



220 events (MED220) were first screened for having a highly symmetric structure that vaguely resembles that of tropical cyclones. But not all these events are Medicanes, most are large baroclinic systems that evolve into symmetrical structures during their occlusion phase.

Figure 2. Large and highly symmetric baroclinic cyclone on 11 April 2005 at 2330 UTC (IR image of Meteosat).

GEOGRAPHICAL DISTRIBUTION

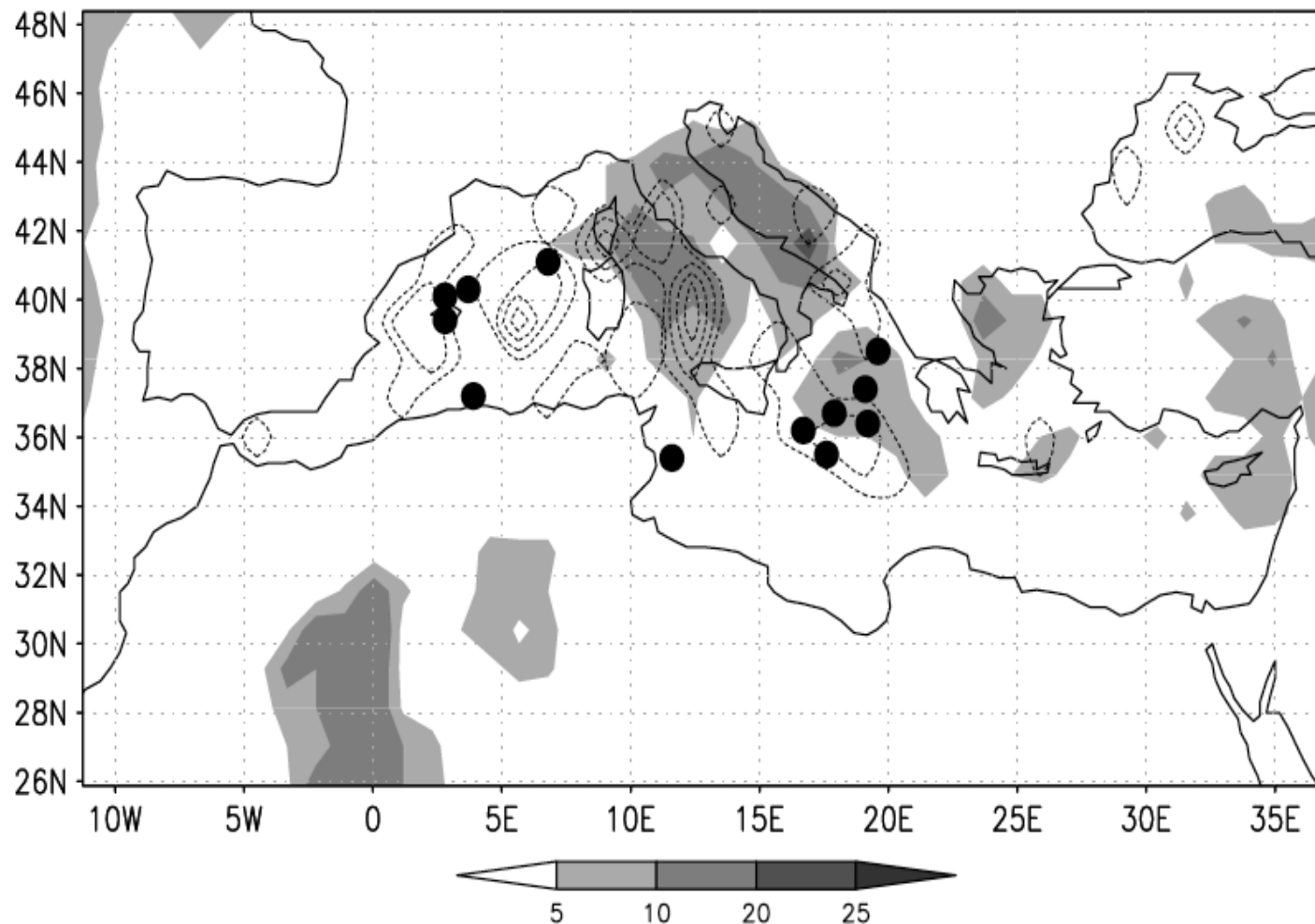
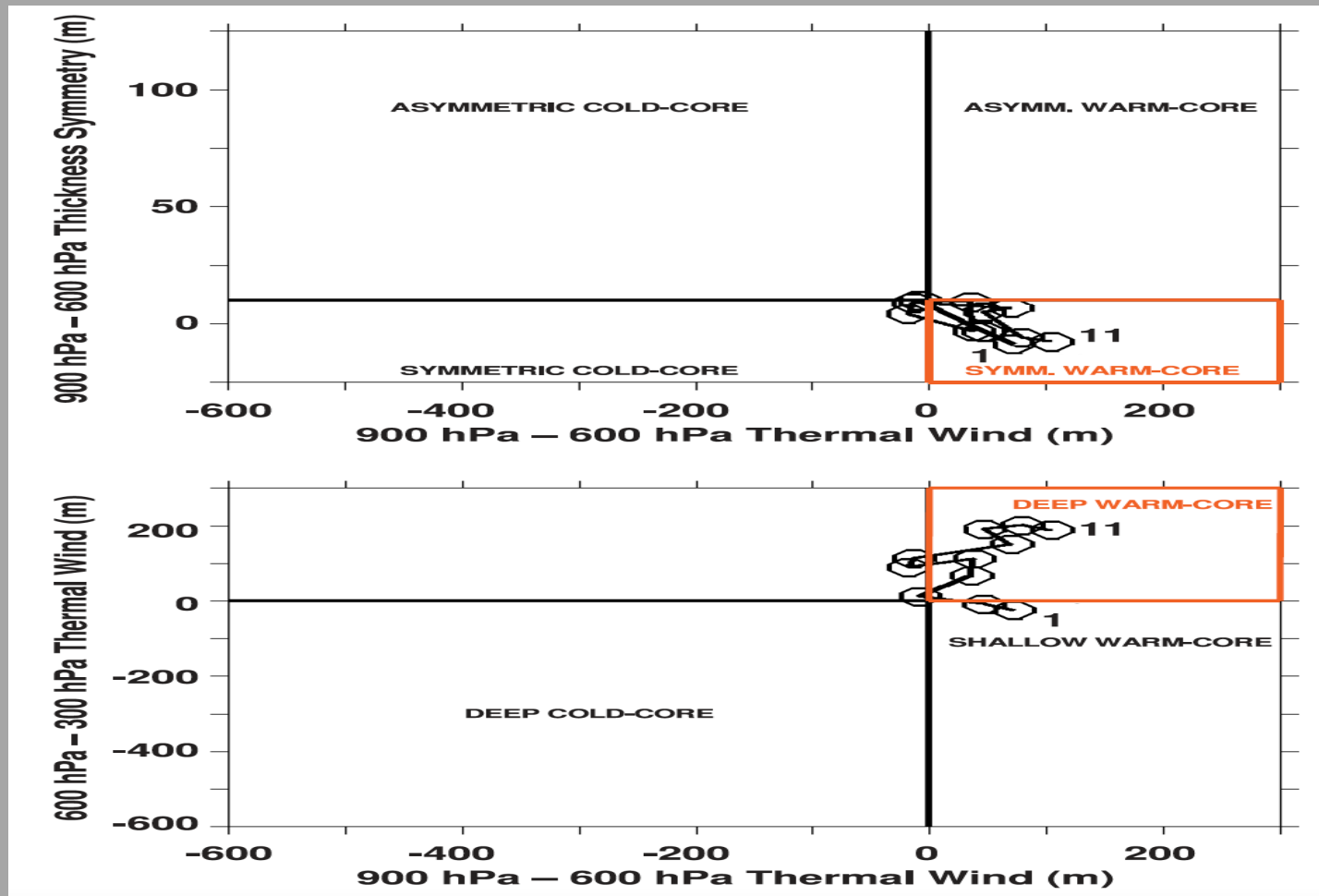


Figure 3. Spatial density distribution of intense cyclones from the MEDEX project (shaded) as number of events in a square of 1.125° lat–lon; density distribution of MED220 cyclones (dashed lines, contour interval is one event/ $(1.125^\circ)^2$ starting at value 1); and the 12 detected medicanes (black points).

How can we discriminate Medicanes from a dynamic perspective?

CYCLONE PHASE SPACE DIAGRAM

Symmetry
Upper-troposphere
Temperature



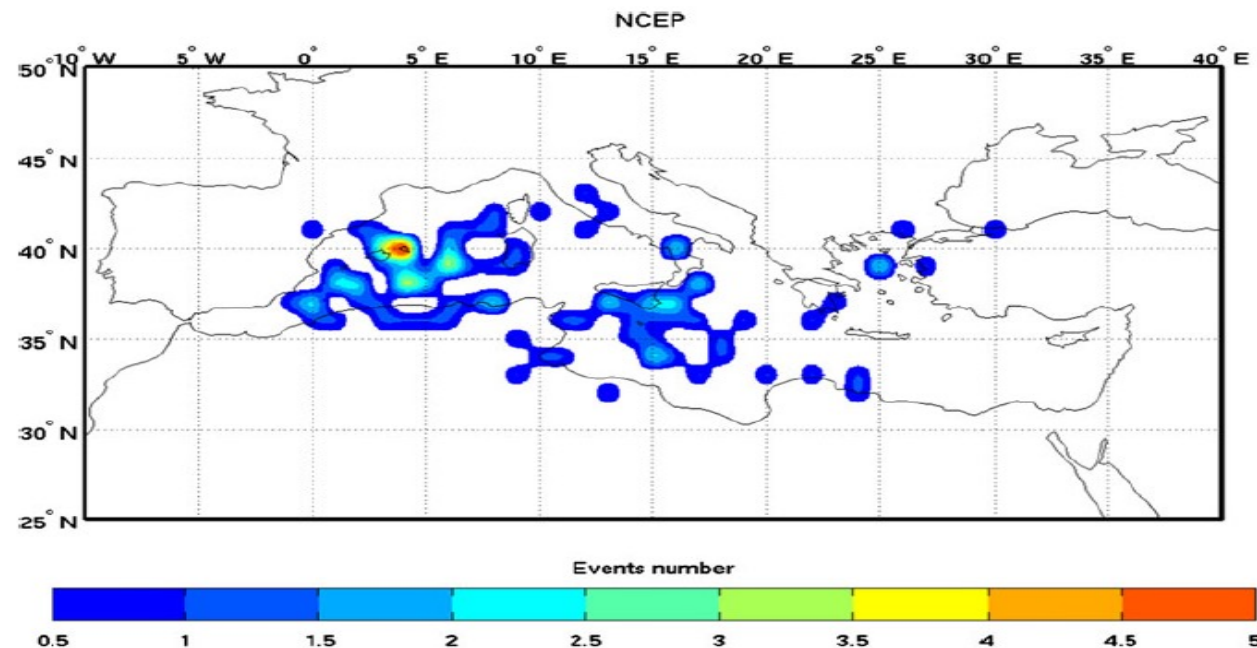
Lower-troposphere Temperature

NOTE: the presence of a warm central core cannot necessarily be due to the release of latent heat due to vapor condensation.

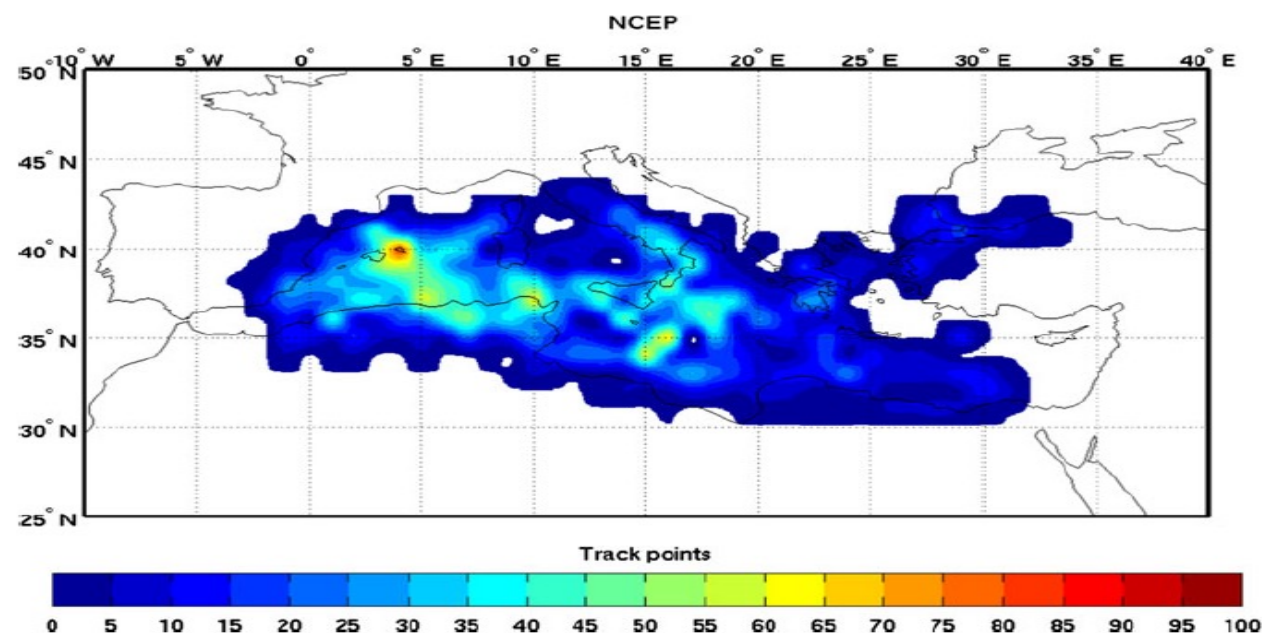
Hart (2003); Gaertner et al. (2007)

Fig. 2 Locations of all the medicanes detected. *Top* genesis density (first location in the track) per $1^\circ \times 1^\circ$ box. *Bottom* track density per $1^\circ \times 1^\circ$ box

Genesis density



Track density



NCEP/NCAR reanalysis
Downscaling by CCLM
10 km resolution
Period: 1948-2011

MONTHLY DISTRIBUTION

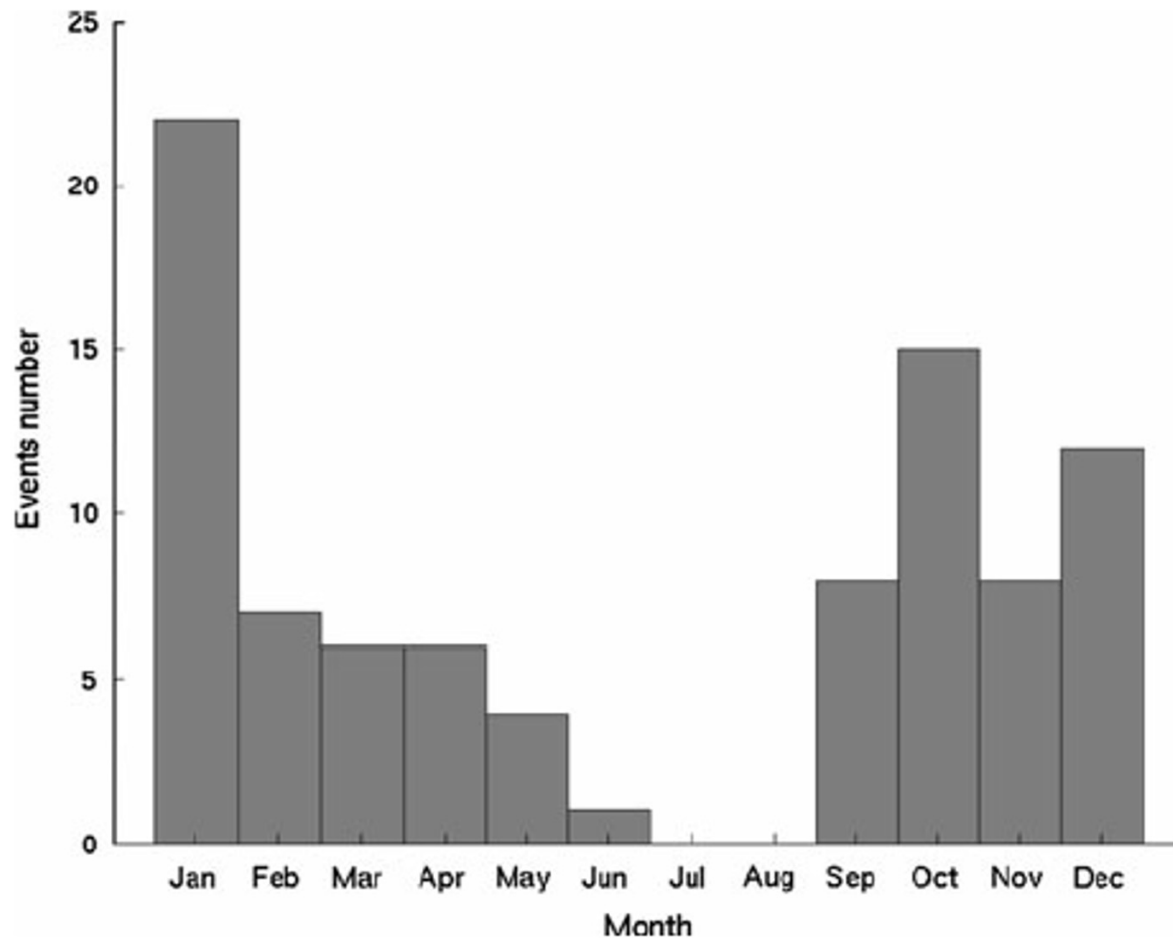


Fig. 3 Number of medicanes per month (total number in the period 1948–2011)

INTERANNUAL VARIABILITY

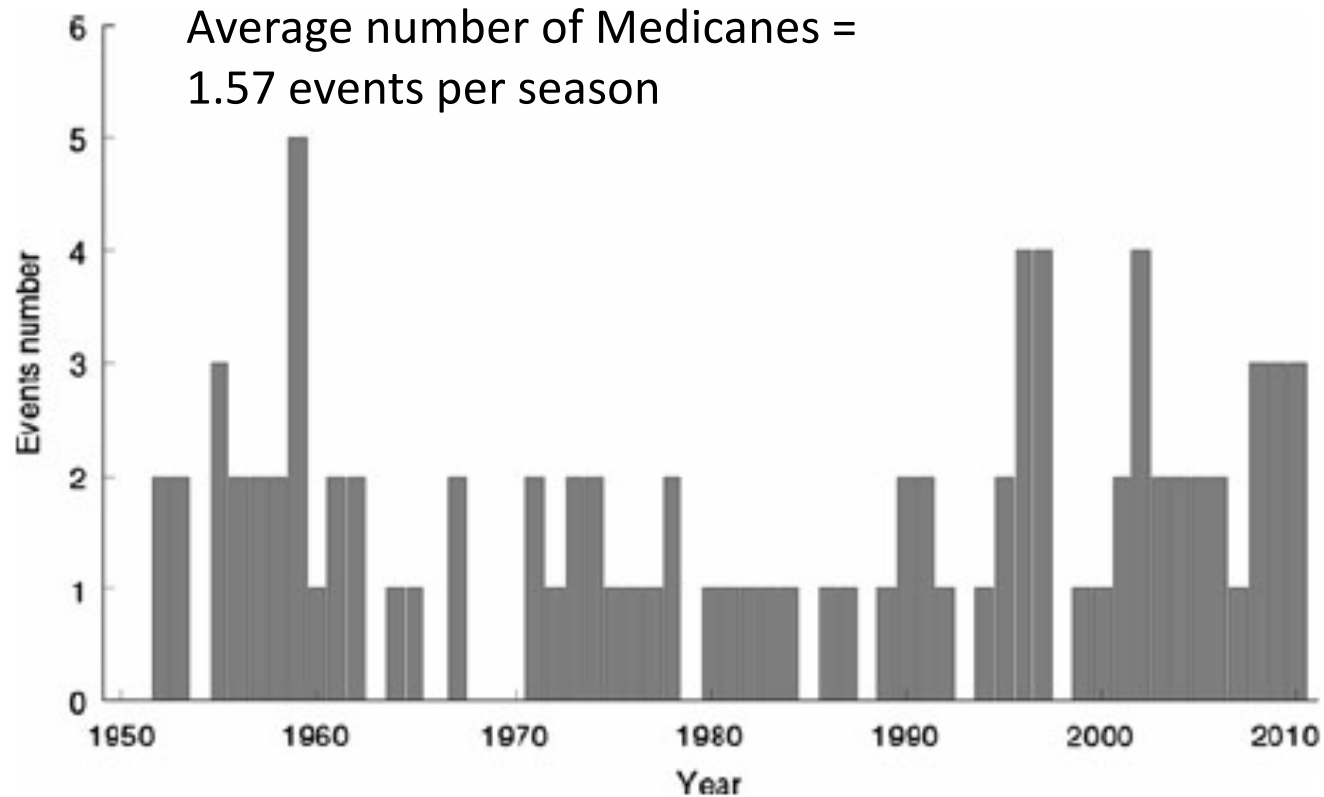
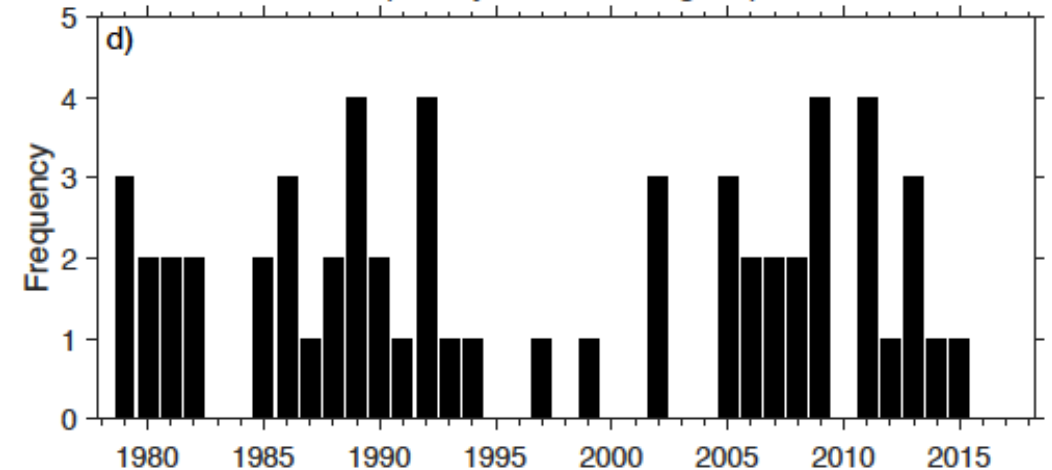
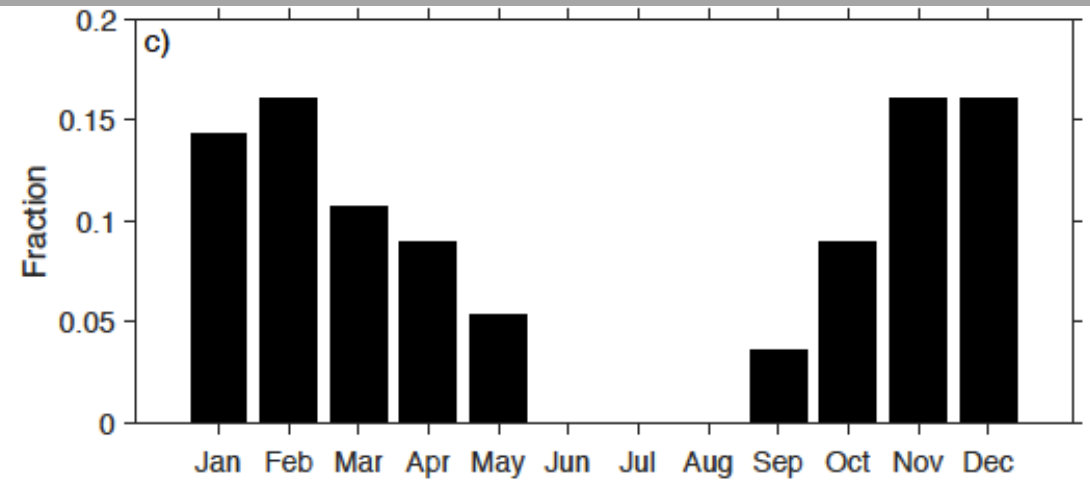
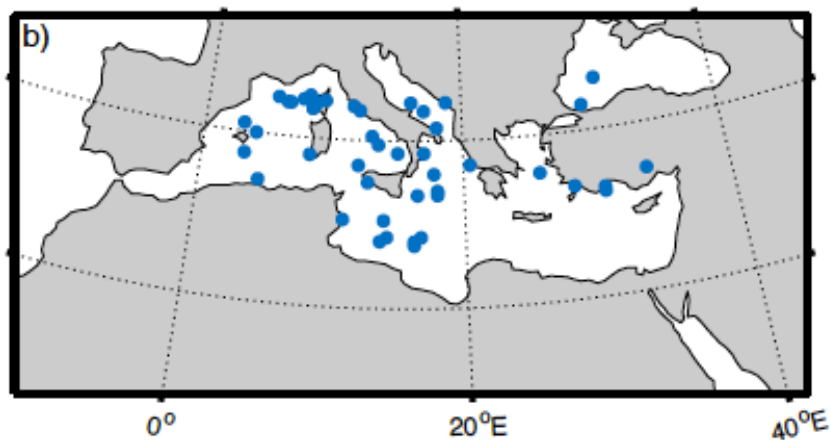
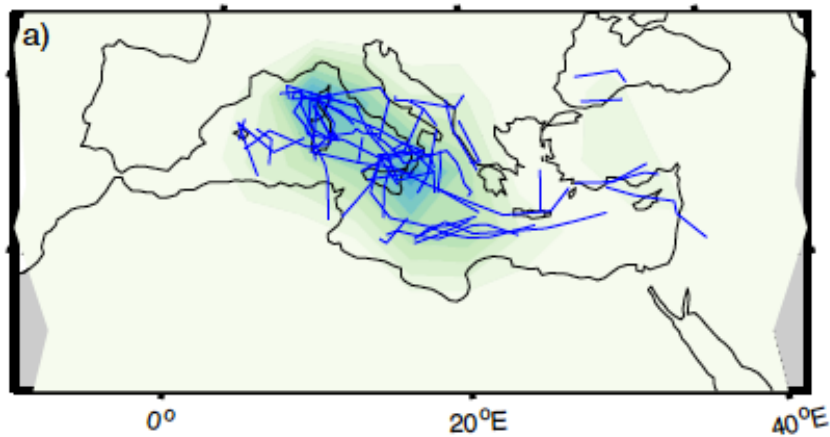


Fig. 4 Number of medicanes per year. Instead of calendar year, “medicane seasons” are reported on the x axis. A medicane season is defined to extend from August every year to July next year

Cavicchia et al. (2013)

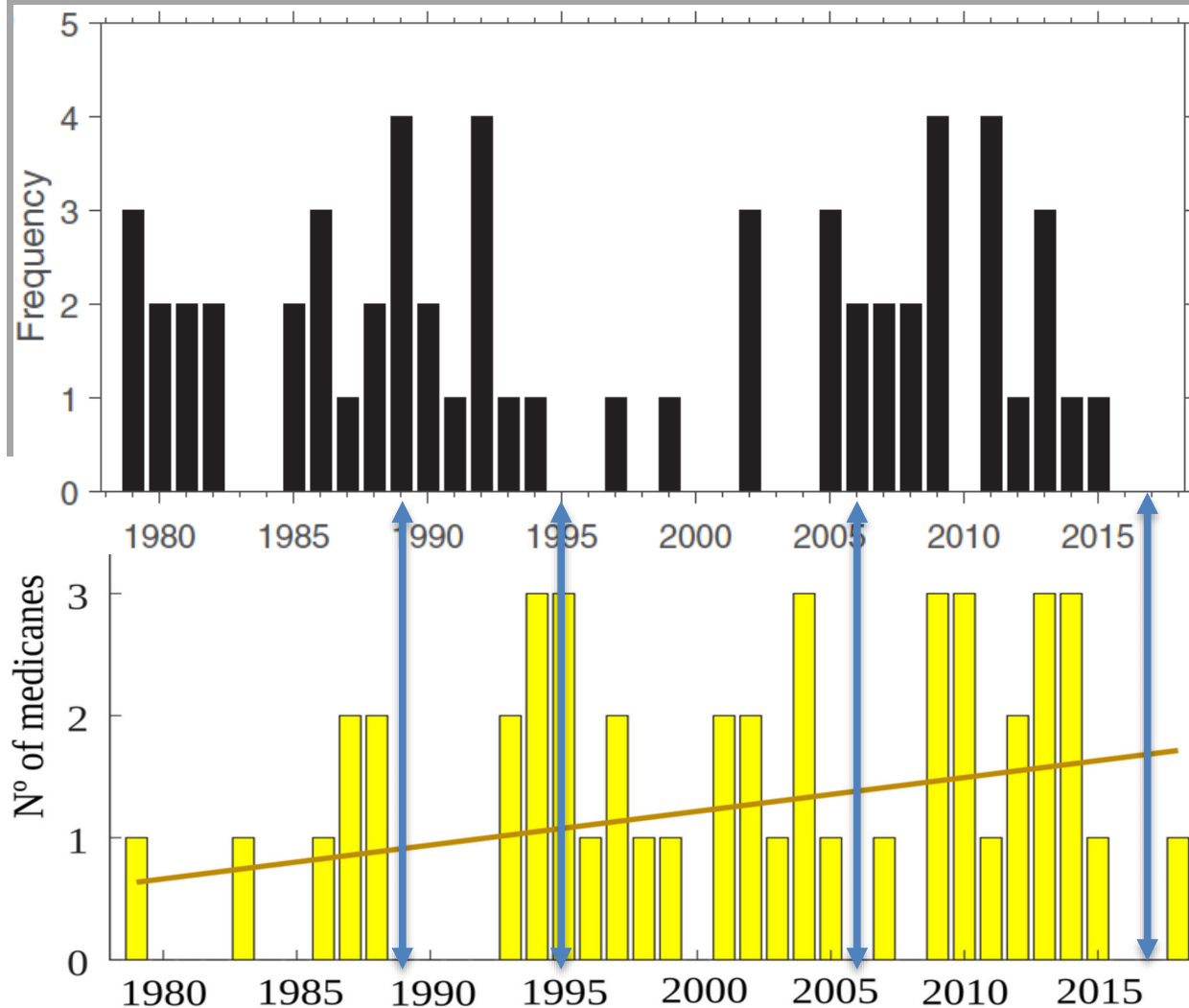
ERA-5 climatology

Average number of Medicanes =
1.51 events per season



ERA-5 reanalysis

ERA-5 climatology



(a) Zhang et al. (2020)

The case of September 2006 is included in (a) but not in (b); in 1989 (a) found 4 cases, while (b) did not find any; in 1995 (a) found 0 cases and (b) 3; neither study includes the known case of November 2017

(b) De la Vara et al. (2020)

Need for a definition!

ANOMALIES OF METEOROLOGICAL PARAMETERS

WESTERN MED CASES

IONIAN CASES

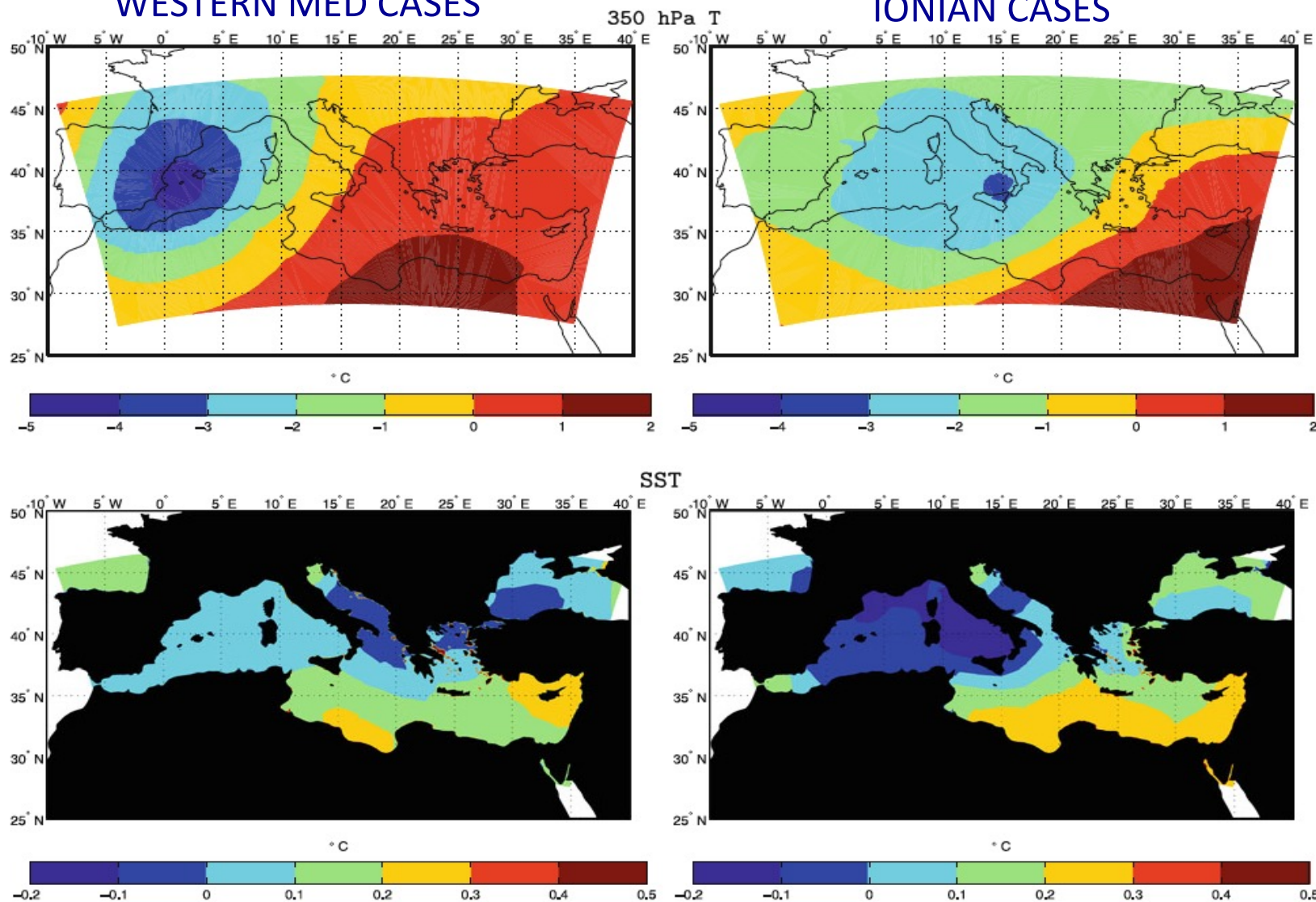


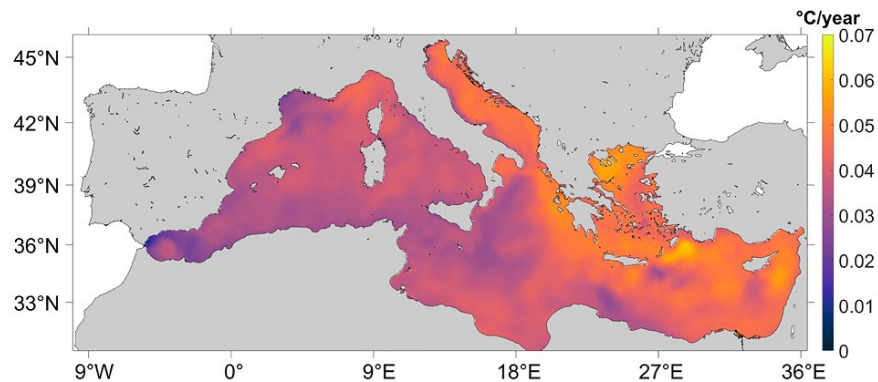
Fig. 9 Composite plots of the daily means, on the day corresponding to the first point in the track, for medicanes in the western Mediterranean (left panels) and Ionian Sea (right panels) of the

anomalies with respect to the climatological monthly means. 350 hPa temperature (top, 1 °C contours), sea surface temperature (bottom, 0.1 °C contours)

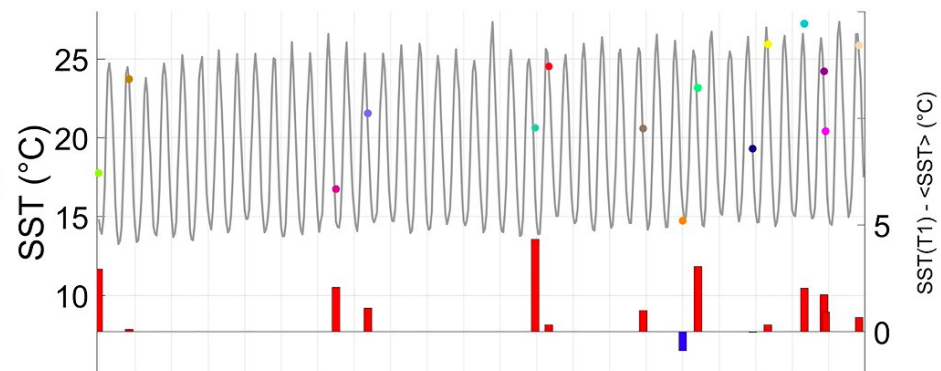
350 hPa
Temperature

SST

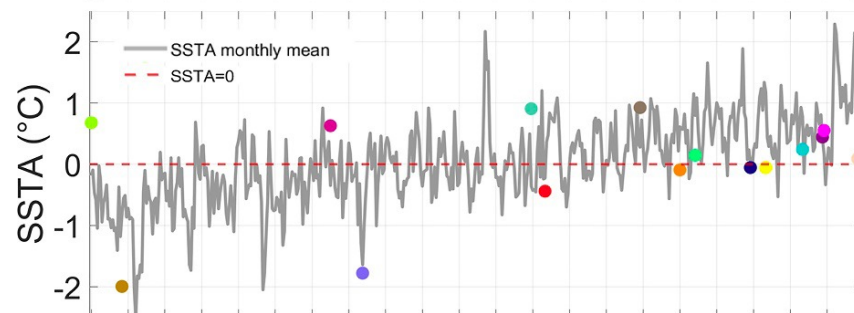
a)



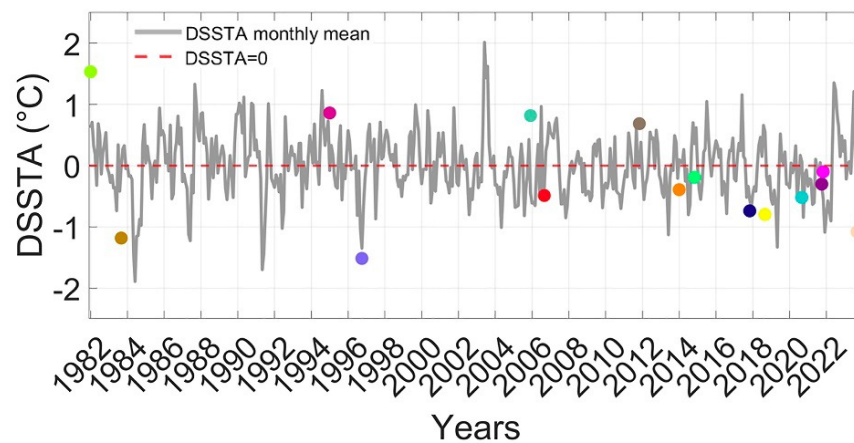
b)



c)



d)



- leucosia
- callisto
- celeno
- cornelia
- zeo
- querida
- rolf
- ilona
- qendresa
- numa
- zorbas
- ianos
- apollo
- blas
- daniel

ANOMALIES OF METEOROLOGICAL PARAMETERS

WESTERN MED CASES

IONIAN CASES

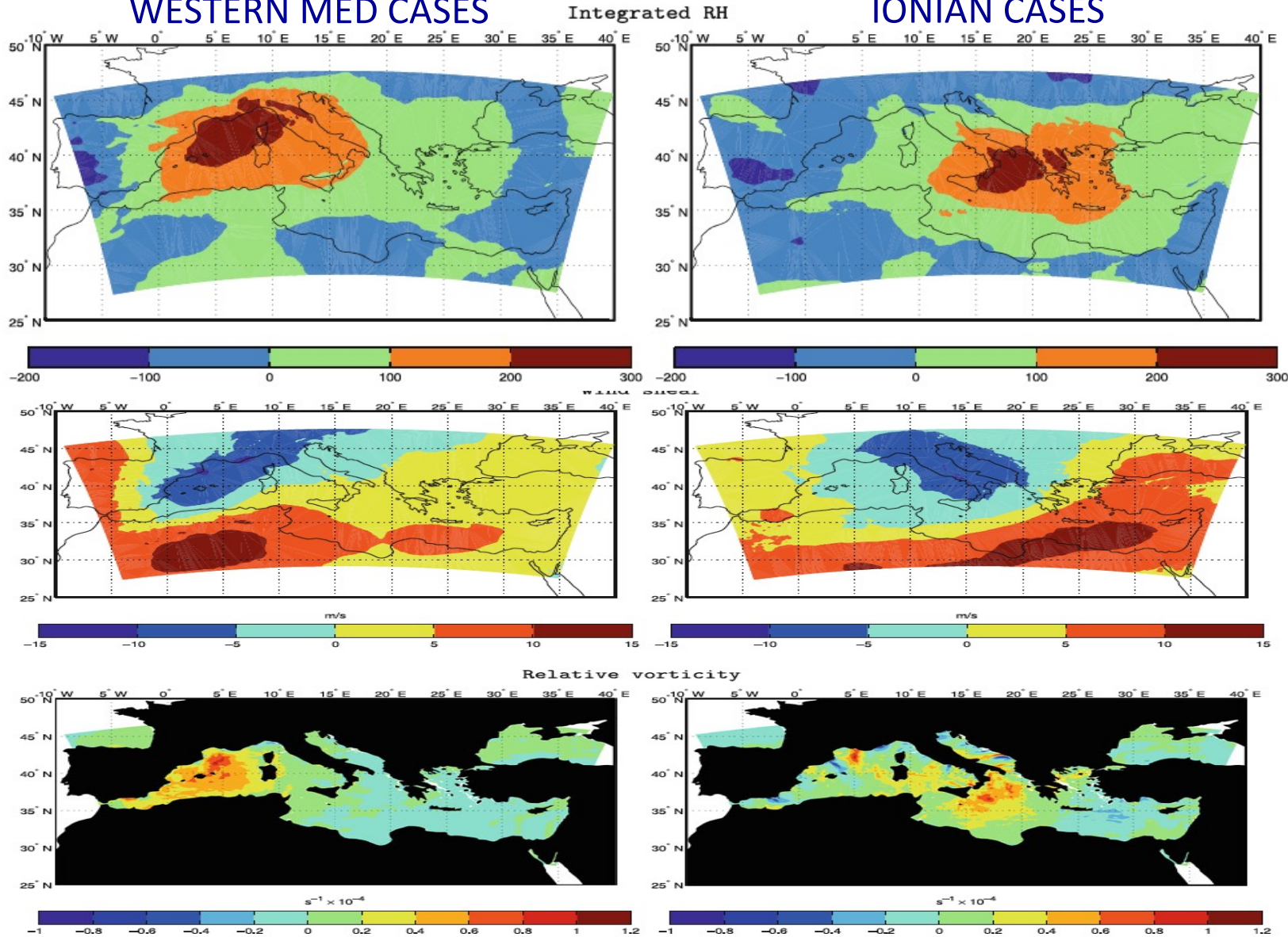


Fig. 10 Composite plots of the daily means, on the day corresponding to the first point in the track, for medicanes in the western Mediterranean (left panels) and Ionian Sea (right panels) of the anomalies with respect to the climatological monthly means. Top

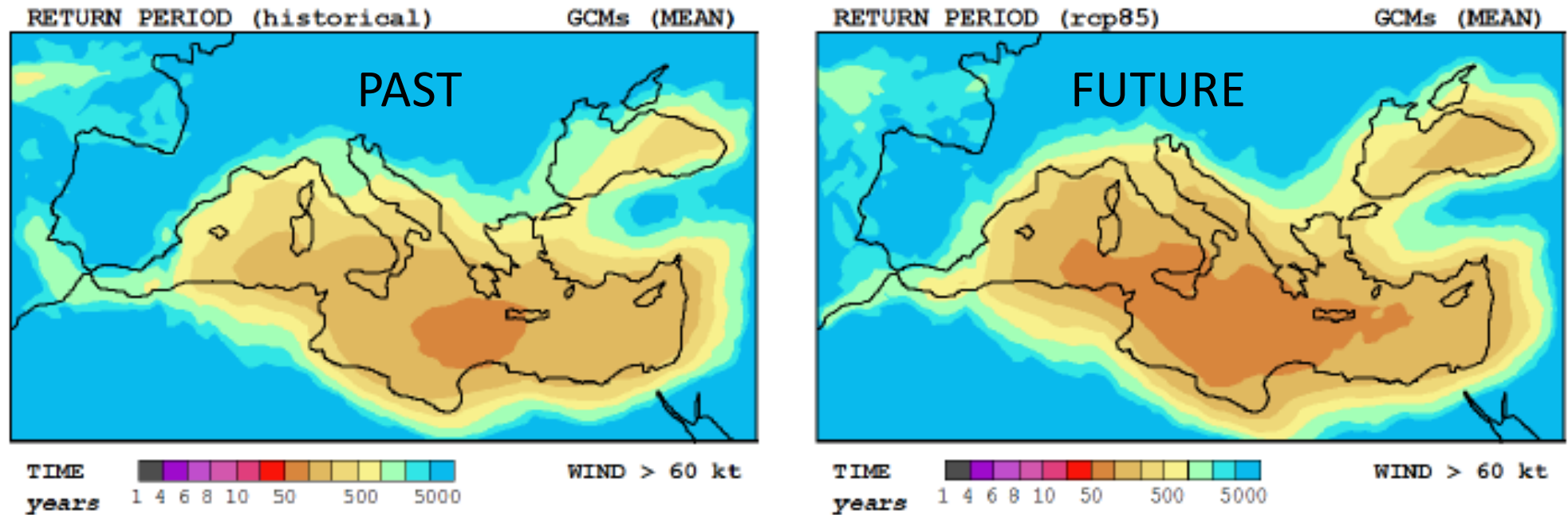
850–250 hPa wind shear (5 m/s contours). Bottom 850 hPa relative vorticity ($0.2 \text{ s}^{-1} \times 10^{-4}$ contours)

Integrated
RH

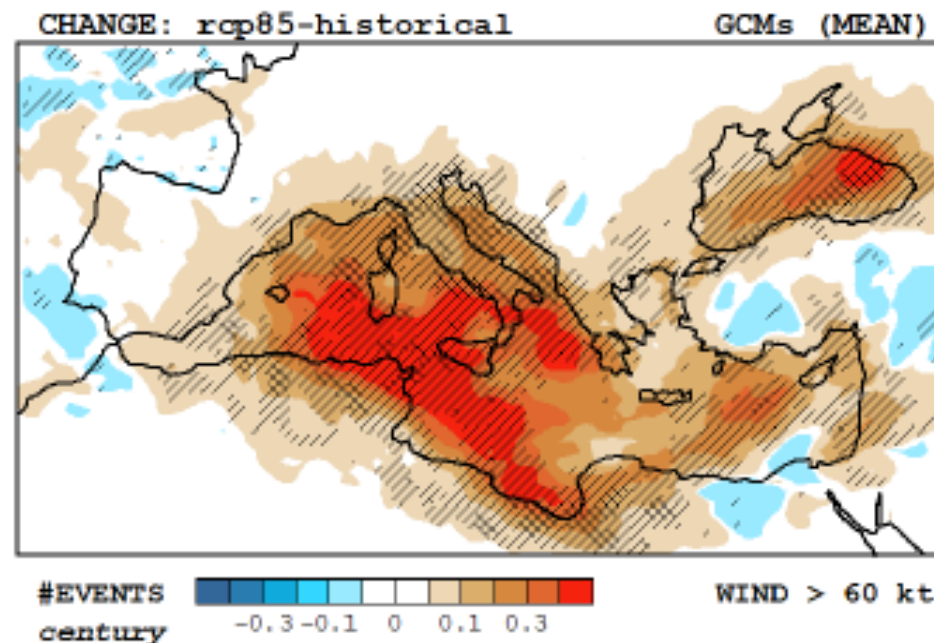
850-250 hPa
Wind shear

850 hPa
Relative
Vorticity

RETURN PERIOD (ENSEMBLE OF 30 MODELS): INCREASE OF INTENSE MEDICANES



FUTURE-PAST N of EVENTS

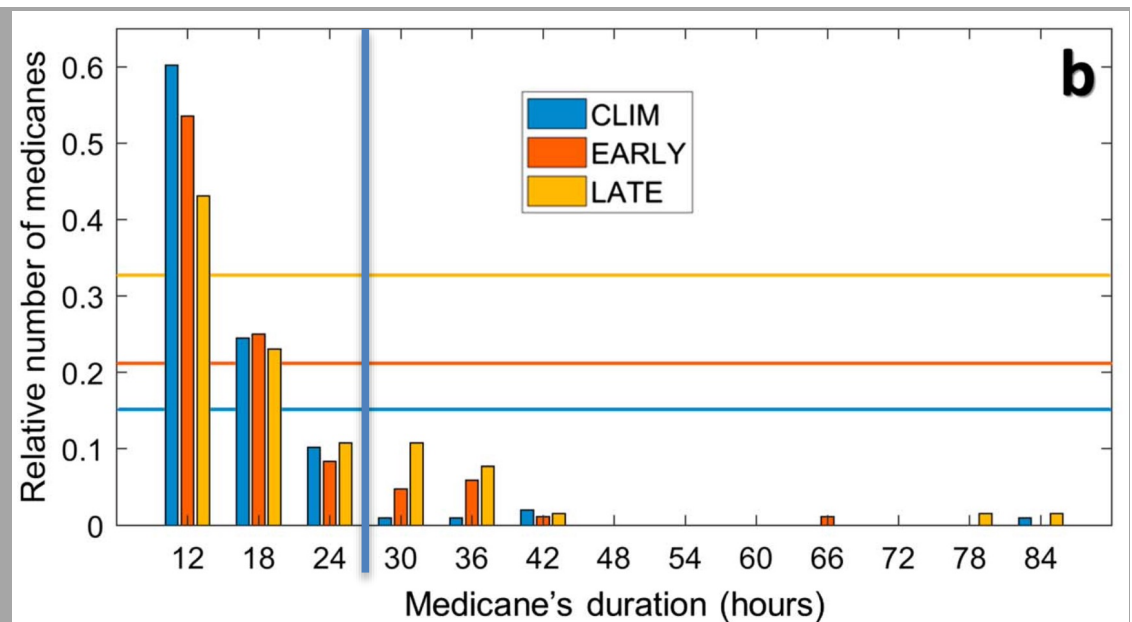


Synthetic Medicanes
30 CMIP5 GCMs
Scenario: **RCP8.5**
Horizontal resolution:
0.7° - 2.8°
Romero and Emanuel
(2017)

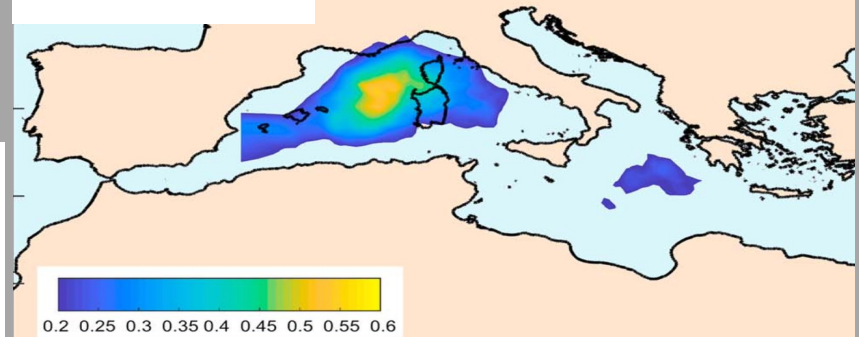
Threshold = 60 KT

MEDICANES AND CLIMATE CHANGE (Gonzalez- Aleman et al., 2019)

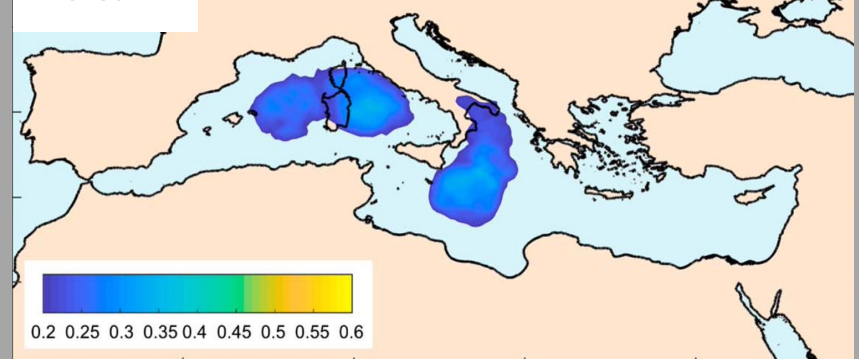
HiFLOR atmospheric-ocean coupled GCM
Intermediate Scenario: **RCP4.5**
Horizontal resolution: **25 km**



PRESENT



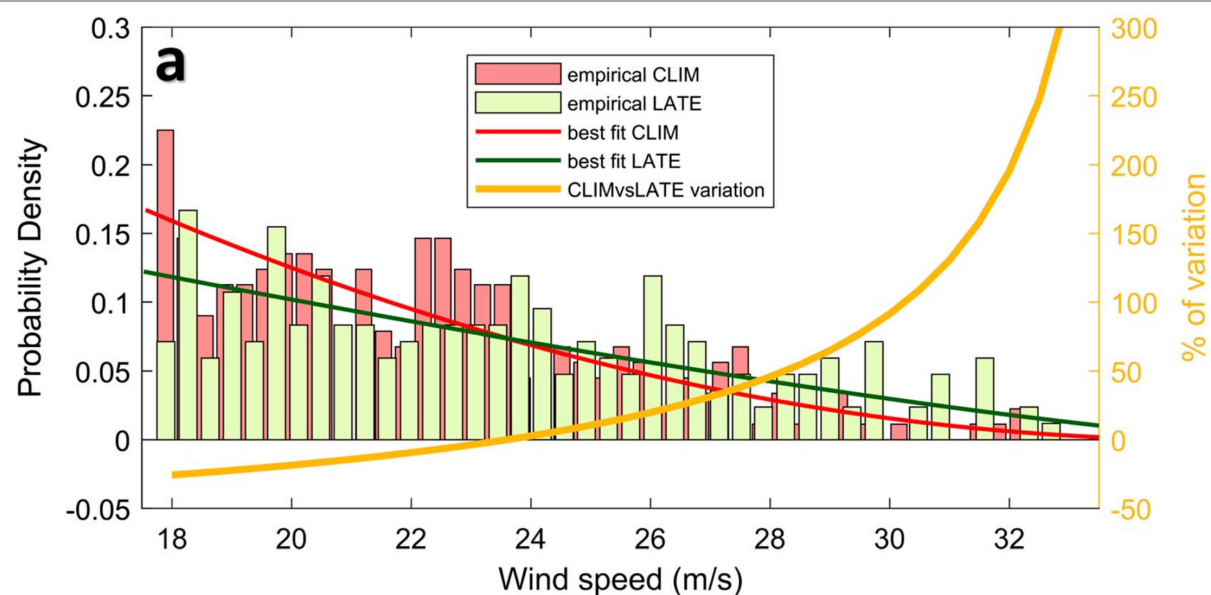
LATE



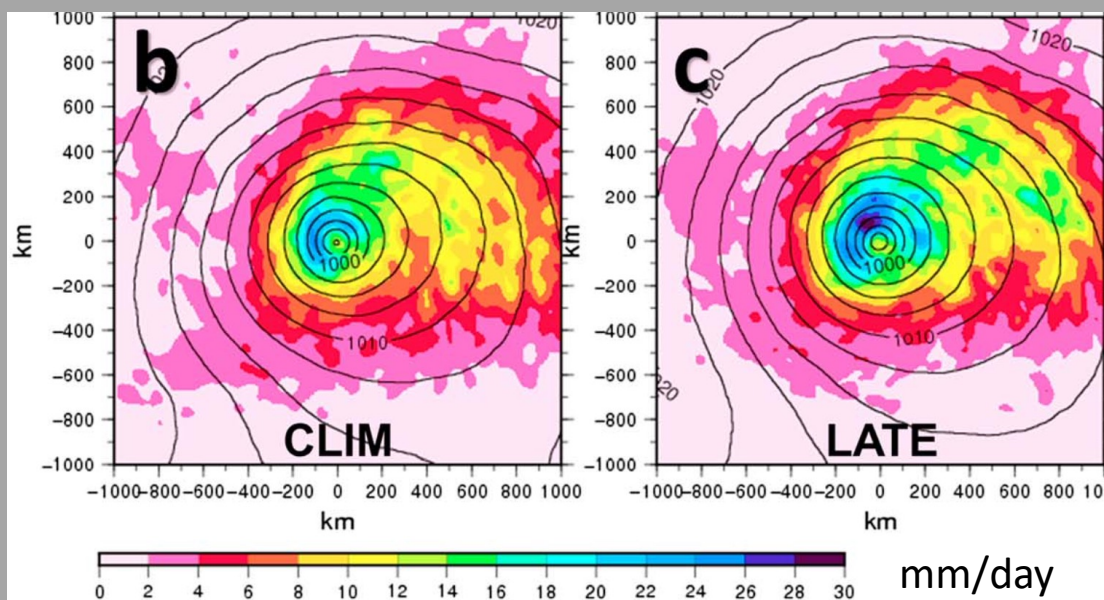
MEDICANES AND CLIMATE CHANGE (Gonzalez-Aleman et al., 2019)

HiFLOR atmospheric-
ocean coupled GCM
Intermediate Scenario:
RCP4.5
Horizontal resolution: **25 km**

WIND



PRECIPITATION



ROLF –

STORYLINE APPROACH

**OR PSEUDO GLOBAL
WARMING (PGW)
Simulation**

Koseki et al. (2020)

- Surface wind speed during SLP minimum for (a) PRS, (b) PGW-ALL, (c) PGW-SST, and (d) PGW-ATMS around the cyclone centre, respectively

