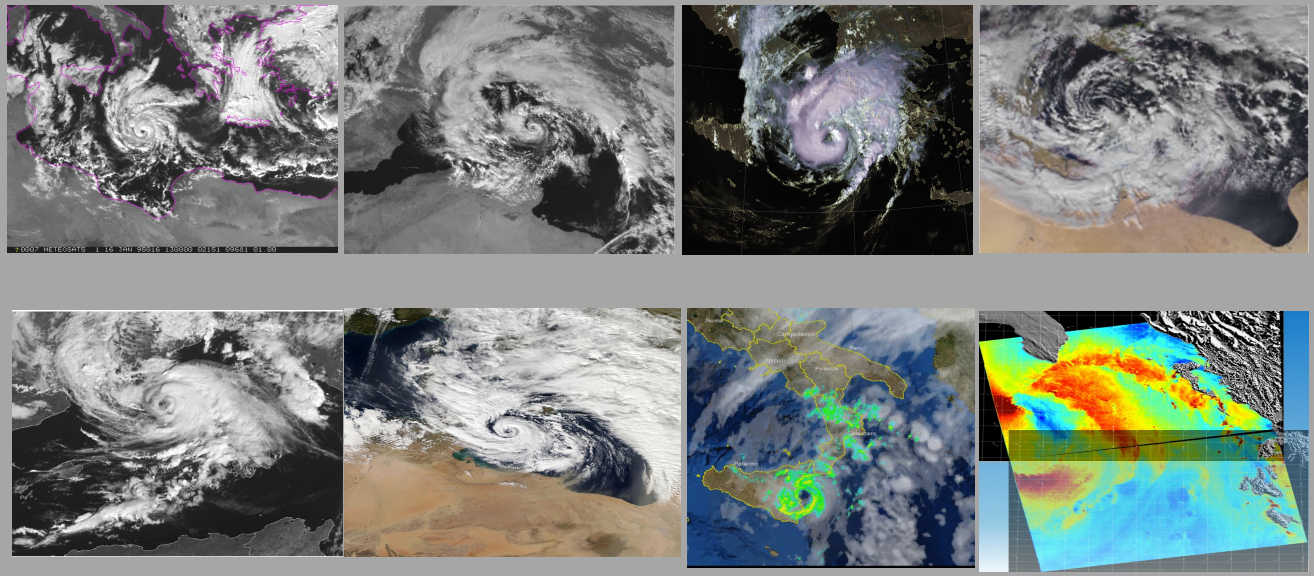
Medicanes: Bridging the Gap Between Tropical and Extratropical Cyclones in the Mediterranean



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TROPICANA 05 June 2024

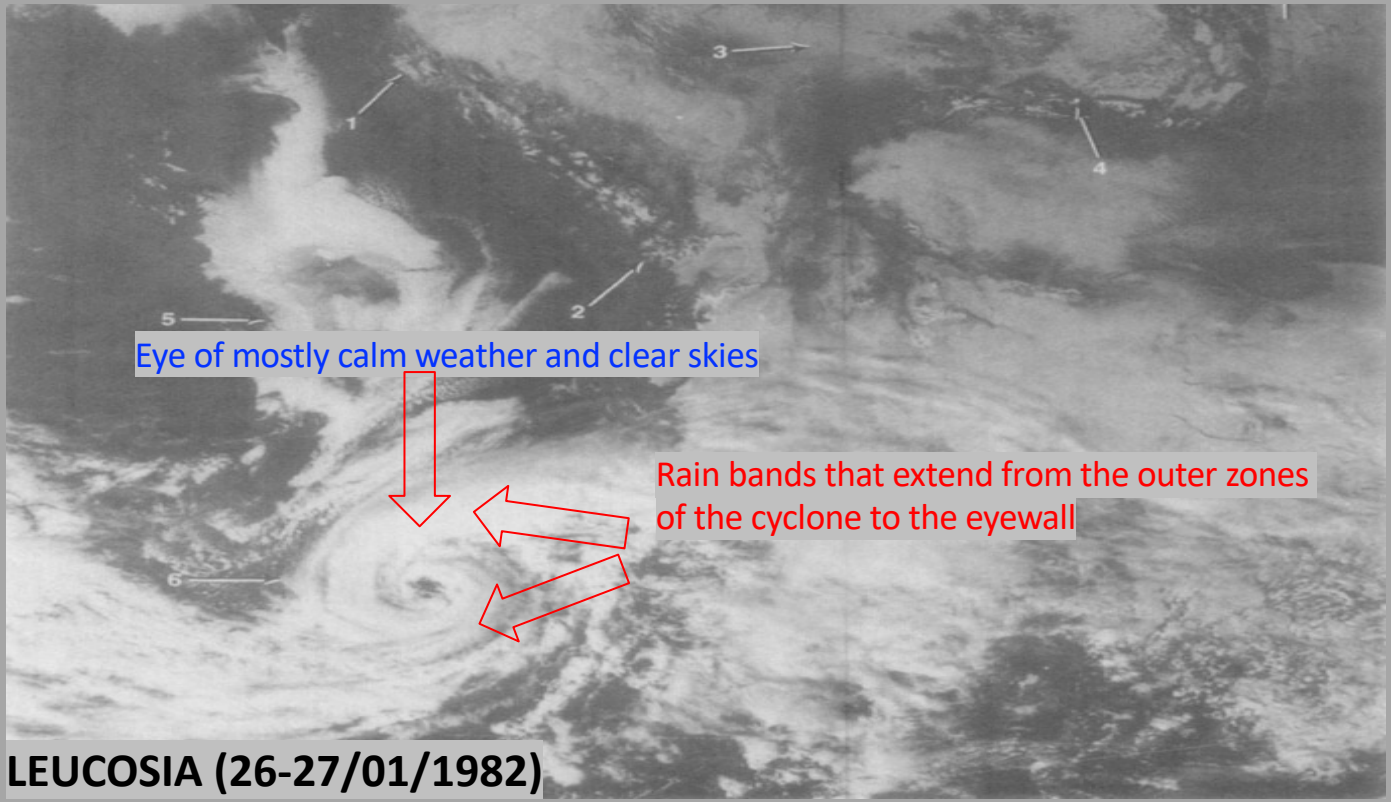
OUTLINE

1. CASE STUDIES

2. MEDICANE CHARACTERISTICS

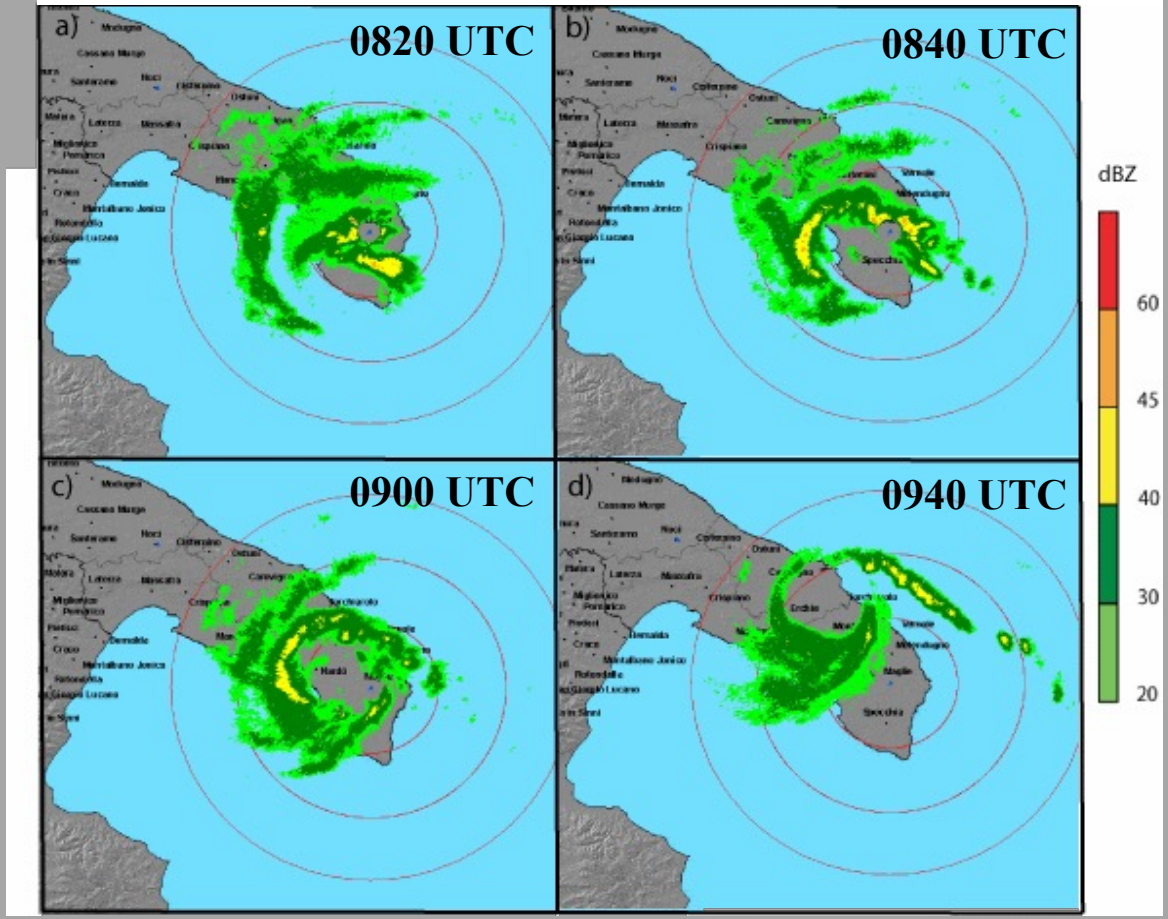
3. TOWARD A DEFINITION OF «MEDICANE»

Since satellite images became available in the 1960s it has been possible to identify vortices in the Mediterranean basin whose characteristics are similar to those of TC.



NOAA-7 visible band image of January 1982 storm. Arrow number 5 indicates southeastern Italy, arrow number 2 corresponds to the coast of Albania (Ernst and Matson, 1983).

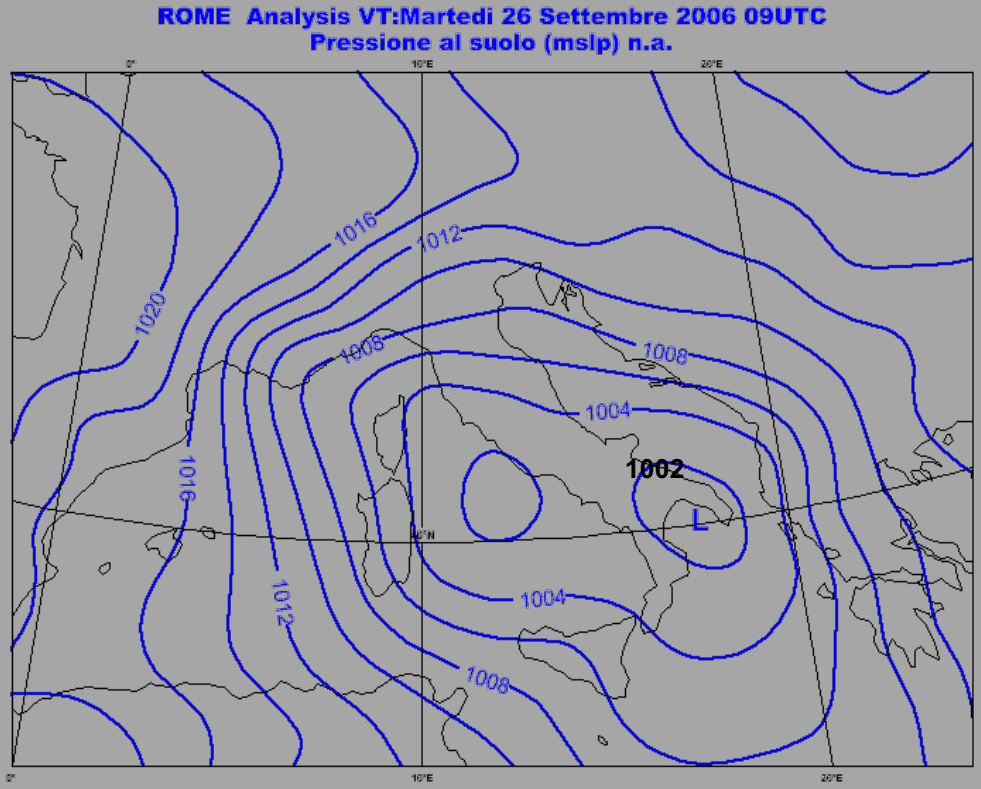
RADAR REFLECTIVITY (dBZ)



MARIA (26/09/2006)

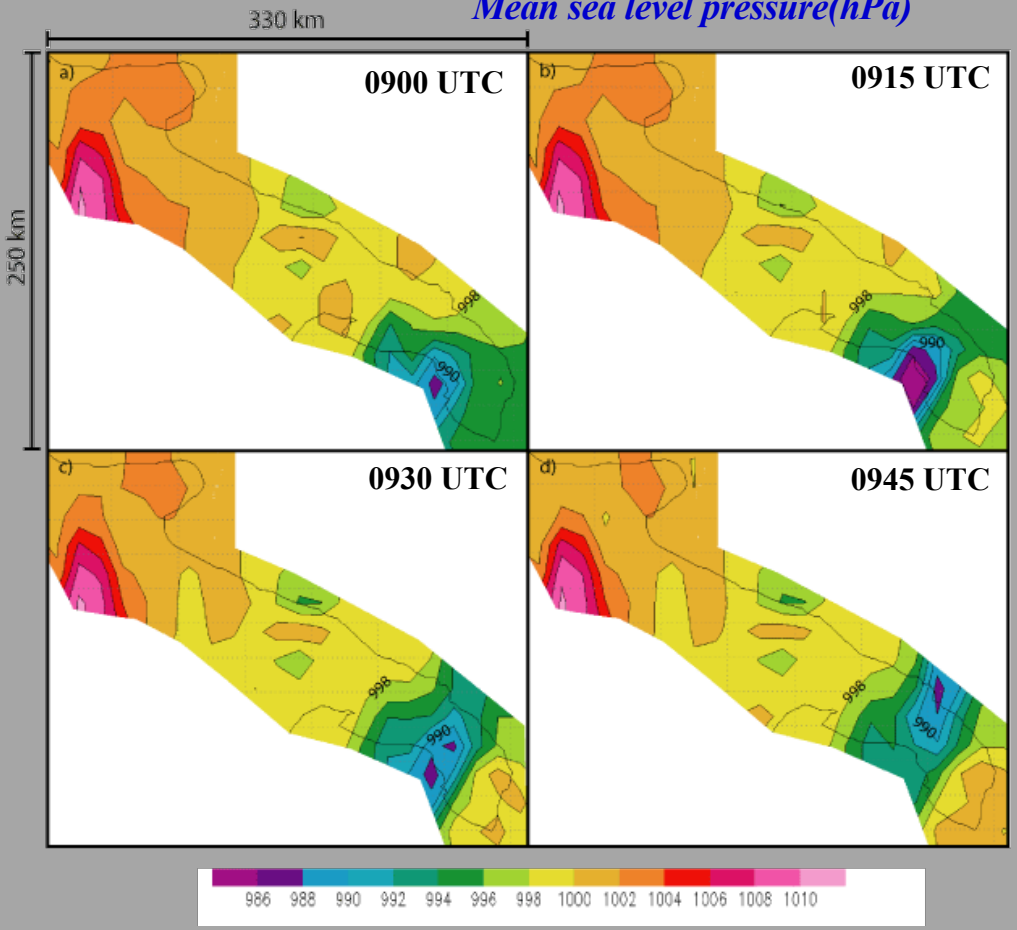
Moscatello et al. (2008a)

SYNOPTIC ANALYSIS 26 September 2006 – 0900 UTC



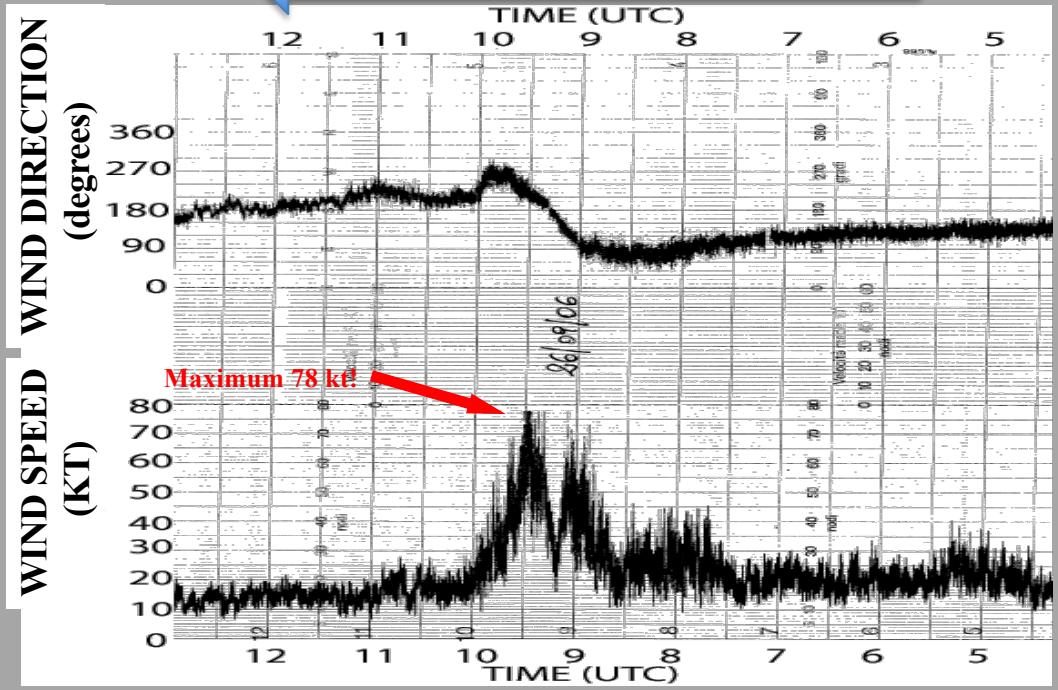
Southern Track

Mean sea level pressure(hPa)



- *33 surface stations*
- *Cressman horizontal interpolation*

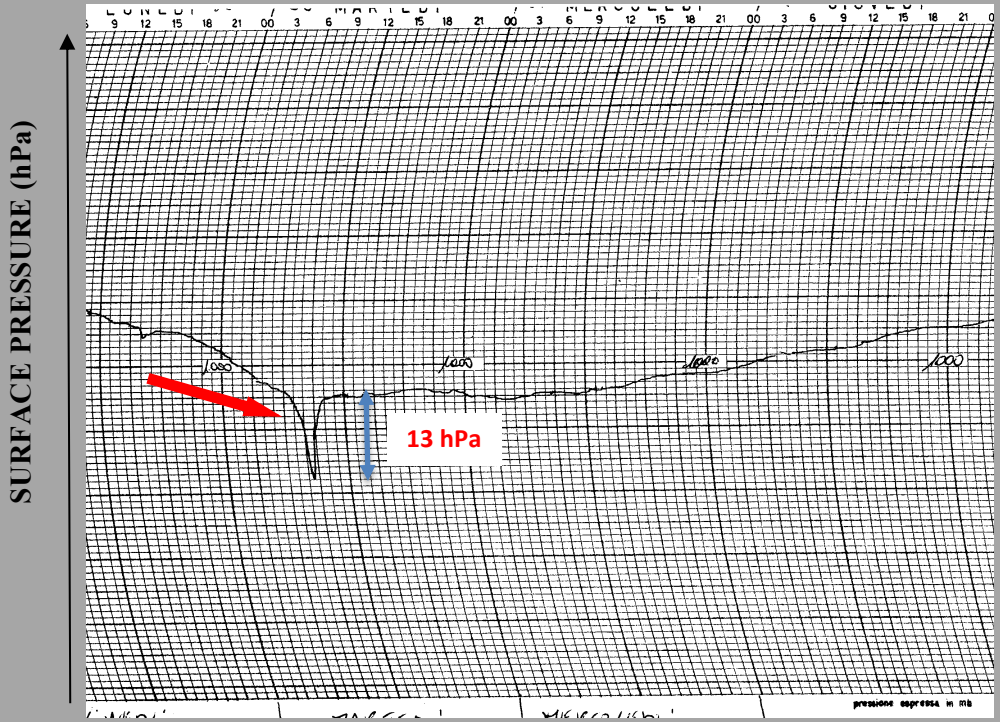
GALATINA AIRPORT



MARIA (26/09/2006)

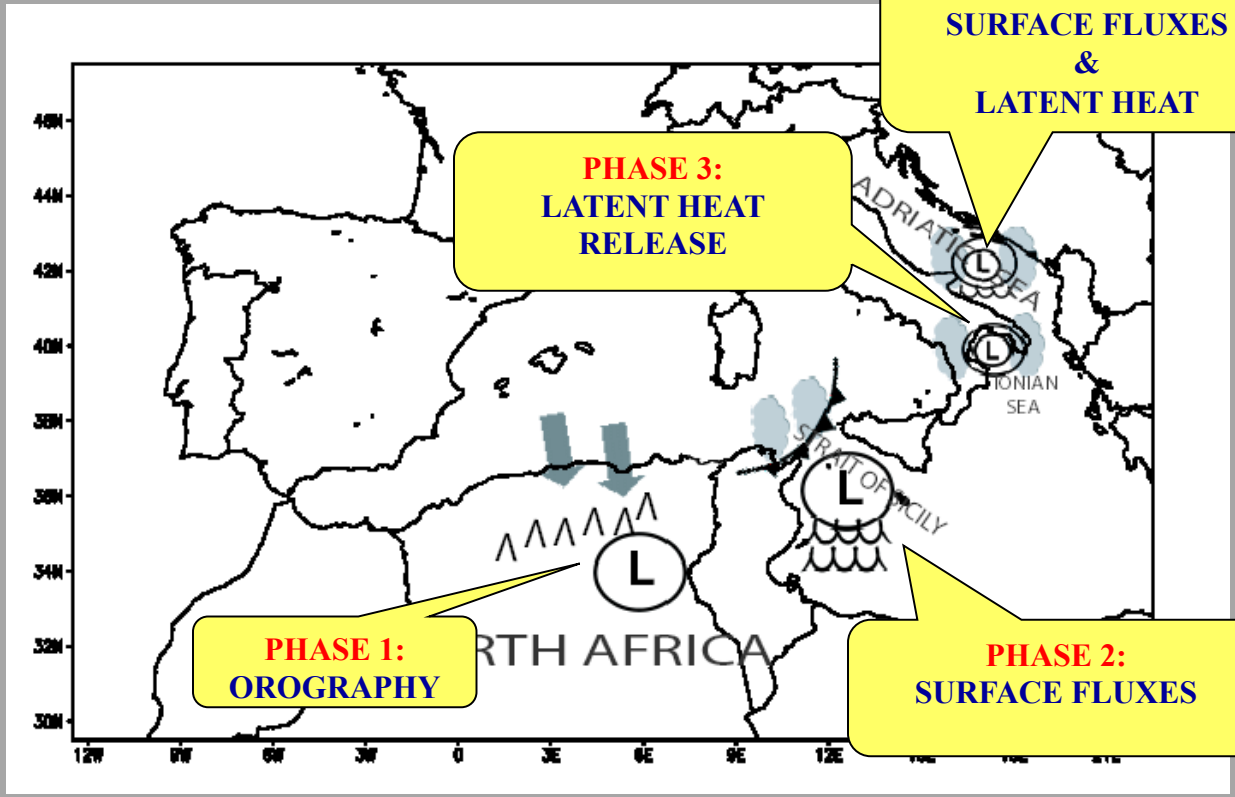
Moscatello et al. (2008a)

GALATINA AIRPORT



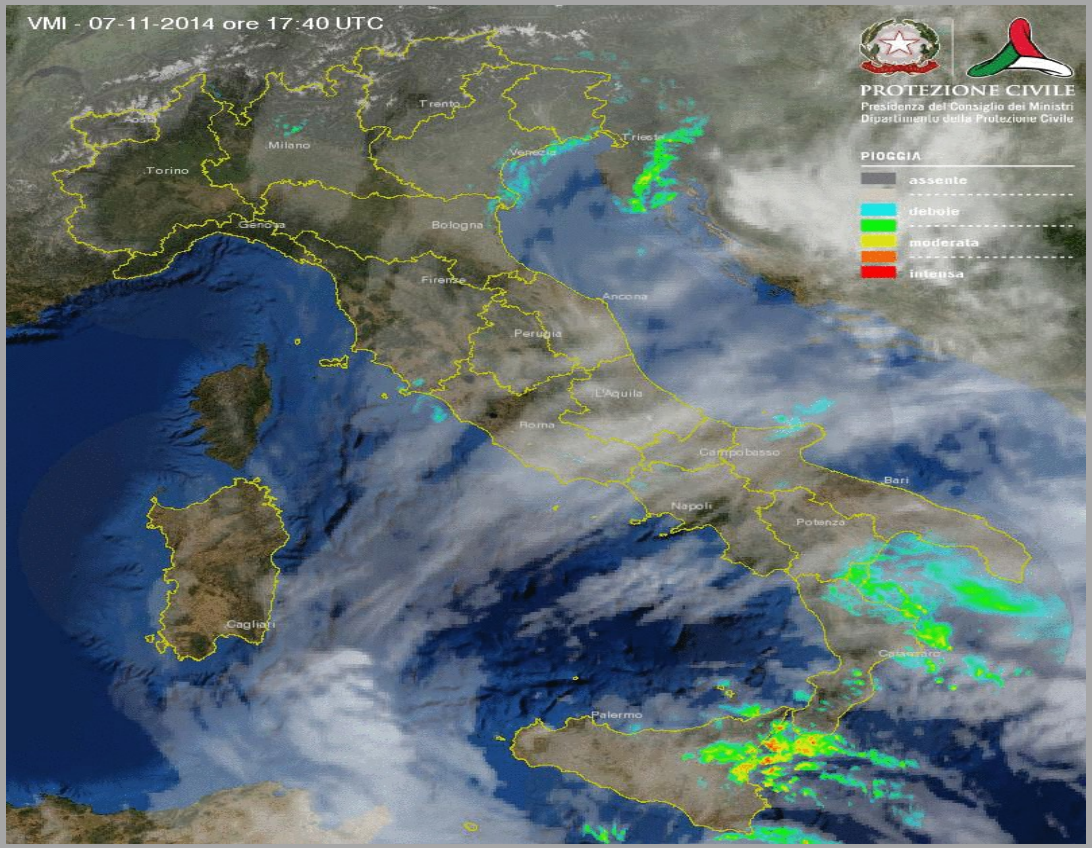
MARIA (26/09/2006)

DIFFERENT PHASES



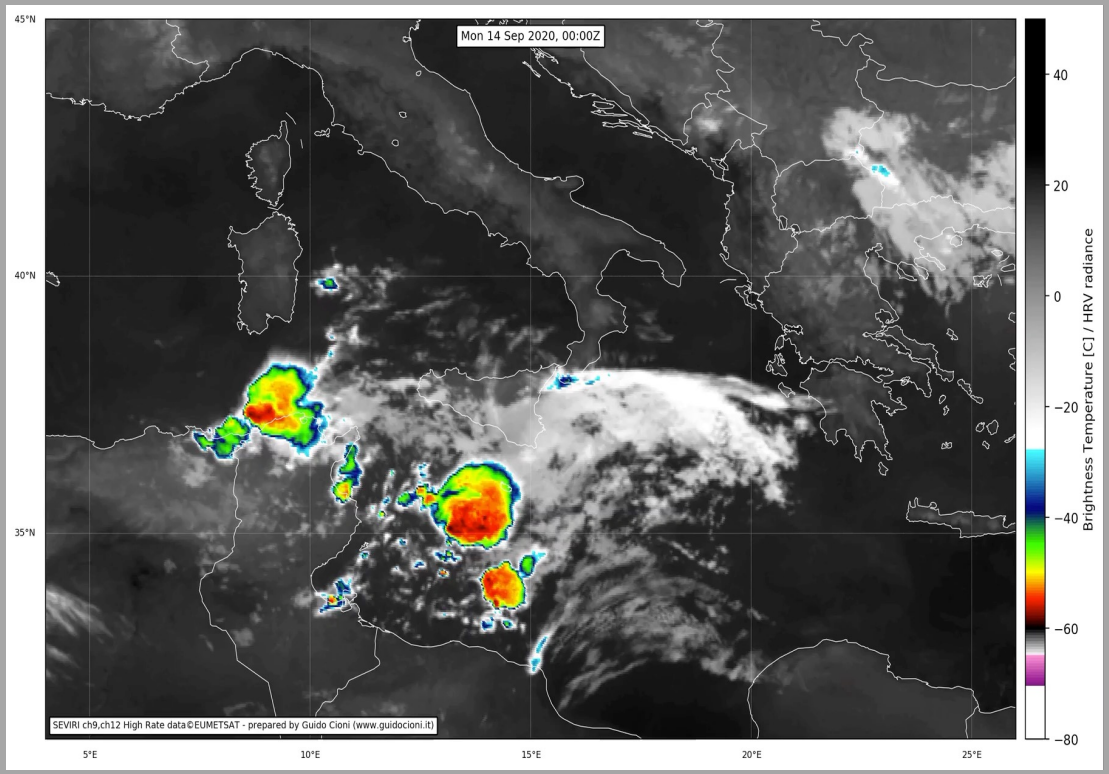
MARIA (26/09/2006)

Moscatello et al. (2008b)



QENDRESA (07/11/2014)

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 54.2 m/s and 645 mm/24 h (769 mm/48 h vs. yearly average of 812.3 mm in Argostoli station) of rain have been recorded on the island of Kefalonia (Lagouvardos et al., 2022:; Diakakis et al., 2023).

IANOS 17-18/09/2020

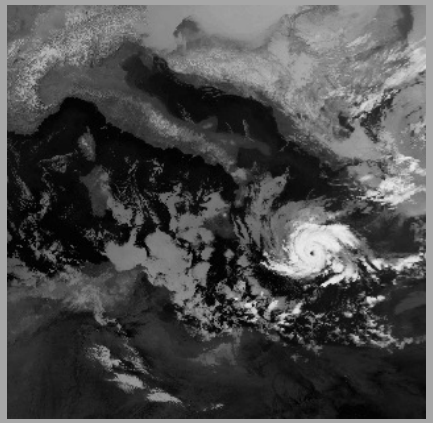
OUTLINE

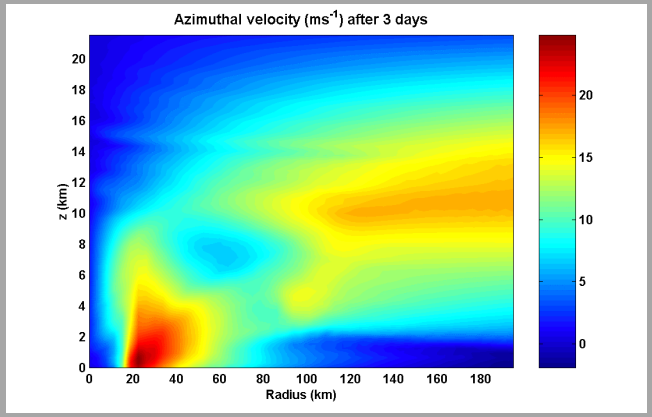
1. CASE STUDIES

2. MEDICANES CHARACTERISTICS

3. TOWARD A DEFINITION OF «MEDICANE»

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

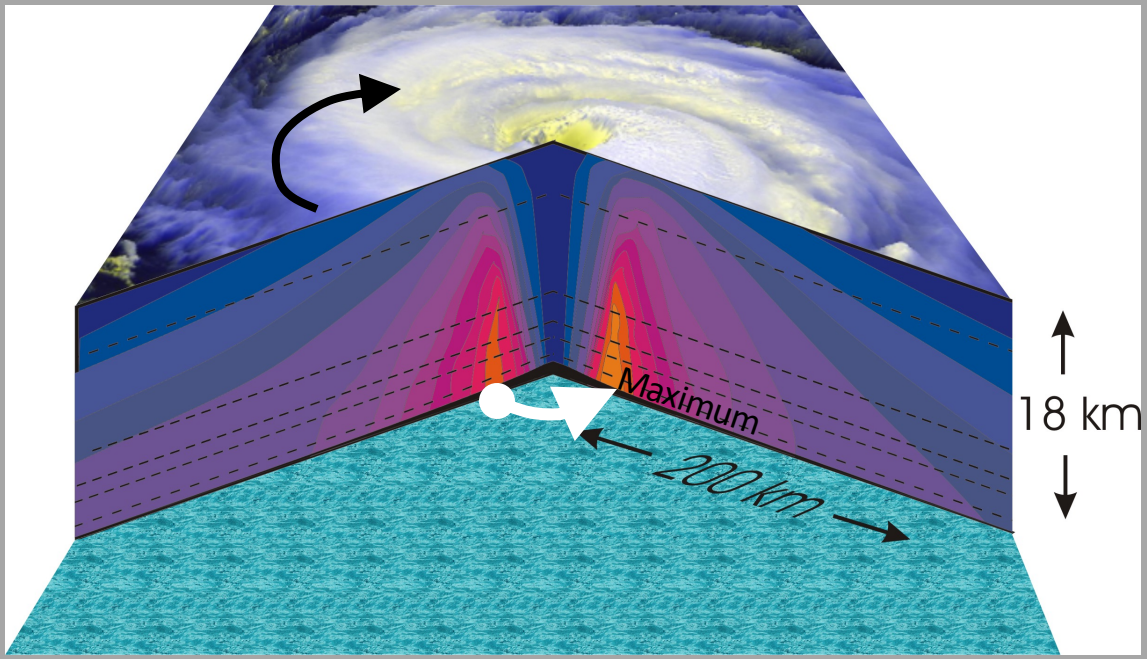




An **axisymmetric, cloud-resolving model** -in which any development may occur only due to the **feedback between surface enthalpy fluxes and wind** – was applied to show that a **cold, upper low** can produce high potential intensity in an Ionian cyclone (Jan 1995)

CELENO (15-17/01/1995)

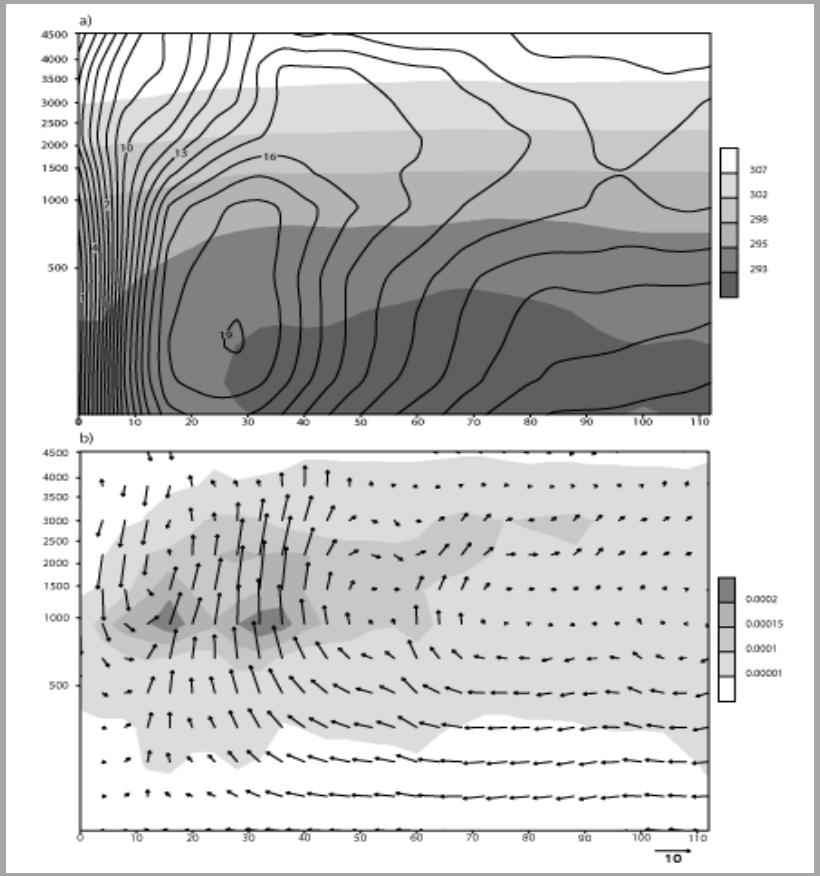
1. WIND STRUCTURE



- Eye: weak wind (20 KT o less)
- Peak at 20-30 km from center, discontinuous with strong gusts
- Wind weakens with distance

Coordinate system origin in the pressure minimum

11UTC
26 Sep 2006



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

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

Moscatello et al. (2008b)

But this pattern is not observed in all medicanes

2. MECHANISM OF DEVELOPMENT

Low SST and initial baroclinic environment

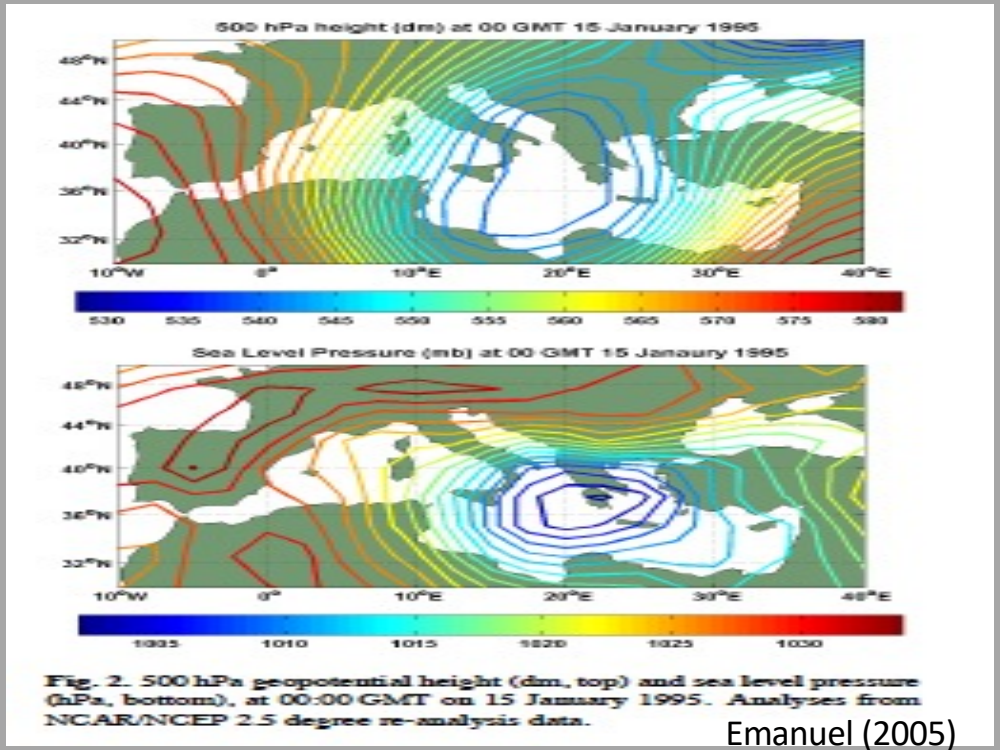


Fig. 2. 500 hPa geopotential height (dm, top) and sea level pressure (hPa, bottom), at 00:00 GMT on 15 January 1995. Analyses from NCAR/NCEP 2.5 degree re-analysis data.

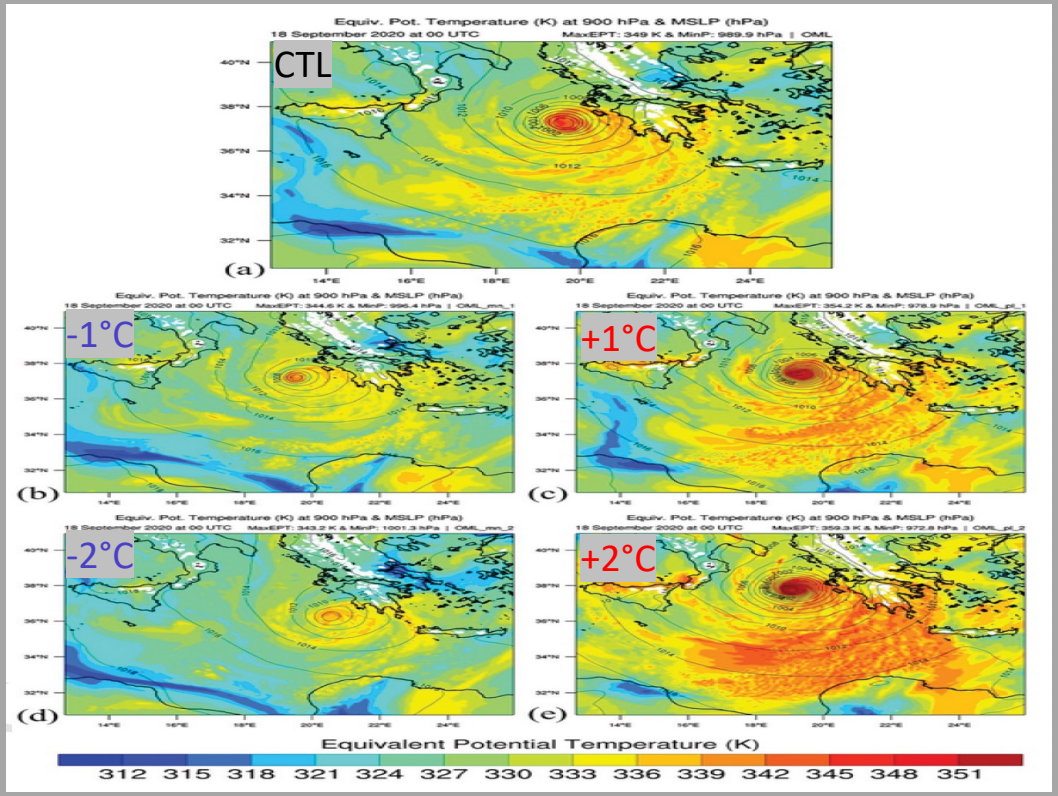
500 hPa Geopotential height

Mean Sea Level Pressure

Emanuel (2005)

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.**

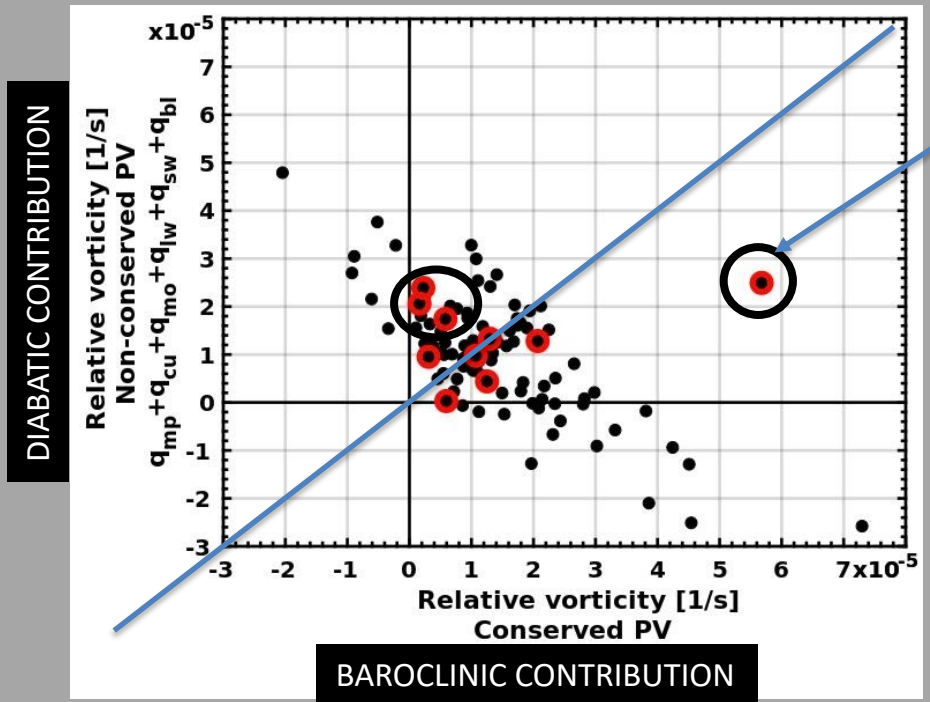
ROLE OF SST ANOMALY



No SST significant anomalies prior to cyclone development, but higher SST anomalies intensify the cyclone warm core and the pressure minimum (e.g., Varlas et al., 2023)

IANOS (15-20/09/2020)

Contribution of baroclinic versus diabatic processes to 850 hPa relative vorticity



Some Medicanes are not exclusively sustained by air-sea interaction

Mature stage

Contribution of different PV sources 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).

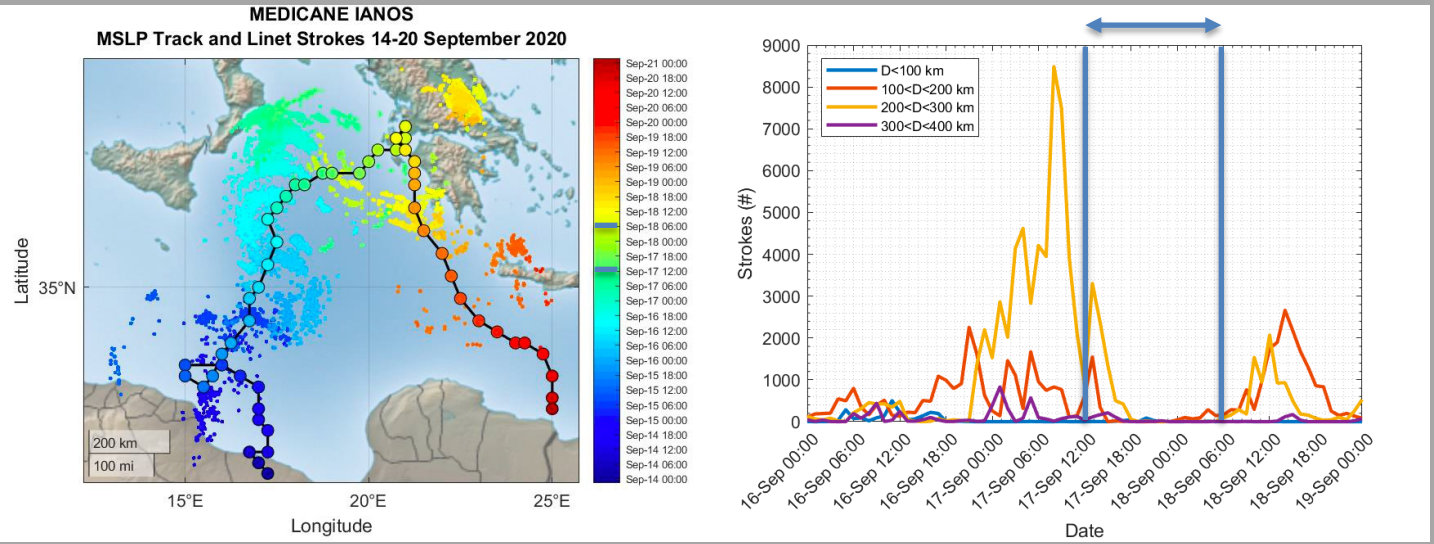
Medicanes (red) do not concentrate in a region of the parameter space.

Flaounas et al. (2020)

3. LIGHTNING AND DEEP CONVECTION

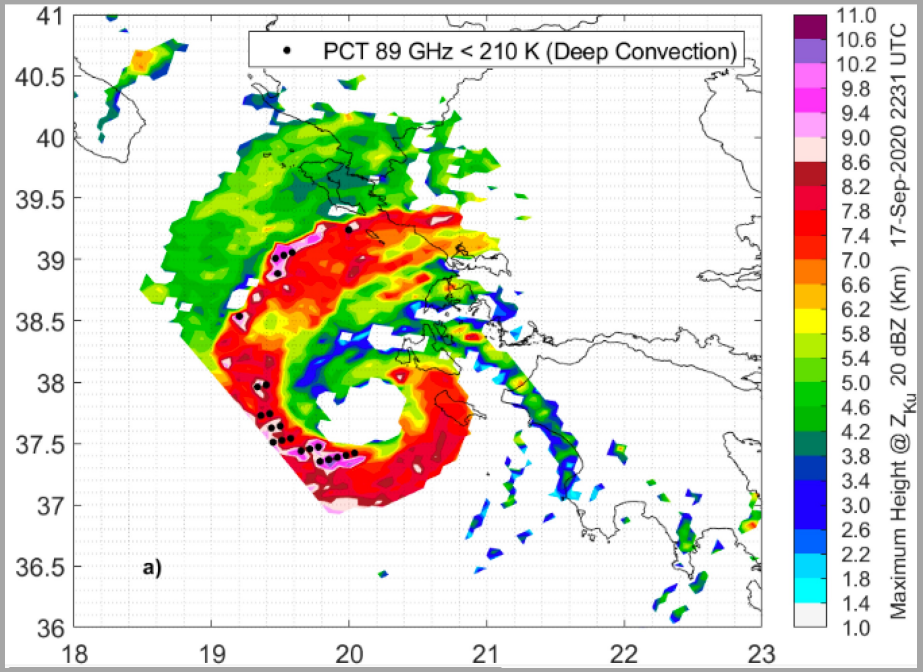
LIGHTNING ACTIVITY IN IANOS

Mature stage



D'Adderio et al. (2022)

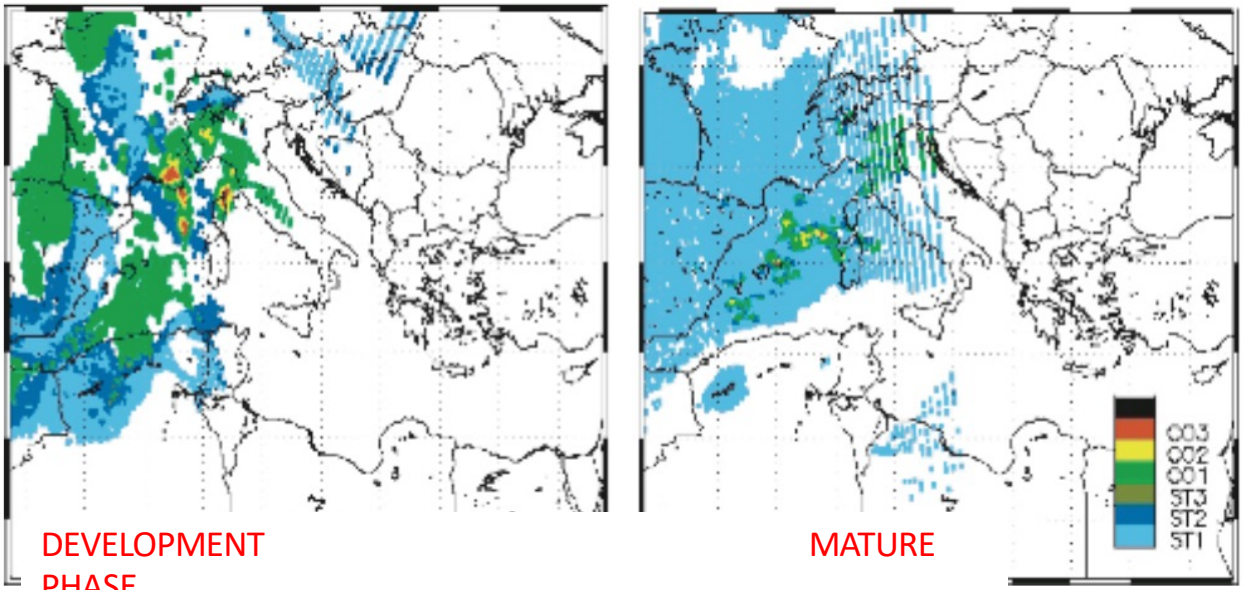
DEEP CONVECTION IN IANOS



D'Adderio et al. (2022)

Satellite analysis- 6-8 November 2011 case

MWCC



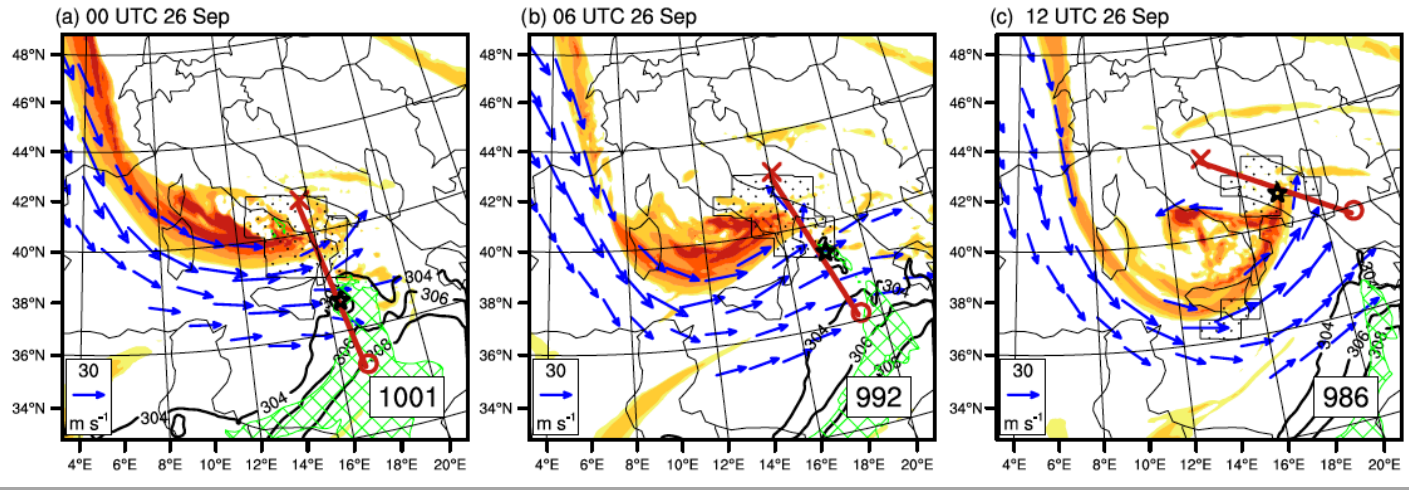
DEVELOPMENT PHASE

MATURE

Fig. 2: Cloud type identification [for mid-latitudes, stratiform type: ST1 (cloud top at: 1÷3 km), ST2 (3÷5 km), and ST3 (5÷6 km); convection type: CO1 (6÷7 km), CO2 (7÷9 km), and CO3 (>9 km); left] from the 183-WSL algorithm at 0247 UTC, 05 November 2011 (left), and 1250 UTC, 07 November 2011 (right).

Miglietta et al. (2013)

4. UPPER-LEVEL DYNAMICS



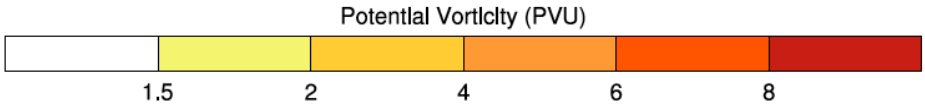


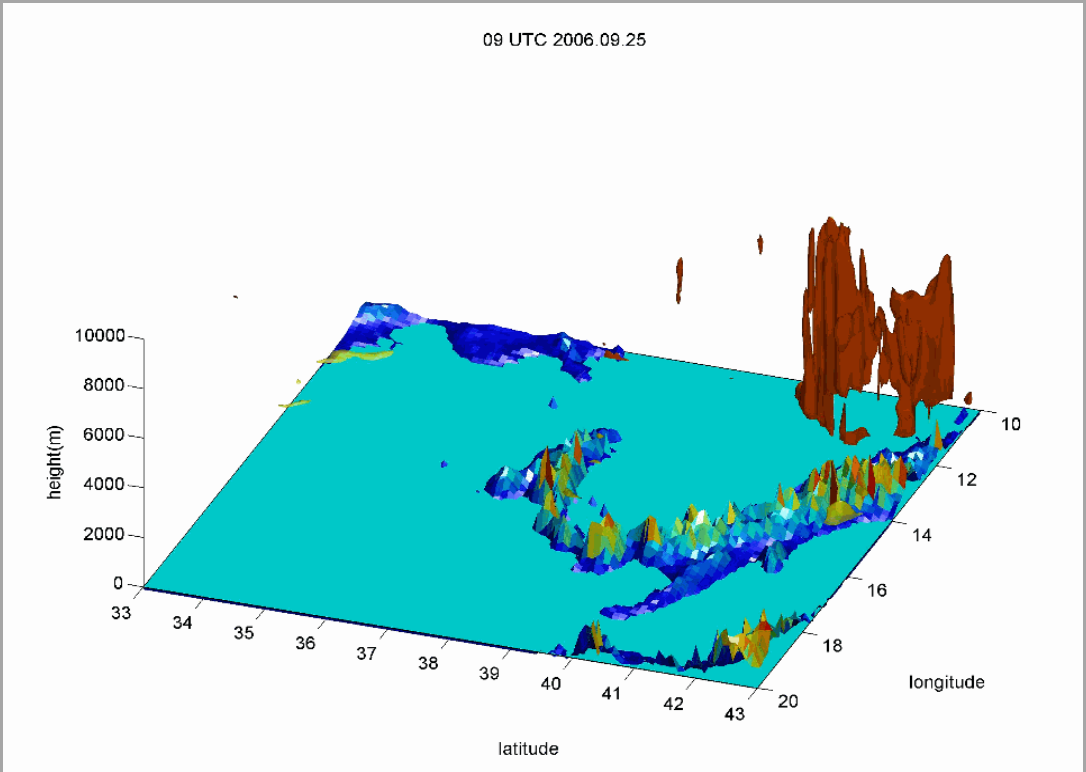
Figure 12. Results for ECMA at 0000, 0600, and 1200 UTC on 26 September 2006. Top: potential vorticity at 300 hPa (shaded, PVU), wind speed at 300 hPa over 30 m s^{-1} (vector), ω_{dyn} at 400 hPa less than -0.4 Pa s^{-1} (dotted) and CAPE larger than 1500 J kg^{-1} (hatched). The star and the figure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

Chaboureau et al. (2012)

Brown: diabatic PV

Yellow: adiabatic (conserved) PV

Green: Intense wind



Miglietta et al. (2017)

UPPER LEVEL DYNAMICS AND PREDICTABILITY ISSUES

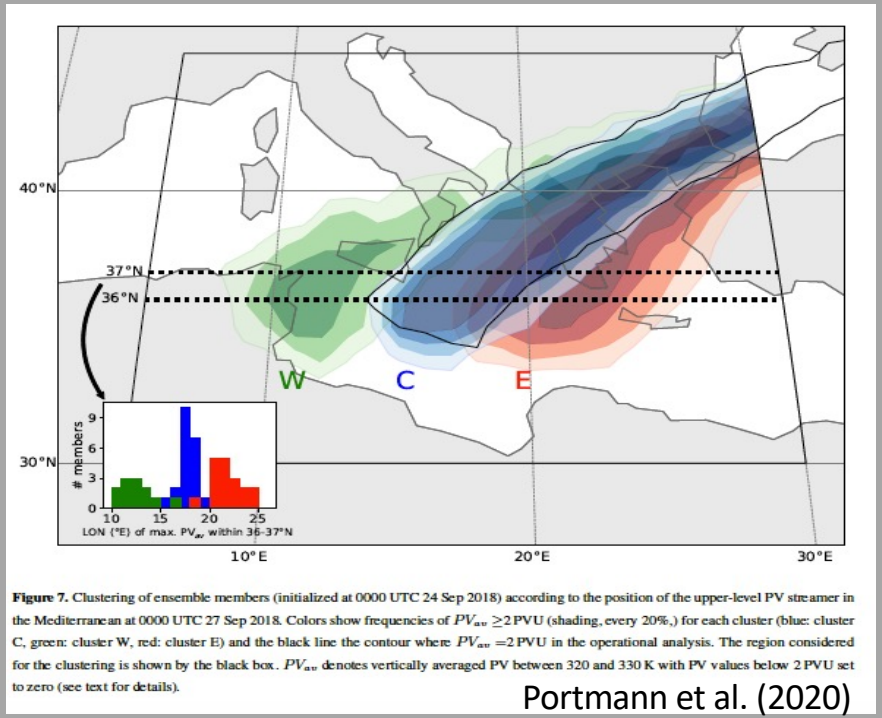


Figure 7. Clustering of ensemble members (initialized at 0000 UTC 24 Sep 2018) according to the position of the upper-level PV streamer in the Mediterranean at 0000 UTC 27 Sep 2018. Colors show frequencies of $PV_{av} \geq 2$ PVU (shading, every 20%,) for each cluster (blue: cluster C, green: cluster 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).

Portmann et al. (2020)

PV streamers control the coupling with the low-levels and determine its location and intensity. Portmann et al. (2020) found that short-wave perturbations on the North Atlantic waveguide a few days before the development of an intense medicane dramatically affected its subsequent evolution.

ZORBAS (27-30/09/2018)

OUTLINE

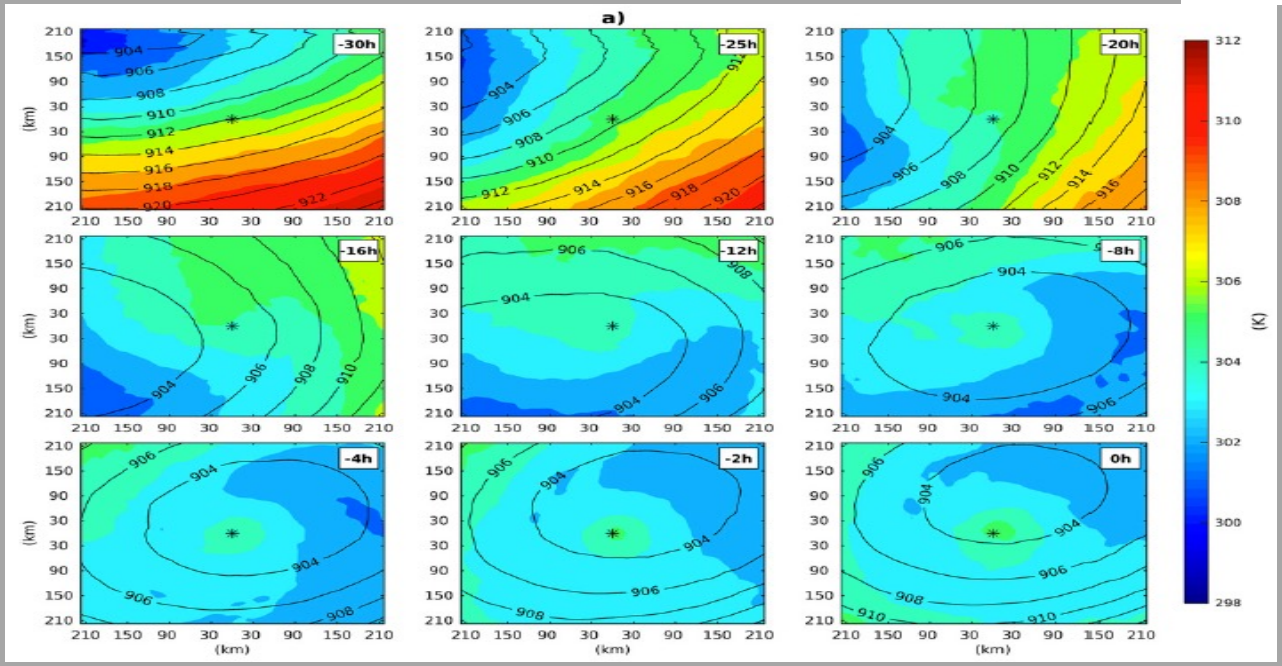
1. CASE STUDIES

2. MEDICANES CHARACTERISTICS

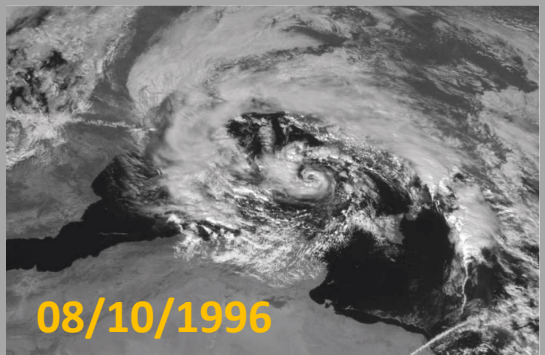
3. TOWARD A DEFINITION OF «MEDICANE»

WARM SECLUSION

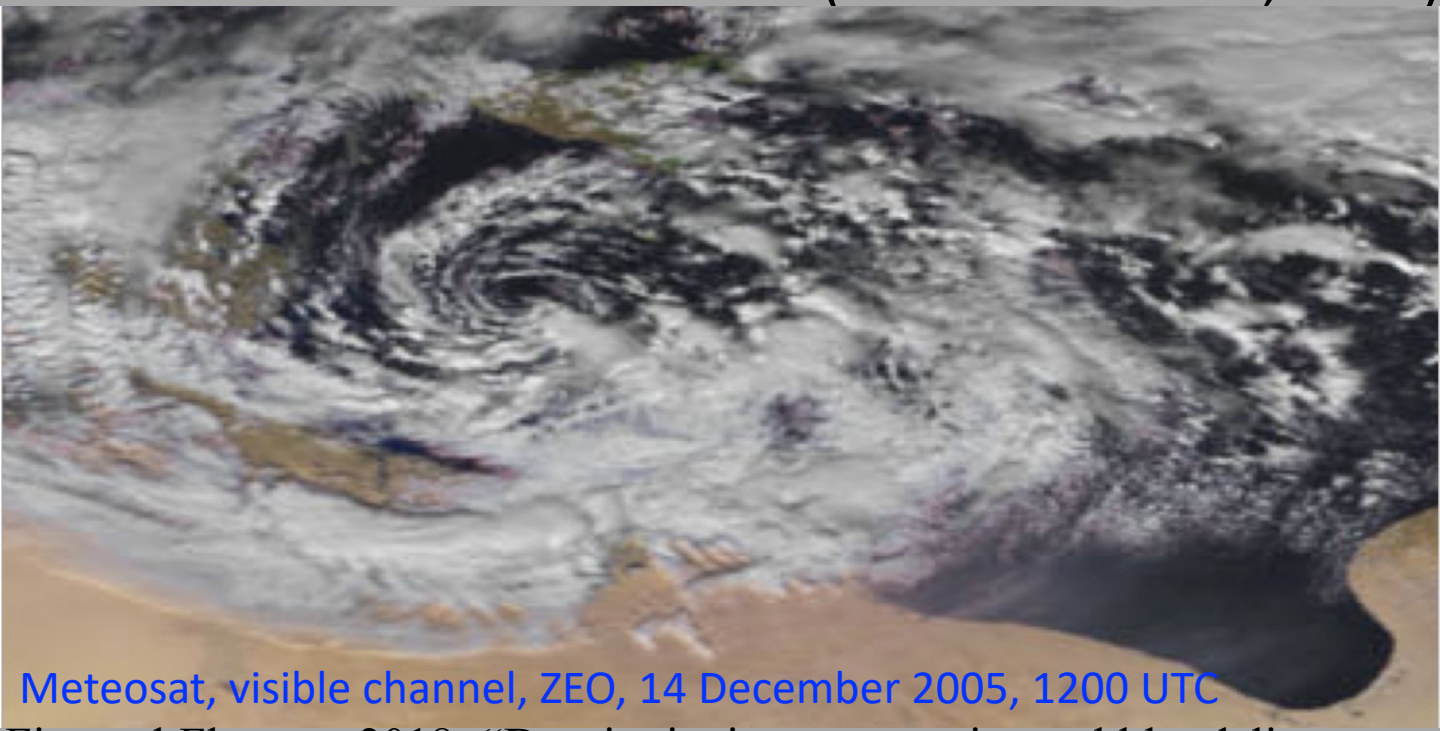
500 hPa θ



Mazza et al., 2017: "The tropical transition takes place as the cyclones undergo a **warm seclusion** … the simulations do not provide sufficient evidence that a cooperative process similar to **WISHE** is in place"



13-15 December 2005 case (Fita and Flounas, 2018)

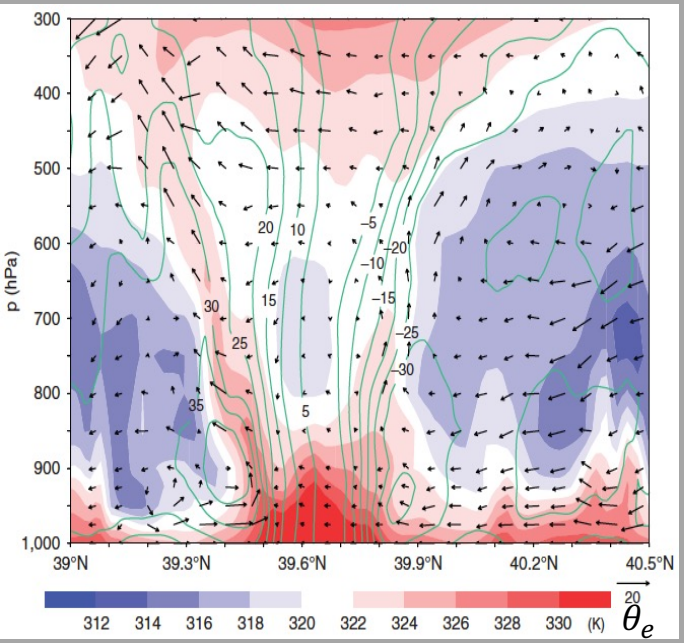


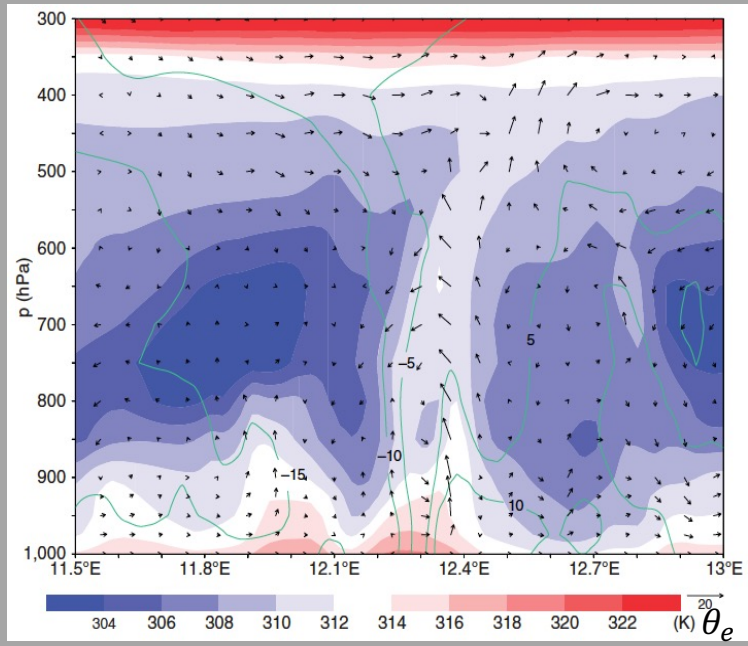
Meteosat, visible channel, ZEO, 14 December 2005, 1200 UTC

Fita and Flounas, 2018: “Despite its importance, it would be delicate to suggest that diabatic heating due to convection is able to sustain the medicane vortex similarly to the **WISHE** mechanism … it is **warm air seclusion** that makes the system to attain a warm core with respect to its environment” (DEC2005 case).

CROSS SECTION ALONG THE CYCLONE CENTER

In both cases symmetric, deep warm core structures but only the first one shows the upward transport of warm/moist air typical of TC
Different contribution of baroclinic versus diabatic processes





CORNELIA (OCTOBER 1996)

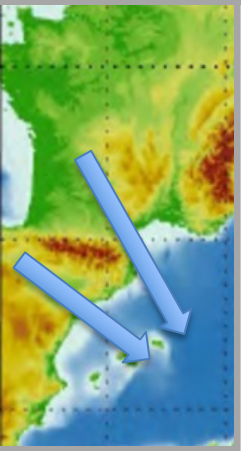
ZEO (DECEMBER 2005)

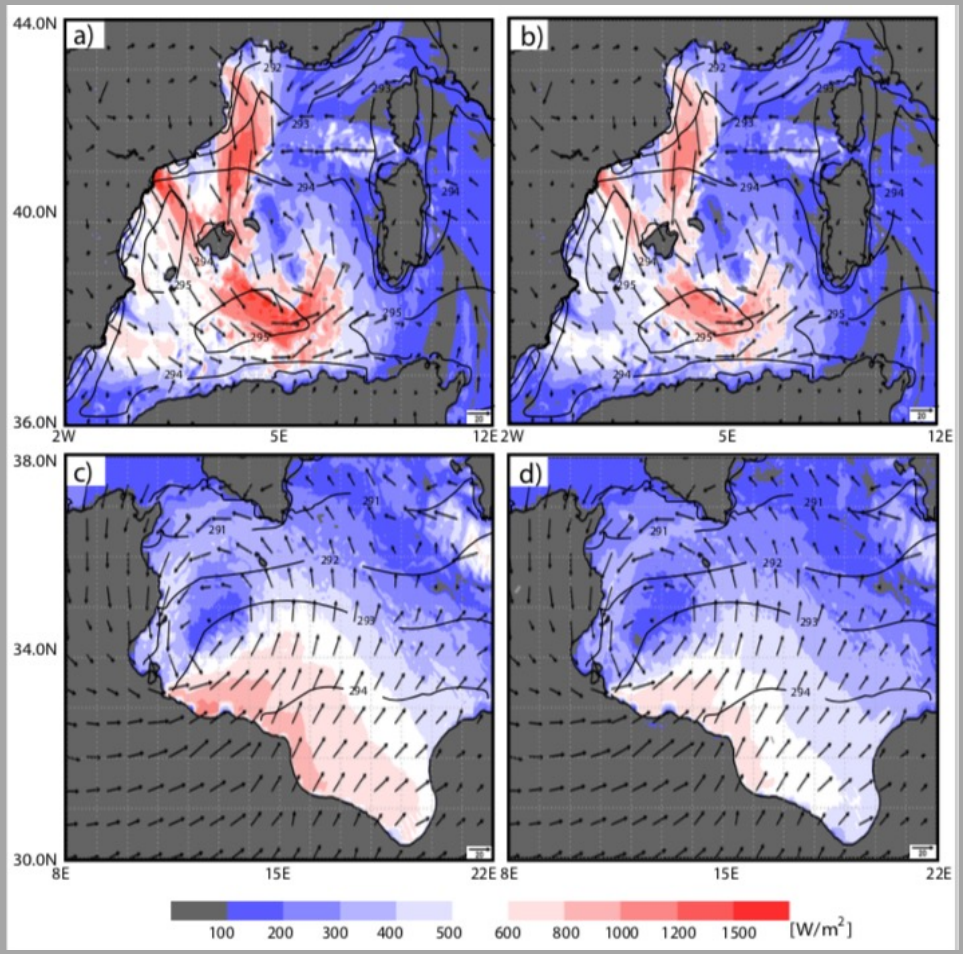
Vertical cross-section of θe (colours), storm-relative winds (vectors), absolute momentum (lines, contour interval=5m/s; zero not shown) near the cyclone centre

Miglietta and Rotunno (2019)

DIFFERENCE IN AIR-SEA INTERACTION

TOTAL SEA SURFACE FLUXES **LATENT HEAT FLUXES**





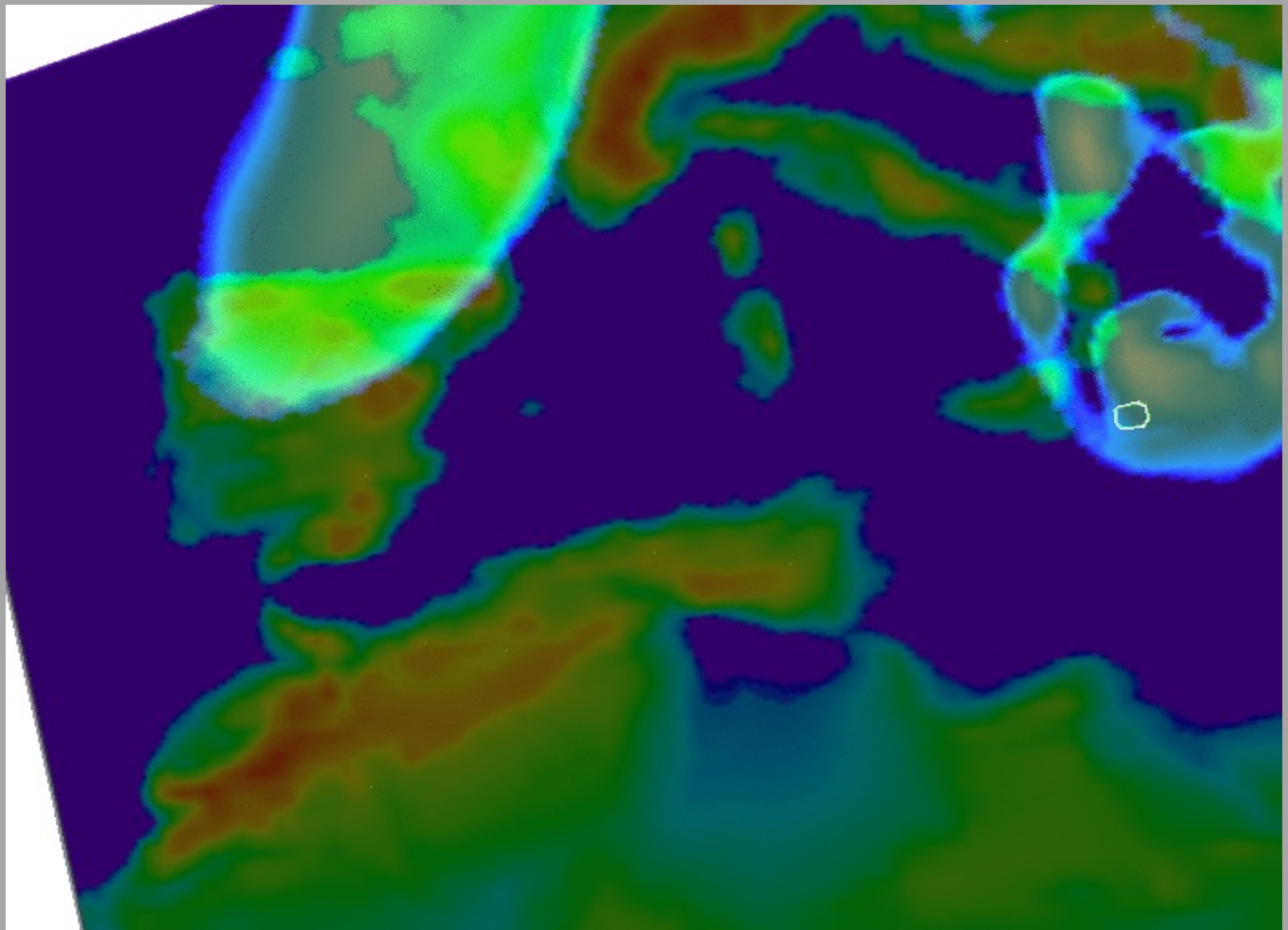
1996 case

0300 UTC
October 7

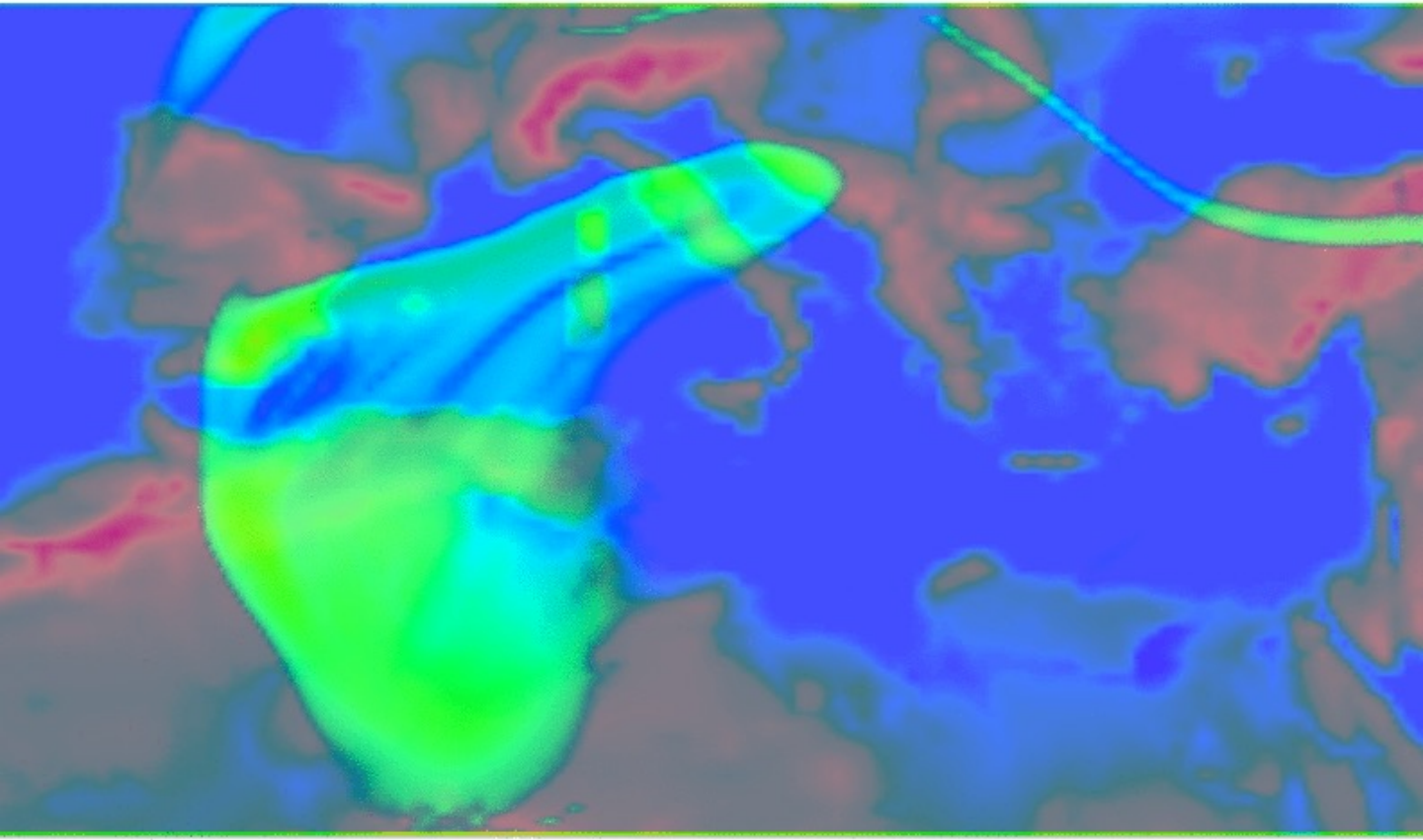
2005 case

0600 UTC
December 14

OCTOBER 1996 CASE: PV @ 9000 m; mslp

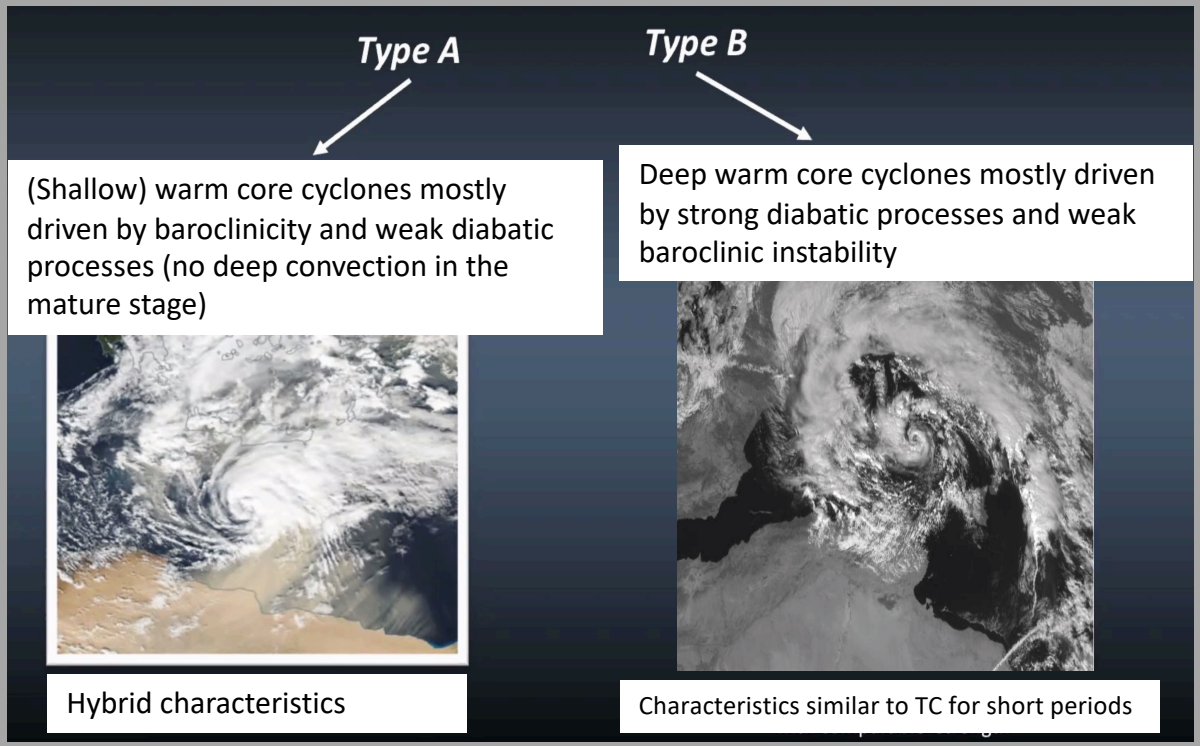


DECEMBER 2005 CASE: PV @ 9000 m; mslp



The term “medicane” has been used to cover a wide range of the continuum existing between ECs and TCs.

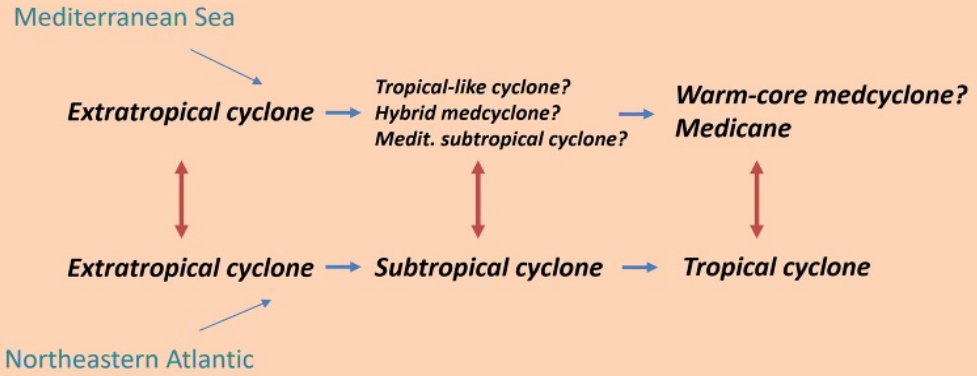
A classification in **categories** was proposed, depending on the dominant process in the mature stage.



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

Toward a definition of Medicanes

- The main idea/hypothesis:

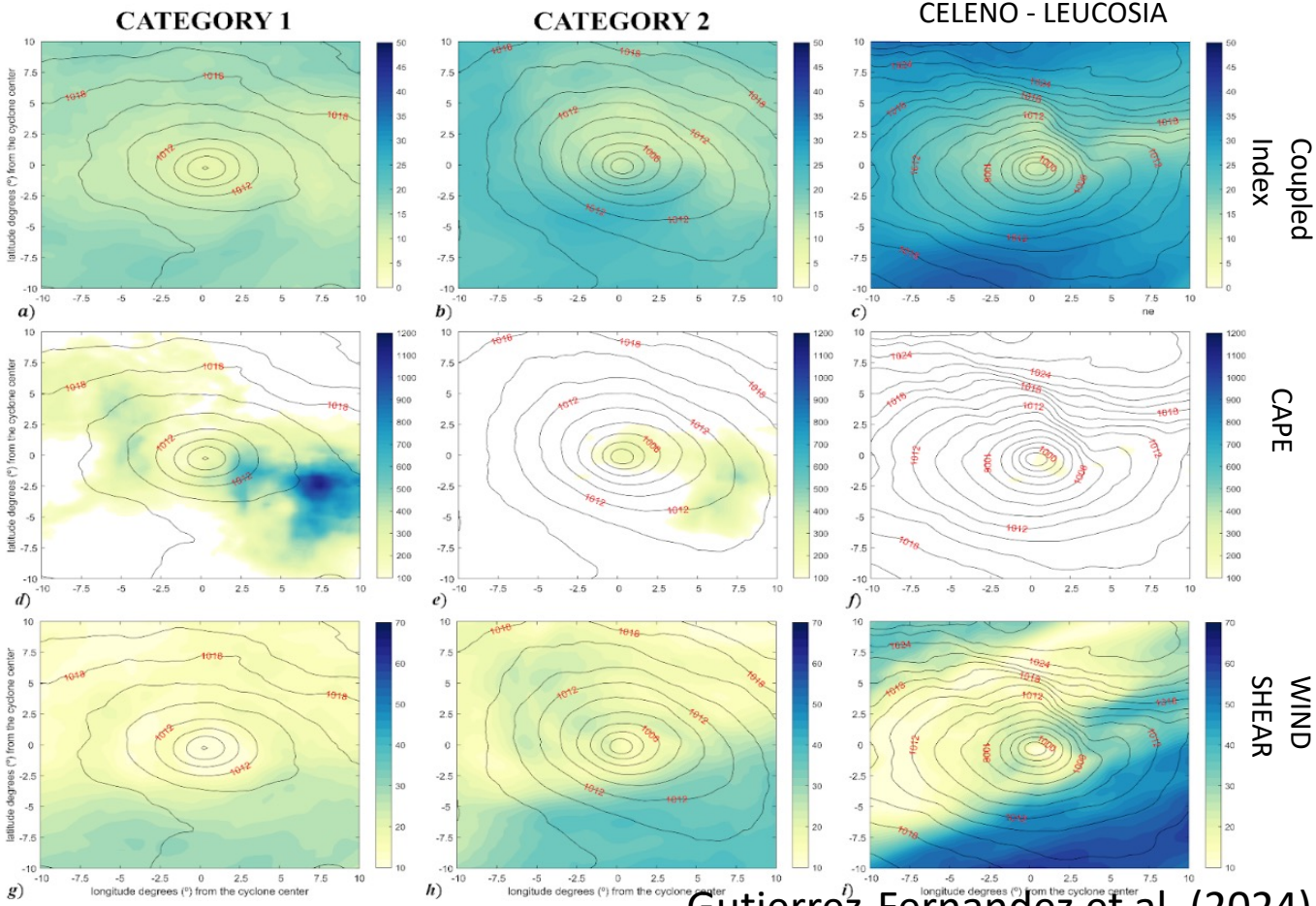


Courtesy: J.J. González-Alemán

Toward a definition of Medicanes

For Mediterranean cyclones one may sustain what Emanuel and Rotunno (1989) noted for polar lows: “there is evidently more than one mechanism operating …, although one mechanism may dominate the other in a particular circumstance. One of these mechanisms is certainly **baroclinic instability** while the other(s) involve … **air-sea interaction**.”

COMPOSITE AT MATURE STAGE



Gutierrez-Fernandez et al. (2024)

TENTATIVE DEFINITION:

- A Medicane is:

(DIMENSIONS) a mesoscale cyclone whose horizontal scale ranges from several tens to some hundreds of km

(WHERE) developing over the Mediterranean Sea

(INTENSITY) whose 10-m wind speed reaches gale force

(MECHANISM) that, in its mature stage, derives most of its energy from convective redistribution of heat acquired from the air-sea interaction, as TCs

(CHARACTERISTICS) weak or absent lightning activity, a symmetric deep warm core, a front-less structure, a closed eye in its center with spiral cloud coverage around are observed in its mature stage.

Medicanes should be differentiated from weaker Mediterranean STC, for which:

- a cloud dense overcast is absent;
- receive a significant part of their energy from baroclinic sources;
- have a radius of maximum wind relatively far from the center (about 100 km vs some tens of km).

Acknowledgements

- COST action CA19109 - MEDCYCLONES “European network for Mediterranean cyclones in weather and climate”
- “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
- TROPICANA (TROPIcal Cyclones in ANthropocene: physics, simulations & Attribution)