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About tropical-like cyclones in the Mediterranean: the Ionian Sea case of 28-29 September 2018

Agustí Jansà[1], J. Campins[2] D. Carrió[1], V. Homar[1], M.A. Picornell[2], A. Maimó[1], C. Ramis[1] i R. Romero[1]
[1] Universitat de les Illes Balears (UIB), Palma (Spain)
[2] Spanish State Meteorological Agency (AEMET), Palma (Spain)
e-mail: agusti.jansa@gmail.com

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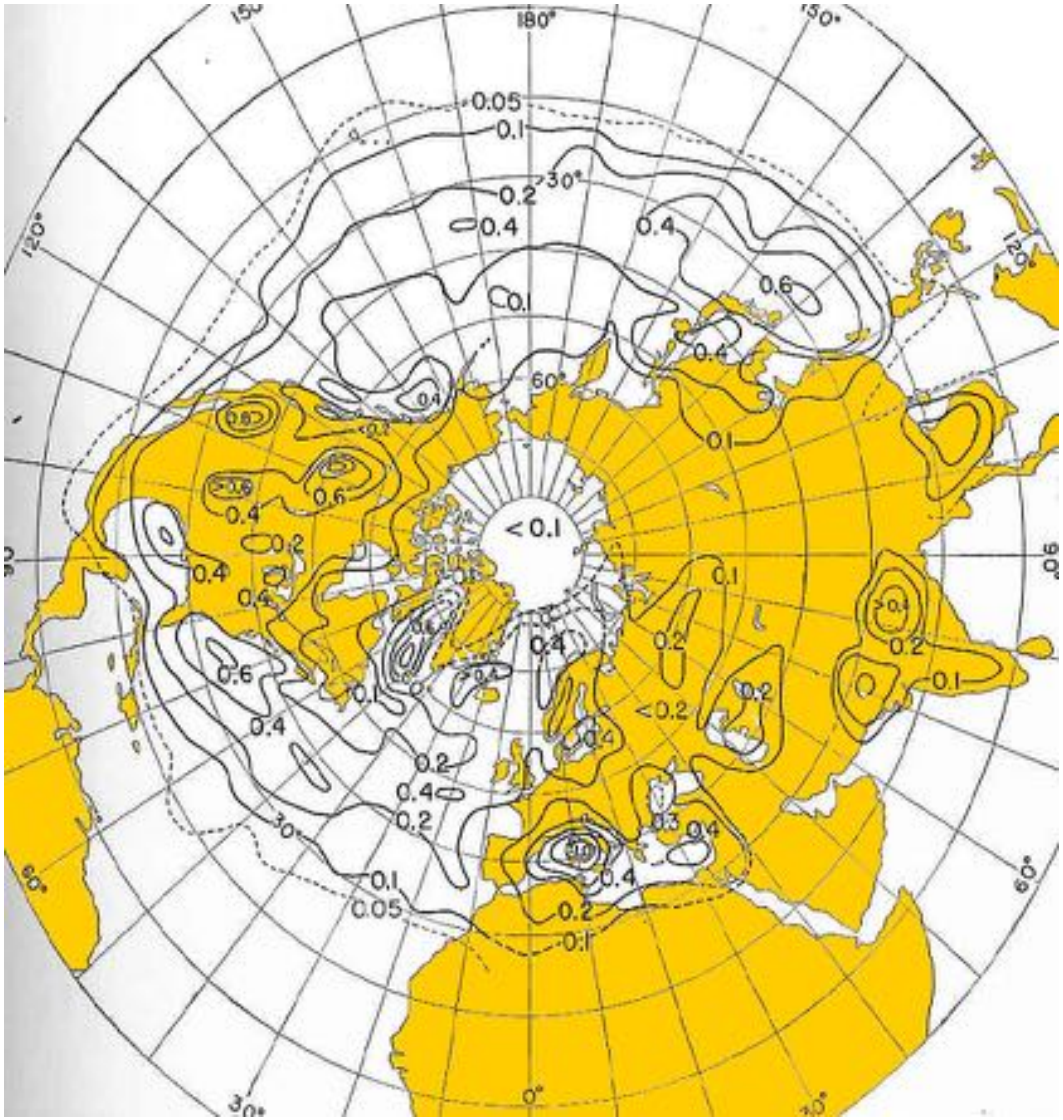
In this presentation:

-Introduction: A review about Mediterranean cyclogenesis pointing to the concept of medicane

-Diagnosis of the Ionian sea medicane of 28-29 Set 2018 (Zorbas):
- -Satellite
- -On land trace
- -Analysed fields
- -Thermal structure

-Predictability
- -EPS
- -Deterministic forecasts
- -Non latent heat release forecast

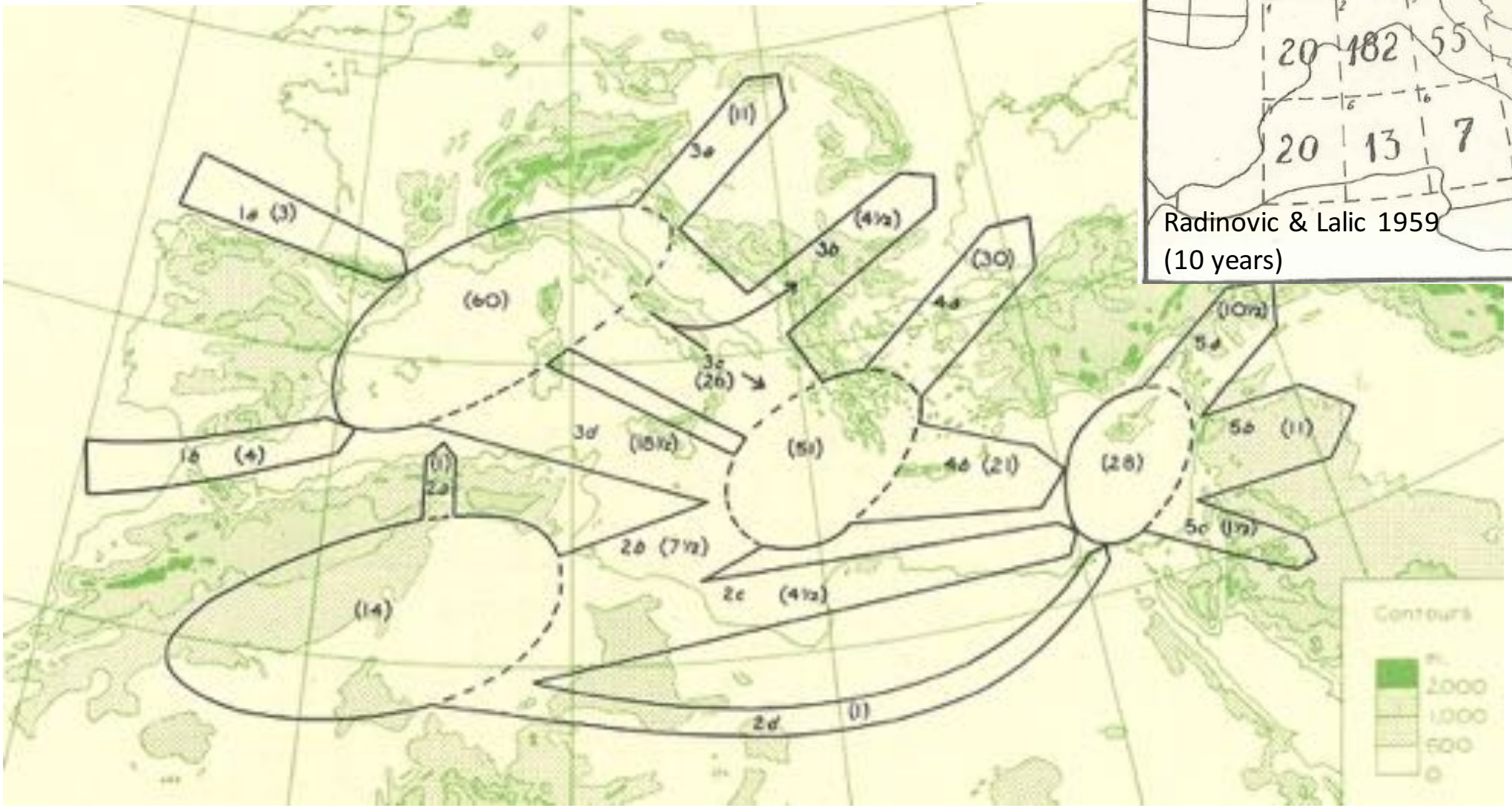
A well known fact:
The Mediterranean is a cyclogenetic region



Frequency of cyclogenesis, winter (*Pettersen, 1956*)

Met Office 1962

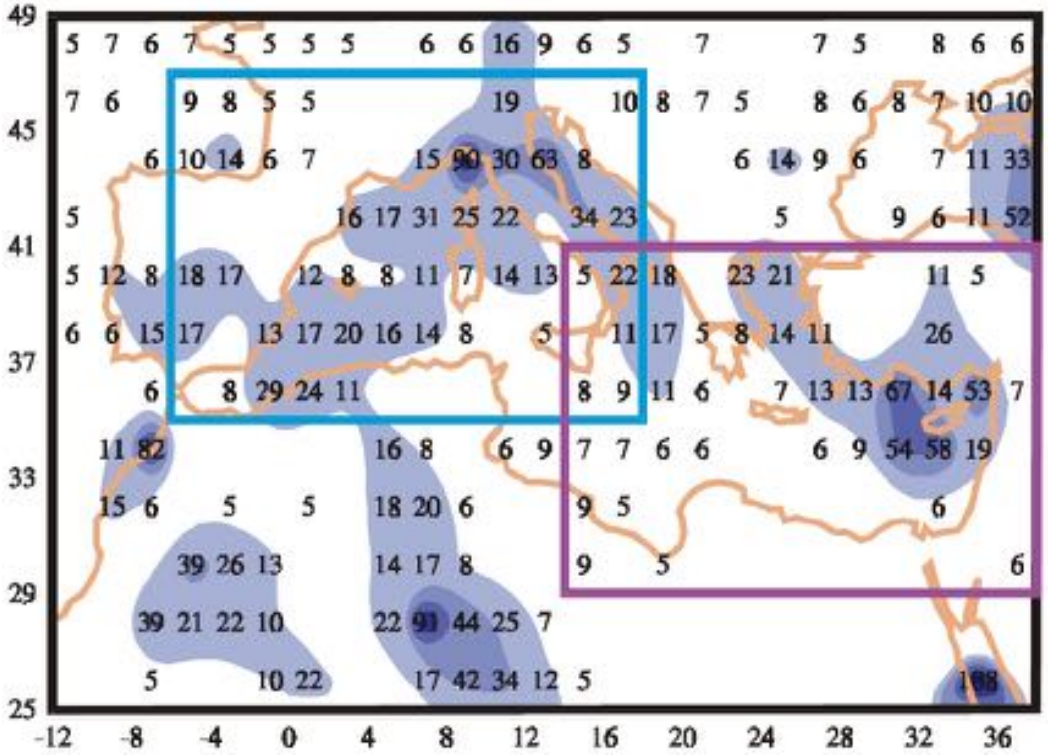
Cyclonic frequency and shifting *(relatively large/intense cyclones, hand analyses)*



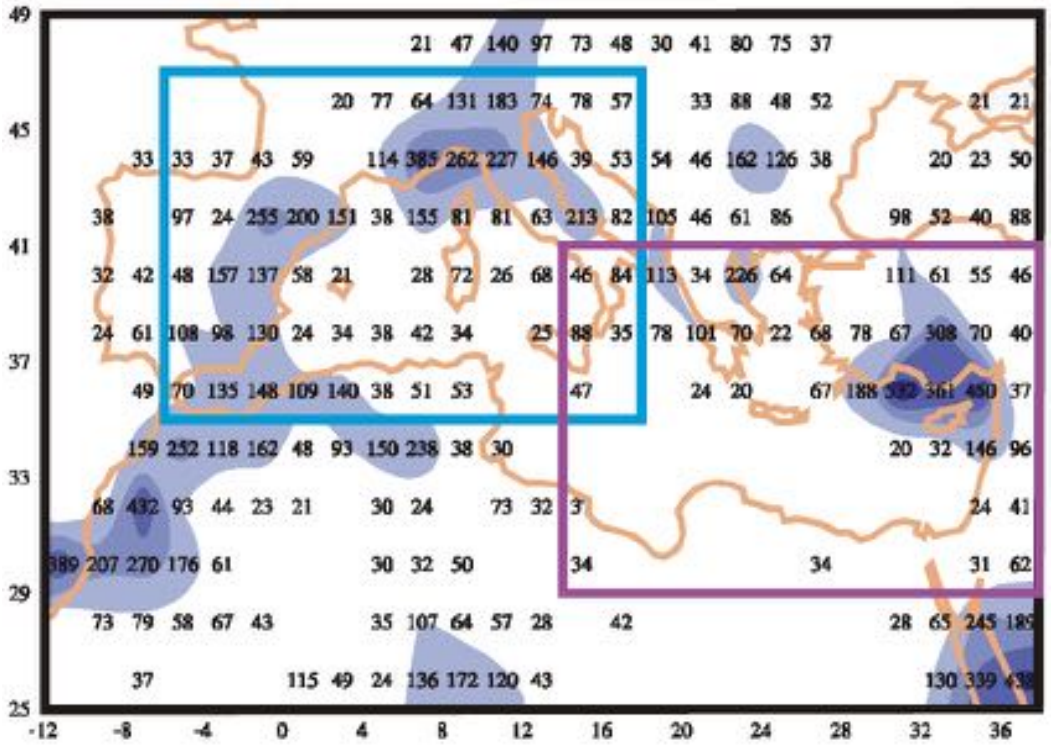
Radinovic & Lalic 1959
(10 years)

How many are the cyclones in the Mediterranean?

It depends on the cyclone definition and on the analyses resolution



Smoothed ECMWF analyses: **437** cyclonic centres/ year



ECMWF analyses, no smoothing: **2910** cyclonic centres/ year

(from *Gil et al., 2003*)

Cyclones with a gradient of at least 0,5 hPa/100 km, detected with smoothed ERA-40 fields: 45 years, 81762 detections (50000 cyclones: 1000 cyclones/year)

CLIMATOLOGY OF MEDITERRANEAN CYCLONES USING THE ERA-40

(Campins, Genovés, Picornell, Jansa, 2011)

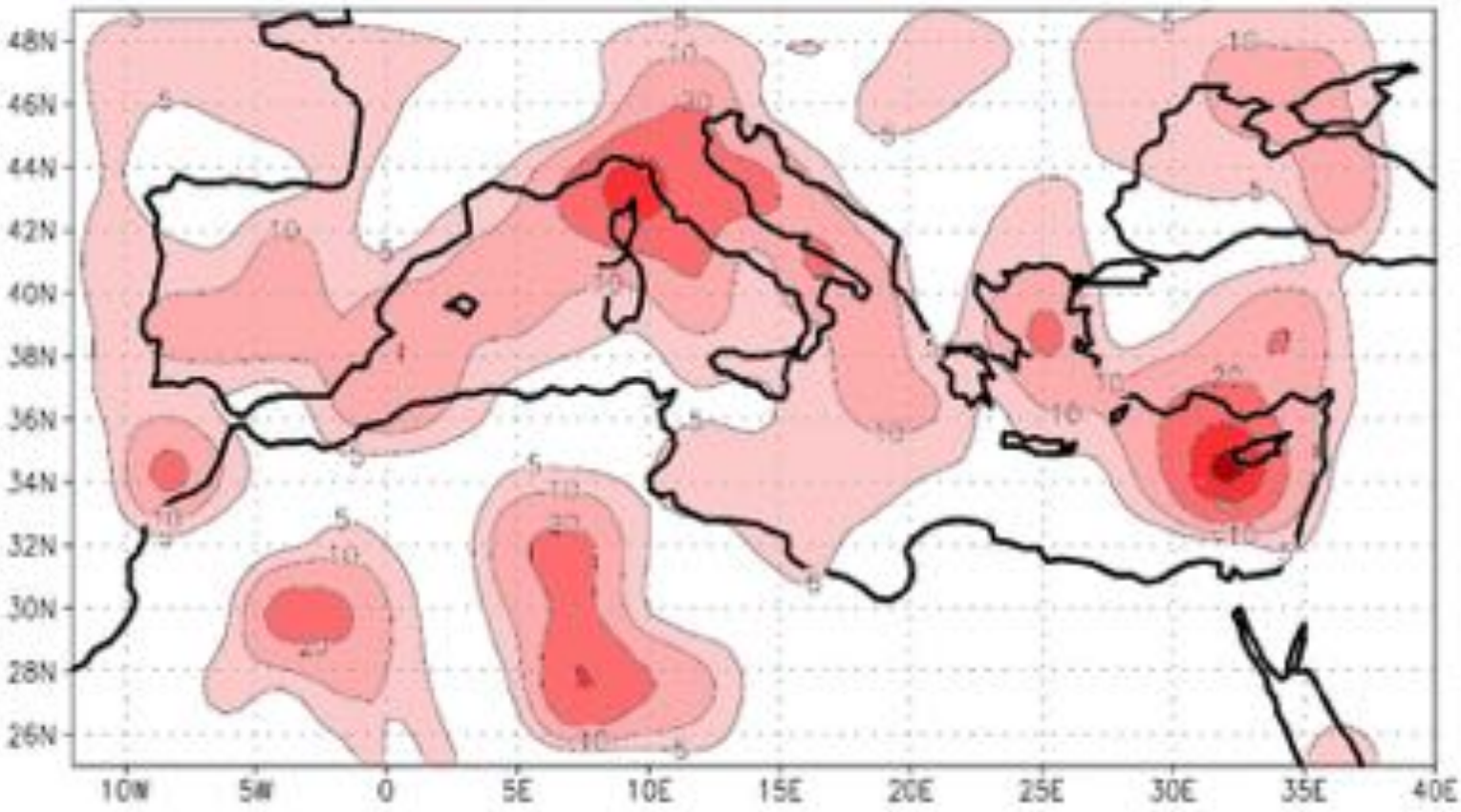
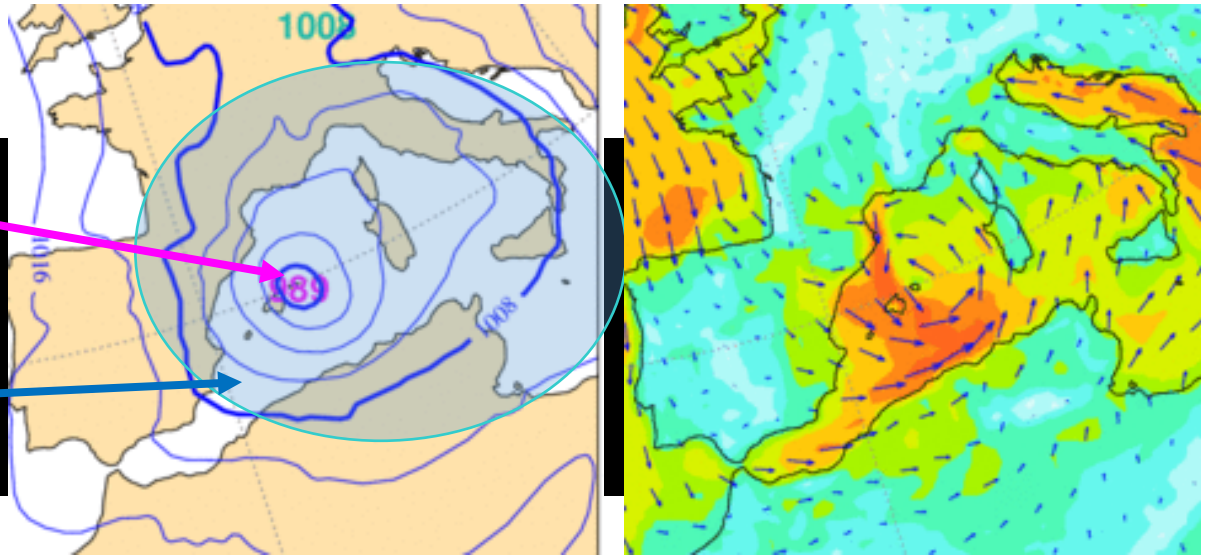


Figure 2. Mean number of cyclone centres in 2.25° × 2.25° latitude–longitude boxes. Contour intervals: 5, 10, 20, 40 and 60 centres/year.

If the “intensity” of a cyclone is defined by the “total geostrophic circulation”

“Cleopatra cyclone”

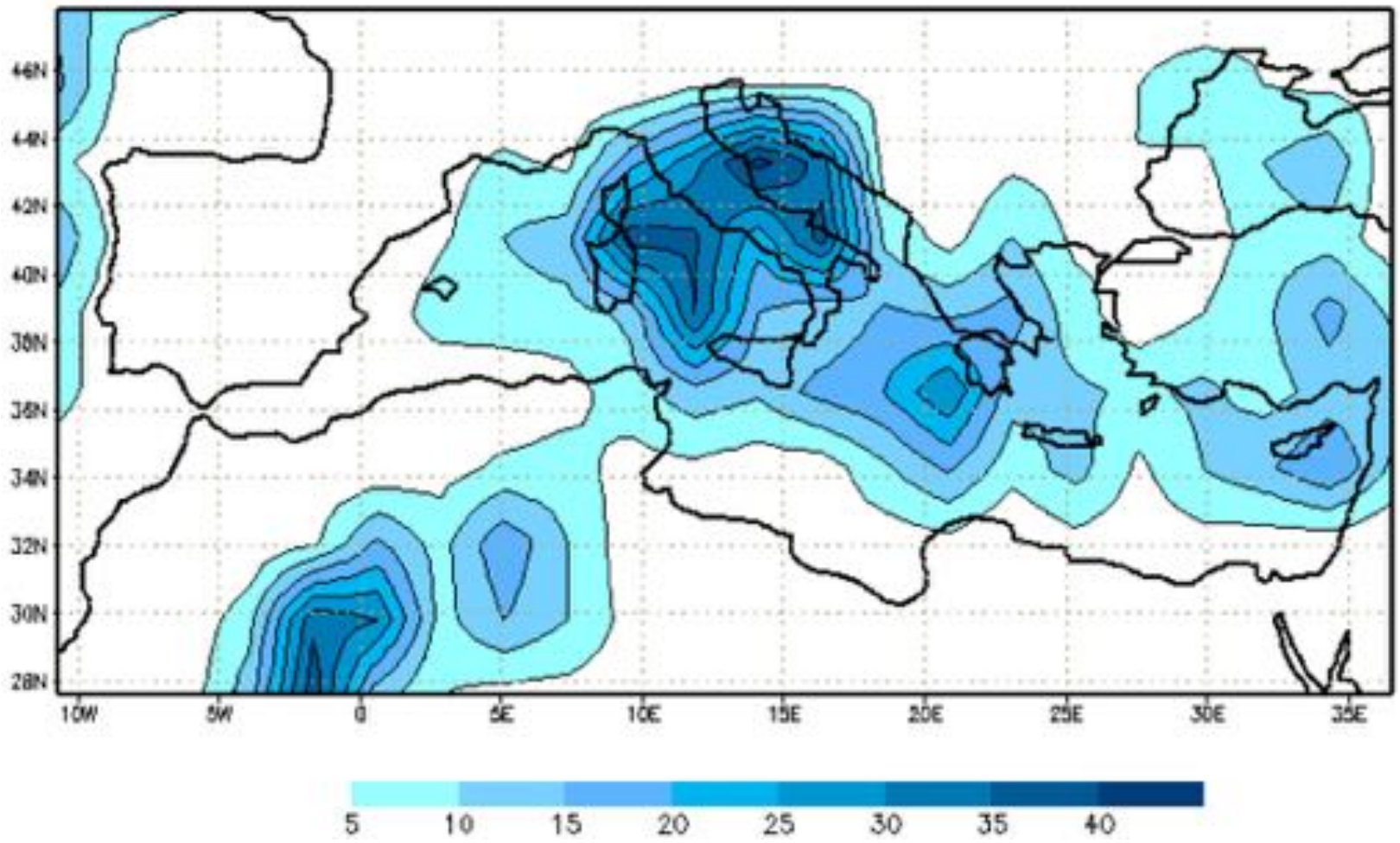
Its domain (A)



$TGC = {}^{avg}\zeta_g \times A$

(1 GCU = 10^7 m^2 s^{-1}, “Cleopatra” ~ 10 GCU)

	Picornell et al. 2001 (no smoothing, high resolution)	Campins et al. 2011 (smoothed, low resolution)
< 2 GCU (weak)	53 %	8 %
> 6/7 GCU (intense)	7% (6 GCU)	6% (7 GCU)



Intense cyclones, defined as cyclones with a GC >= 7 GCU (= 10^7 m^2 s^{-1}) / >= 24 h duration
About 30 per year

(elaborated by Campins, published in Homar et al., 2007)

Note that if the **cyclone intensity** is defined by the **total circulation** the size of the domain is important:
Small cyclones would not never be intense cyclones:
total circulation in **the so called Mediterranean tropical-like cyclones or medicanes would be only moderate** cyclones.

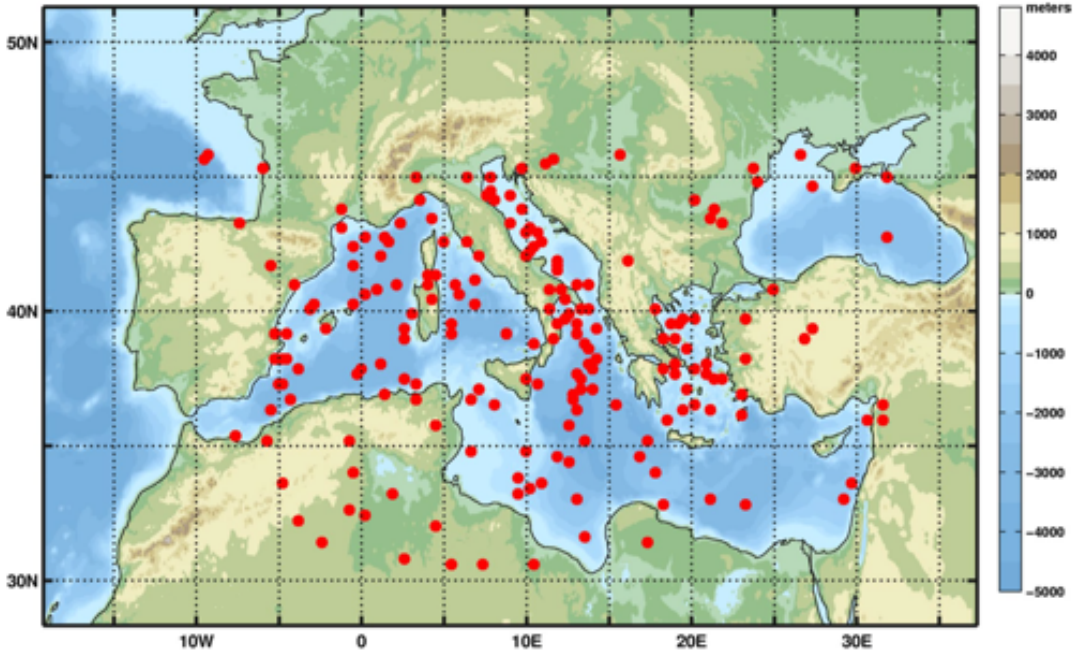
Alternative criteria, like **central vorticity, central pressure gradient or sustained wind speed** would be considered

Mediterranean cyclones can be weak and shallow disturbances (most of them) or can develop into **intense and deep** cyclones.

Which is the way to do that?

Secondary cyclogenesis **baroclinically** driven (extratropical typical development) is the most frequent way for an incipient cyclone to become intense, but a **continuous spectrum** of development can be identified:

Extratropical cyclone → *Hybrid/Subtropical* → *Tropical-like*
Baroclinic → → → → → → → → → → Diabatic (latent heat release)

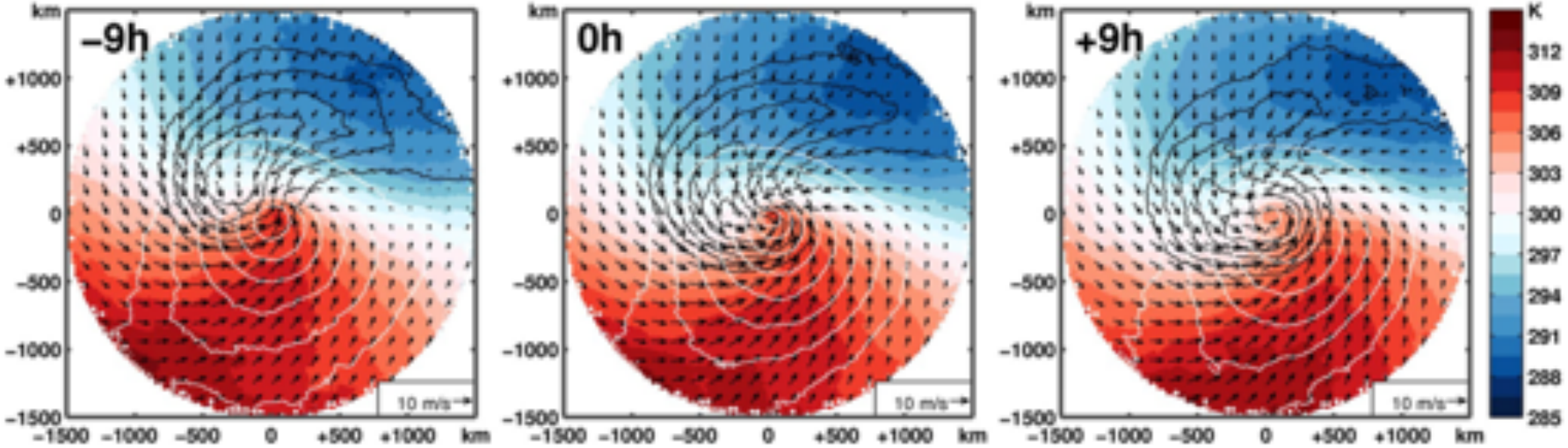


Most of the intense Mediterranean cyclones seem to be baroclinically driven

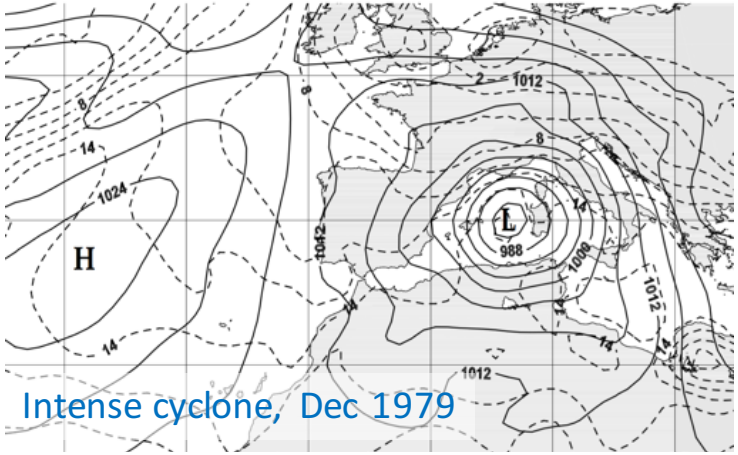
200 most intense cyclones, defined by the 850 hPa relative vorticity (size independent):

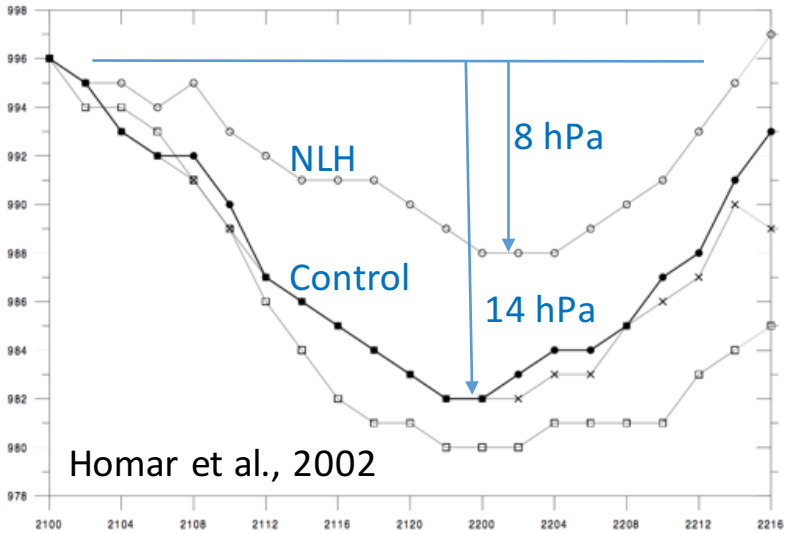
850 hPa composite PT and wind

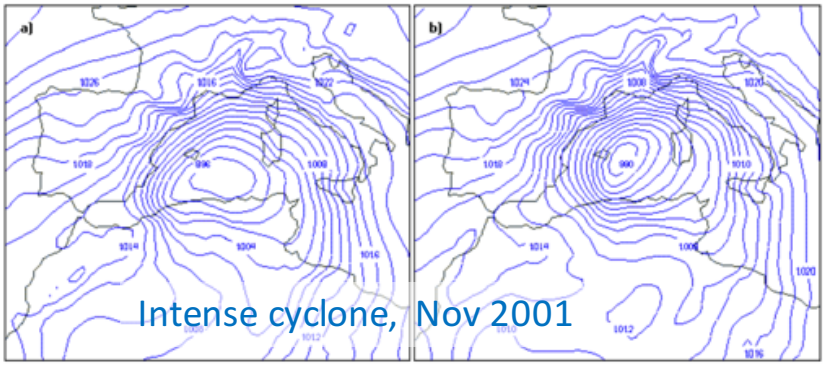
Flaounas et al., 2014

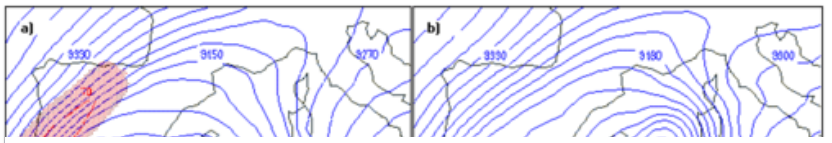


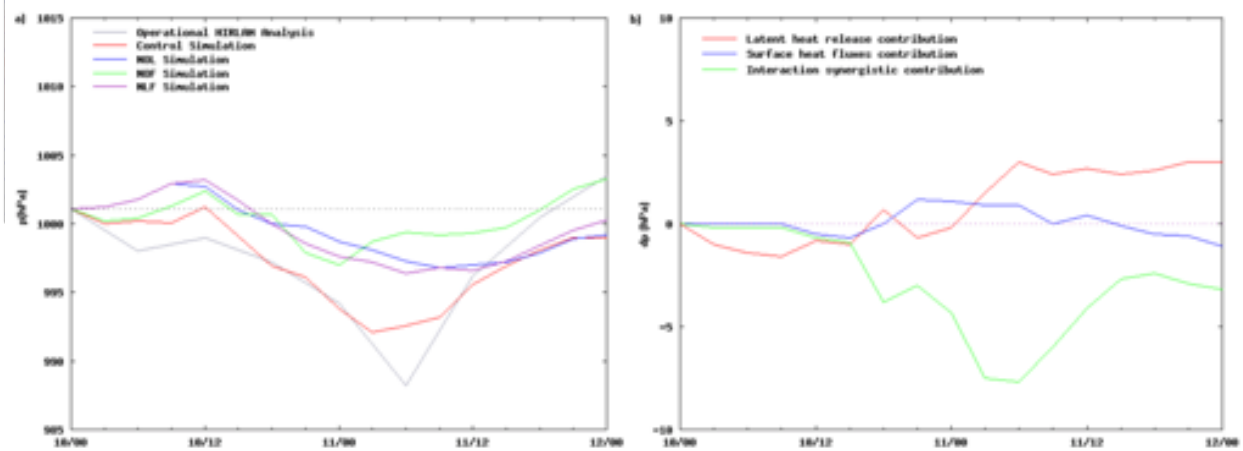
Nevertheless, in some cases of large scale intense cyclone the diabatic factor has been demonstrated to be, not the main, but a significant ingredient of the cyclogenesis.











Genovés & Jansà, 2003

Baroclinic contribution present –upper air vorticity advection with significant upper air wind-, until vertical alignment of low and upper level low.

Diabatic contributions (LH+SF) also present: their interaction is important

About the cyclogenetic mechanism of intense Mediterranean cyclones, there is a *continuous spectrum:*

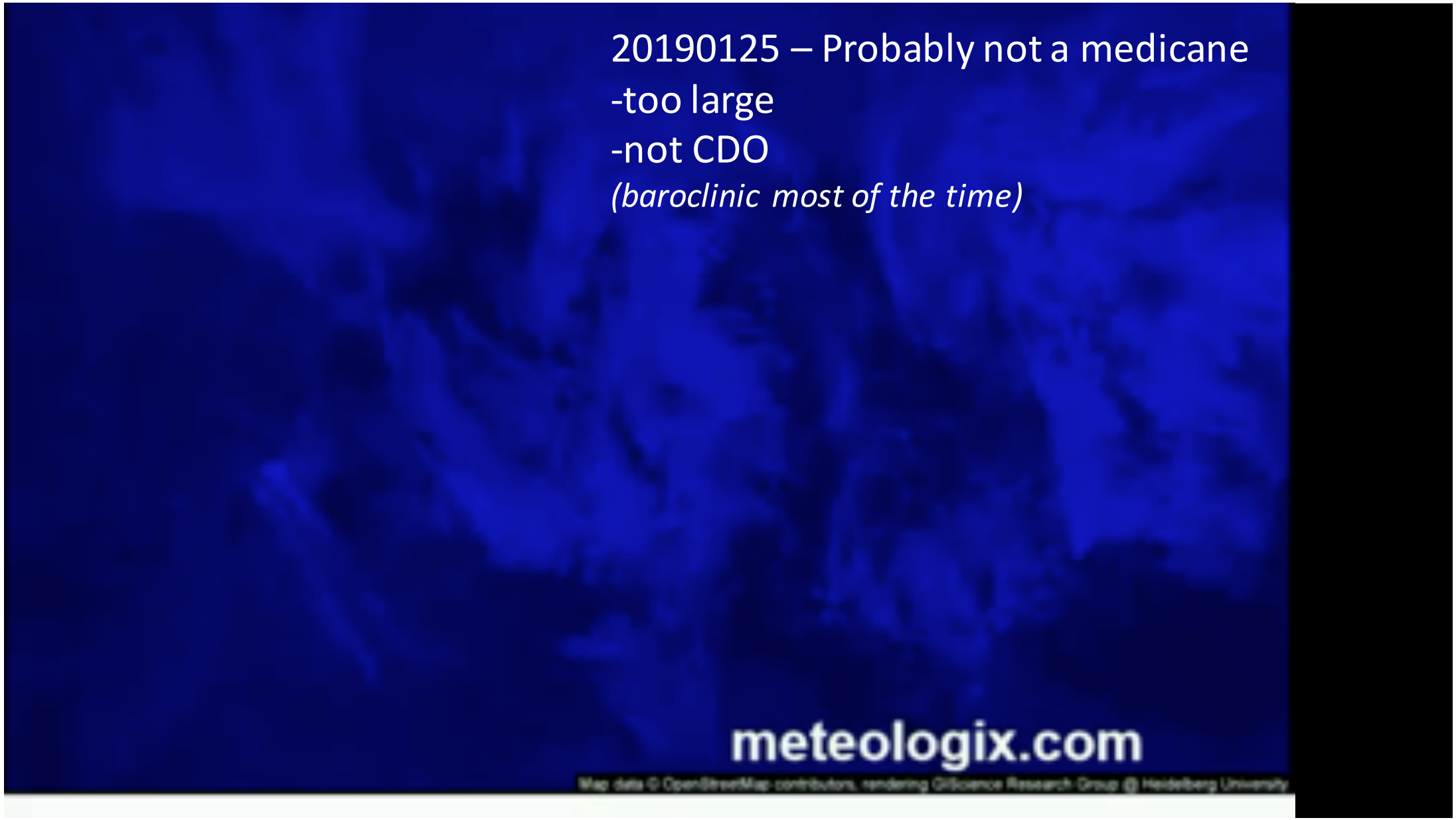
Extratropical cyclone → *Hybrid/Subtropical* → *Tropical-like*
Baroclinic → → → → → → → → → → Diabatic (latent heat release)

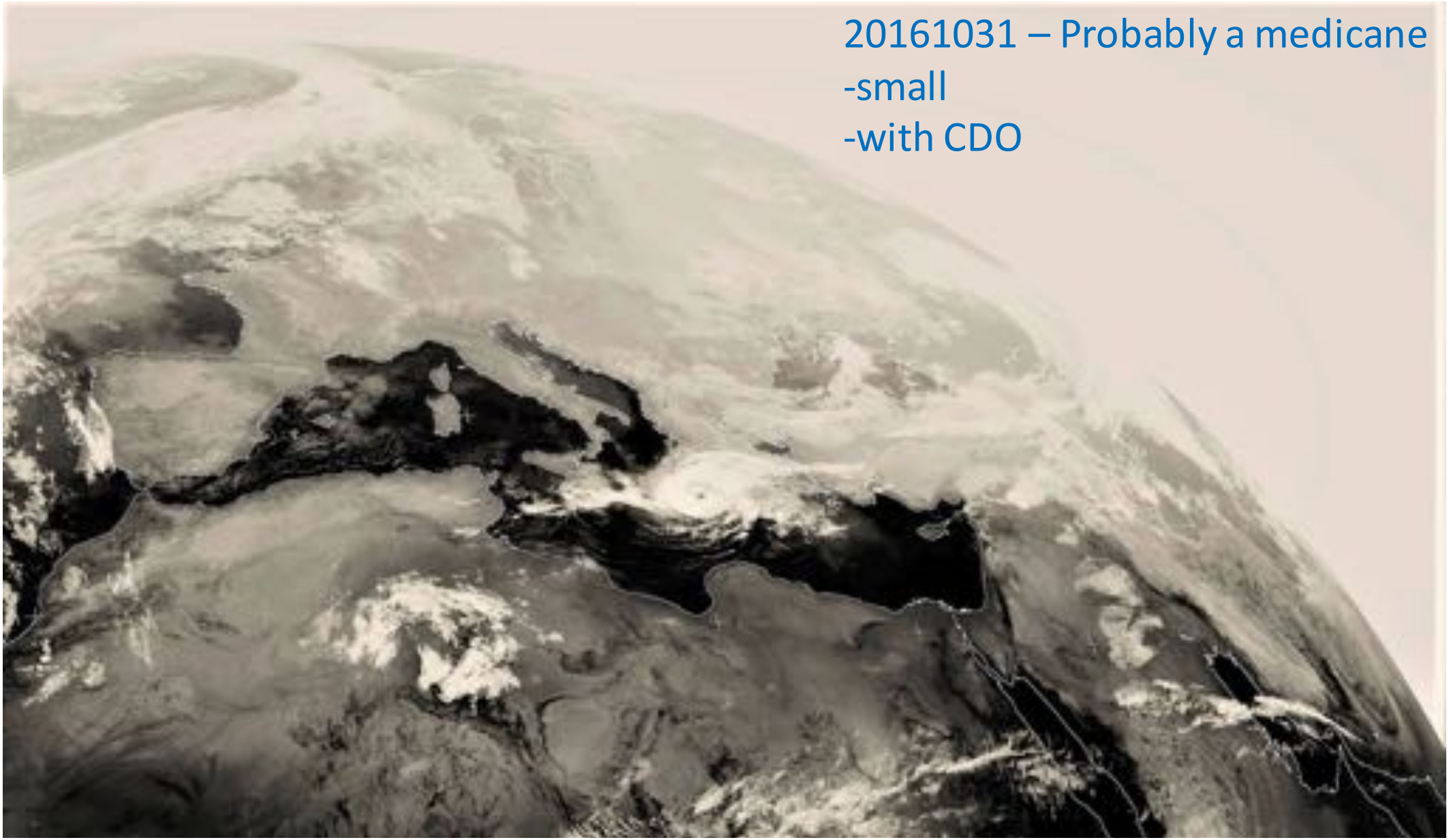
What a *medicane* is ?
(*Medicane* = Mediterranean tropical-like cyclone, warm core cyclones, mini-cyclone)

Central dense overcast (CDO, according glossary NHC) (Tous & Romero, 2011, 2013; see Dvorak, 1975)
Characterisation (size, gradient, wind: ⌀ < 300 km, 1 hPa/10 km, w > f8, f10, f12 B) (Jansà, 2003)
Thermal structure (Hart diagrams: warm/warm/symmetric?) (Picornell et al., 2014, among other)
Cyclogenetic mechanism (purely diabatic? Diabatic process necessary but not enough? Baroclinic/diabatic synergism?)

Two examples of intense Mediterranean cyclones
(provided by González-Aleman, 2019)

Are they medicanes?


20190125 – Probably not a medicane
-too large
-not CDO
(baroclinic most of the time)
meteologix.com
Map data © OpenStreetMap contributors, rendering GIScience Research Group @ Heidelberg University


20161031 – Probably a medicane
-small
-with CDO

What is Zorbas, the Ionian Sea intense cyclone that developed from 27 to 29 September 2018?

Is it a *medicane*?

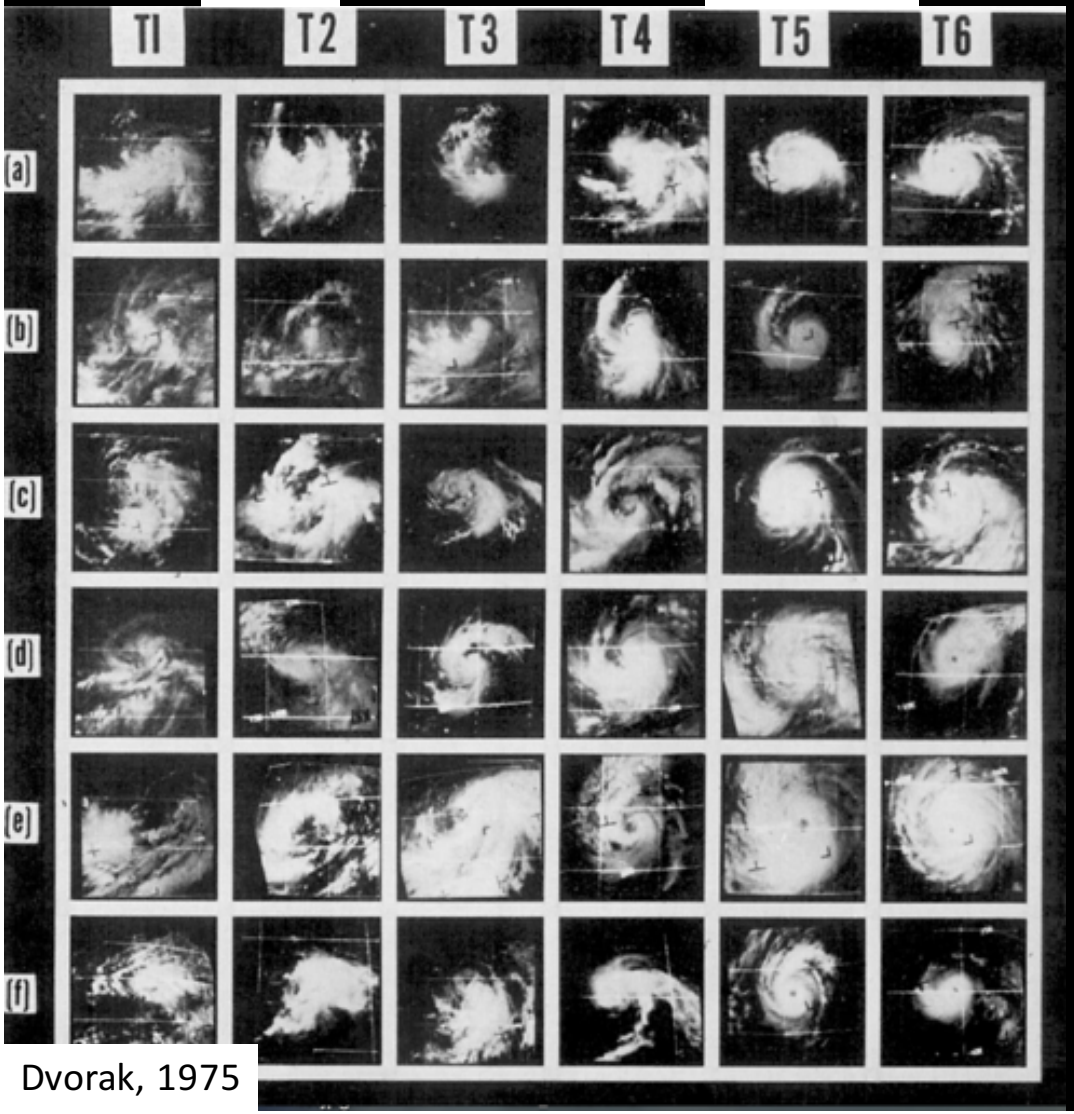
The intense cyclone called Zorbas was in the central Mediterranean and moved mainly in the Ionian Sea on 28-29 Sep 2018, passing across Greece before disappearing. **Was it a Mediterranean tropical-like cyclone or medicane?**

Kalamata Beach (Greece), 29 Sep 2016

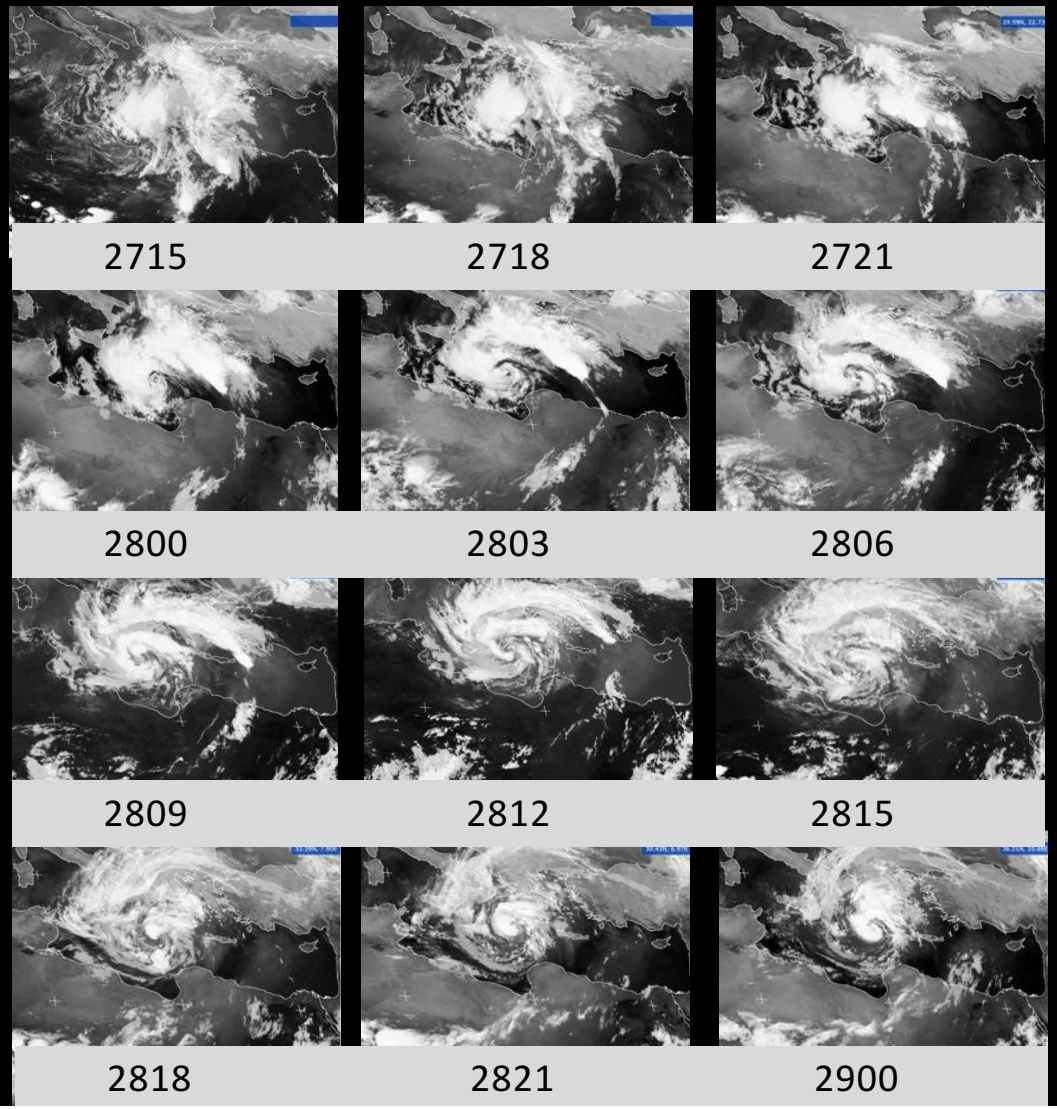
Taken from La Vanguardia (Barcelona)

Destrozos en la playa de Kalamata tras fuertes vientos causados por el ciclón 'medicane' Zorba (Nikitas Kotsiaris / EFE)

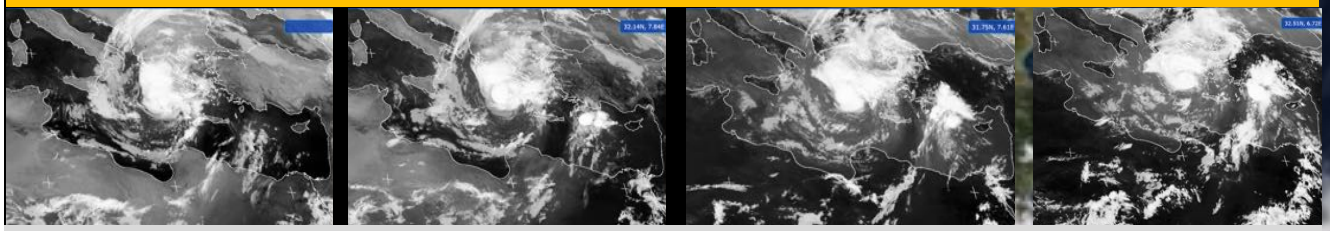
Ionian sea 28-29 Sep 2018 cyclone (Zorbas): Has it a ***central dense overcast***?



Dvorak, 1975



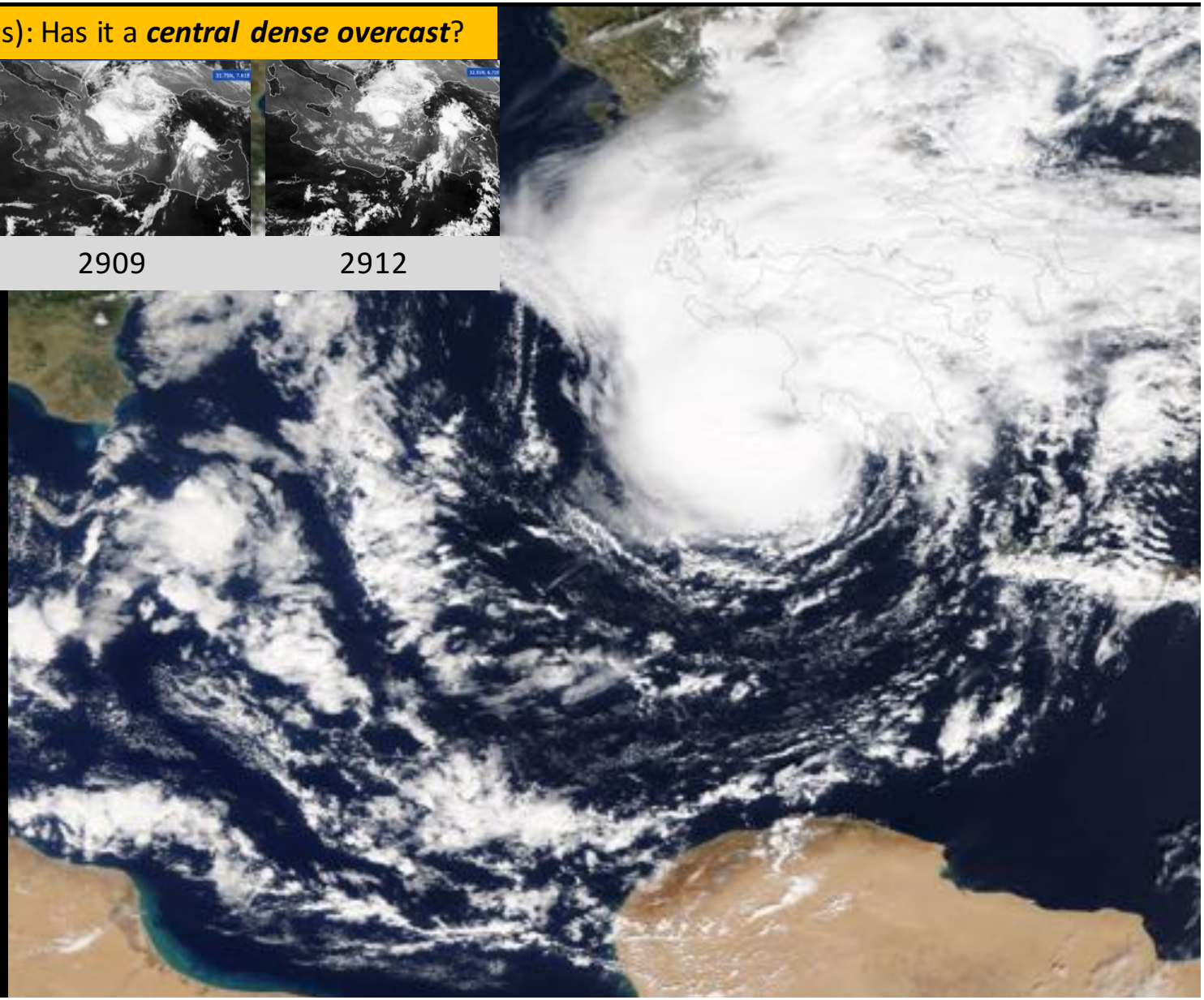
Ionian sea 28-29 Sep 2016 cyclone (Zorbas): Has it a ***central dense overcast***?



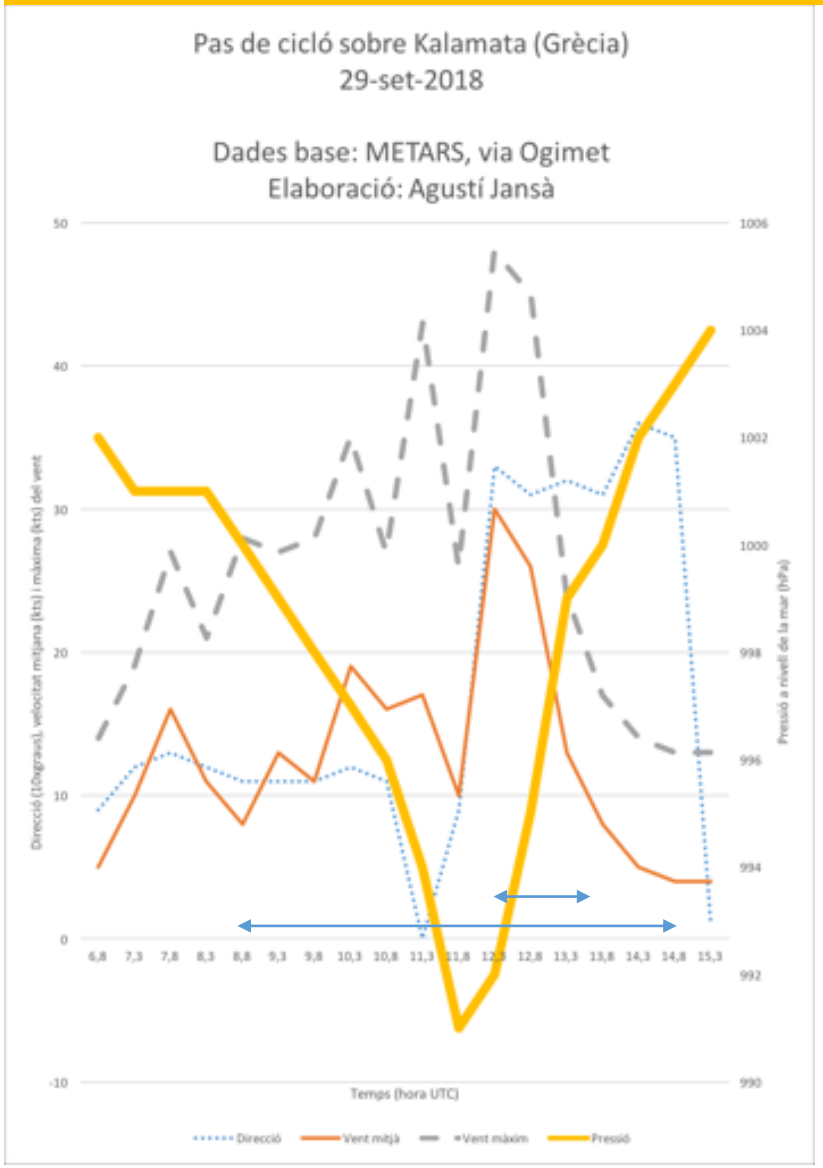
2903 2906 2909 2912

Quite clear **CDO** from 2821 to 2912.

Possible **CDO** by 2800-2806.

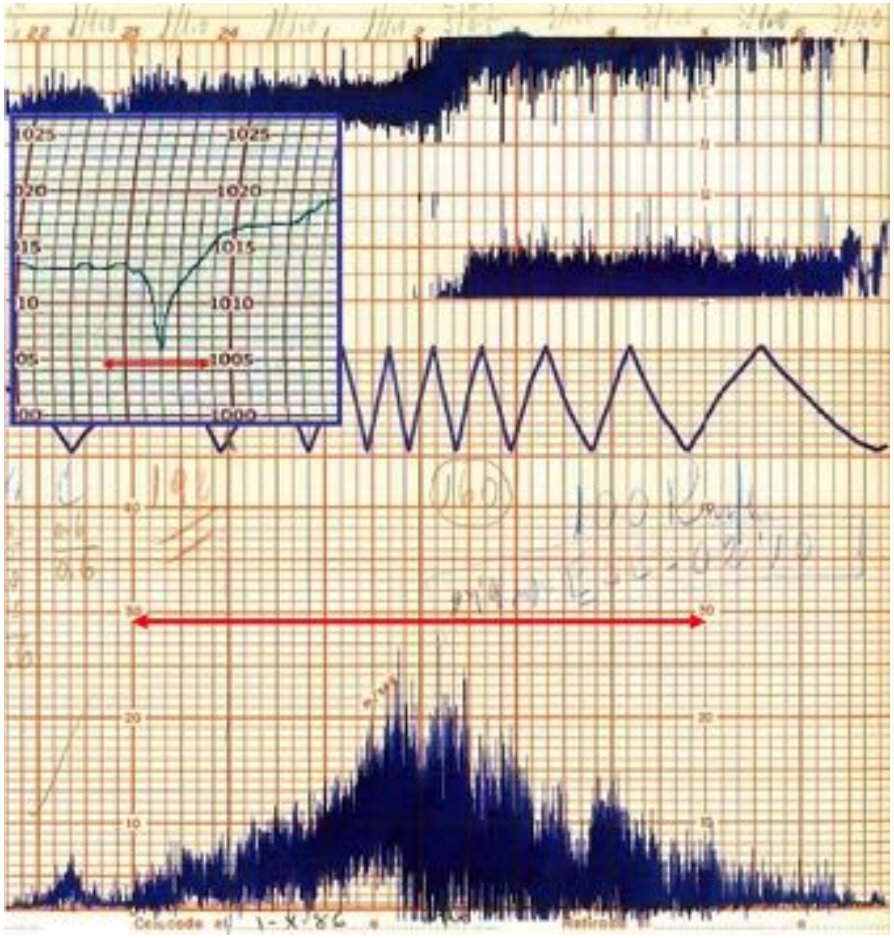


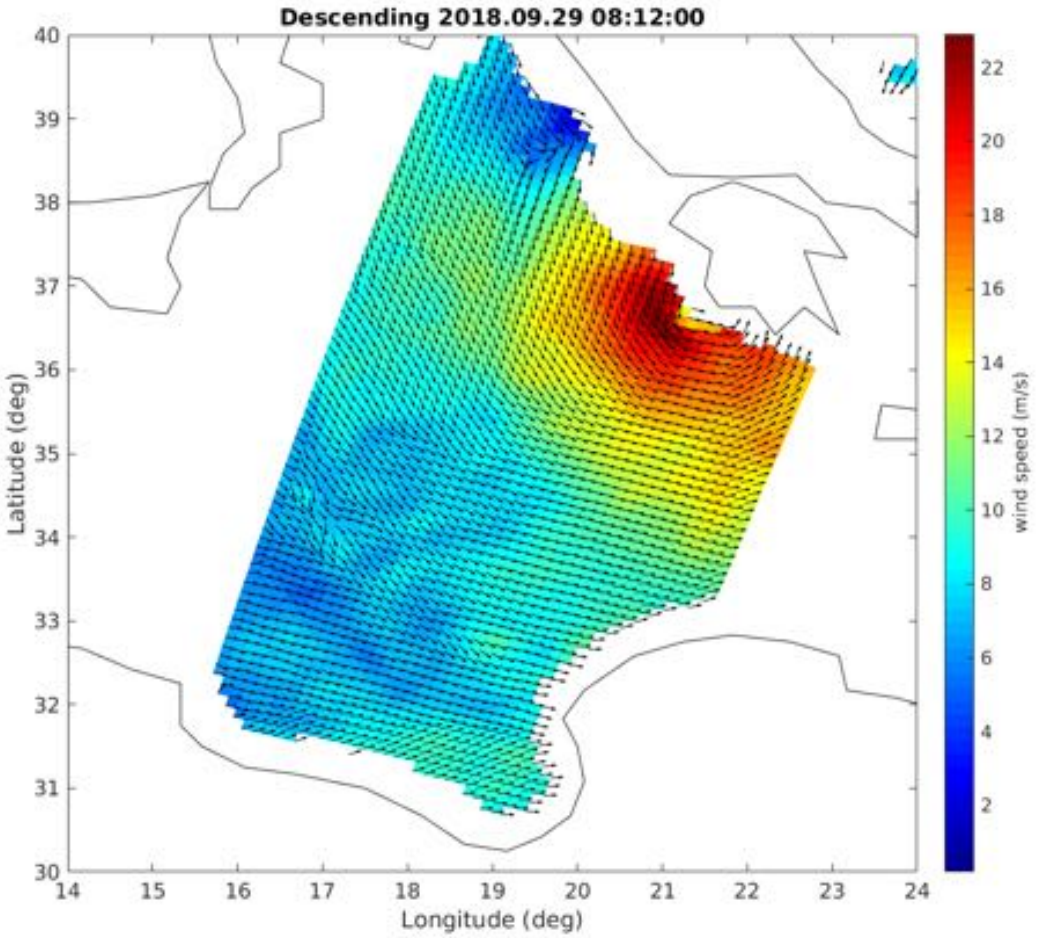
Does Zorba fit a medicane **characterisation (on land trace)?** (size, gradient, wind: ⌀ < 300 km, 1 hPa/10 km, w > f8, f10, f12 B)



Speed of translation (from satellite and tracking based on analyses):
22 km/h → 6 hrs ← → 132 km (⌀ ⍰⍰ 150 km)
Gradient ~ 7 hPa / 1.5 h = 33 km ~ 2 hPa/10 km
Total △p = 13 hPa
Sustained wind (on land):
30 kts
(7 Beaufort)

A comparison:
Tropical-like cyclone in Palma de Mallorca, 2 Oct 1986

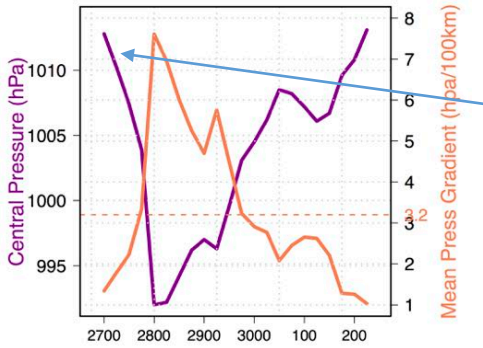




Wind at sea → 22 m/s (8-9 Beaufort)
ASCAT image

(courtesy of Marcos Portabella)

A quick look to the cyclone evolution from ECMWF operational analyses



Baroclinic phase

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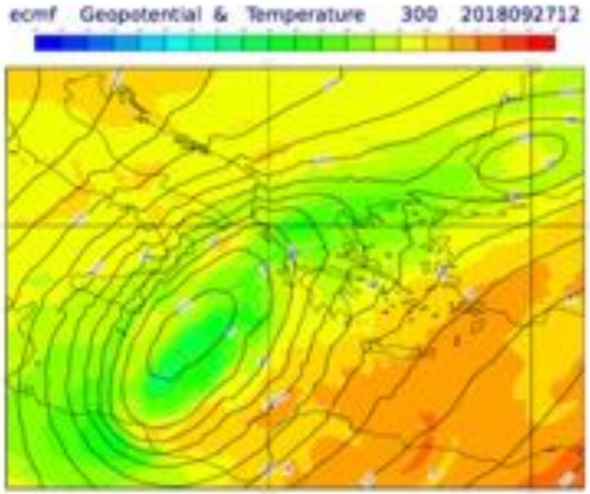
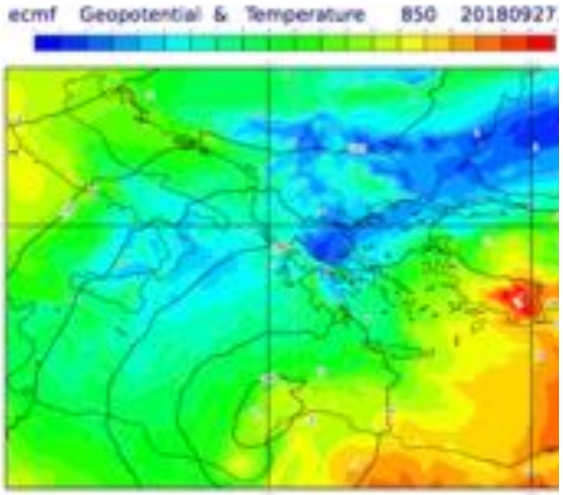
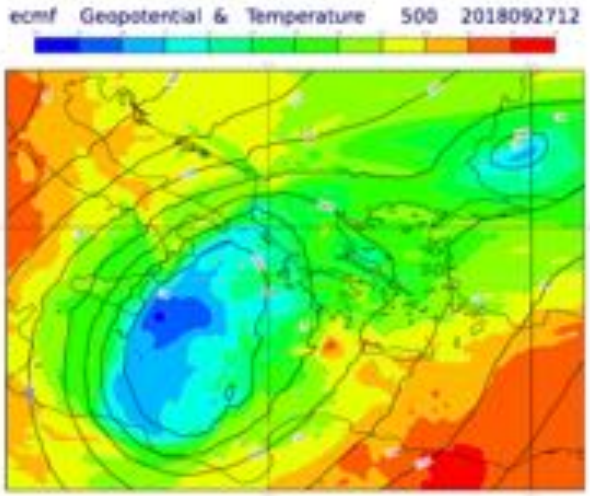
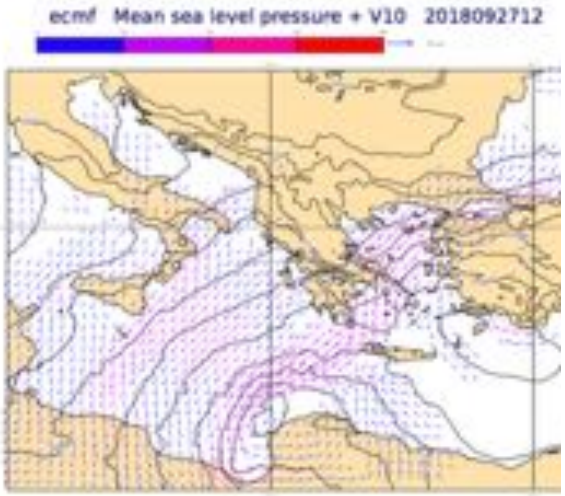
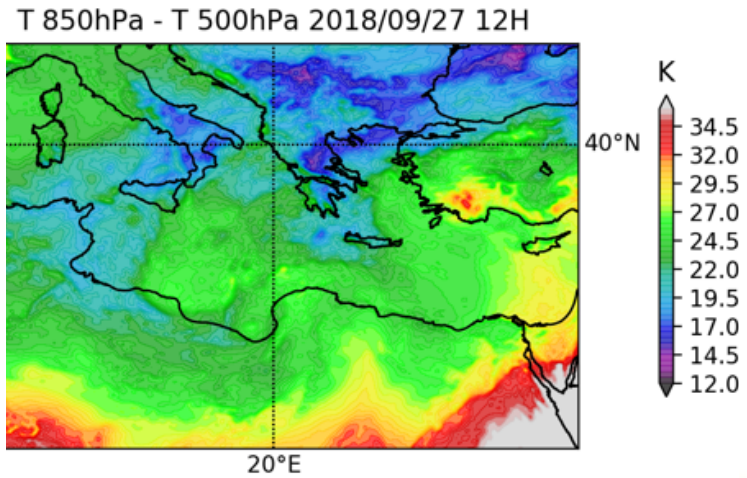


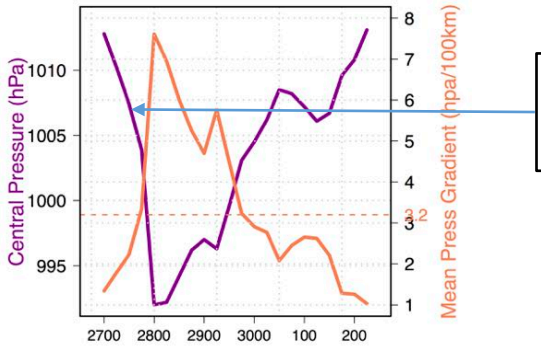




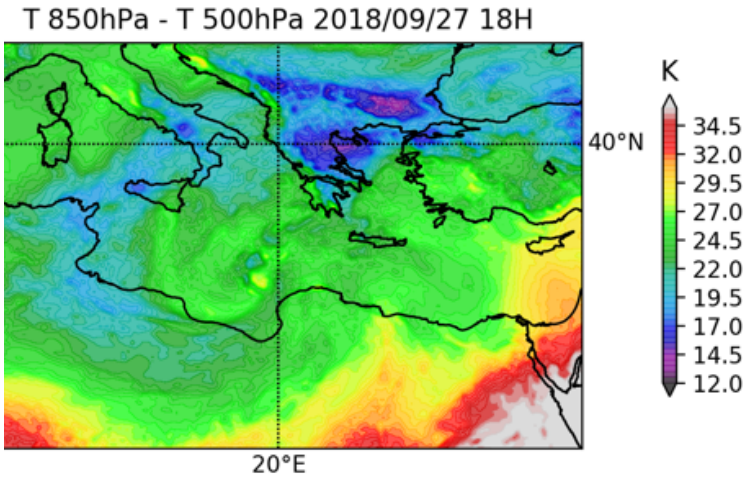




A quick look to the cyclone evolution from ECMWF operational analyses



Baroclinic phase



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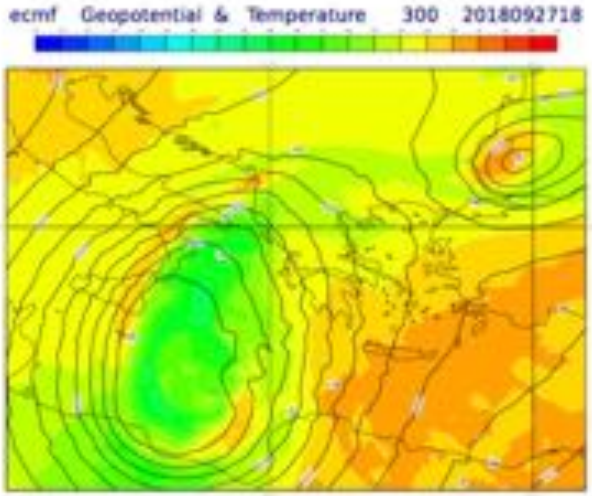

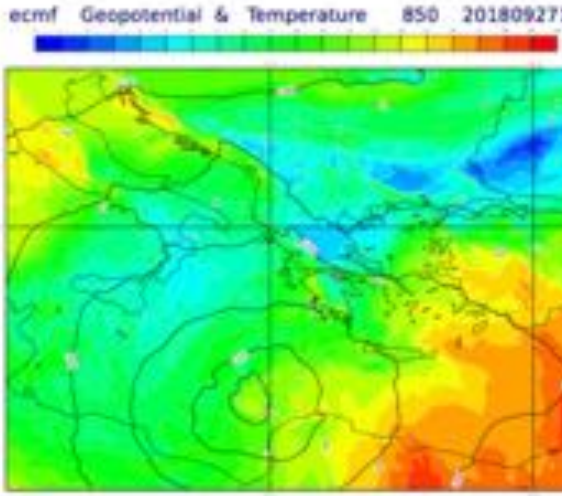

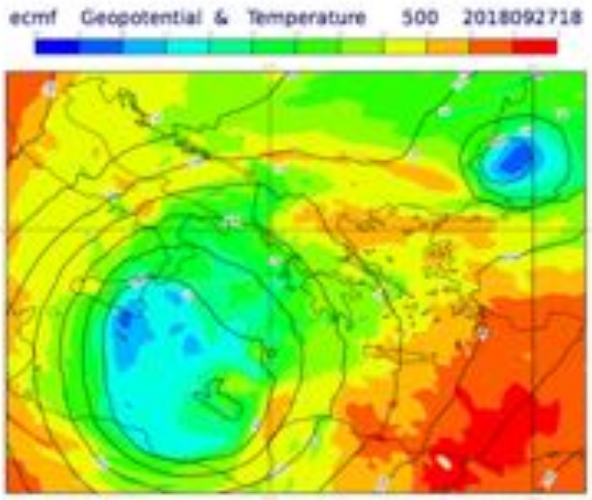

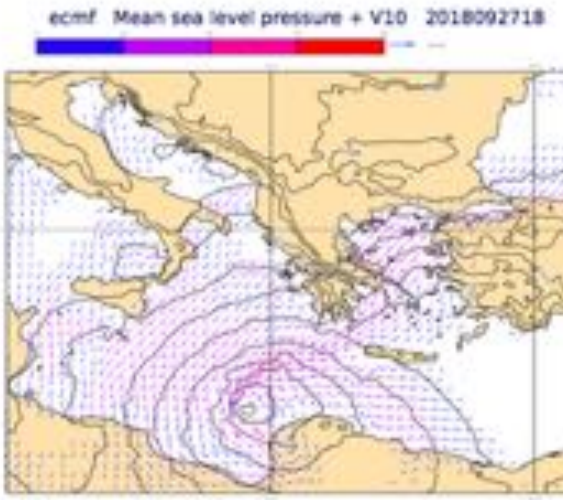

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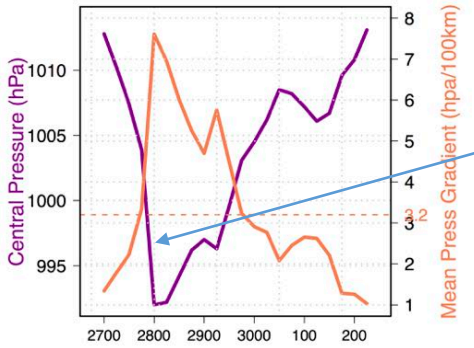

Sudden diabatic deepening

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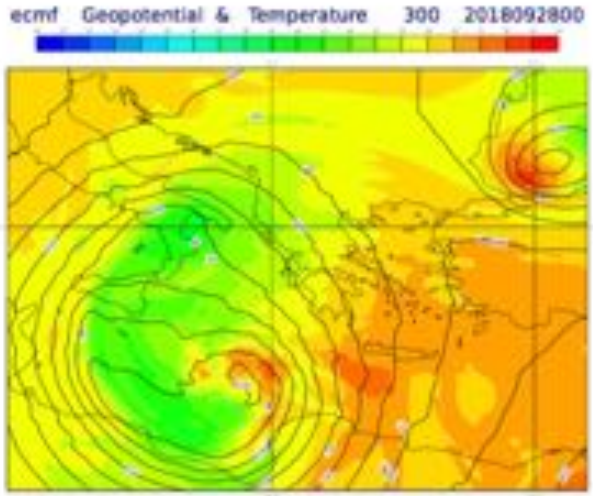

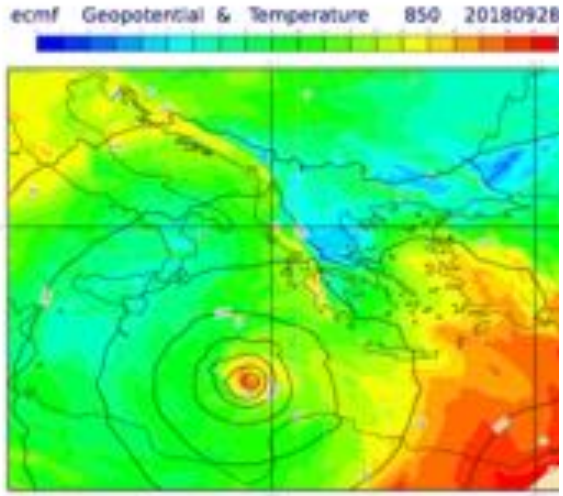

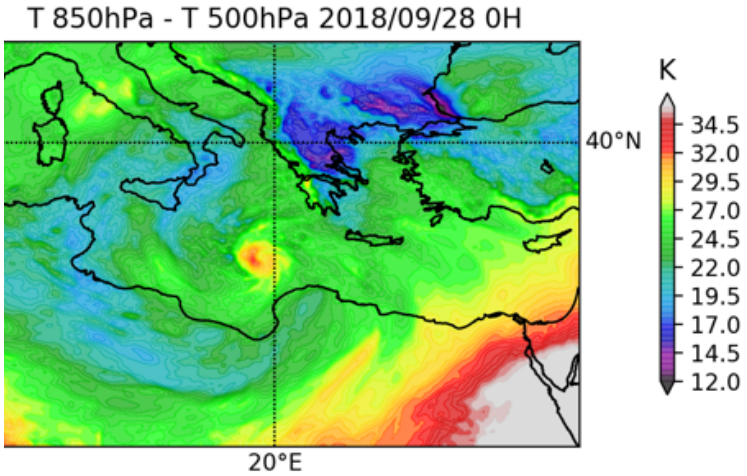

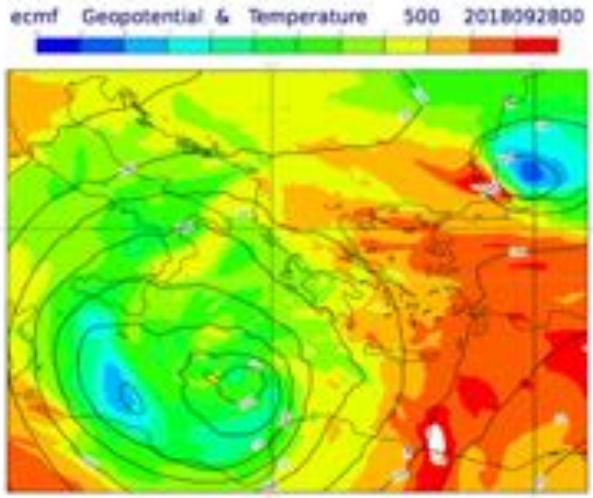

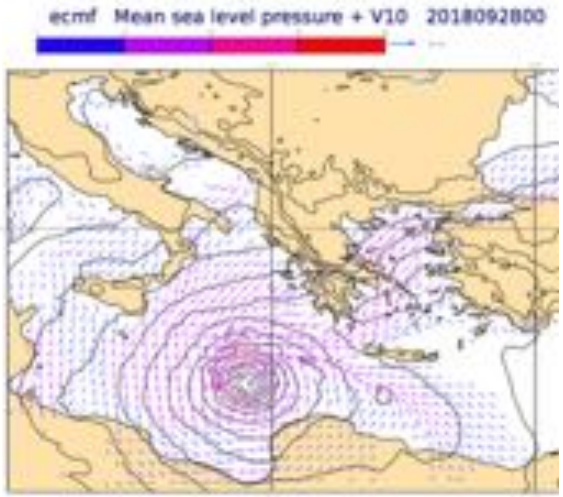

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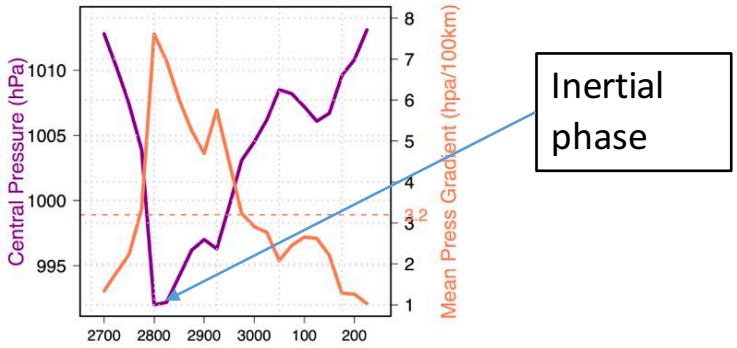

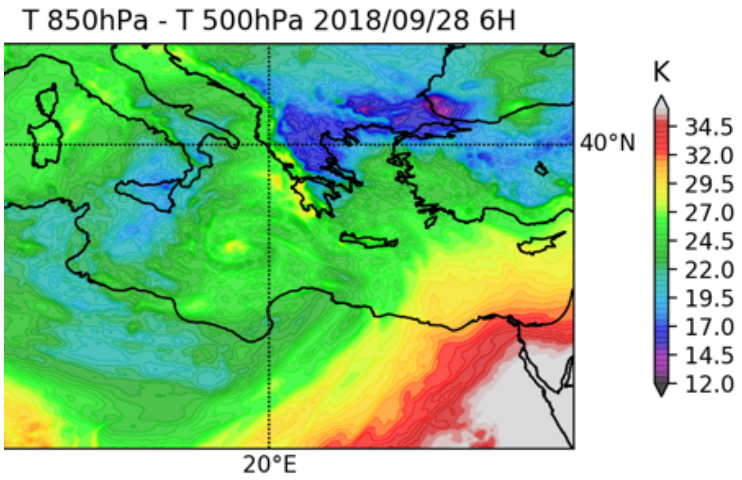

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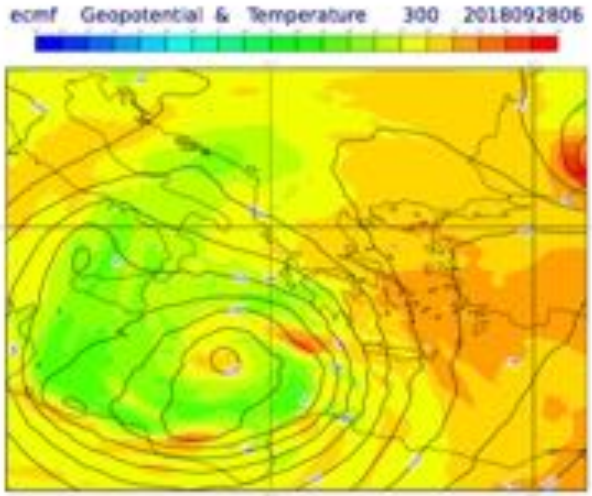
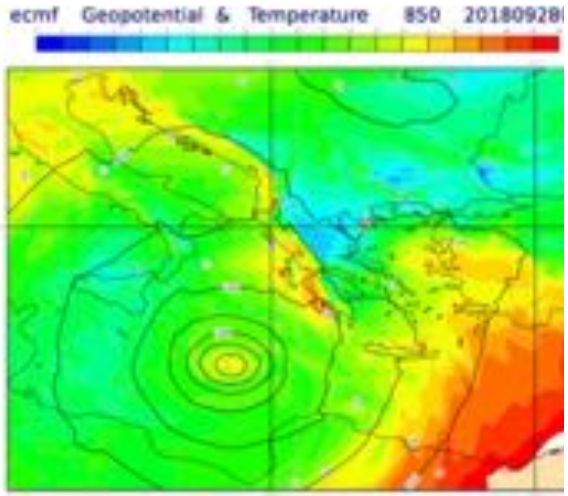
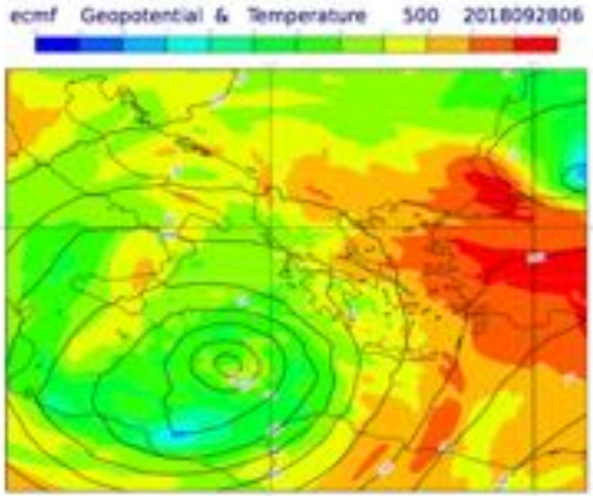
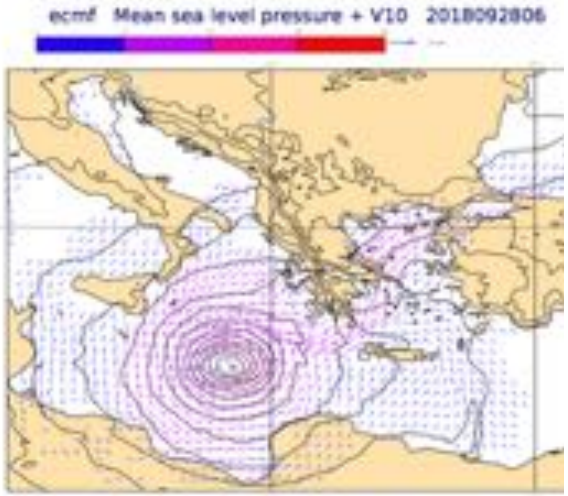
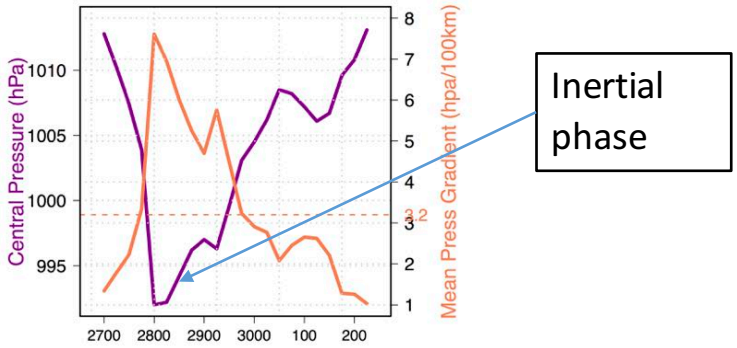






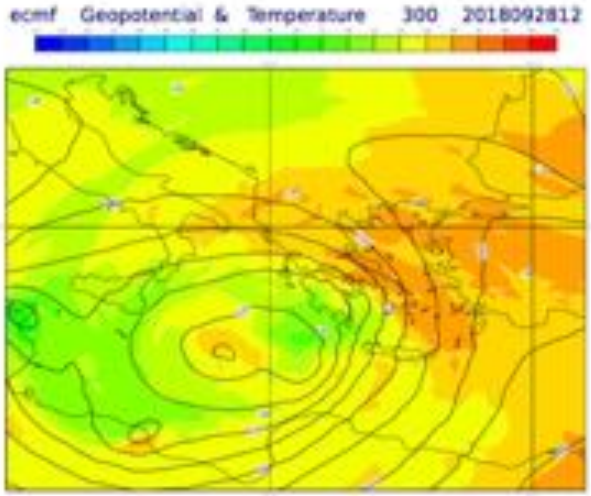


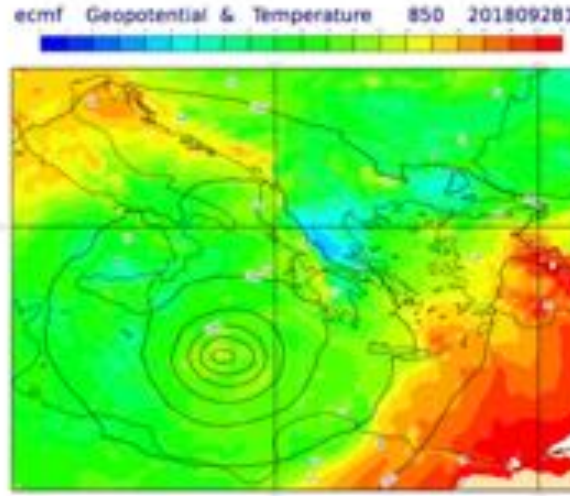
A quick look to the cyclone evolution from ECMWF operational analyses

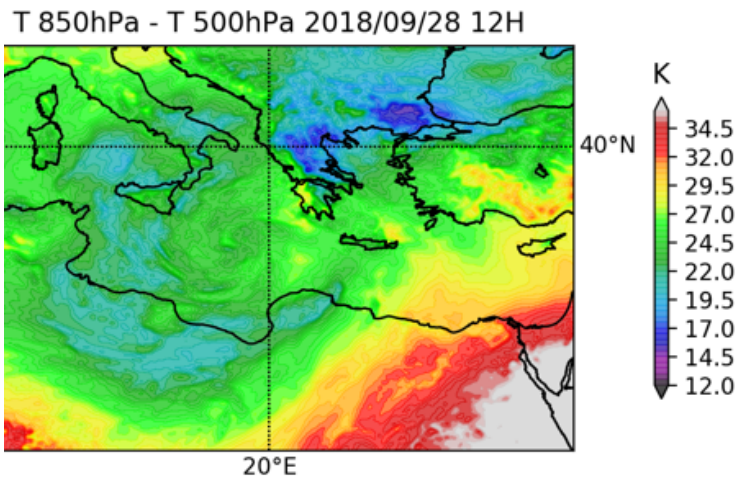


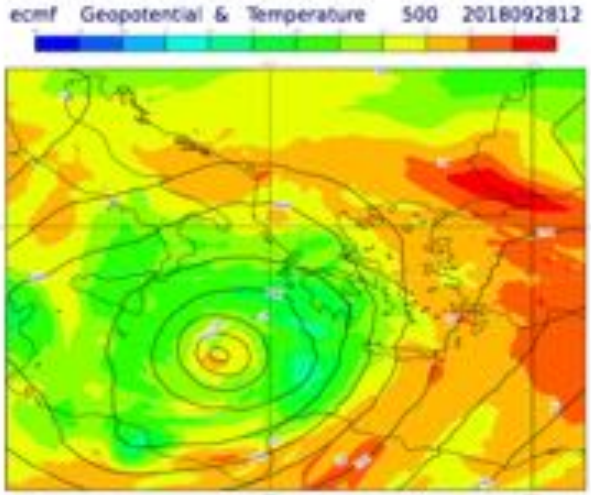
Inertial phase

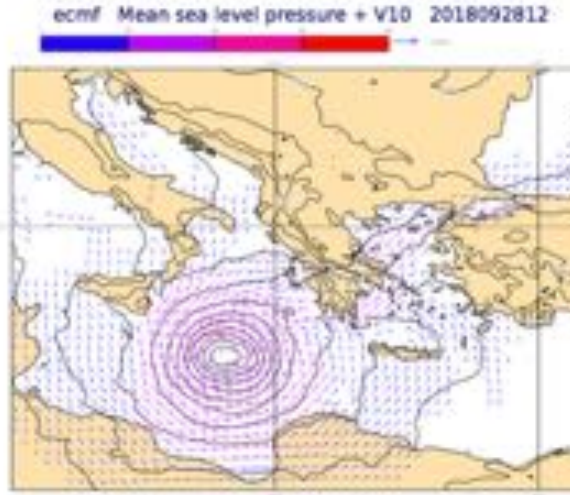
28 SEP 12UTC





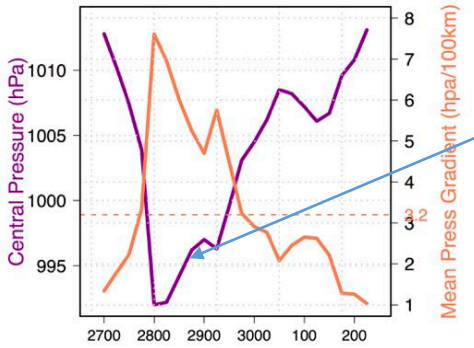




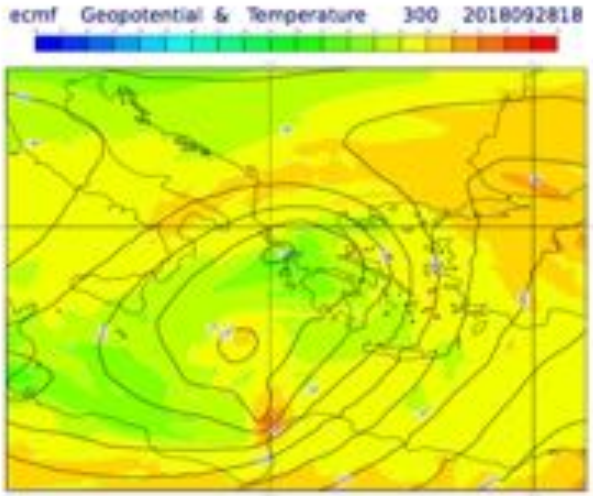


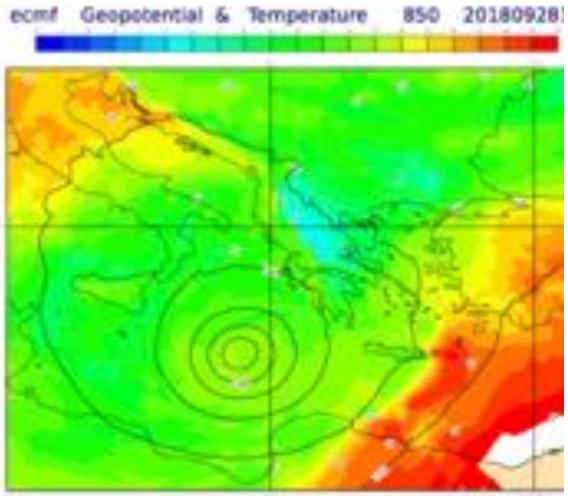
A quick look to the cyclone evolution from ECMWF operational analyses

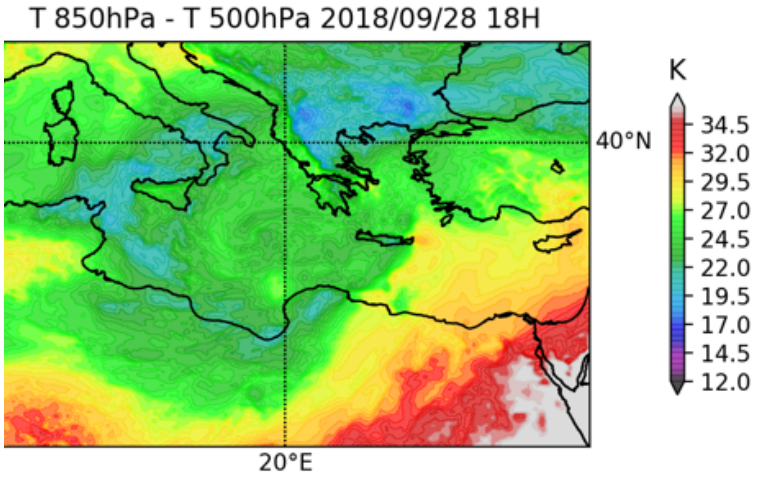
28 SEP 18UTC

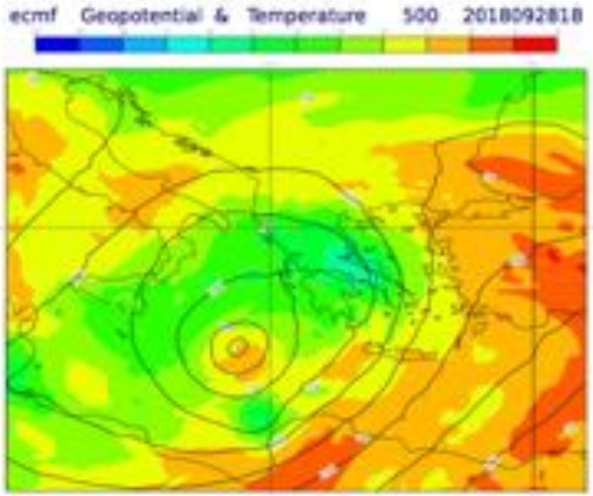


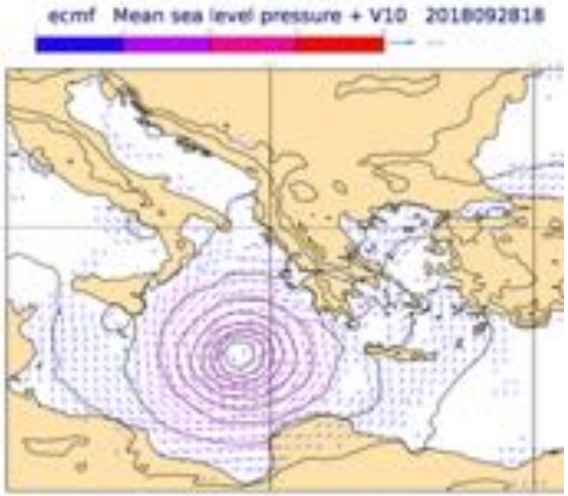
Inertial phase











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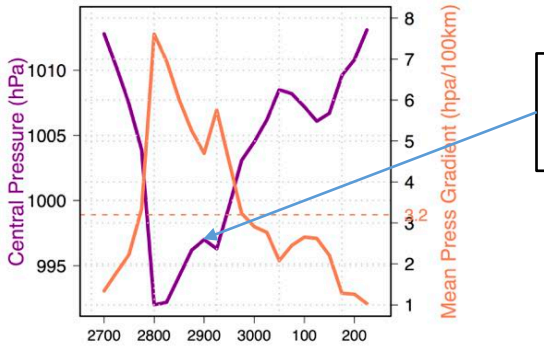

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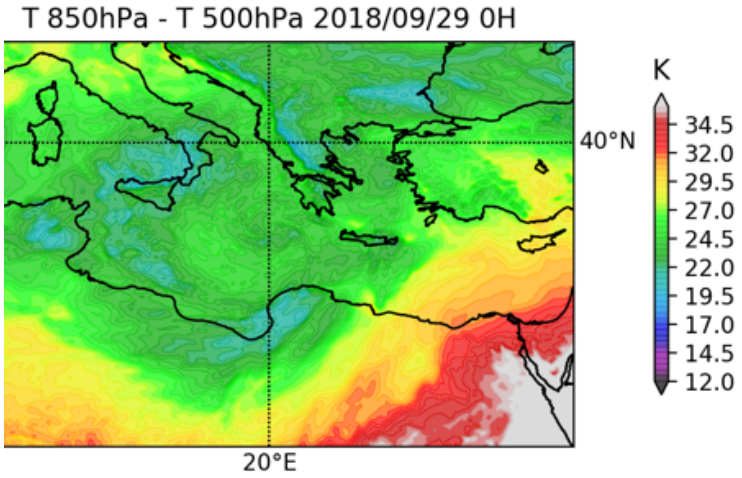

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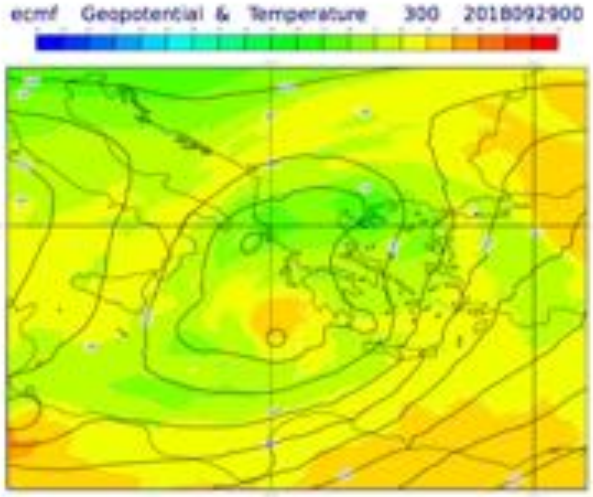

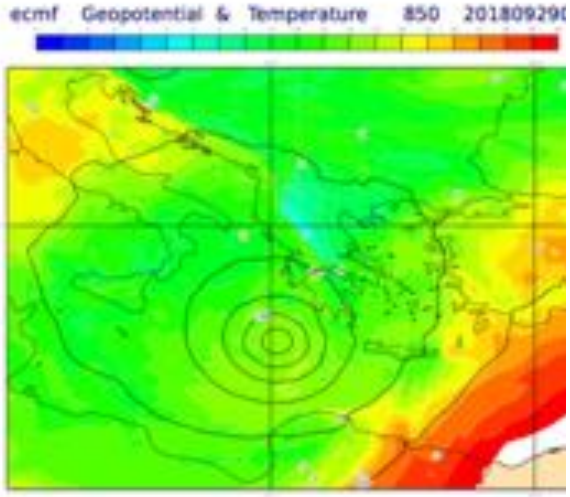

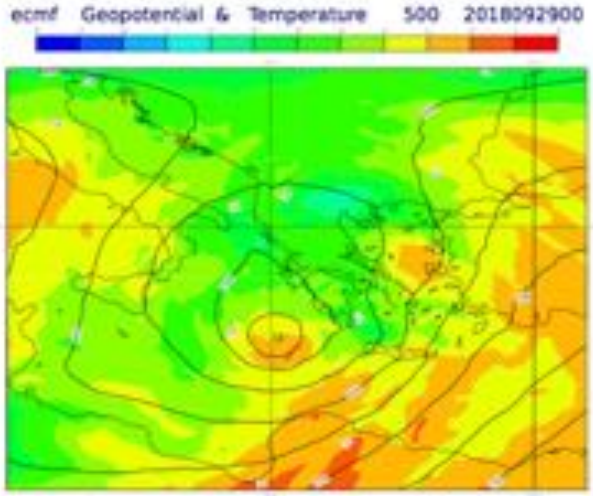

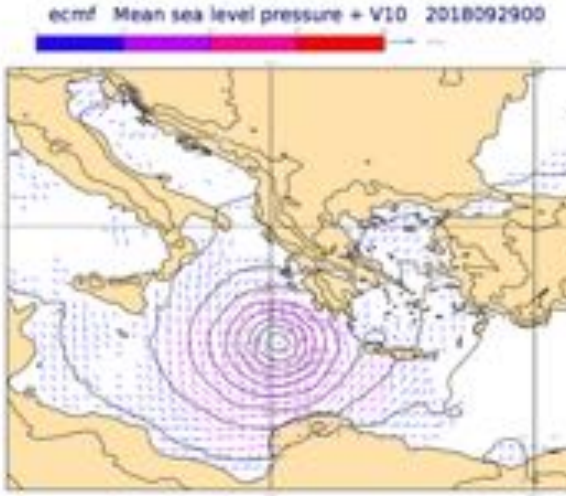

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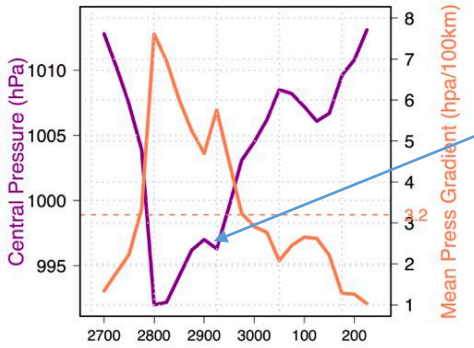

Second diabatic phase

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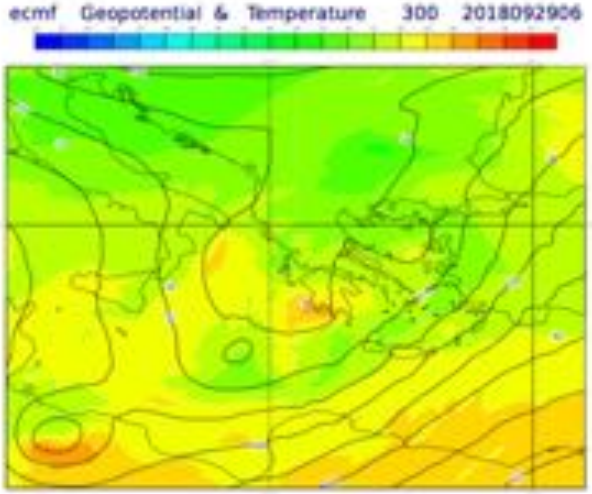
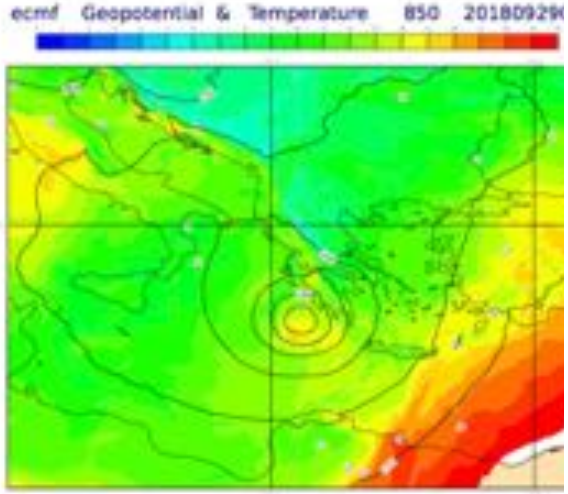
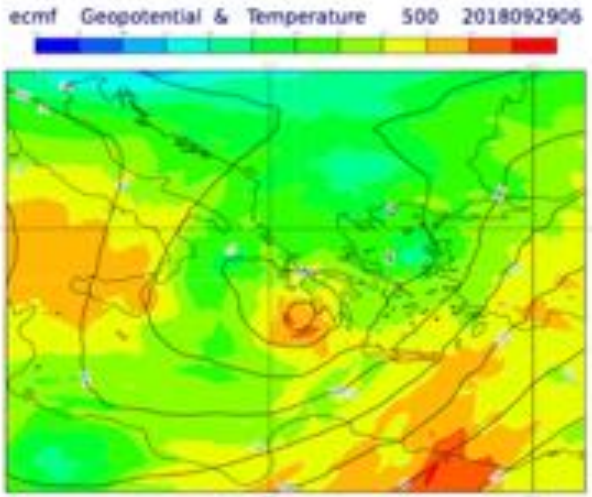
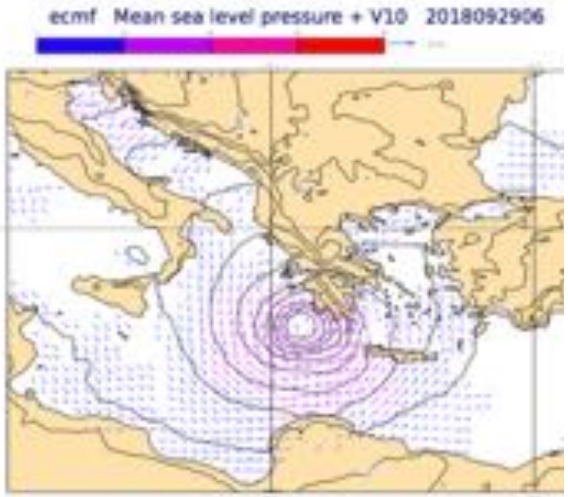
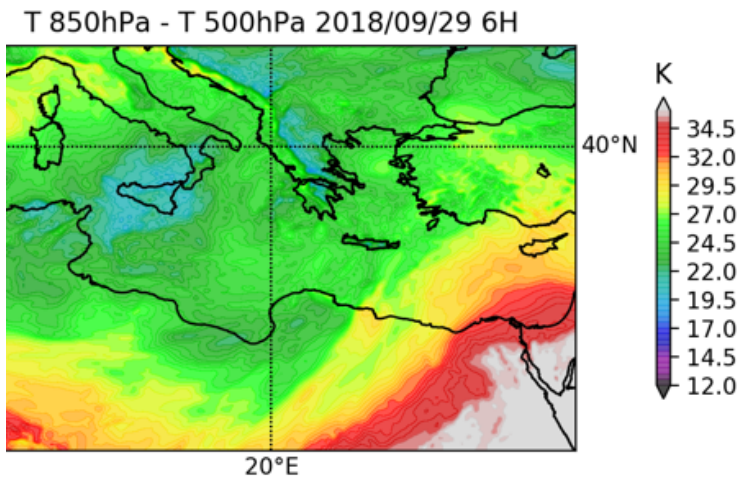


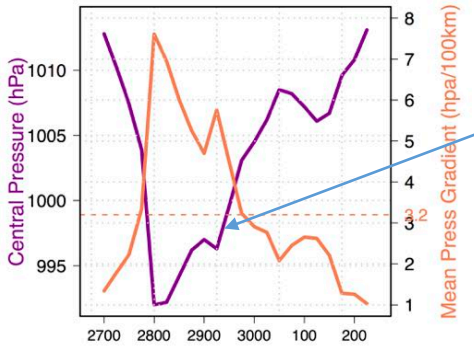




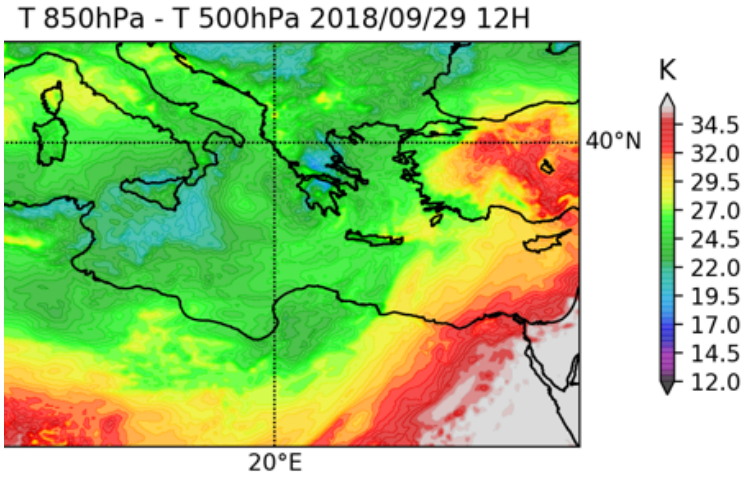




A quick look to the cyclone evolution from ECMWF operational analyses



Disolution phase



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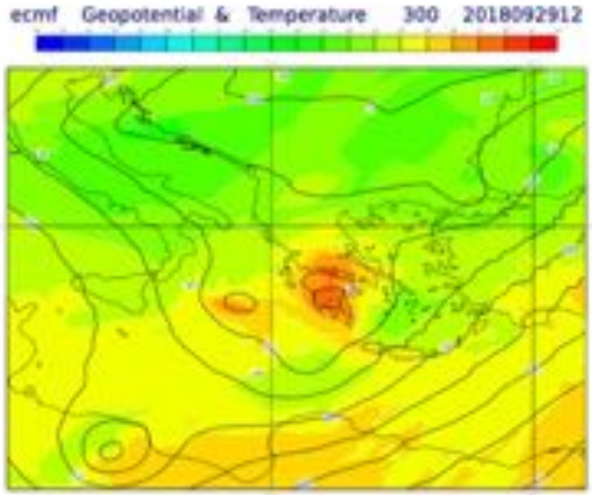
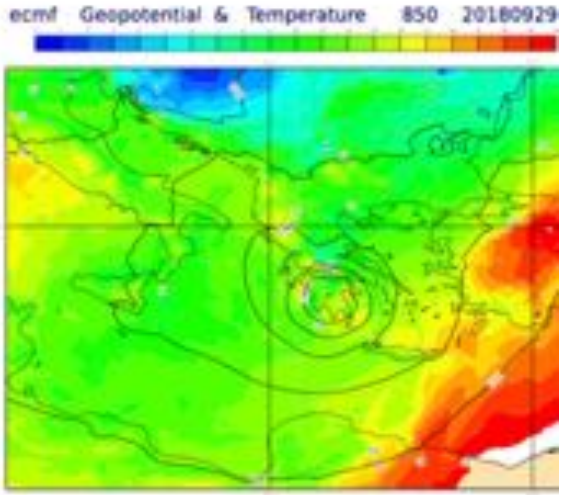
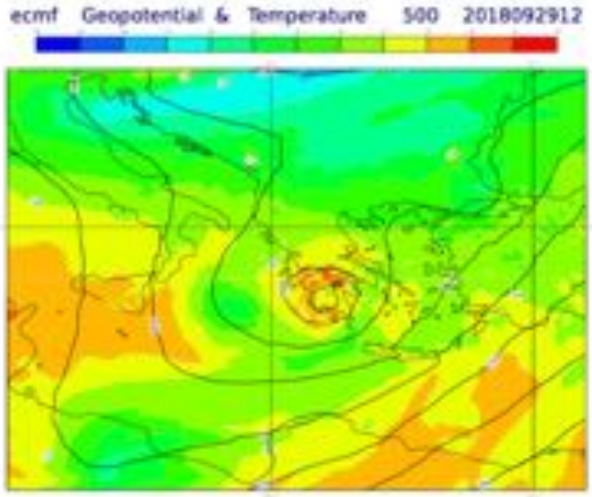
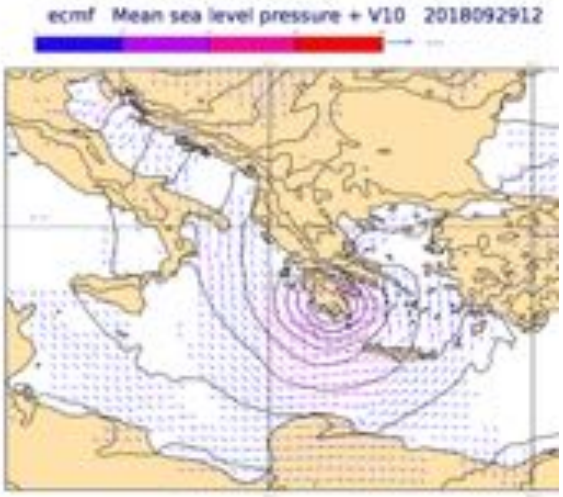
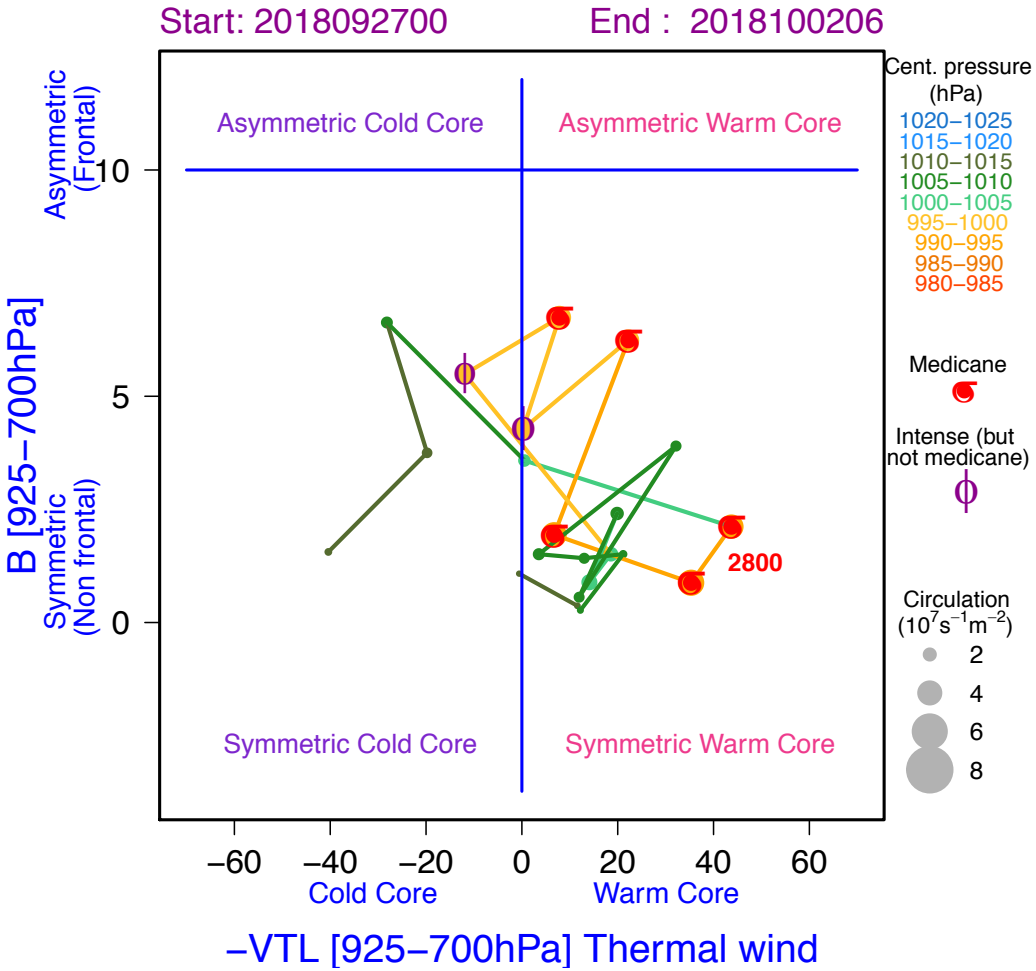


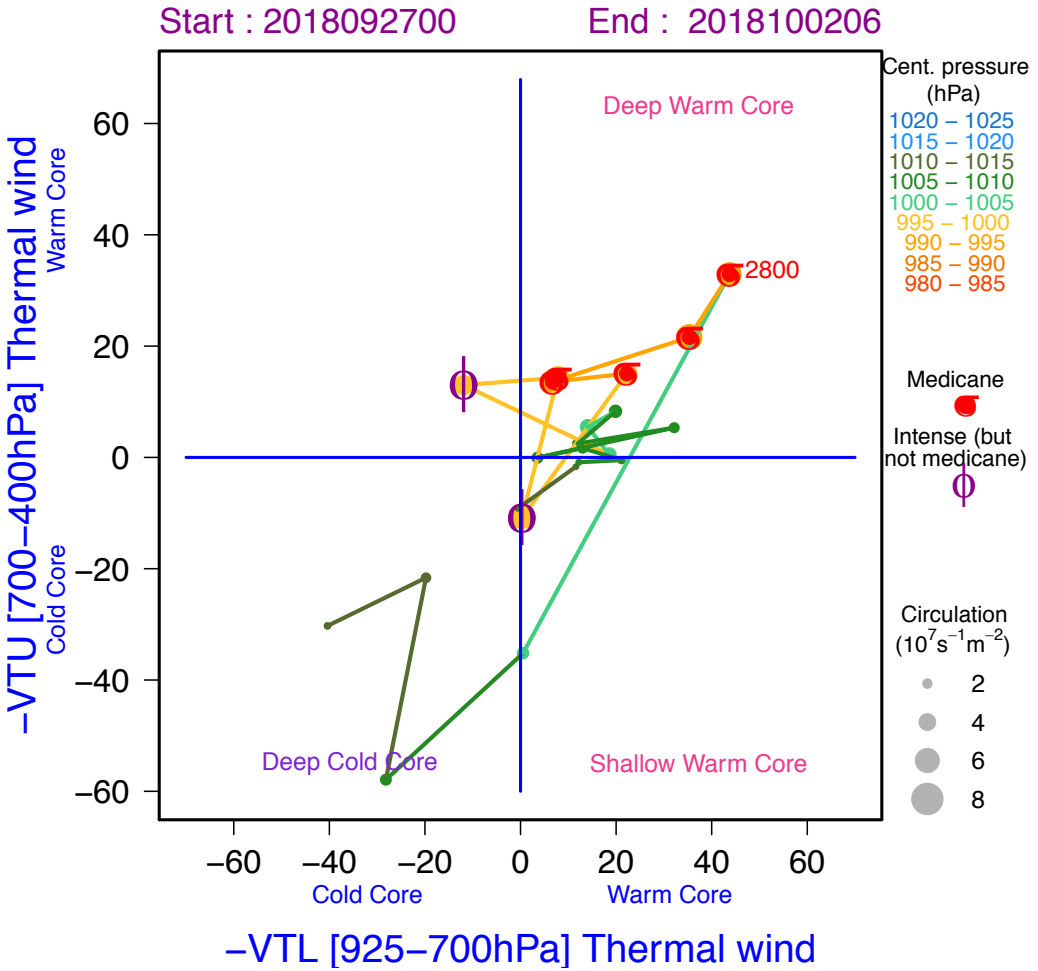




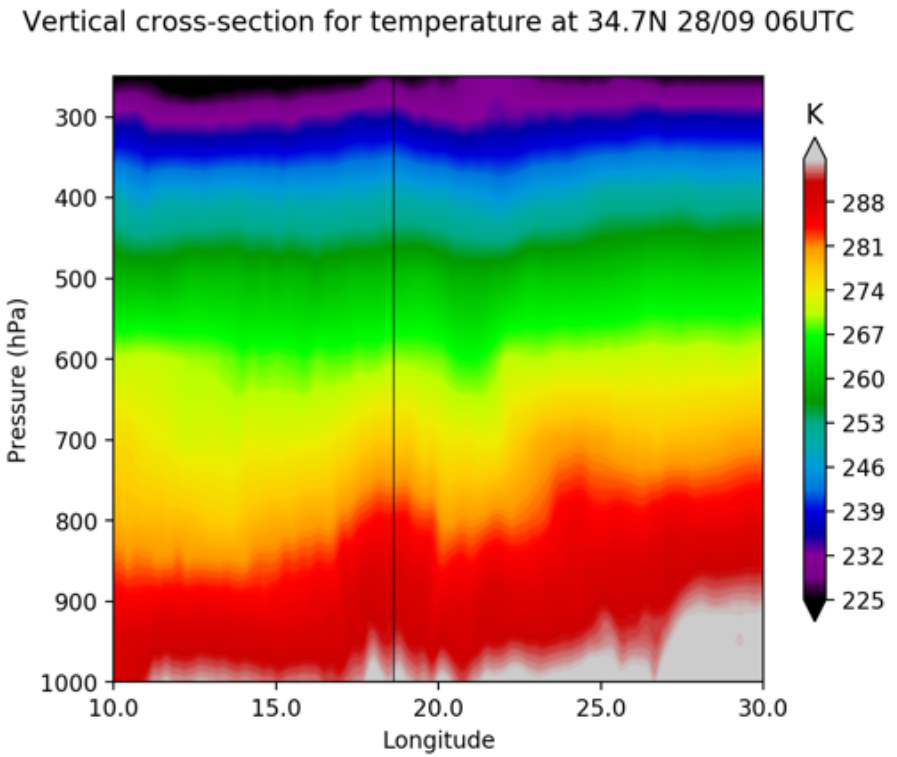


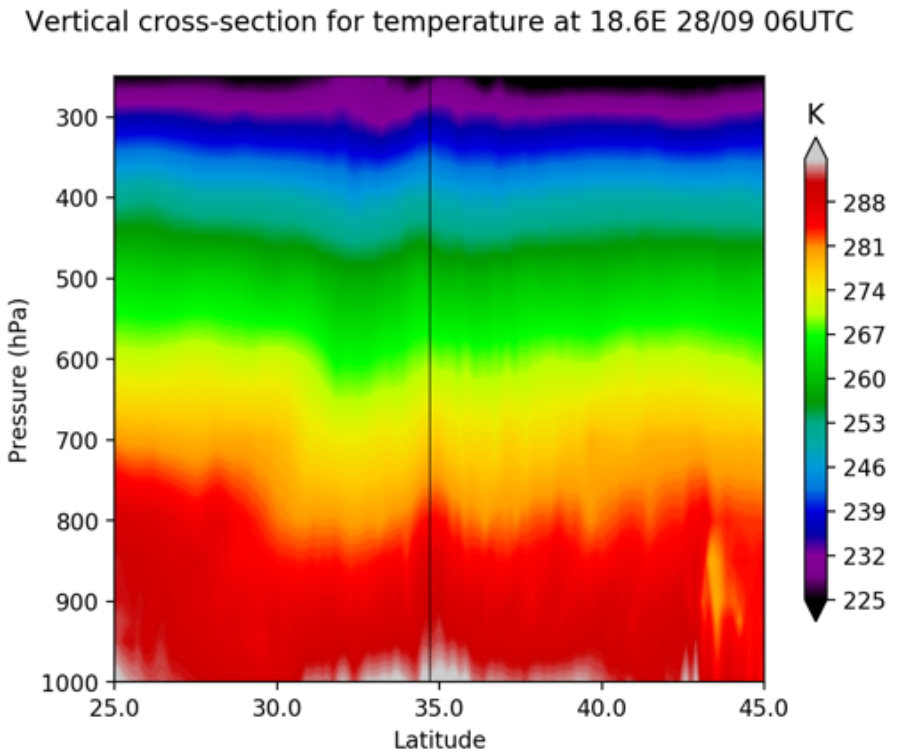
Thermal structure:
Hart's diagrams, adapted as in Picornell et al., 2014



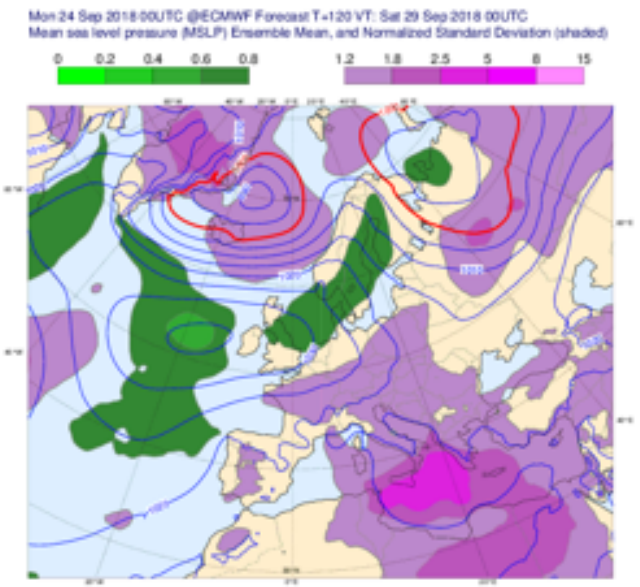


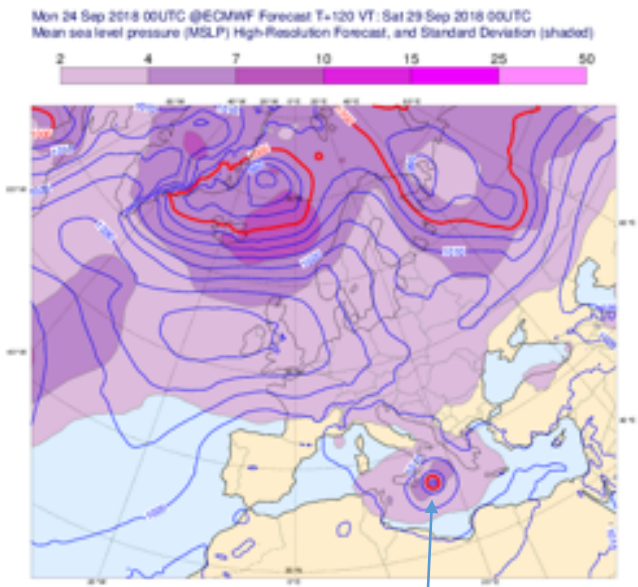
Thermal structure:
Vertical profile of temperature





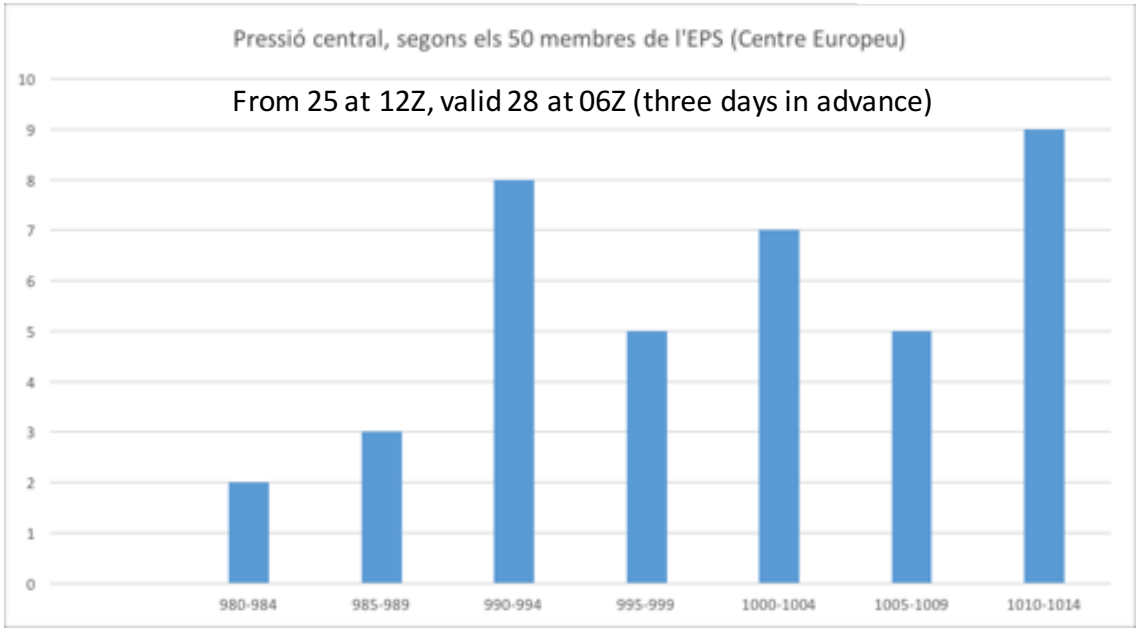
Predictability
Probabilistic: ECMWF EPS





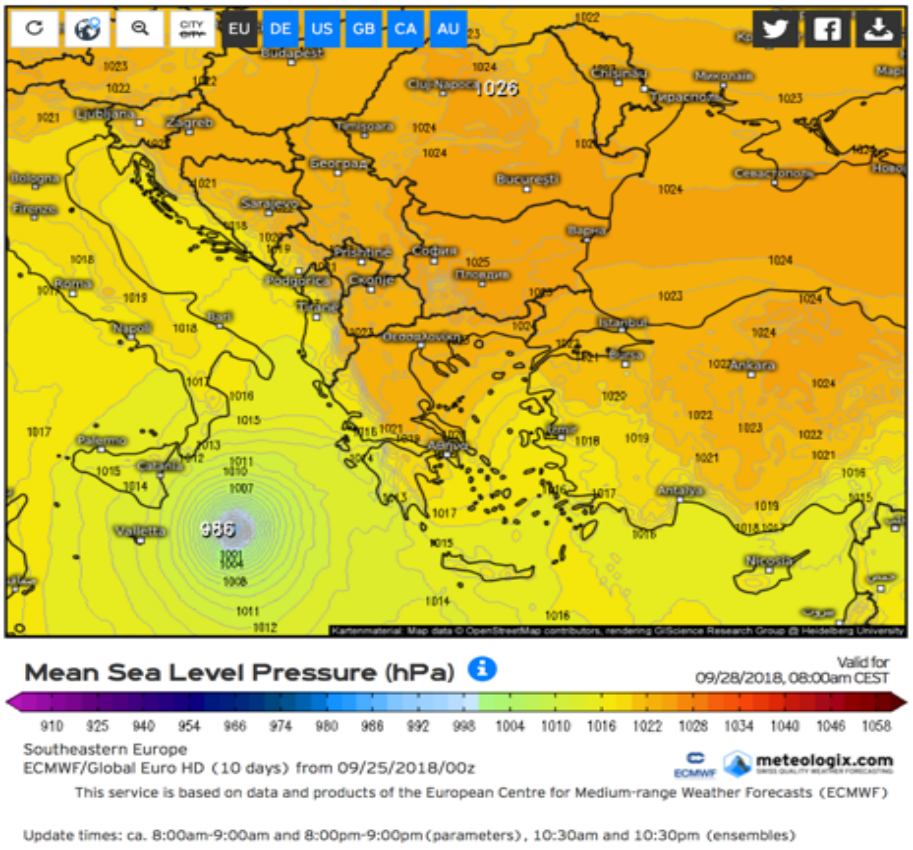
From 24 at 12Z, valid 29 at 06Z
(5 days in advance)

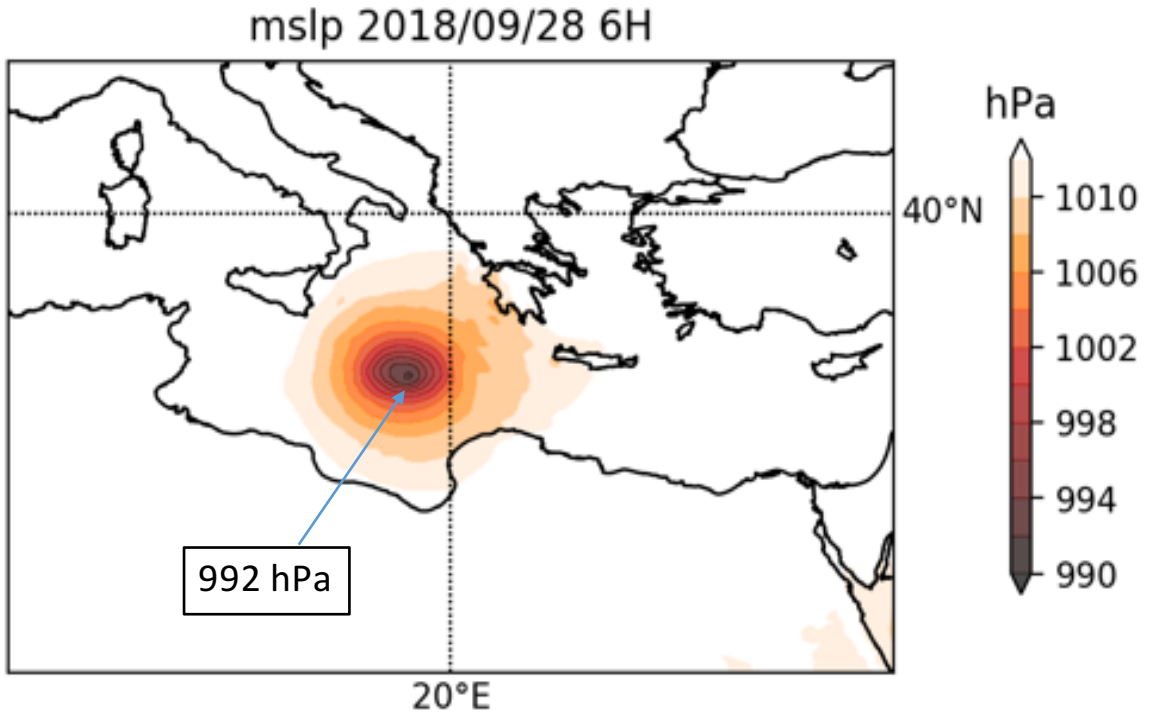
993 hPa



Even 4-5 days before members of the ECMWF EPS were able to anticipate a small and intense cyclone, not far from the later observed location, although the uncertainty is important

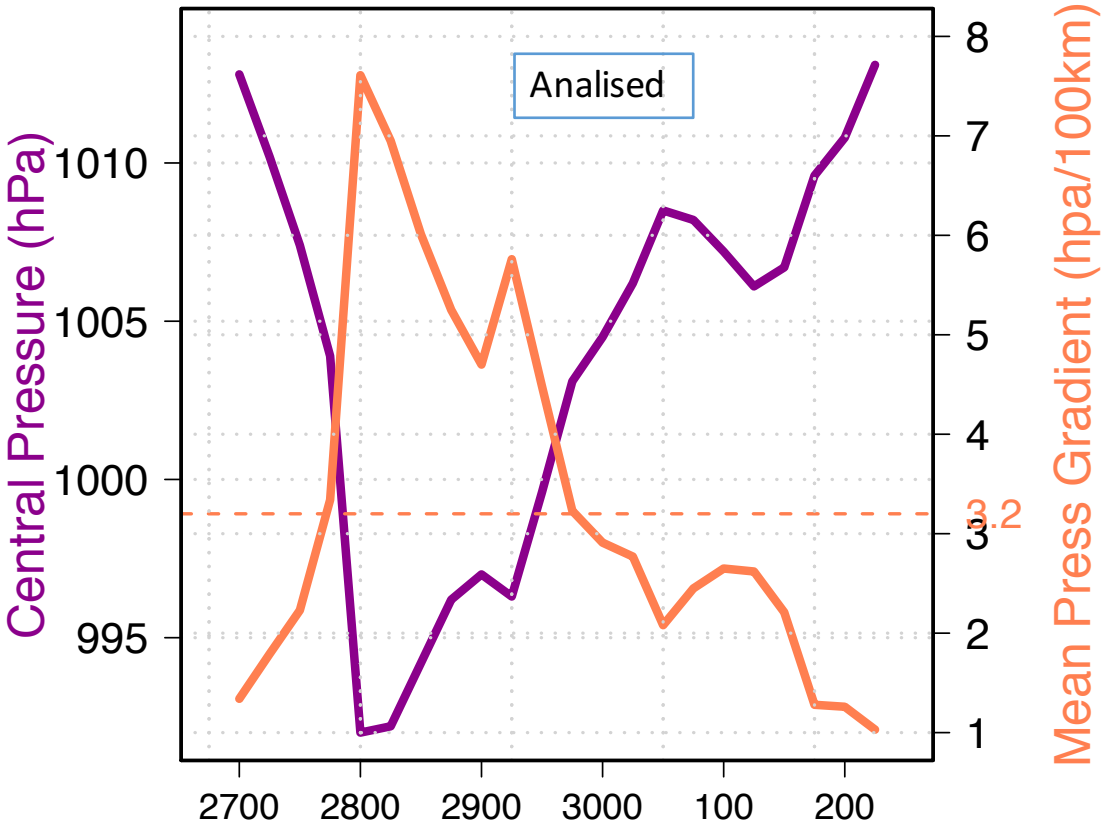
Predictability
Deterministic: ECMWF IFS forecast vs ECMWF analysis

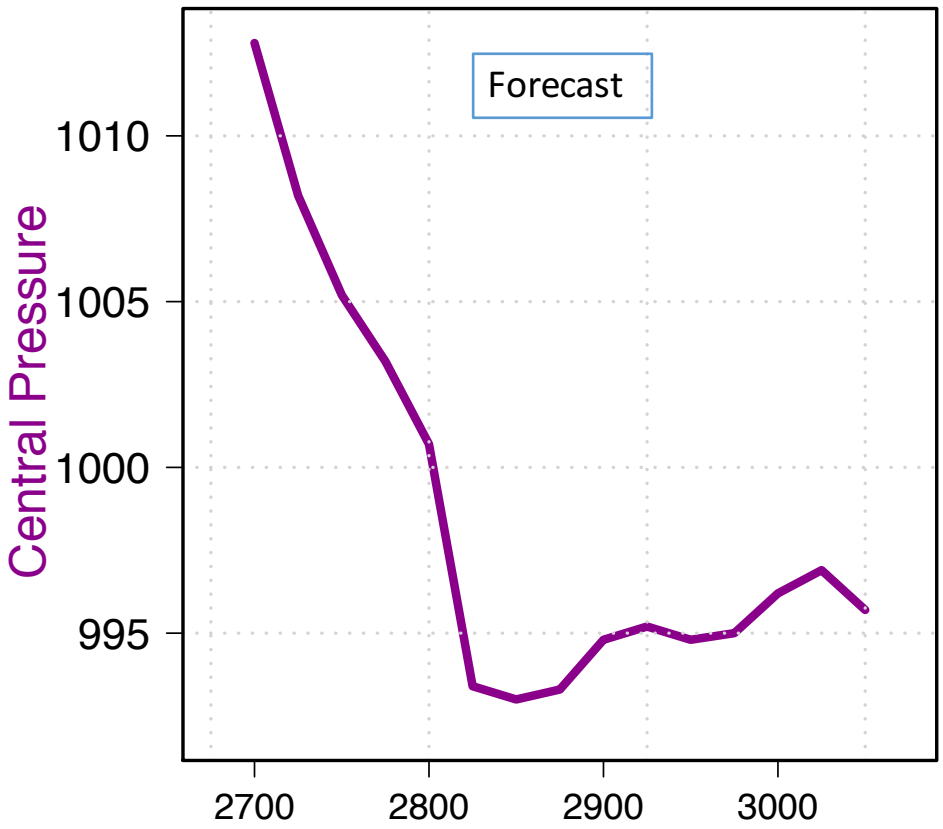




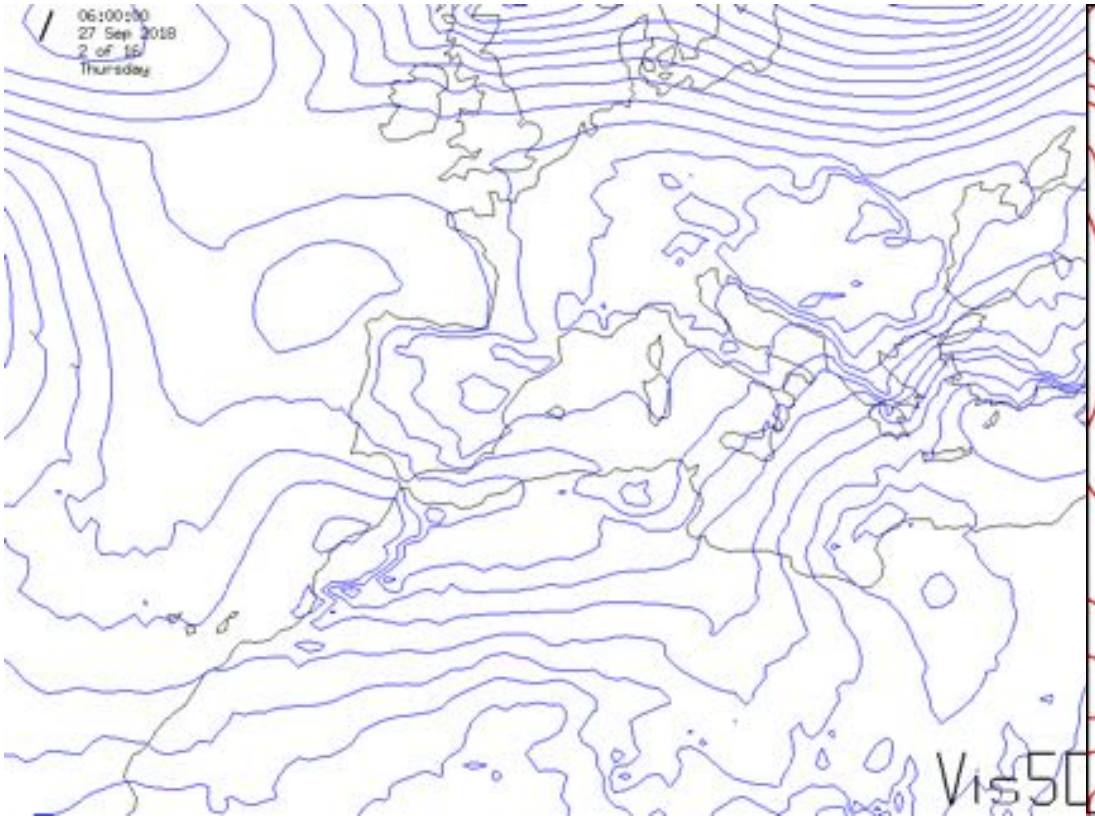
3 days in advance, the deterministic ECMWF forecasted cyclone is even deeper than the cyclone later analysed.
The location is not bad.

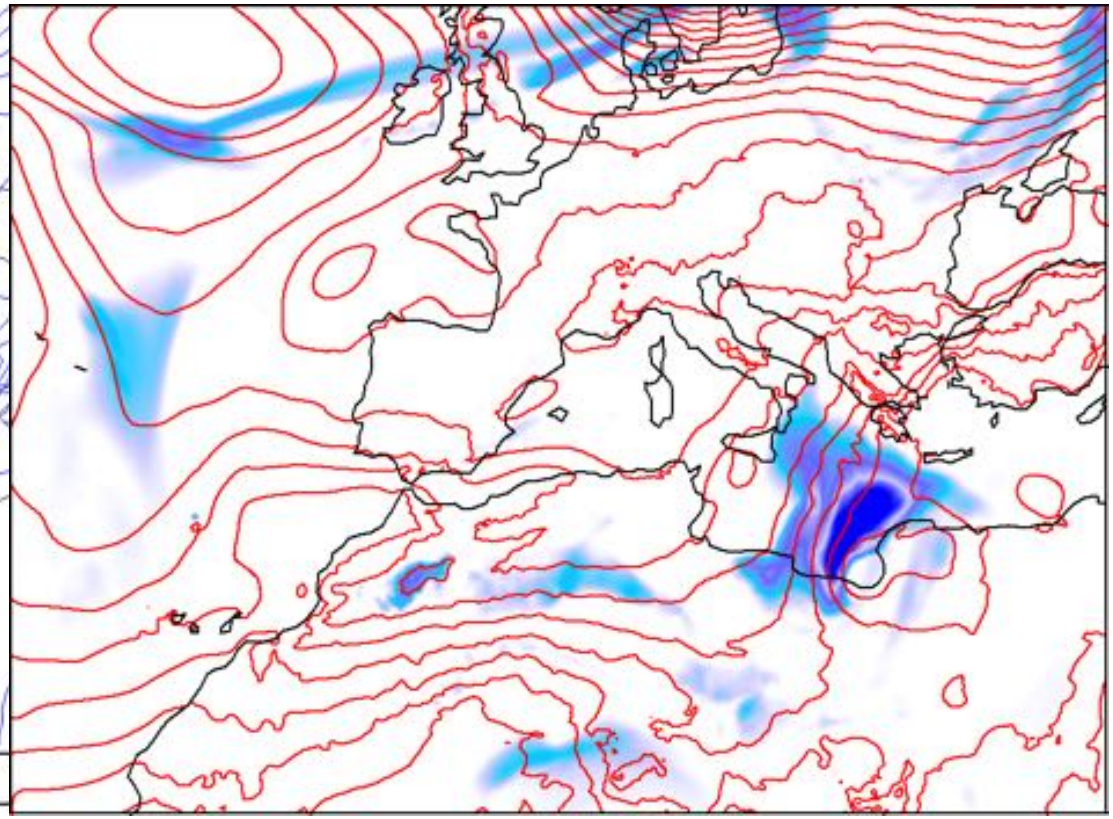
In the short range (from 2700), the EVMWF IFS deterministic is quite accurate, although some details are not perfect.





On the physical process:
What a dry, adiabatic, not hydrostatic model can predict?
A small cyclone develops, but not a medicane: not so intense as a medicane. The two critical phases diabatic phases are, of course, not predicted.
The TRAM model [developed by Romero, 2018] has been used here





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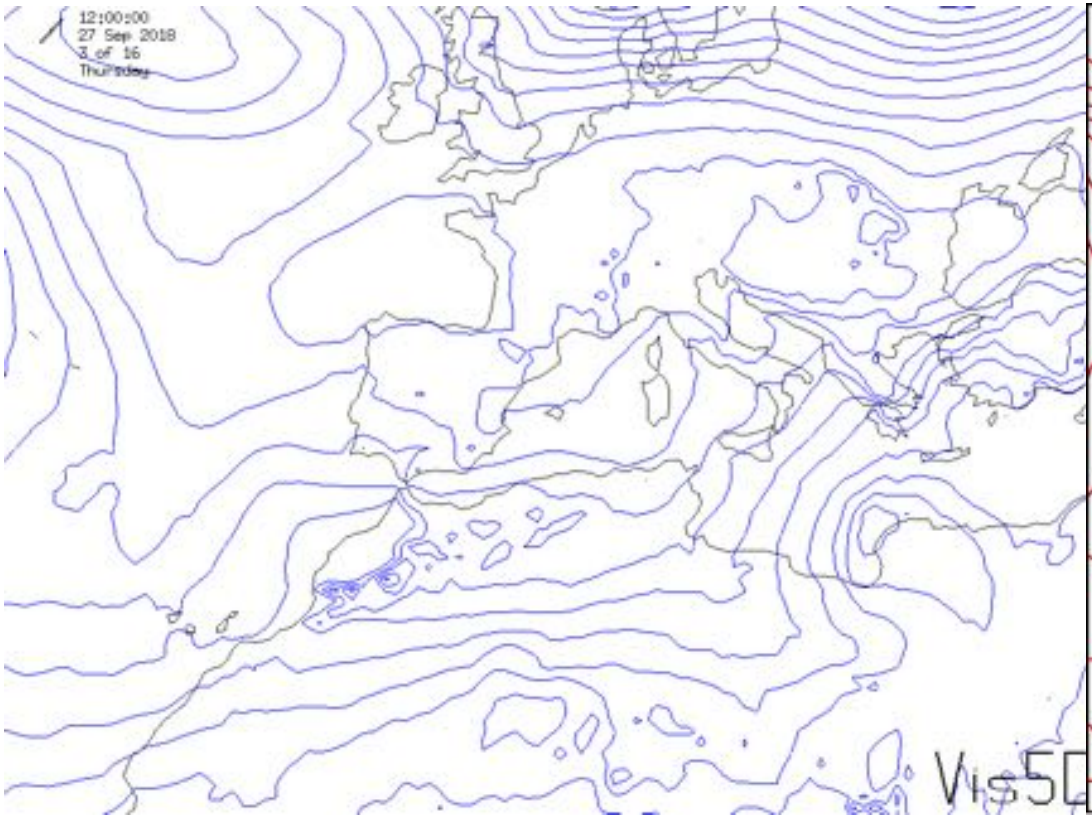

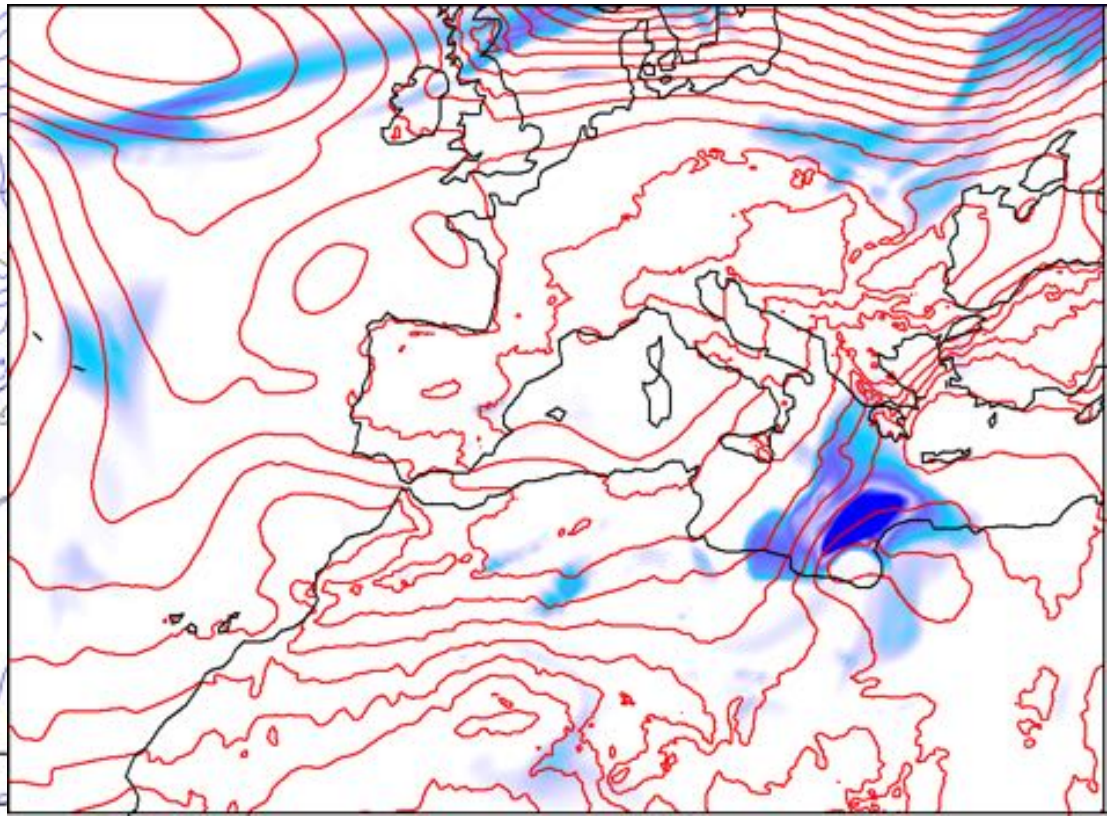

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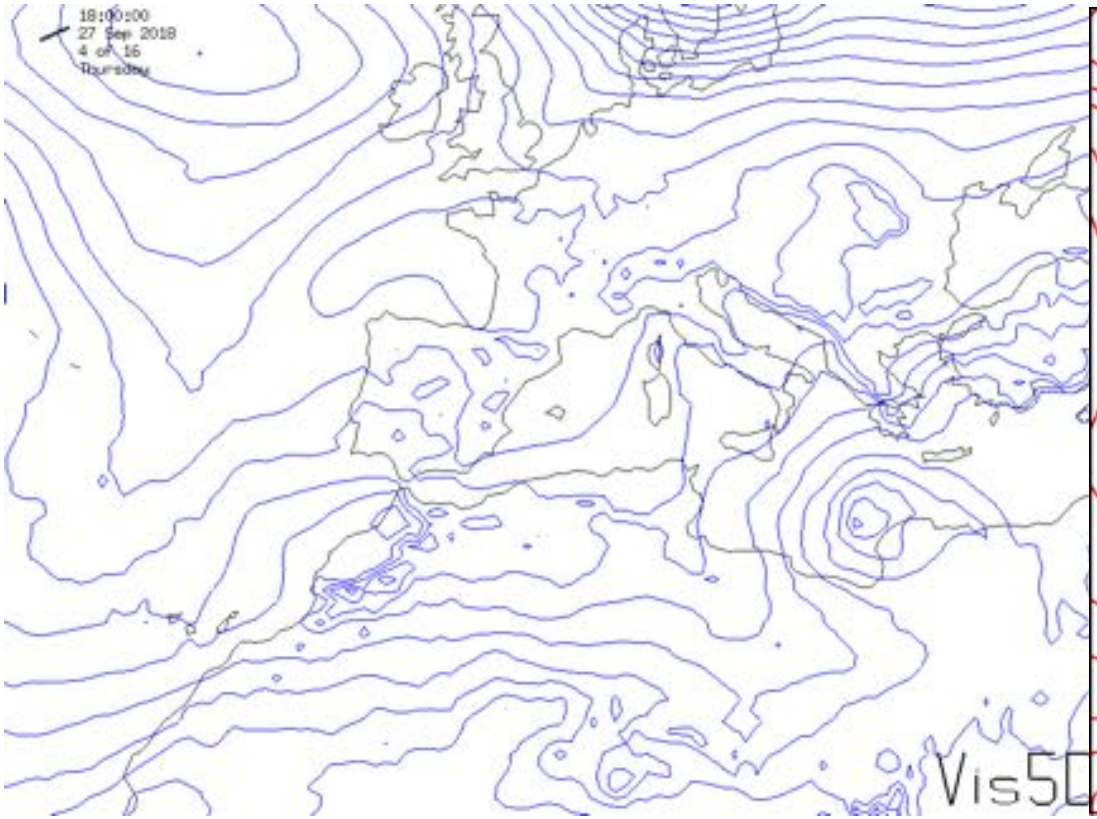

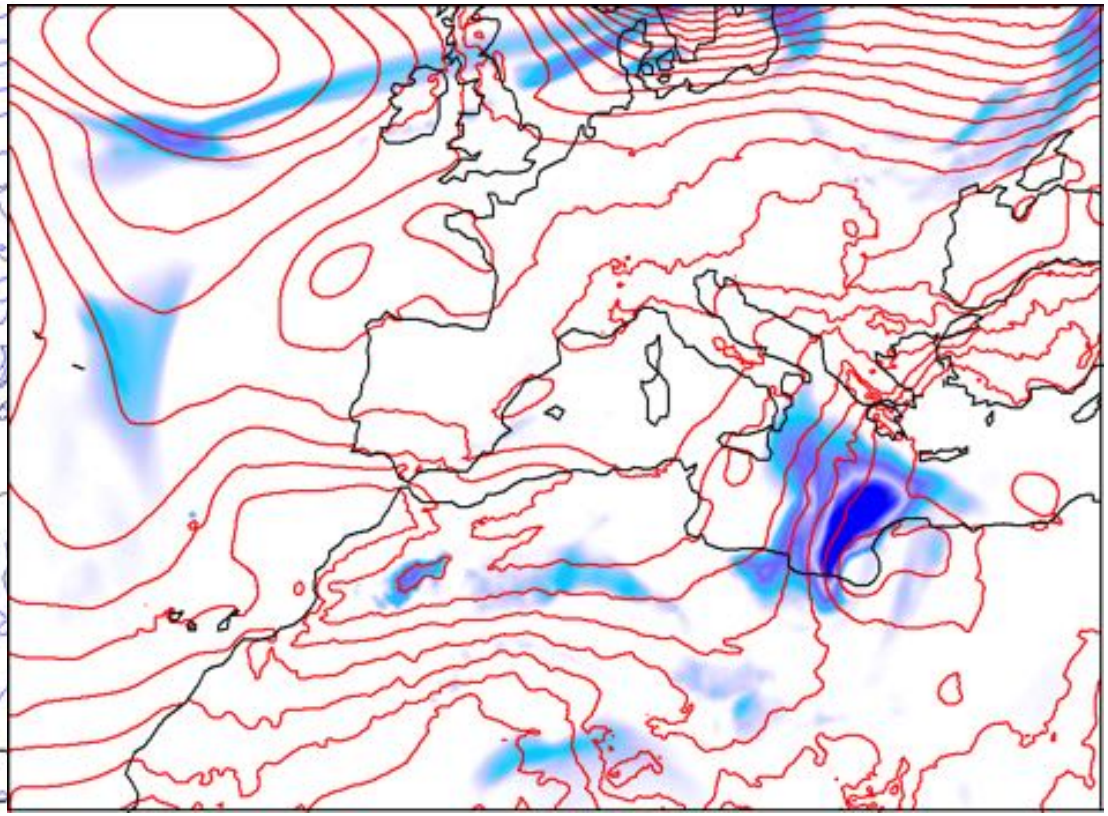

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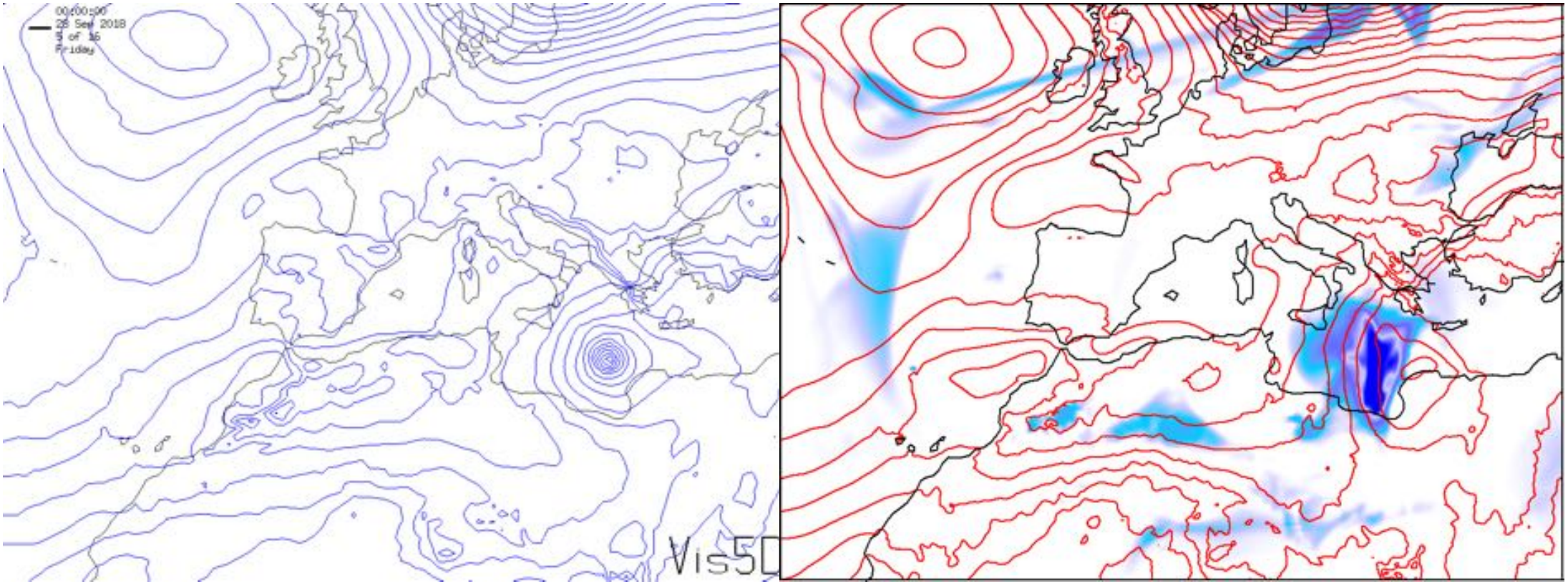

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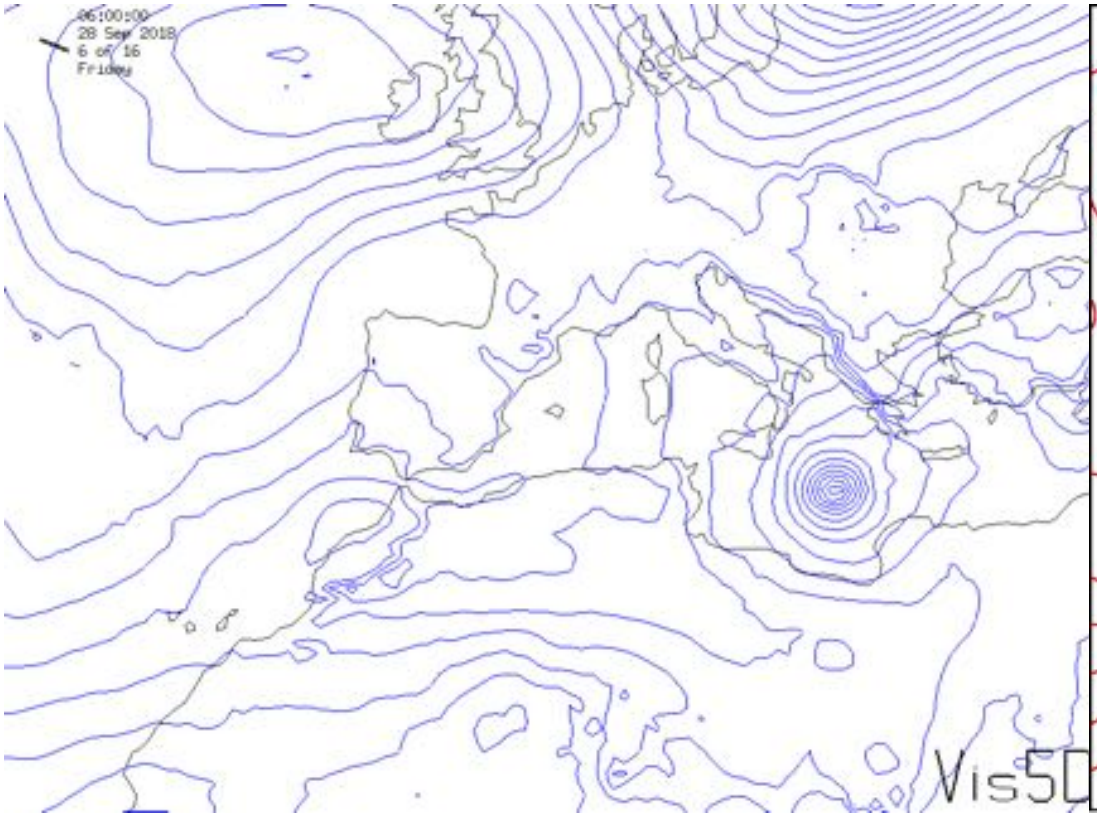

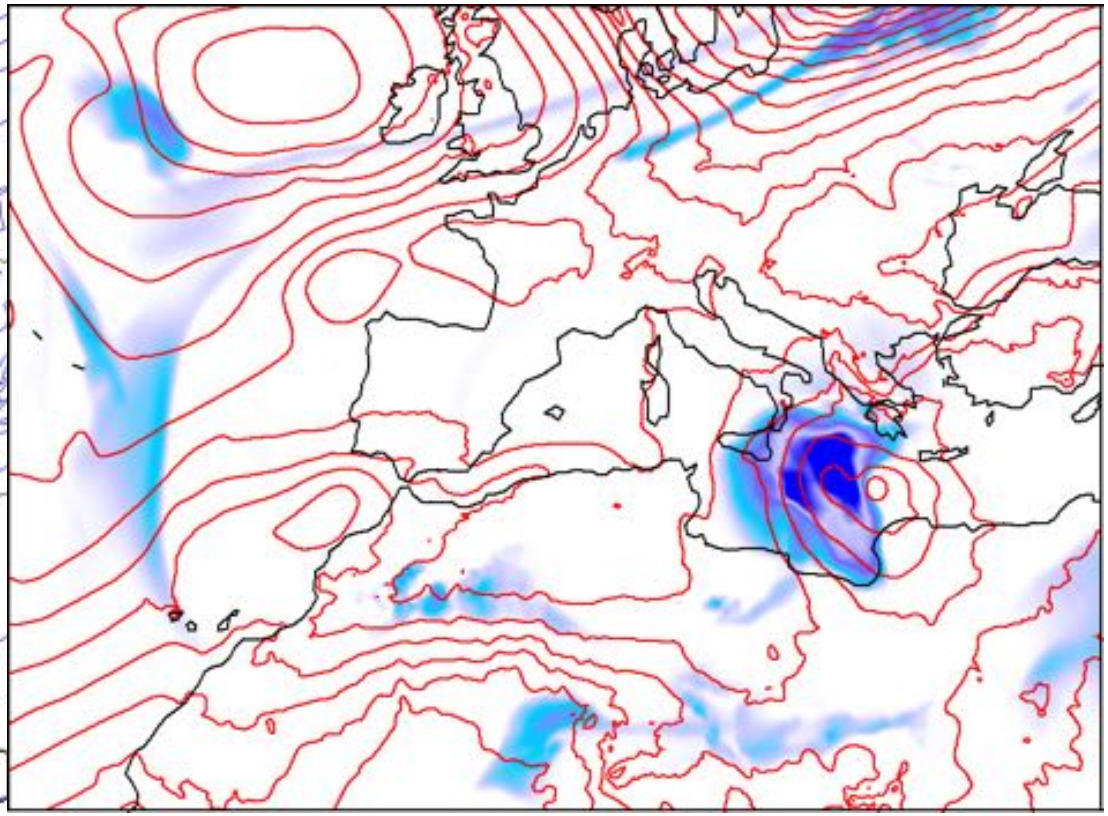

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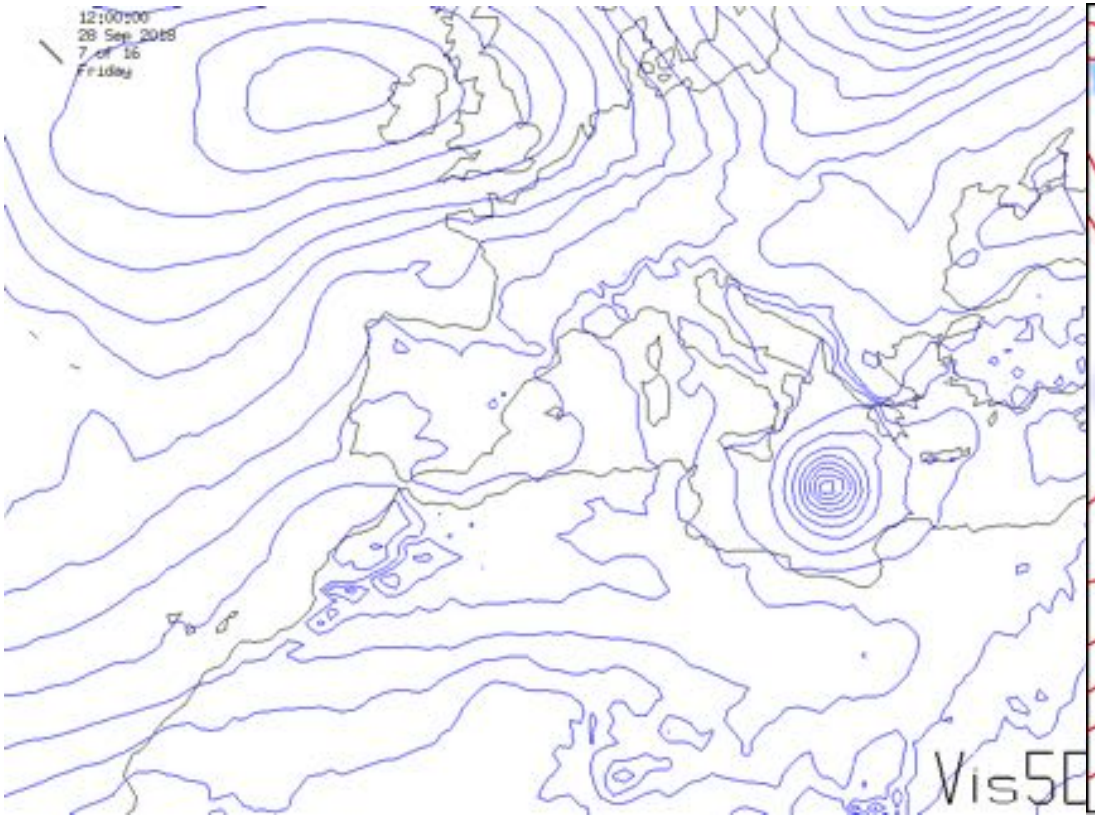

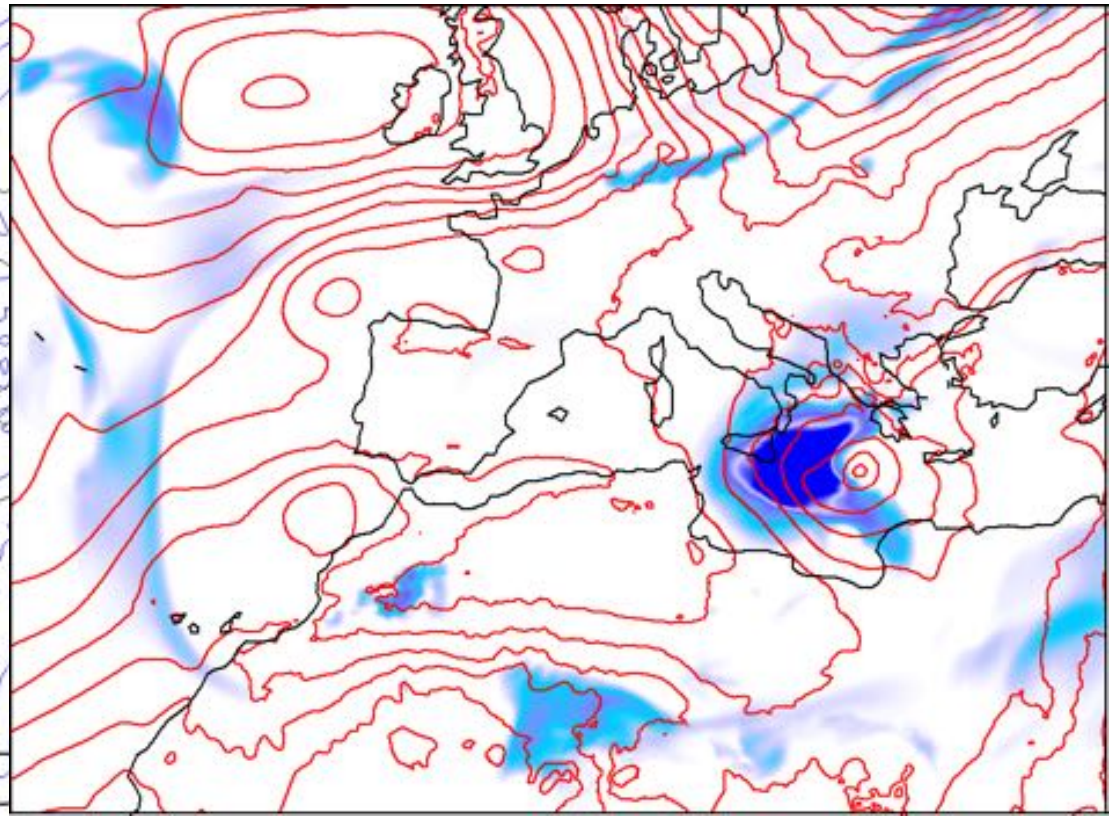

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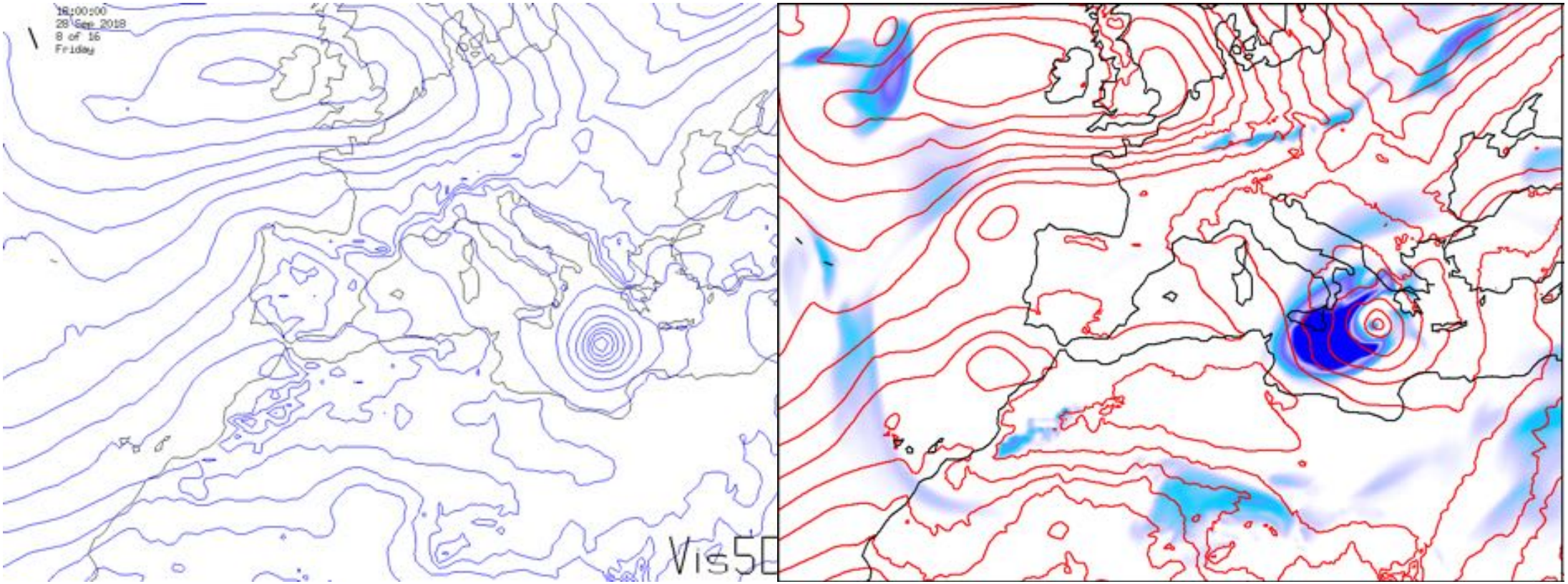

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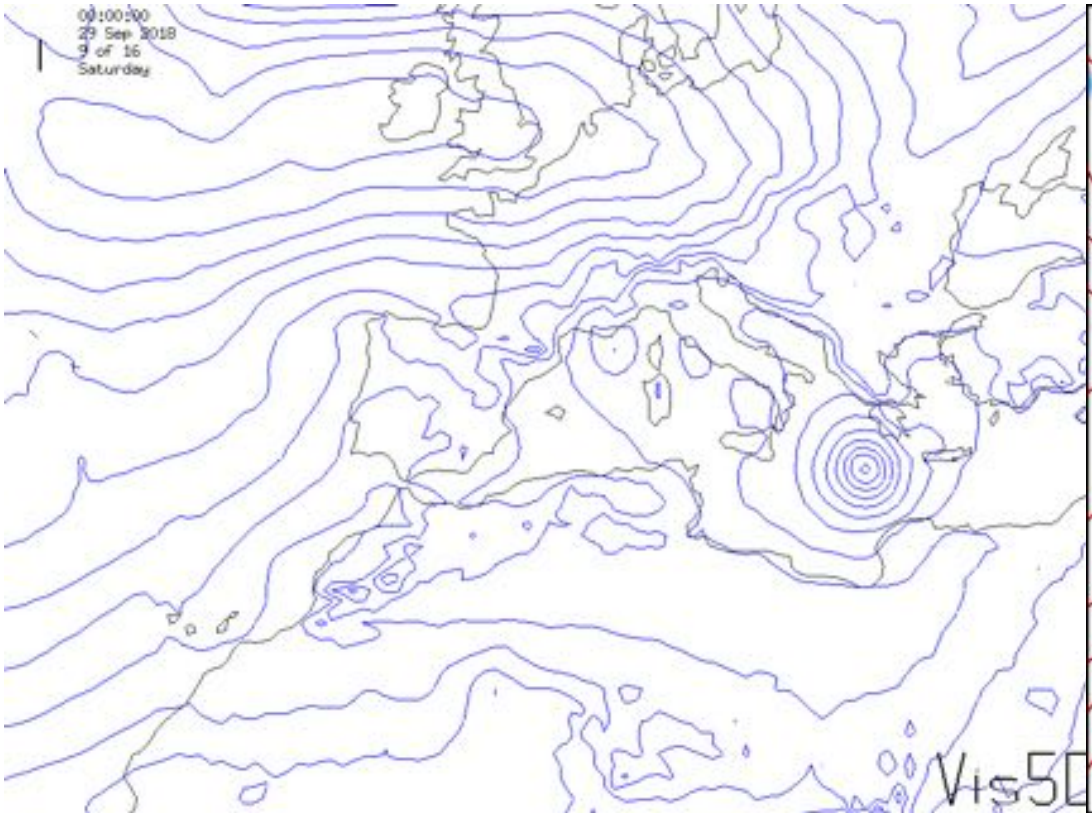

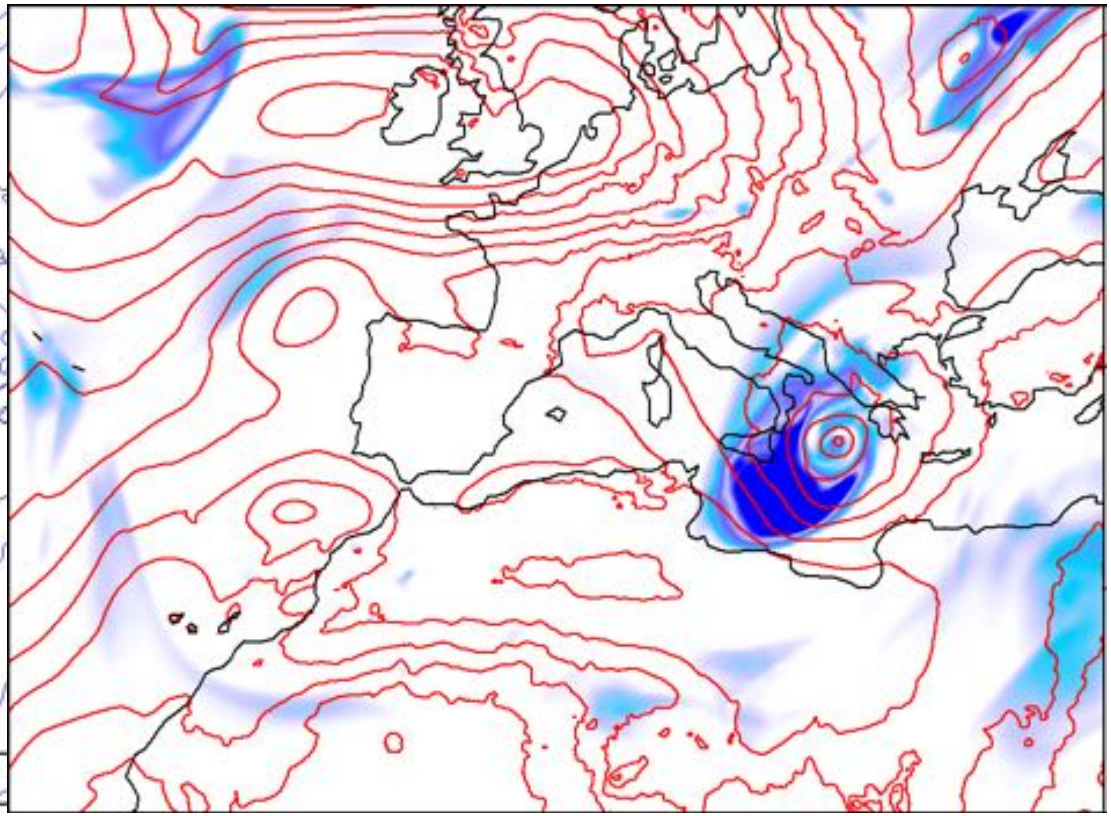

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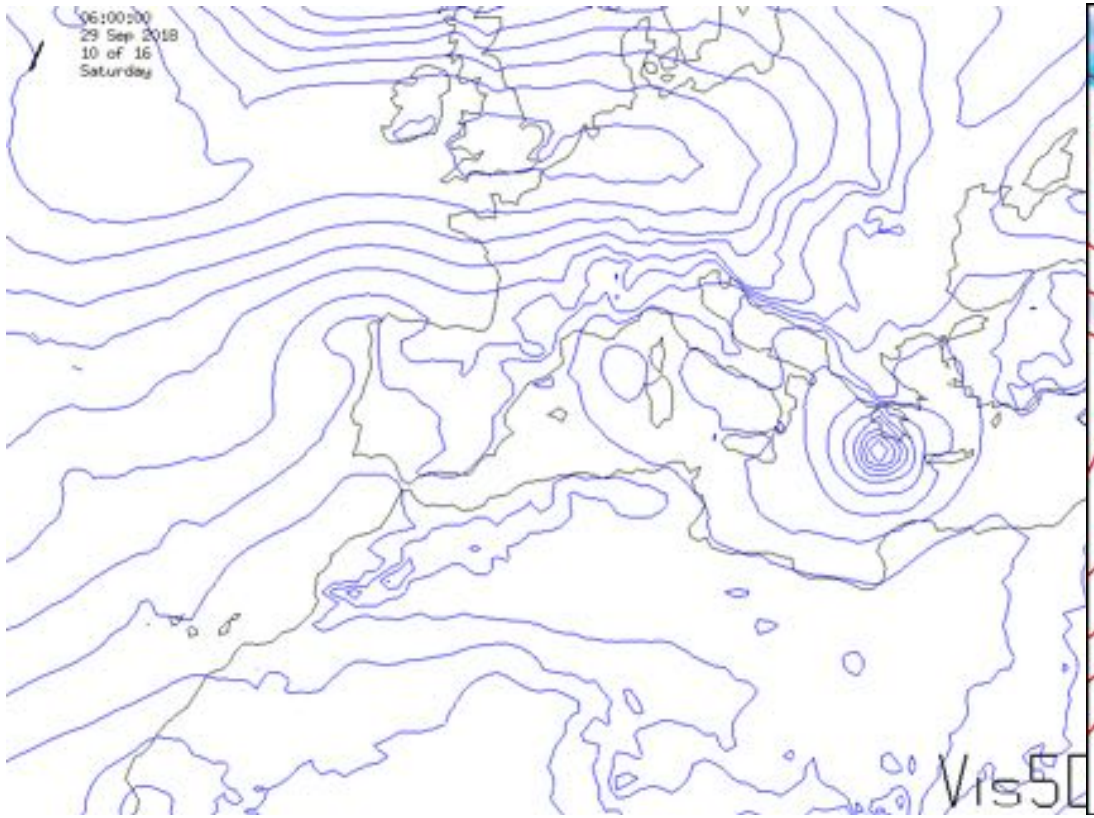

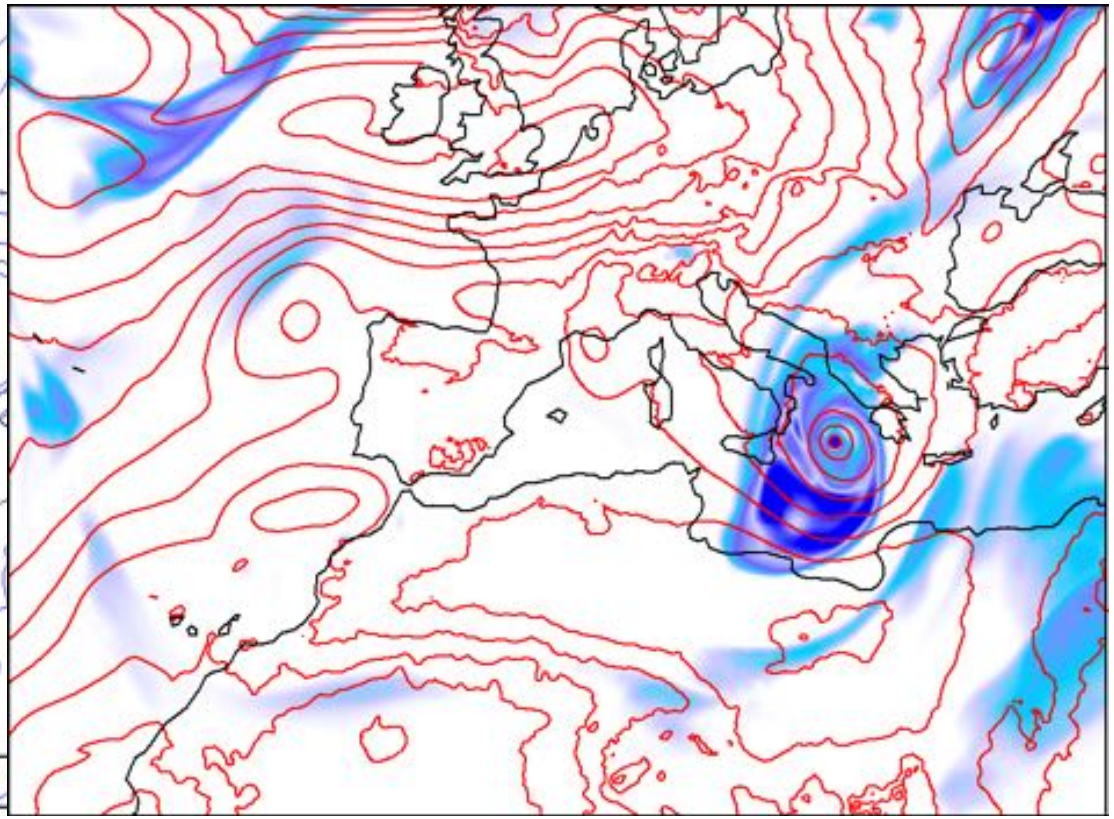

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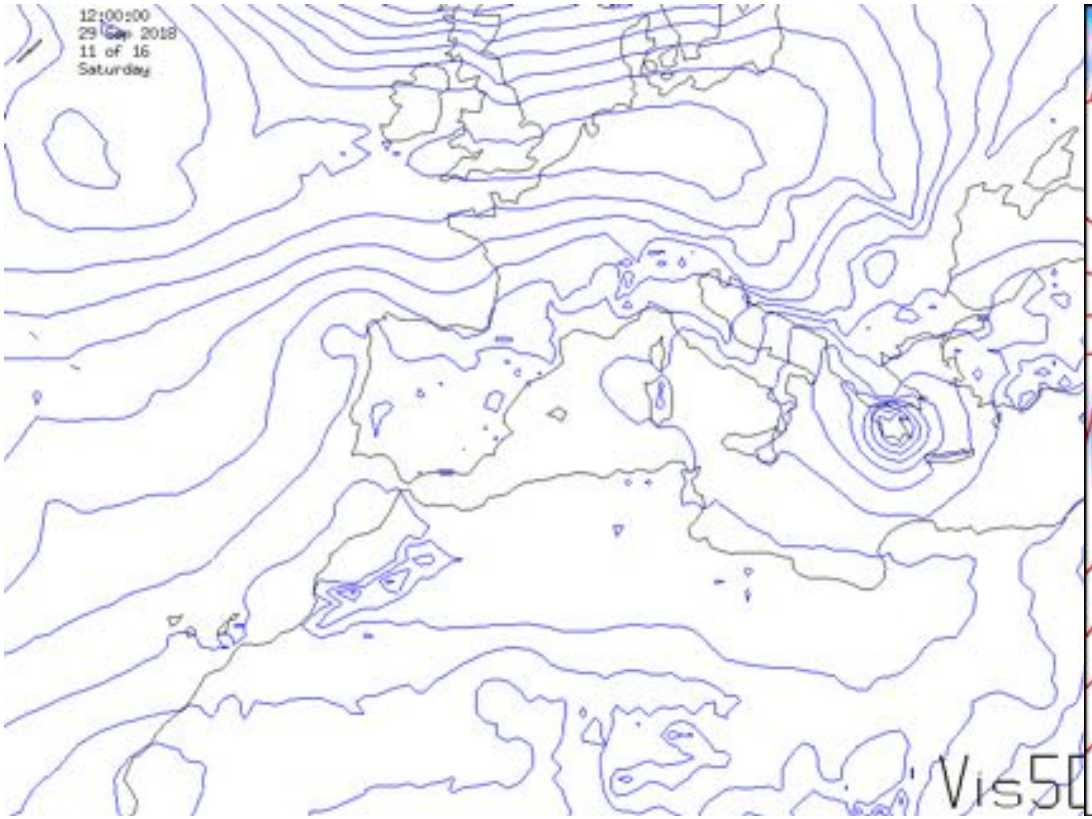

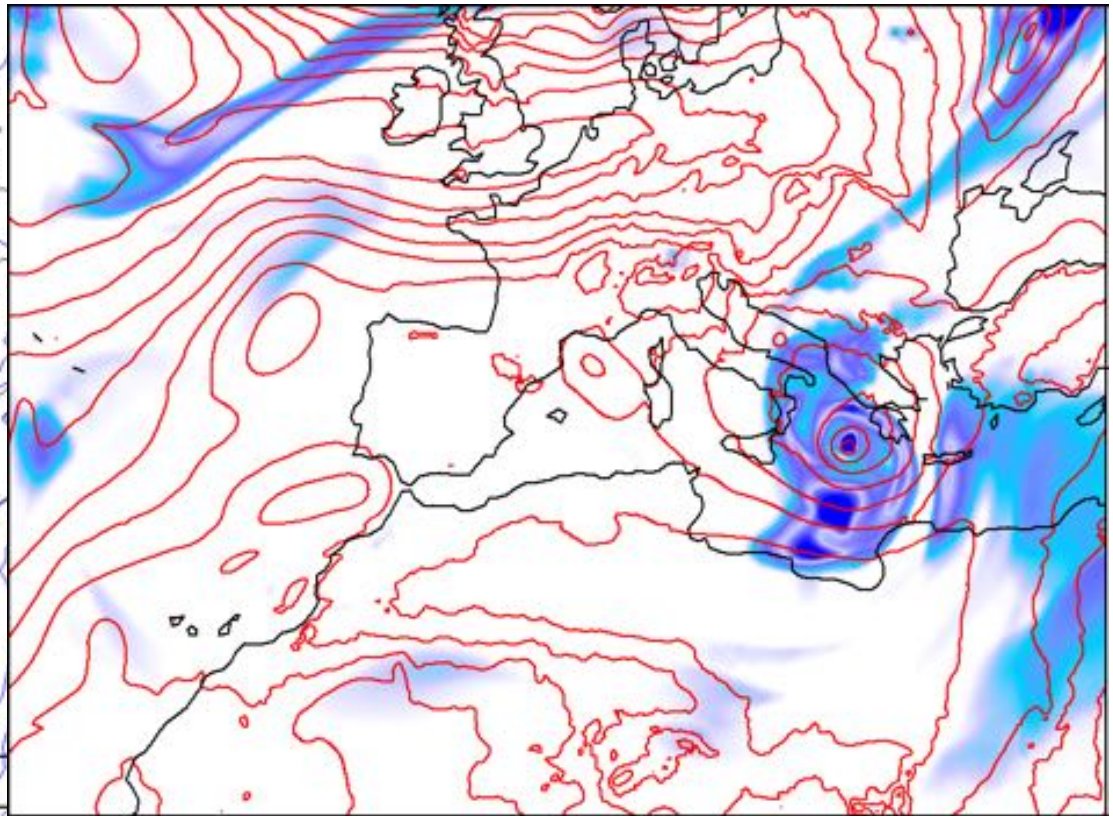

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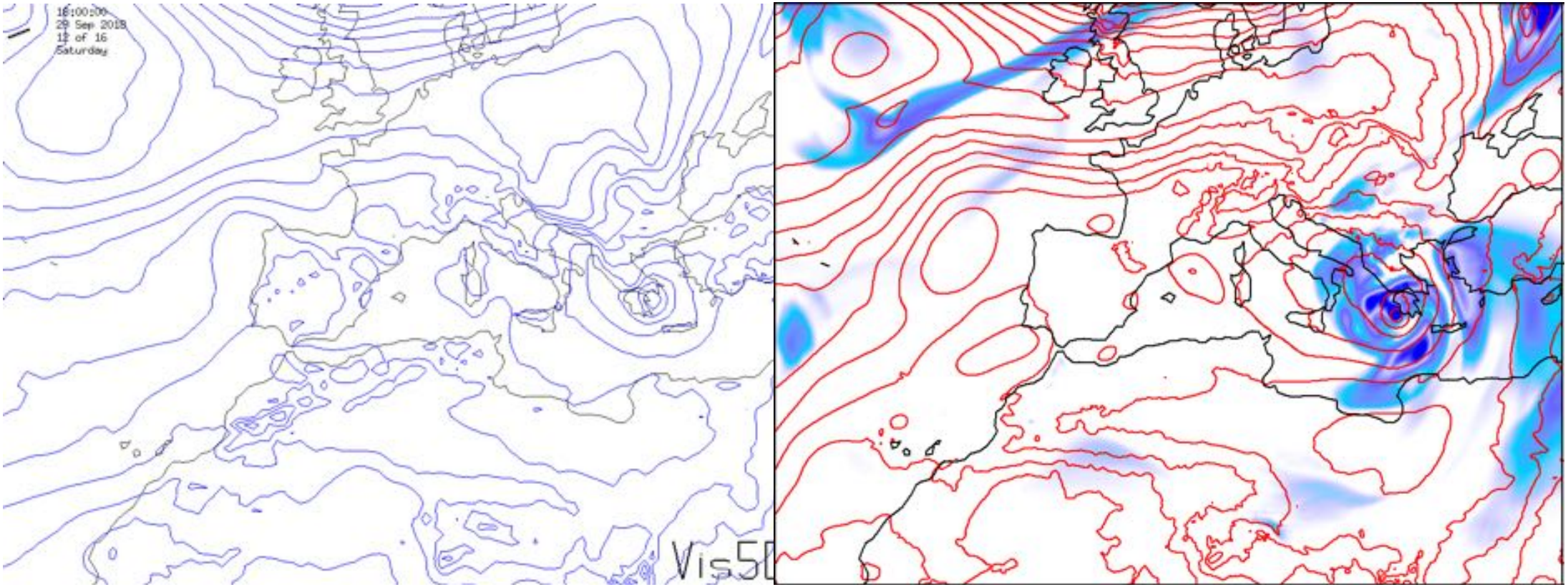
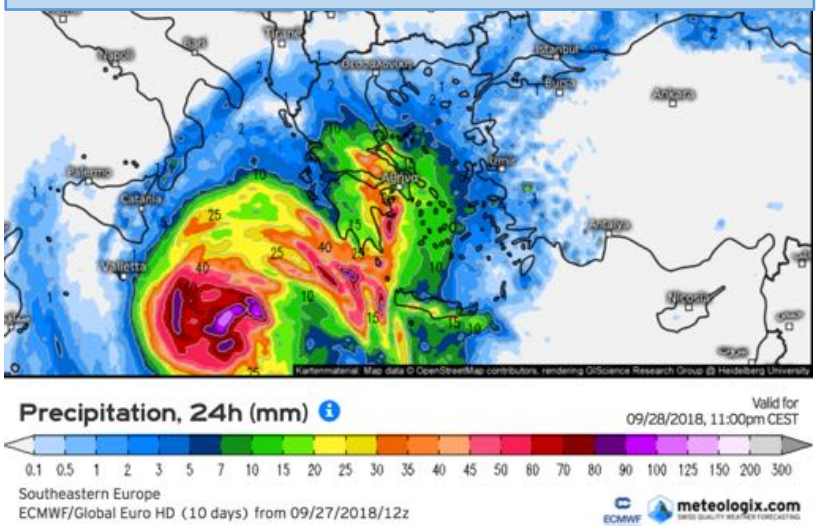
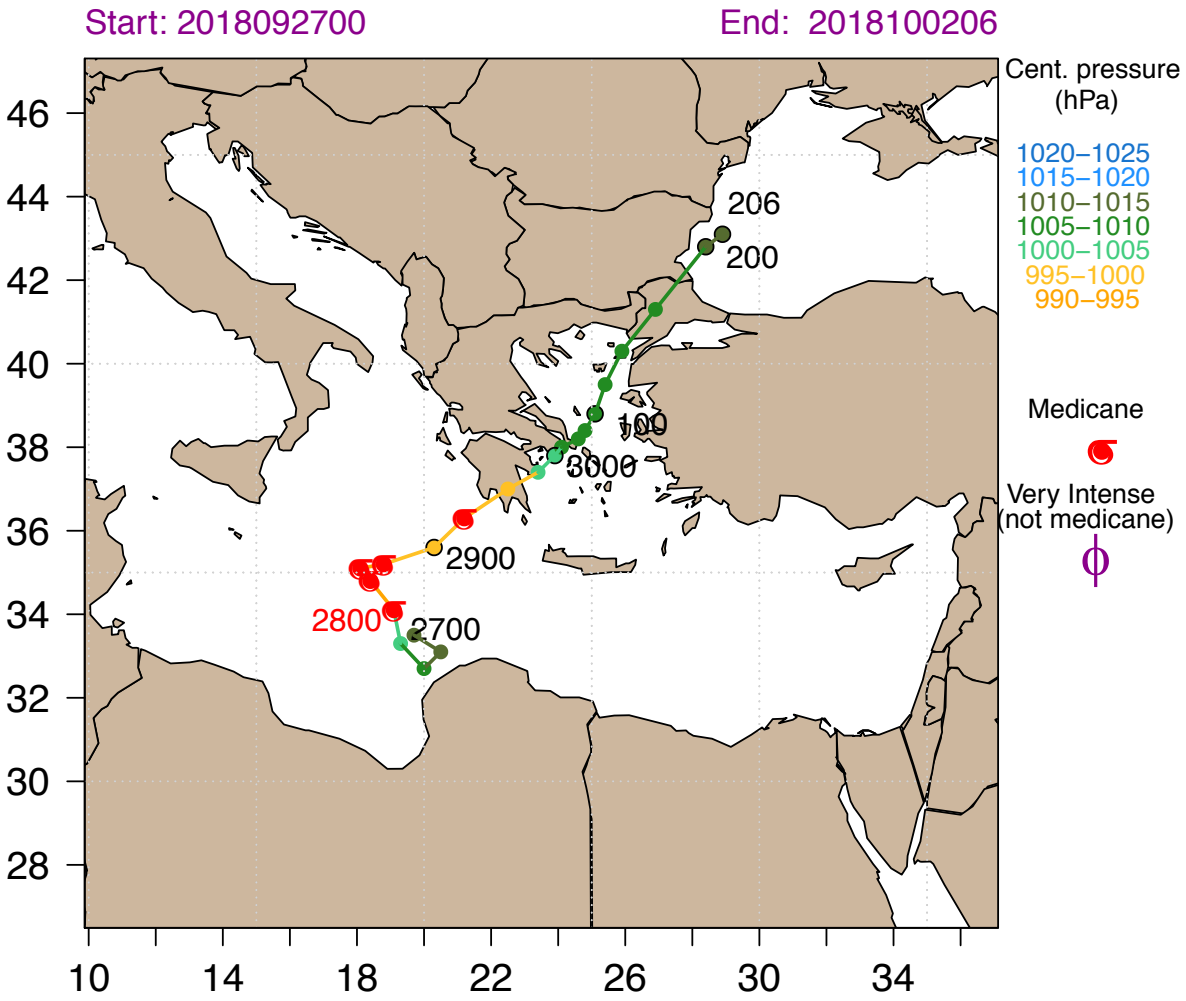


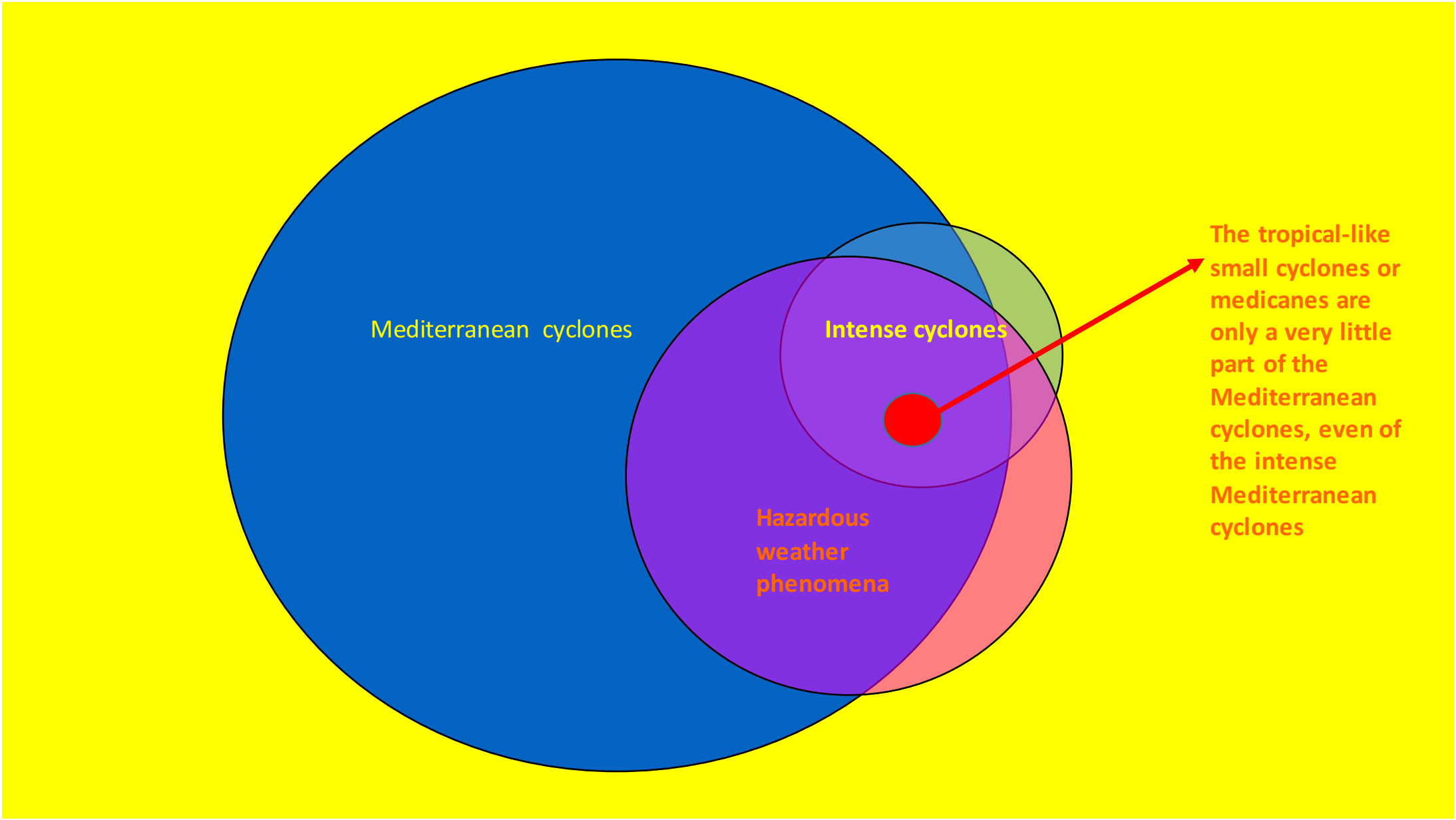
Summary and conclusions

Zorbas developed in a mixed way:
First mainly baroclinically
Later diabatically, but particularly during two short phases:
From 2718 to 2800 (sudden deepening)
From 2900 to 2906
The cyclone becomes tropical-like (medicane) after both phases

The rapid diabatic deepening occurs after heavy and extensive rainfall within the cyclone:






Mediterranean cyclones
Intense cyclones
Hazardous weather phenomena
The tropical-like small cyclones or medicanes are only a very little part of the Mediterranean cyclones, even of the intense Mediterranean cyclones


Thank you