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Permanent and changing factors in extreme Mediterranean precipitation events

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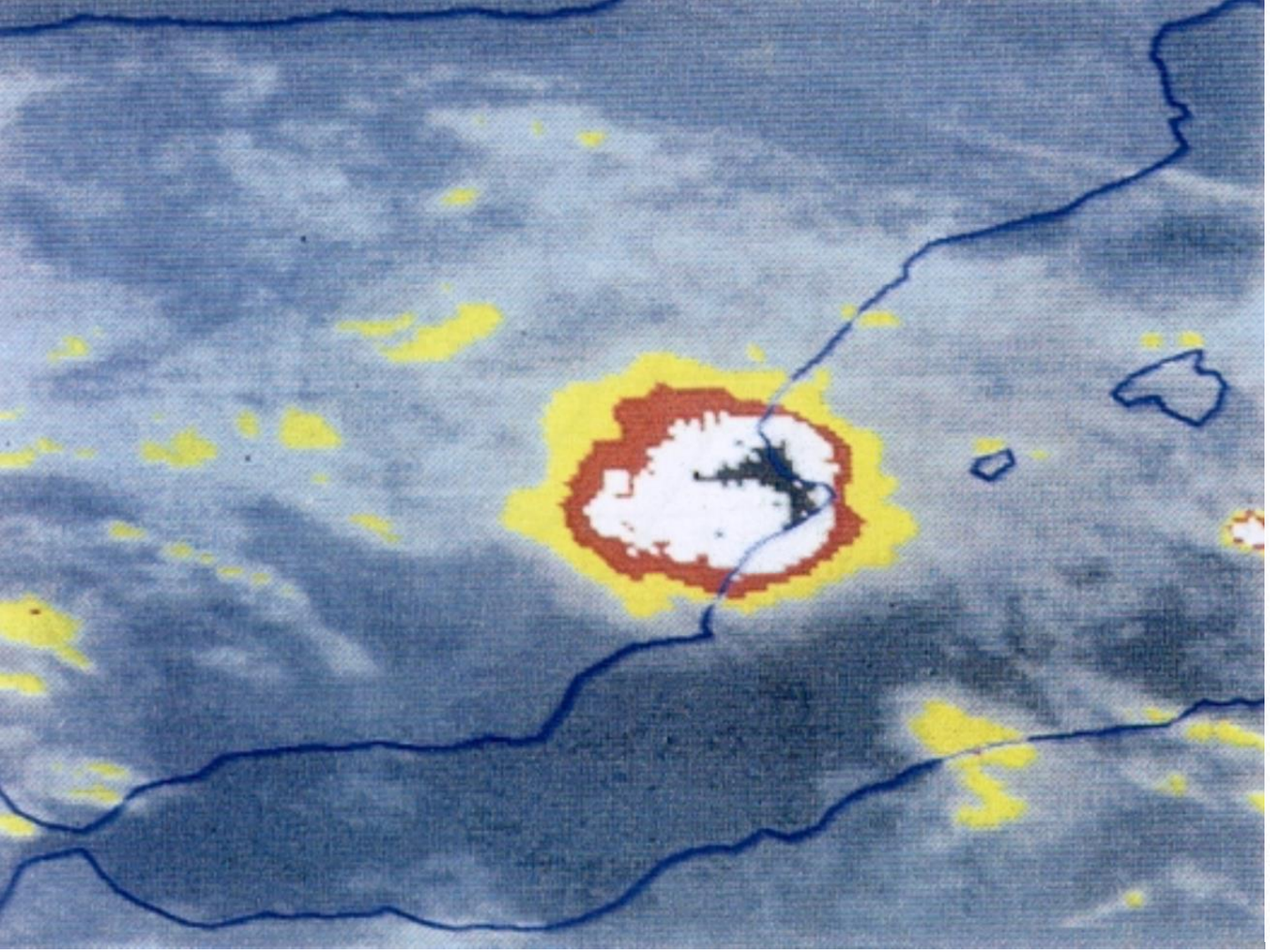
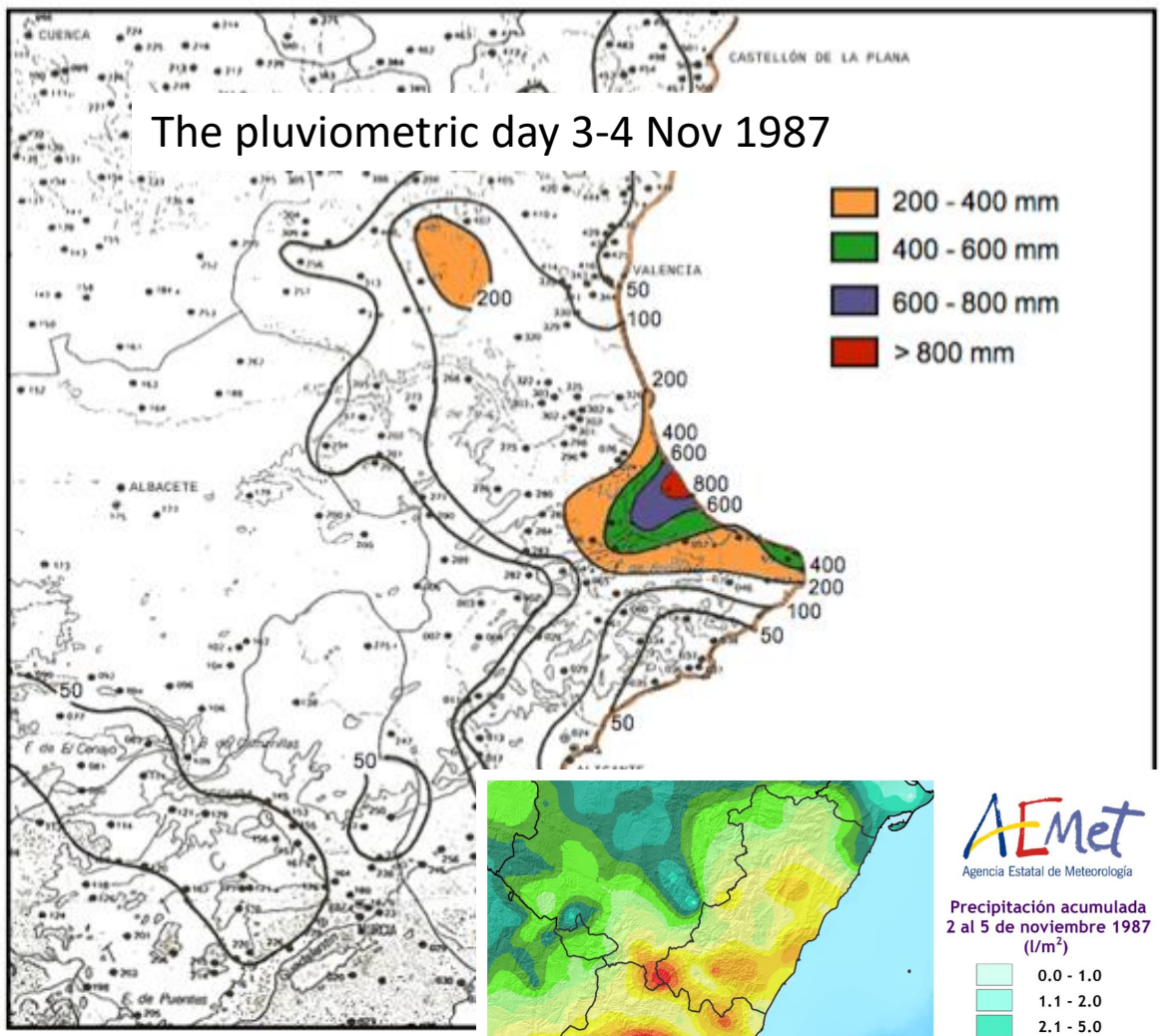
A very extreme event, the Oliva-Gandia case

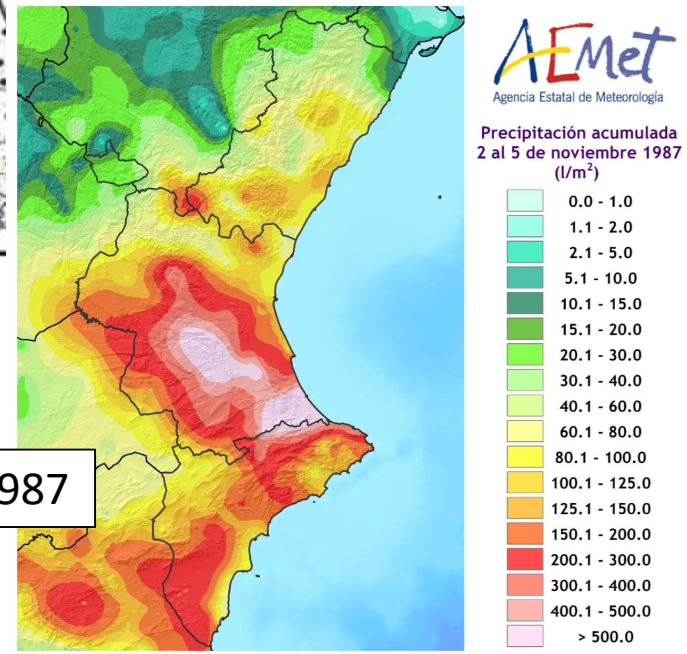
During the pluviometric day 3-4 November 1987, **817 mm/24 h** were recorded at **Oliva** (La Safor, **València**), that is the absolute record of rainfall in Spain, in *normalised* 24 h periods

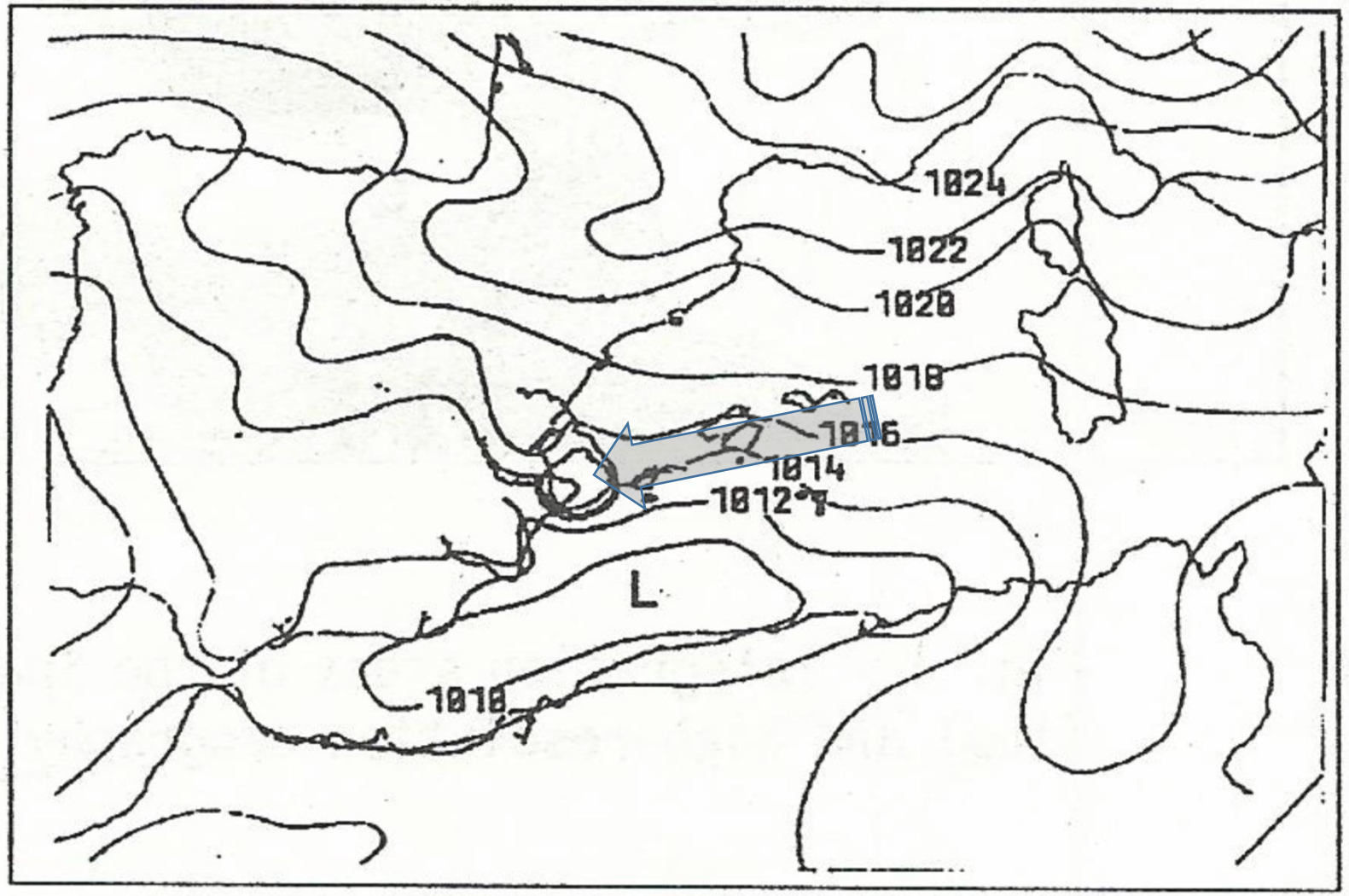




The immediate cause of the event (for the coastal part of the event, at least) was a quasi-stationary **Mesoscale Convective System (MCS)**

The whole event 2-5 Nov 1987





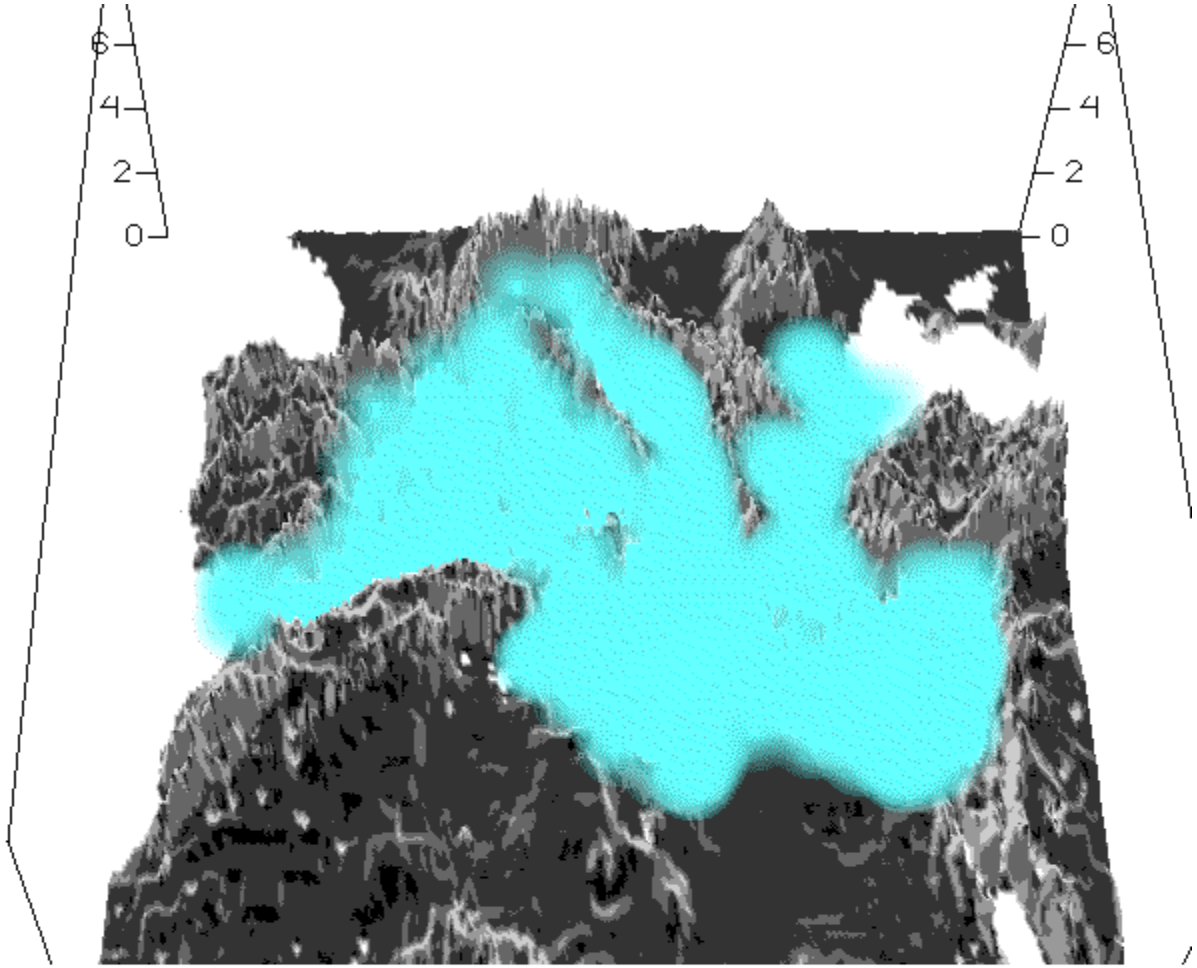
The local orography would also have played a significant role for the triggering and organising of the MCS, but note that the main rainfall maximum was coastal

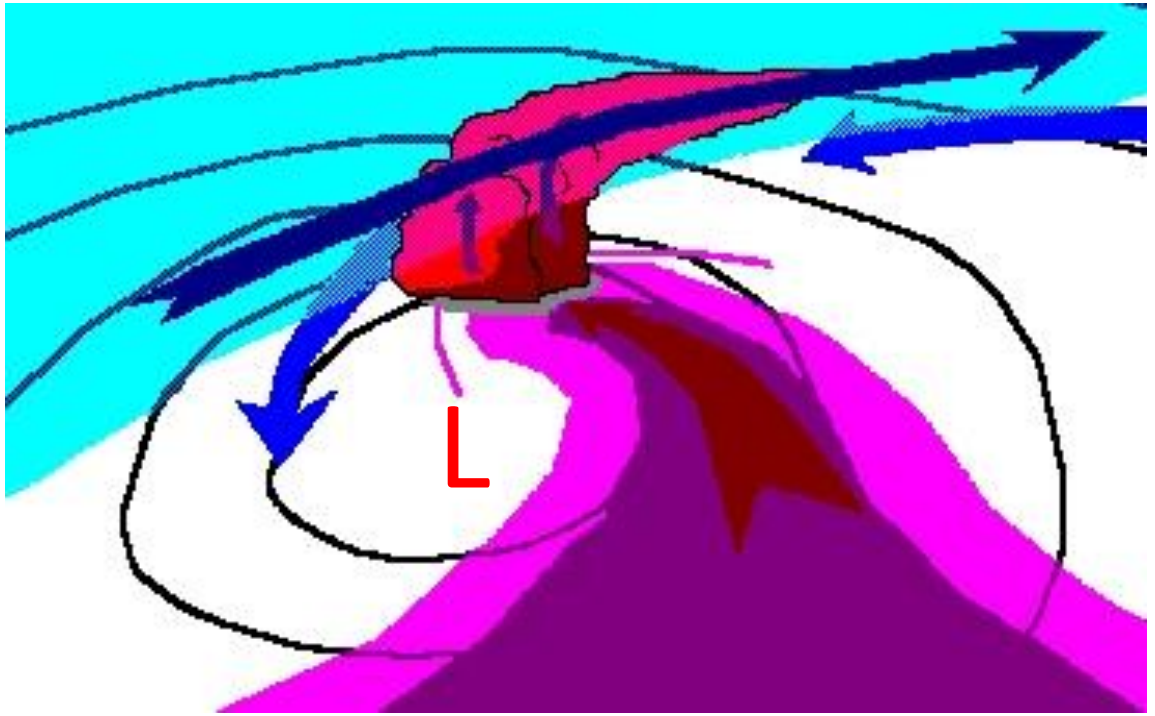
A hand made analysis suggests that the MCS was triggered and sustained by a Mediterranean flow advecting warm and moist air

The Mediterranean flow (limited and well defined) was at its time organised by a moderate low pressure centre (L)

The Mediterranean basin is a bucket, a cooking pot, sometimes filled by a warm and humid air-mass

This air-mass can be mobilized and directed to particular zones by local circulations, namely cyclonic circulations





A cyclone centre (even when it is small and weak) may favour the organization of a Mediterranean air-mass flow, forming a “small atmospheric river”, towards a zone with upward forcing (produced by coast + orography or by wind convergence: a frontal line, a convective outflow boundary, …)
The “Mediterranean river” feeds the rainfall and contributes to instability, providing heat and humidity

Heavy rain → feeding flow → cyclone?

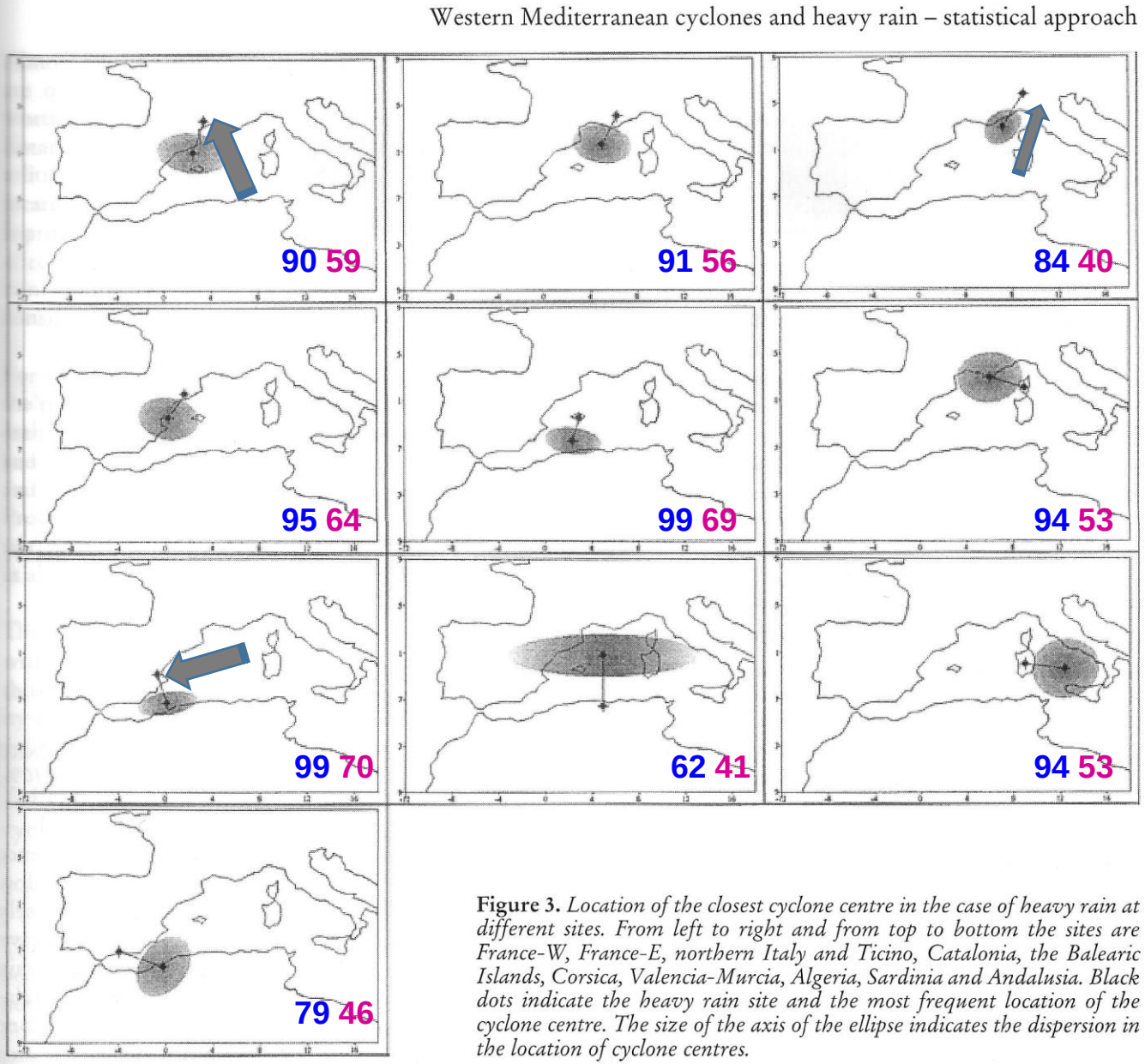


Figure 3. *Location of the closest cyclone centre in the case of heavy rain at different sites. From left to right and from top to bottom the sites are France-W, France-E, northern Italy and Ticino, Catalonia, the Balearic Islands, Corsica, Valencia-Murcia, Algeria, Sardinia and Andalusia. Black dots indicate the heavy rain site and the most frequent location of the cyclone centre. The size of the axis of the ellipse indicates the dispersion in the location of cyclone centres.*

% of heavy rain events (60 mm/day) with a cyclone at < 600 km

% random events with a cyclone at < 600 km

All cyclones (weak, moderate or intense, shallow or deep, are included)

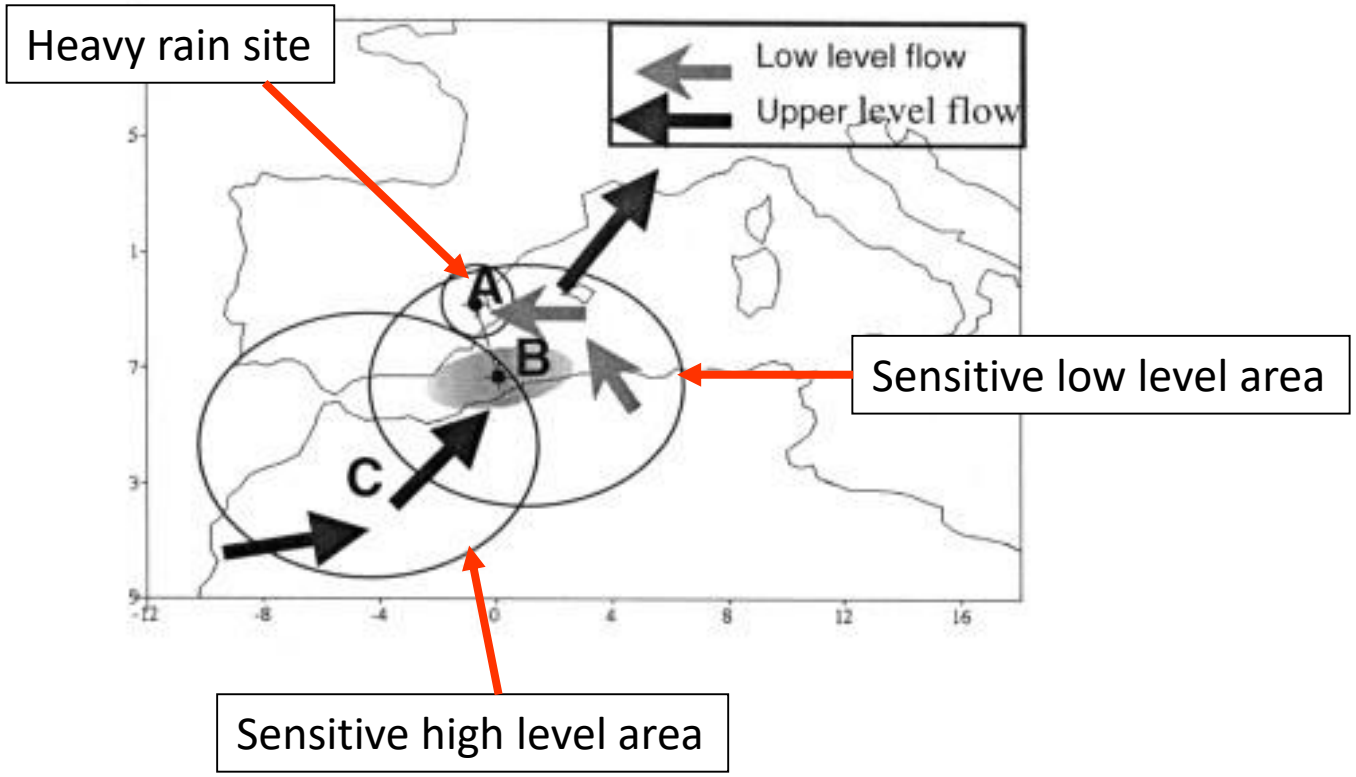
Jansà et al., 2001

A chain of factors:

Low level Mediterranean warm/humid flow against coast/mountains or convergence lines (producing MCS or convective, even no convective heavy rain)

←**low level cyclone** organising the low level flow (coming from lee effect or upper level dynamics)

←**upper level cut-off low** or open trough organising upper level flow → lee depression and/or ascending air (upper level divergence)



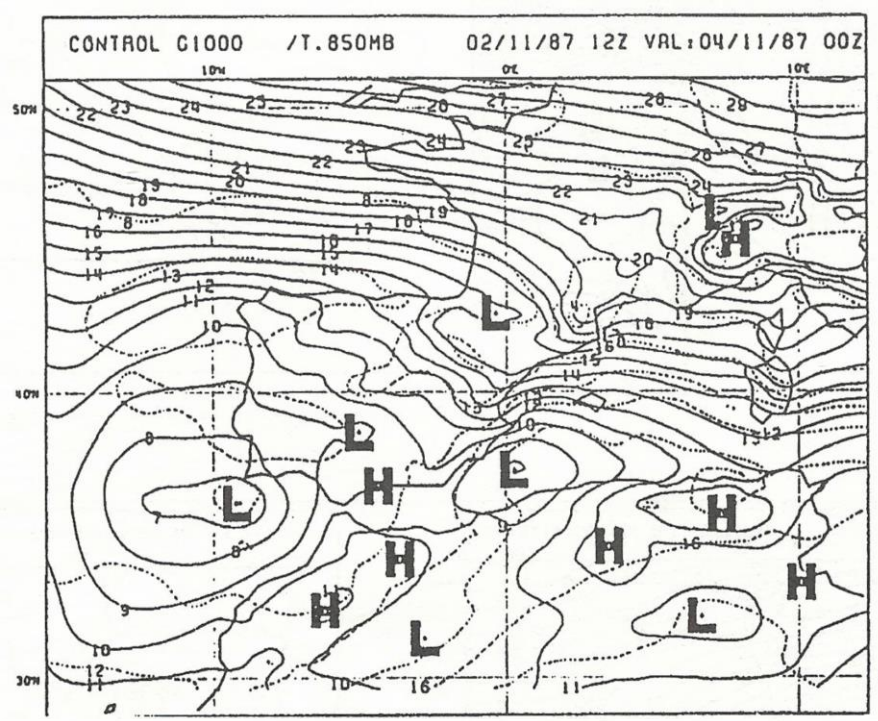
Some predictability experiments:

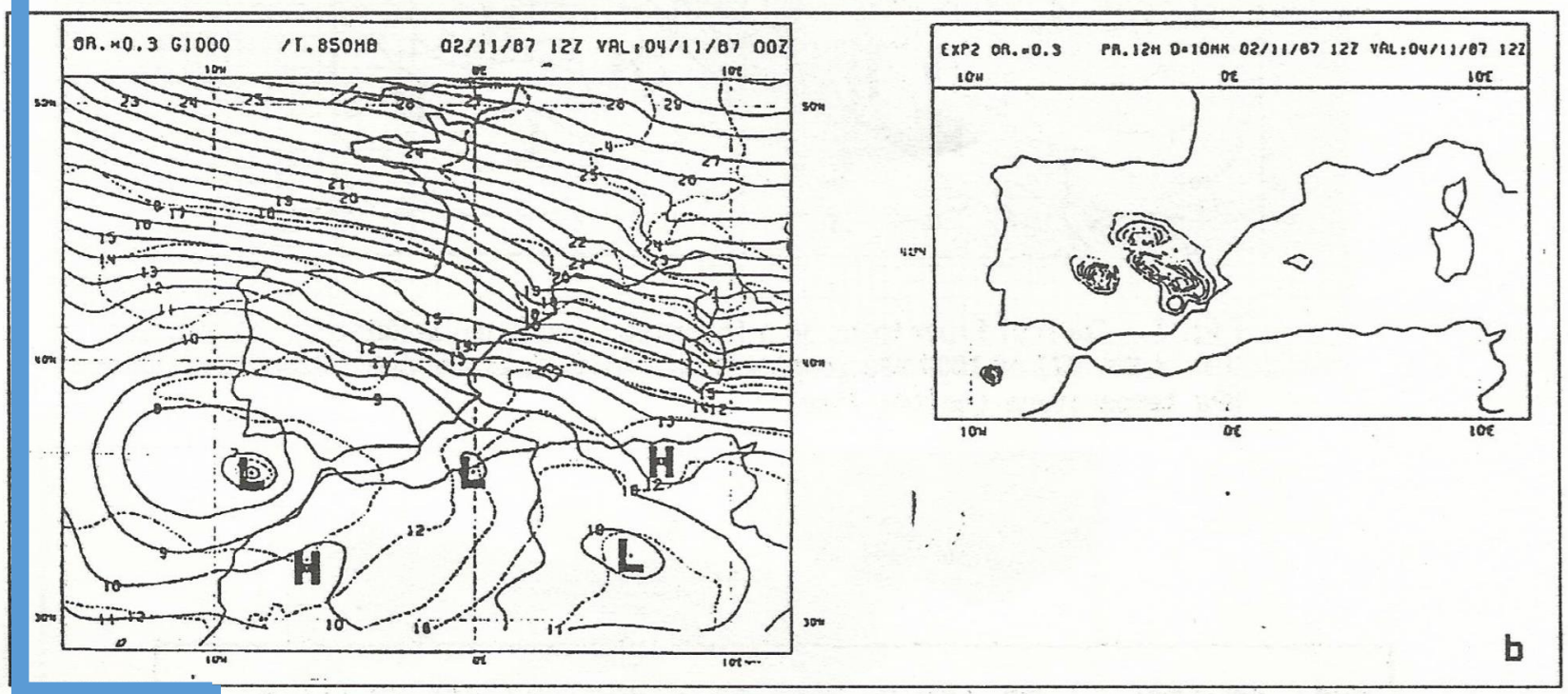
-Old experiment, with INM/LAM/ECMWF model, 0.455 º lat x lon
Sensitive experiment, orography x 0.3 [Jansa et al., 1991)

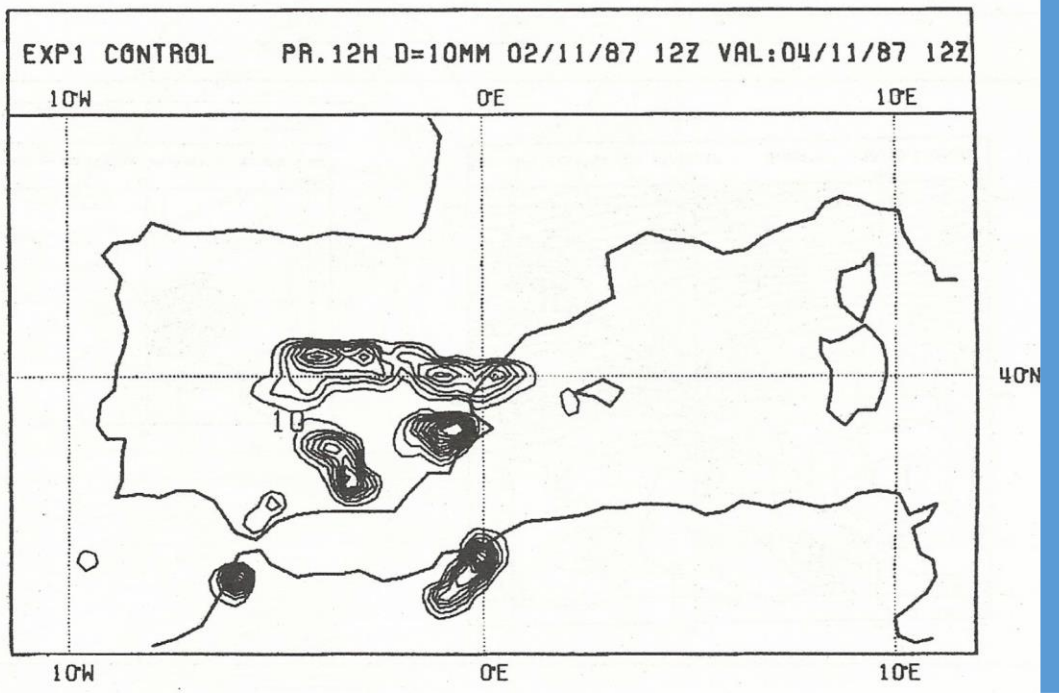
-Revisiting the case using current up to date numerical tools:

-Deterministic experiment with mesoscale model (AEMET/Harmonie/Arome), 2.5 km lat x lon (initiated with ERA-Interim) [Simarro & Armengot, 2017]

-Probabilistic experiment with the multimodel/multianalyses ensemble AEMET-gamma-SREPS, 2.5 km lat x lon [Callado & Compte, 2017]





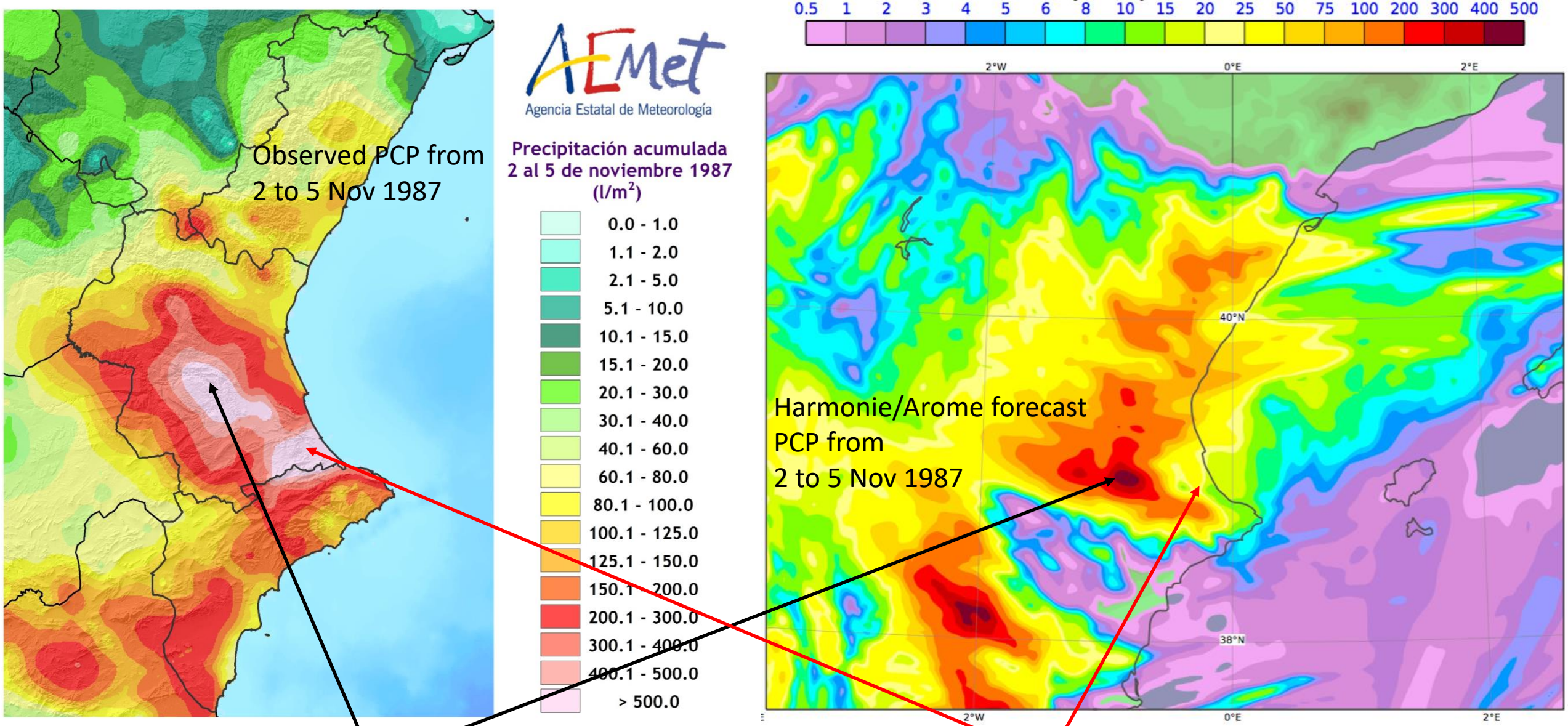


A “prehistoric” numerical experiment (1991):

- “control run”, on the left
- “orography X 0,3 experiment”, above

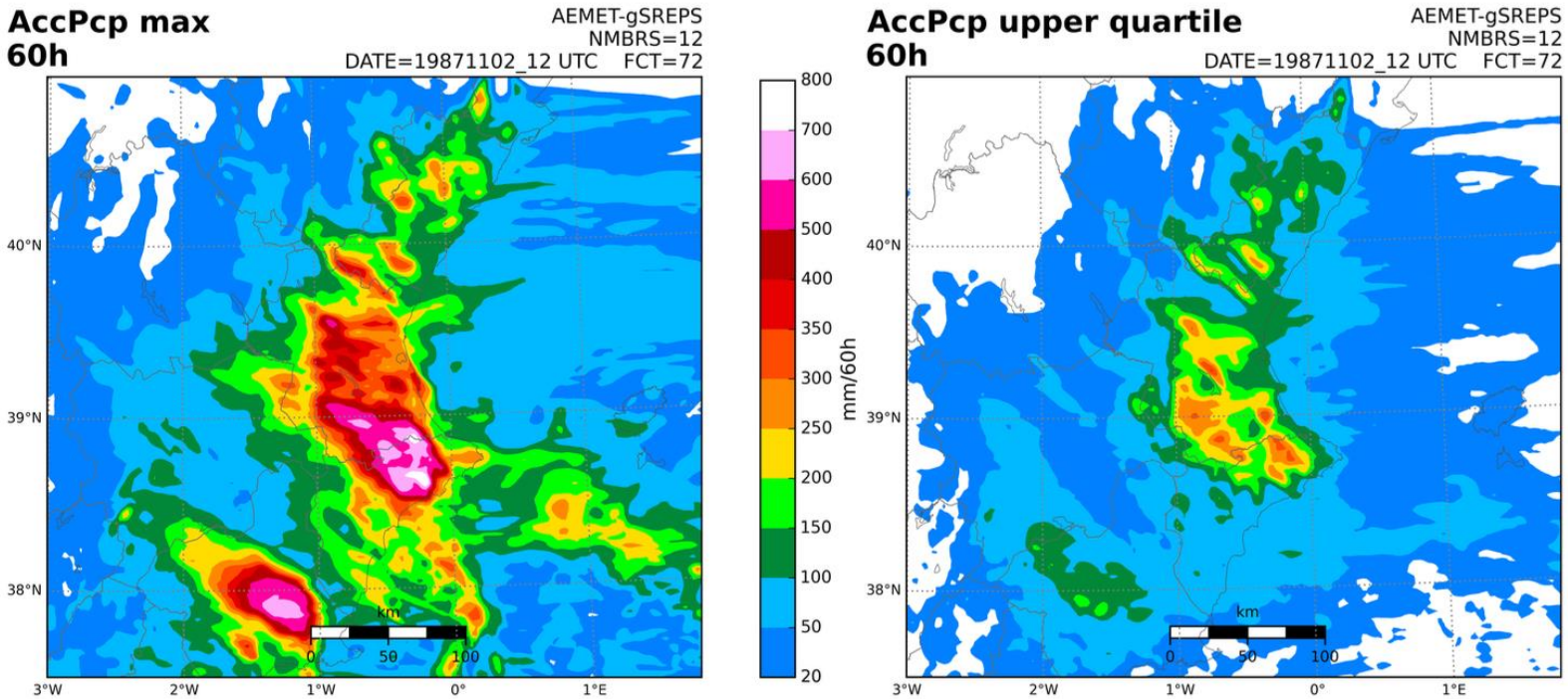
When the orography is reduced, the Mediterranean low centre becomes weaker and the “atmospheric river” loses organization, with a reduction and de-concentration of the rainfall maximum area.

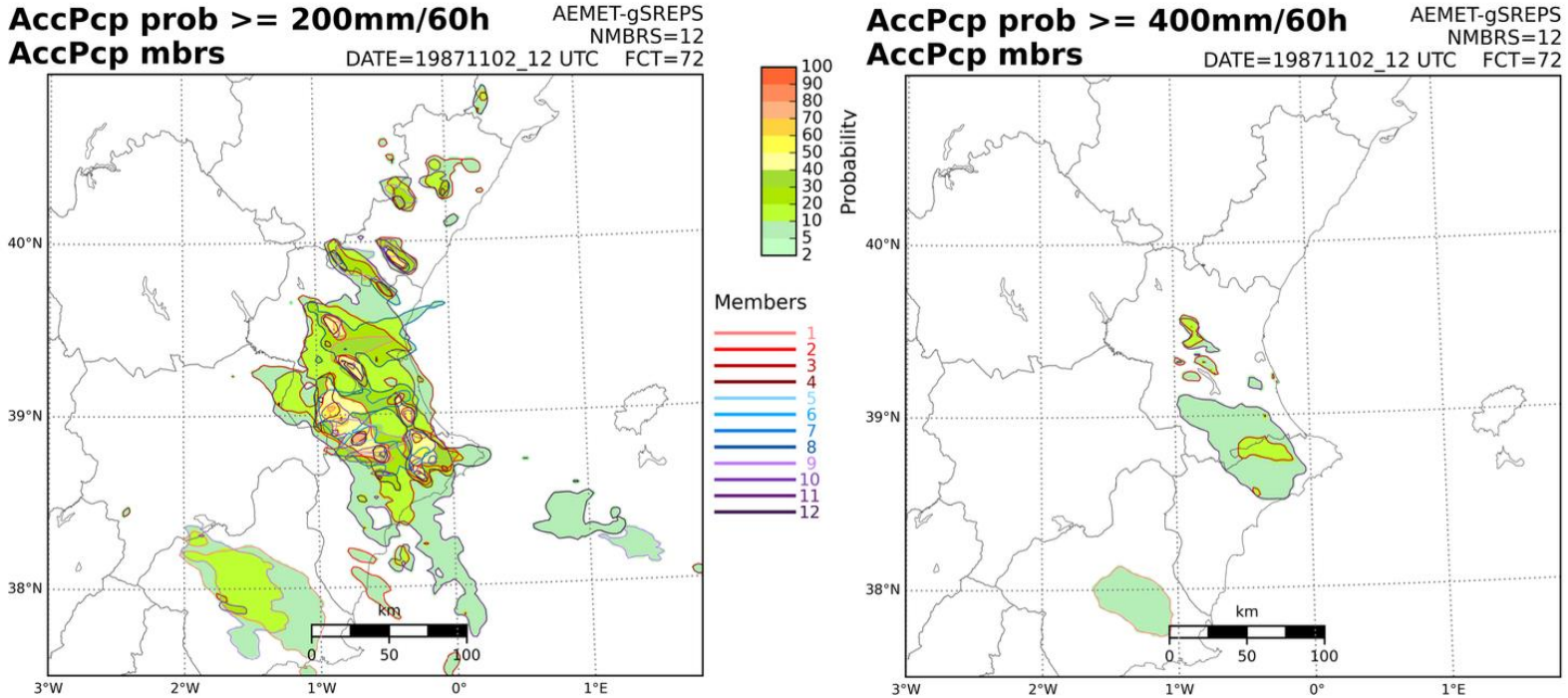
Through the generation of the Mediterranean low, the north-African orography can even be more important than the local orography for the rainfall maximum generation.



A probably more orographic nucleus is much better forecast than the more coastal nucleus

Improving the deterministic model quality the predictability of extreme orographically induced maximum rainfall increases, but the predictability of other (coastal) rainfall maximum does not increase so much.





A high resolution ensemble forecast can give a rough indication about the probability of an extreme precipitation event, but details are not well caught.

Once more, the most orographically induced nuclei are better forecasted than the coastal ones.

About predictability:

When upper level, large structures are well forecasted, even old, low resolution models can reproduce with sufficient accuracy the low level structures associated to extreme precipitation (that is: low pressure centre and feeding flow), at least when the orography plays a role in its generation → an indication about heavy precipitation can also be explicit

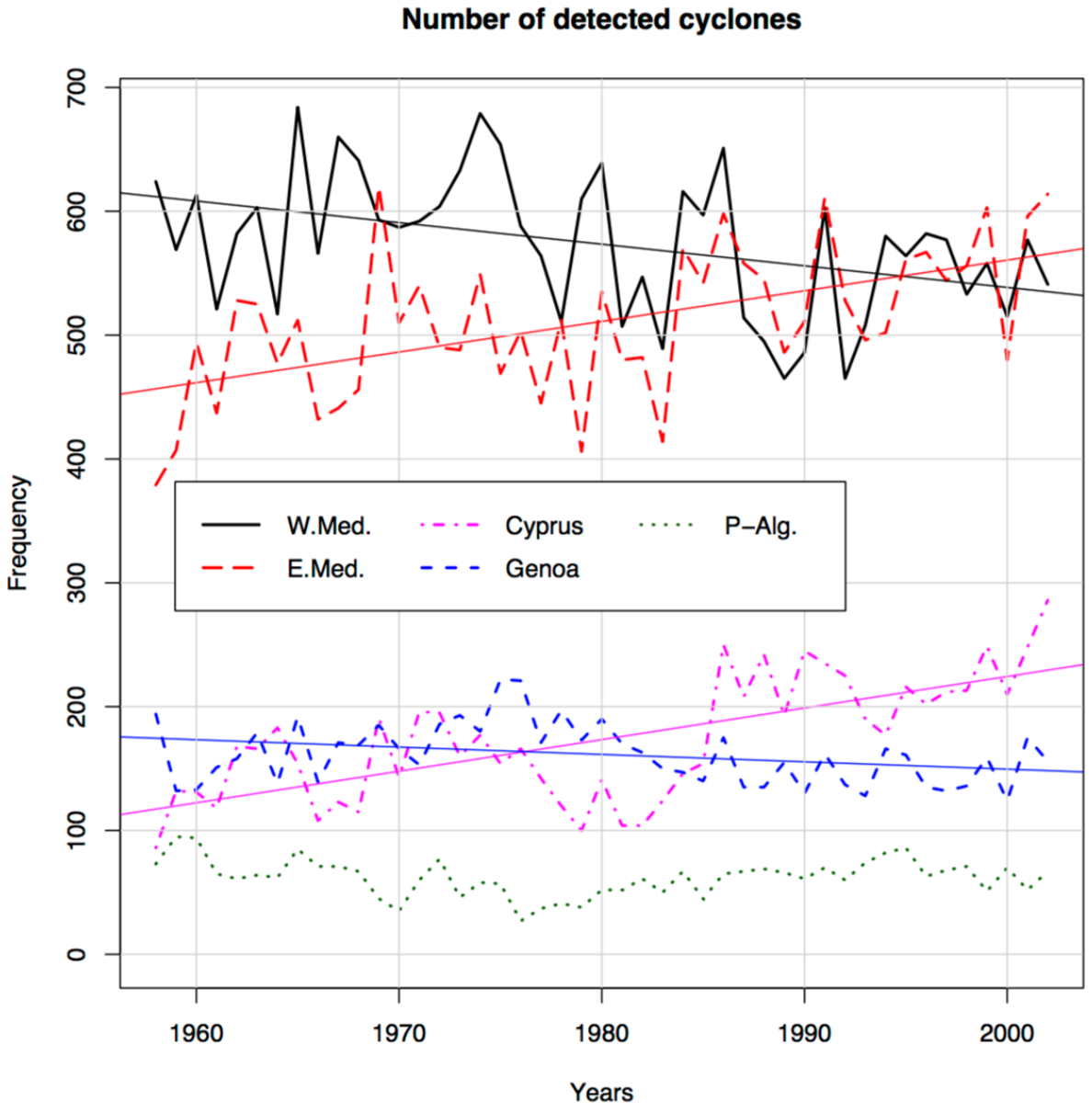
Realistic amounts of extreme rainfall are only numerically predictable with modern, high resolution models. Even with those, not all convective structures are forecast: the more important the local orography factor is, the more predictable the rainfall.

Regarding the case of Oliva, the coastal maximum is not well caught not even by modern models

Long term time evolution of factors favouring extreme precipitation:

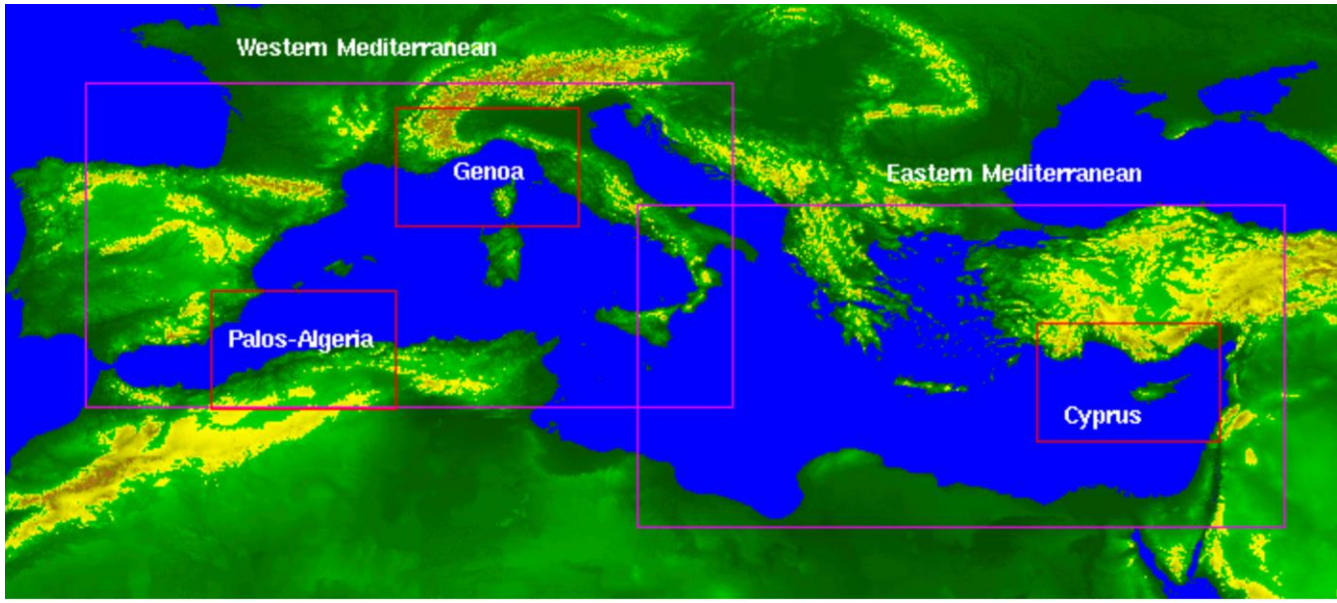
Of course, there is no evolution of the orography (considered as a possible factor of triggering precipitation systems and a possible factor of low level cyclonic centres in the Mediterranean)

What about the involved low and upper level meteorological systems themselves?



Observed tendencies on the frequency of some surface Mediterranean cyclones

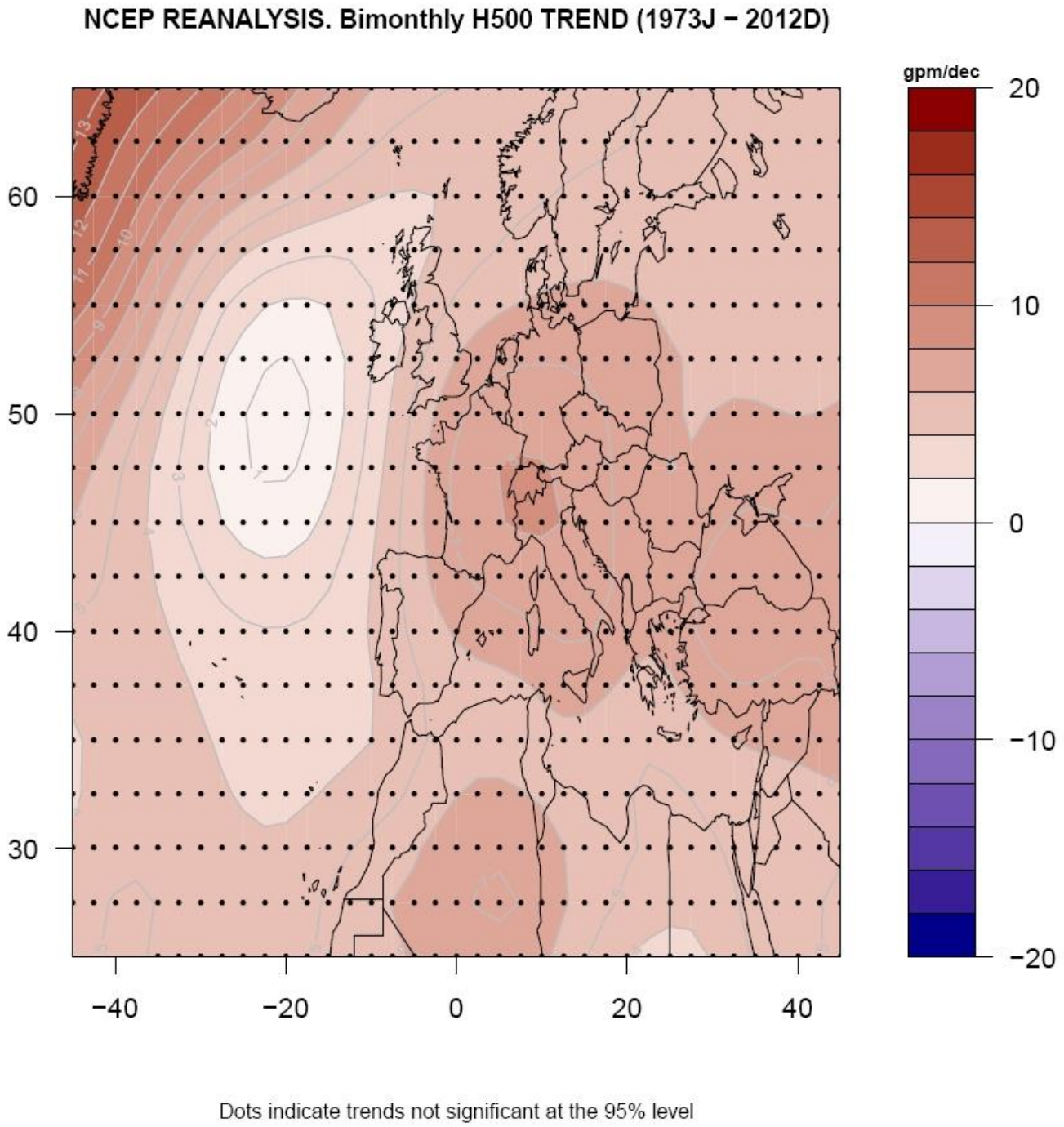
(1957-2002 , from Guijarro et al, 2006)



No decreasing in the frequency of cyclone centres in the Palos-Algeria region ...

Although the annual tendencies are not significant, ERA-40 indicates **less increasing of the 500 hPa geopotential in the Atlantic areas than in the European (Alpine) ones:** This can suggest *higher frequency of Atlantic cut-off lows and lower frequency of Alpine-Genoa cut-off lows.*

(Jansa et al., 2017)



Neither the low level, nor the upper level meteorological systems involved in extreme rainfall events in the Valencia area have a decreasing frequency with observed climate change -> the probability of extreme rainfall in this area may not decrease in the near future.

Perhaps it is not the same in other Mediterranean areas.

Thank you!