

50-year wind record and rissaga event associated with a winter squall line in the Balearics

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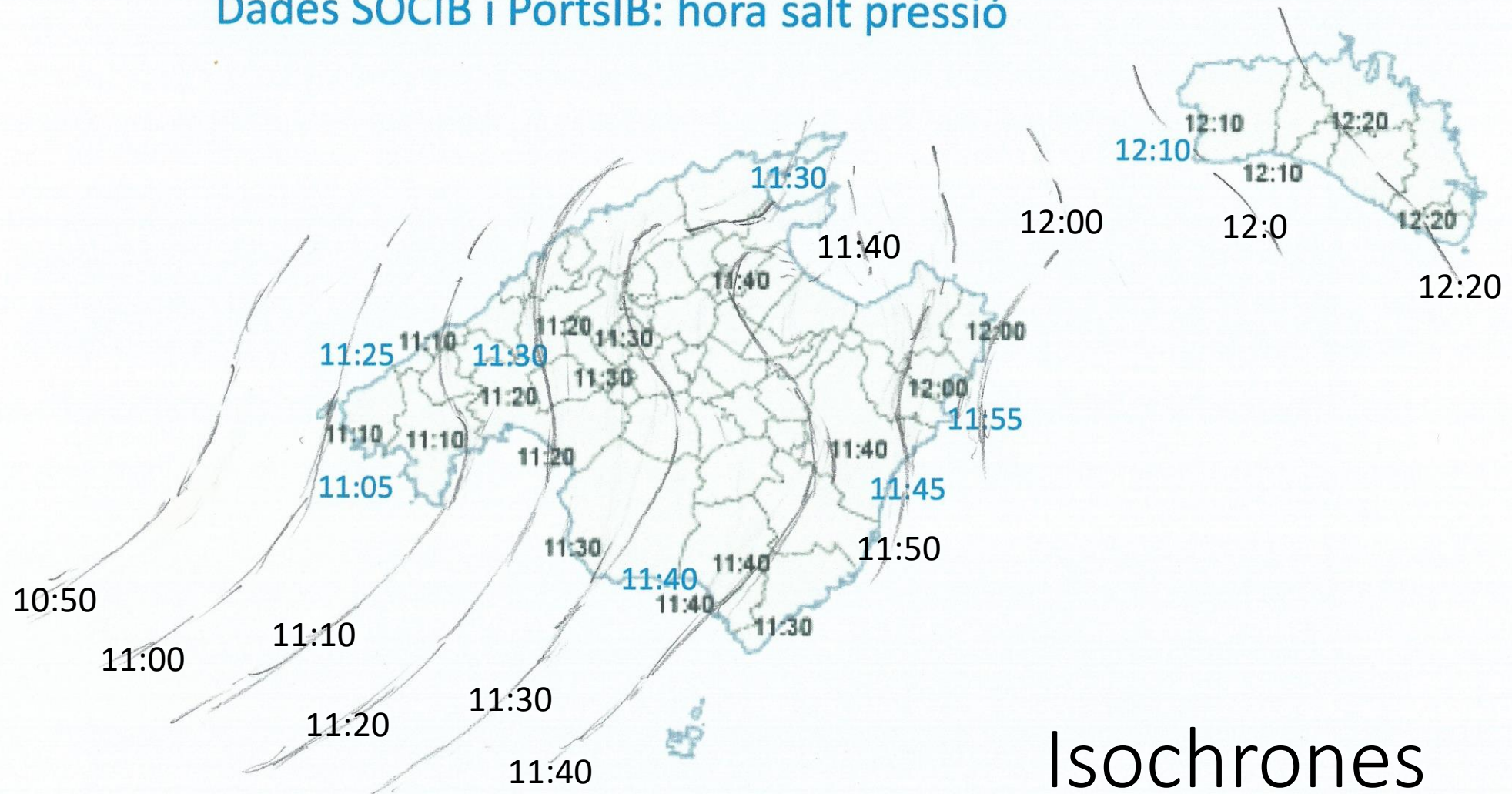
Preliminary research in the frame of the
COASTEPS funded project

Content:

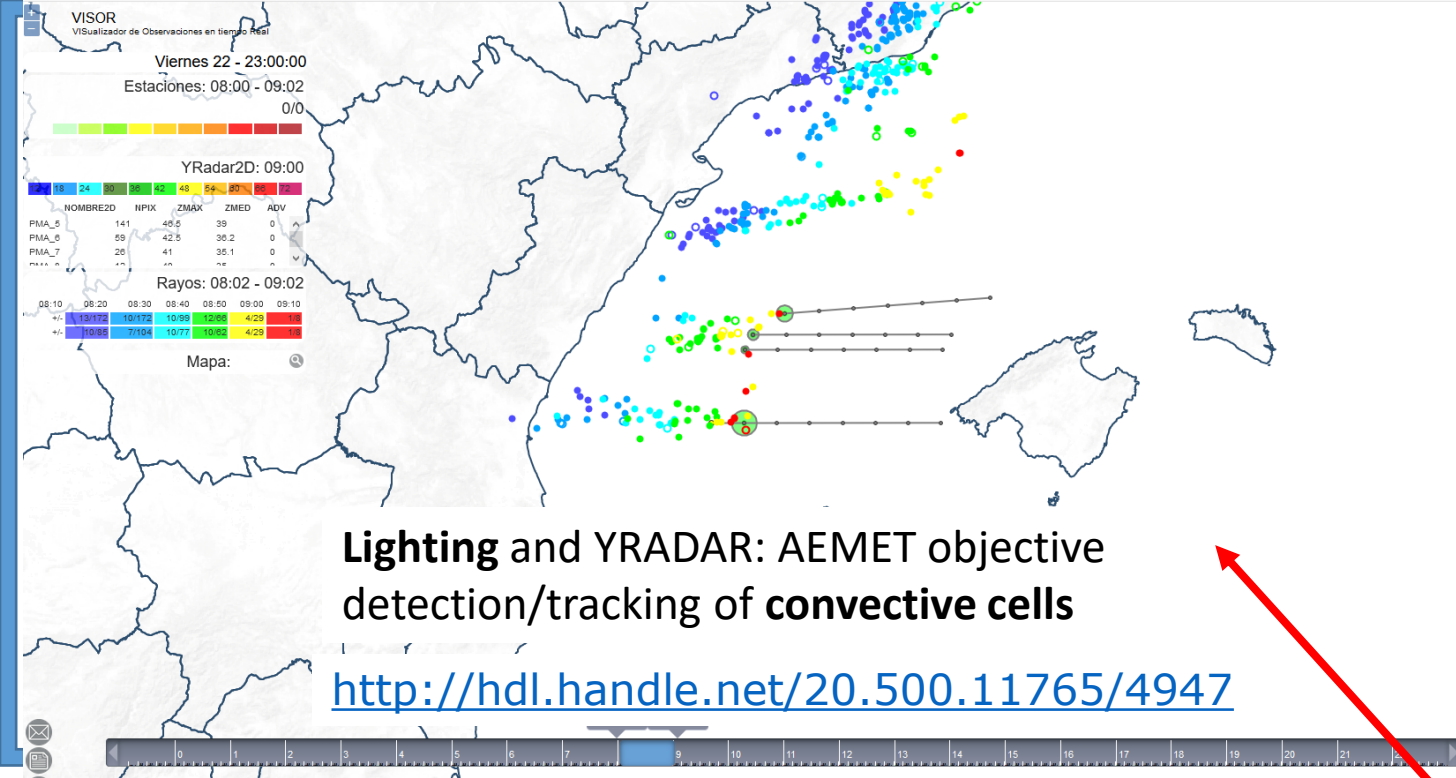
- Observations:
 - General view (squall line across the Balearics on 22-Jan-2021) and details: wind, pressure, long waves / meteotsunamis
- Diagnosis:
 - Synoptic frame and mesoscale aspects
- Predictability:
 - Results from models, concerning wind, concerning meteotsunamis

Observations

Dades AEMET i PortsIB: hora ratxa màxima
Dades SOCIB i PortsIB: hora salt pressió

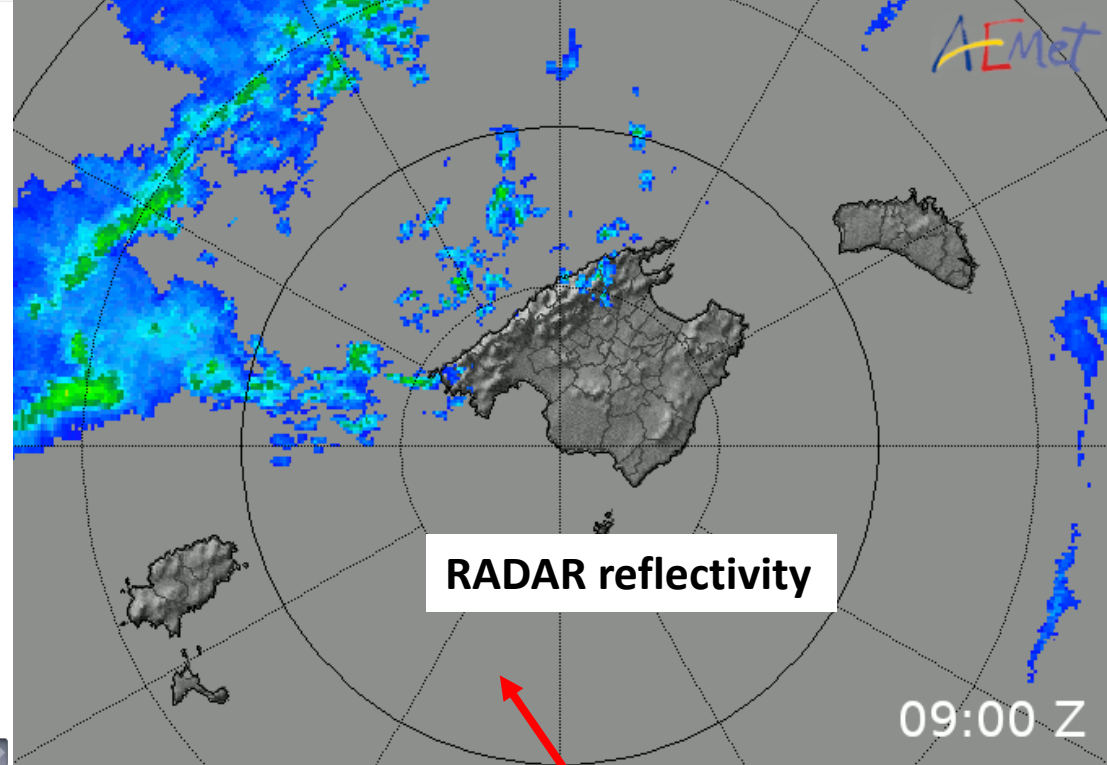


Isochrones
CET



Lighting and YRADAR: AEMET objective detection/tracking of convective cells

<http://hdl.handle.net/20.500.11765/4947>

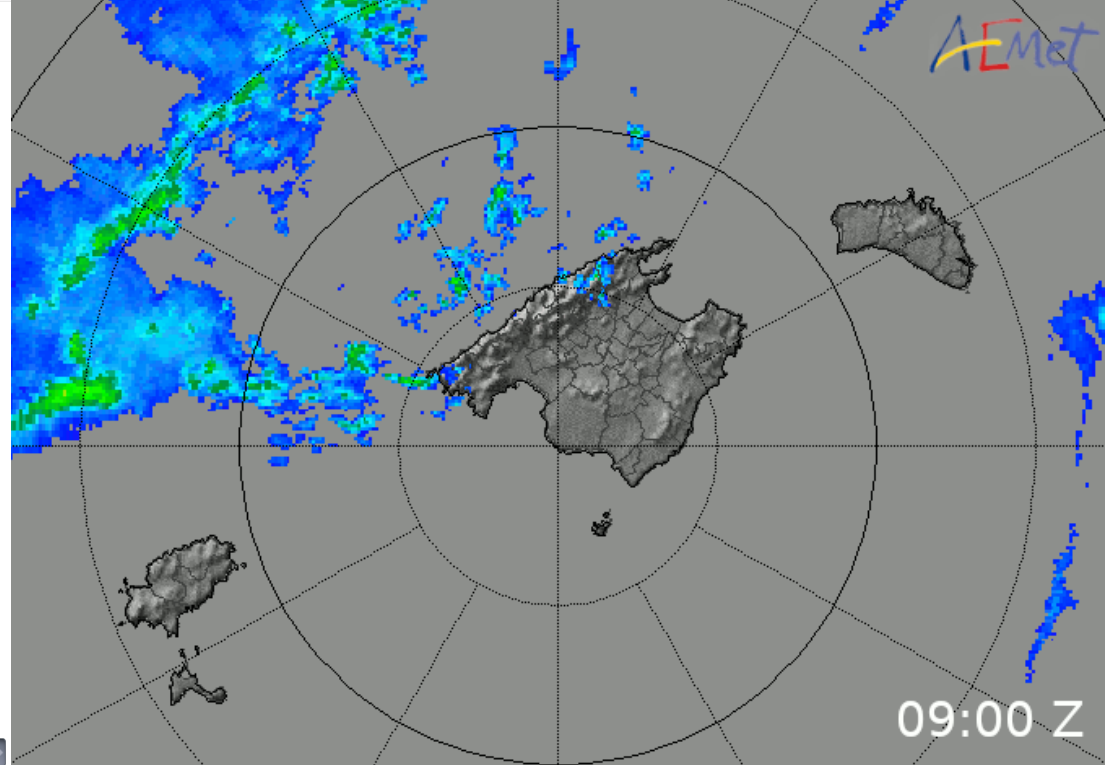
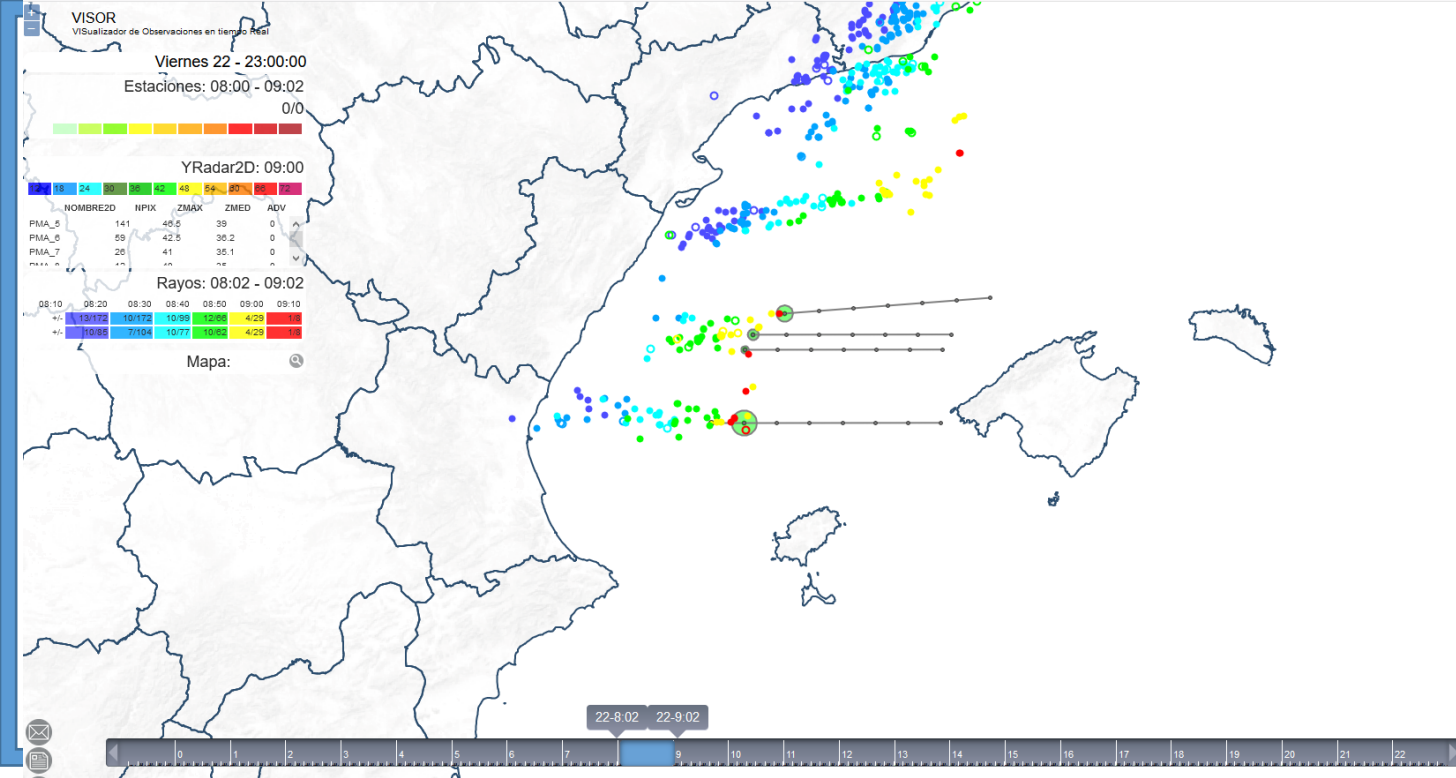


Every ten minutes, we are showing **lighting and convective cells, radar reflectivity, radial velocity, details, isochrones**

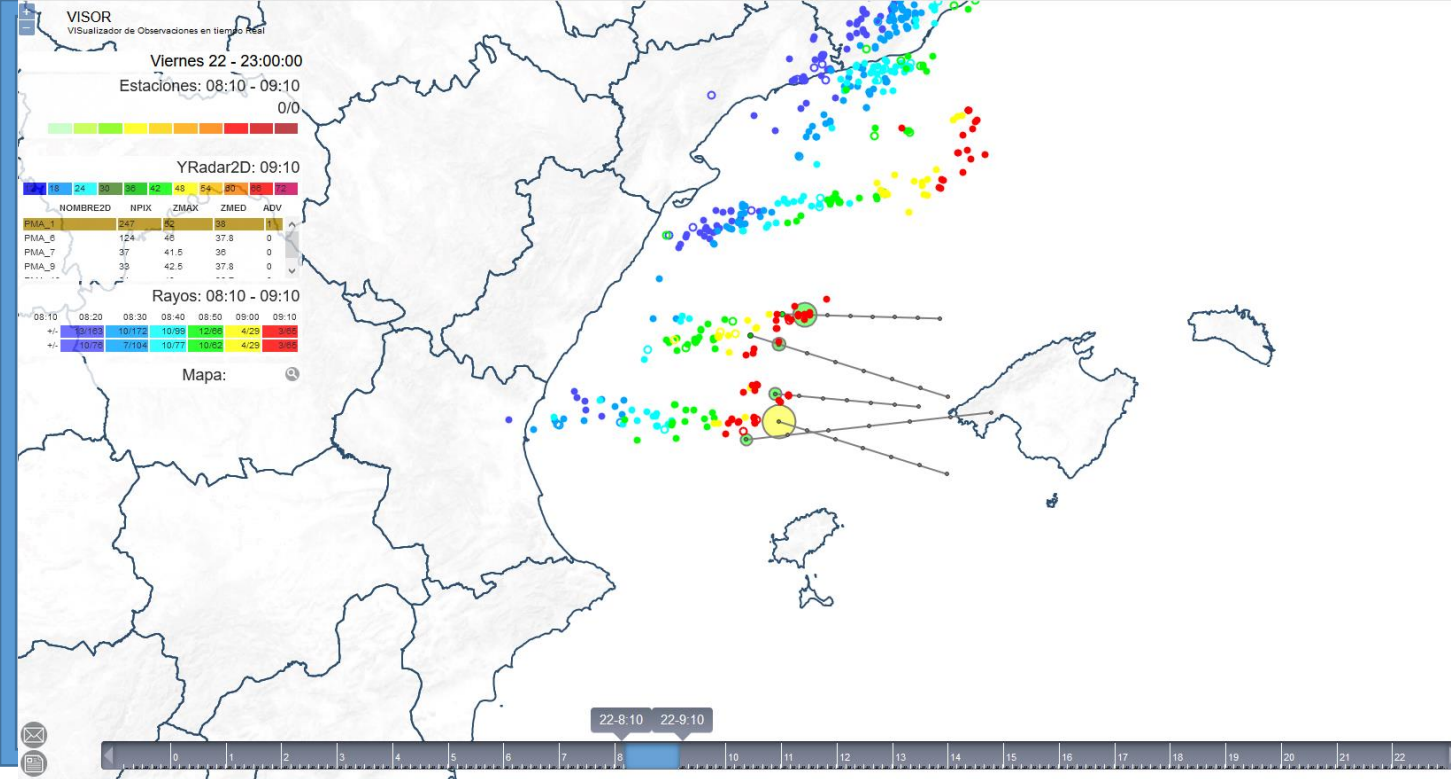
[Doppler RADAR]

Details

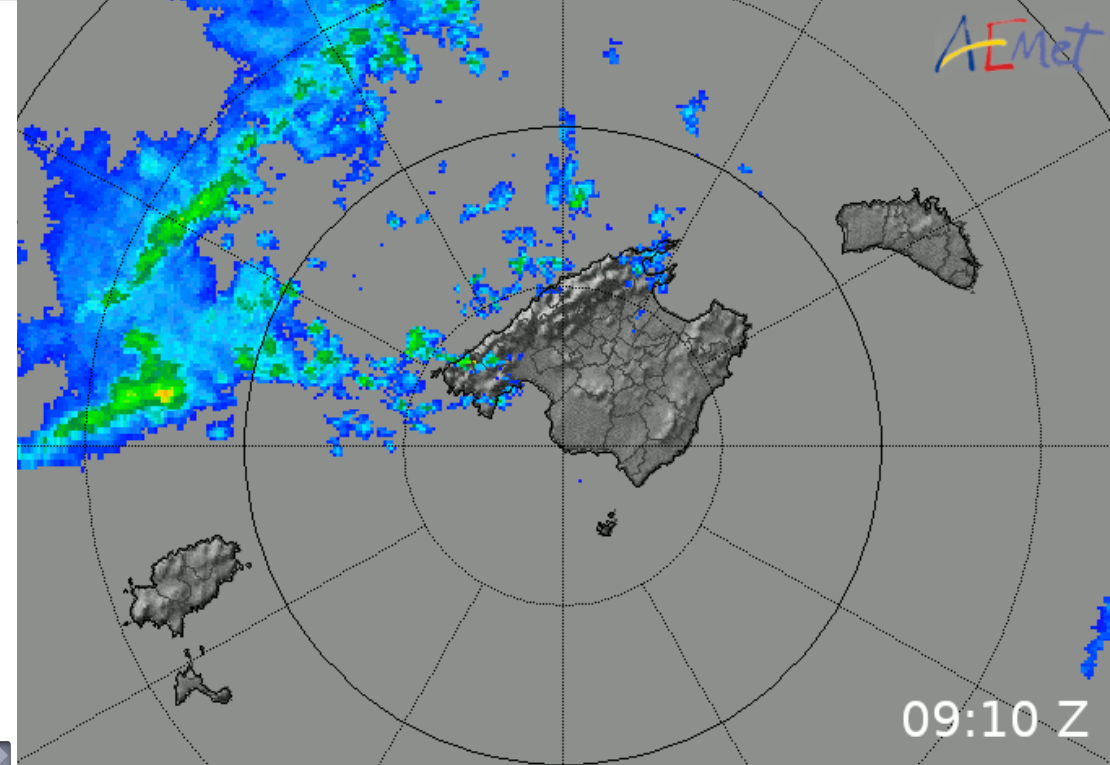
Isochrones

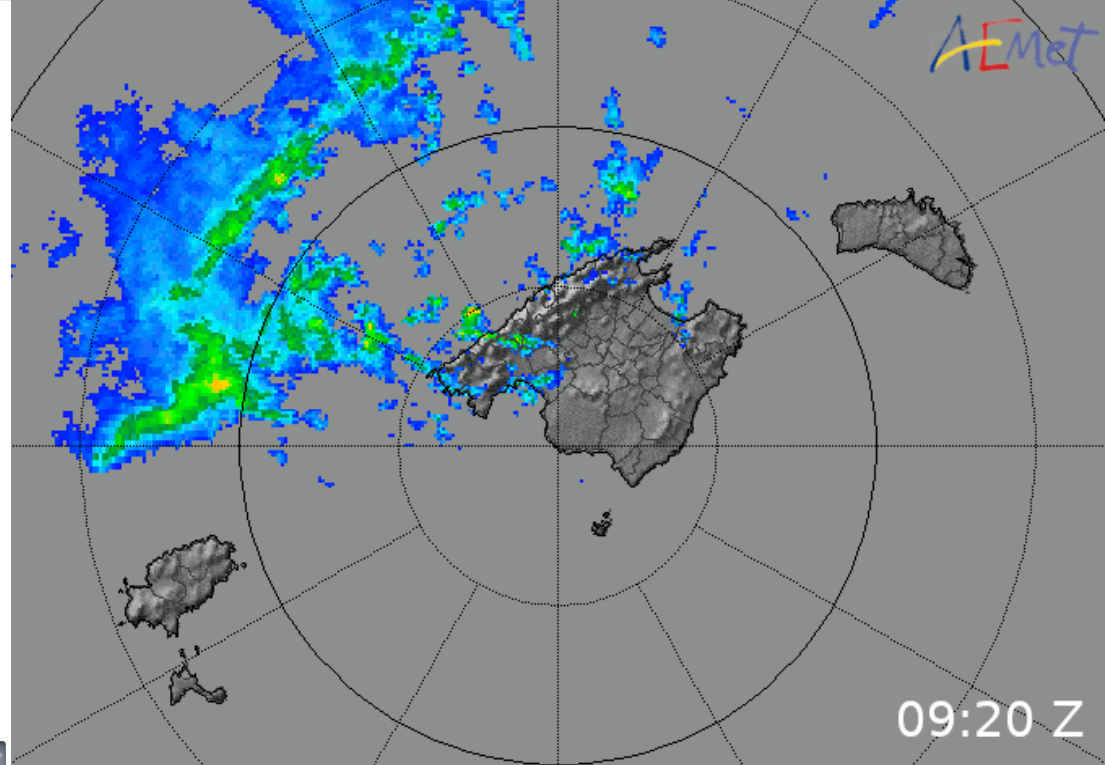
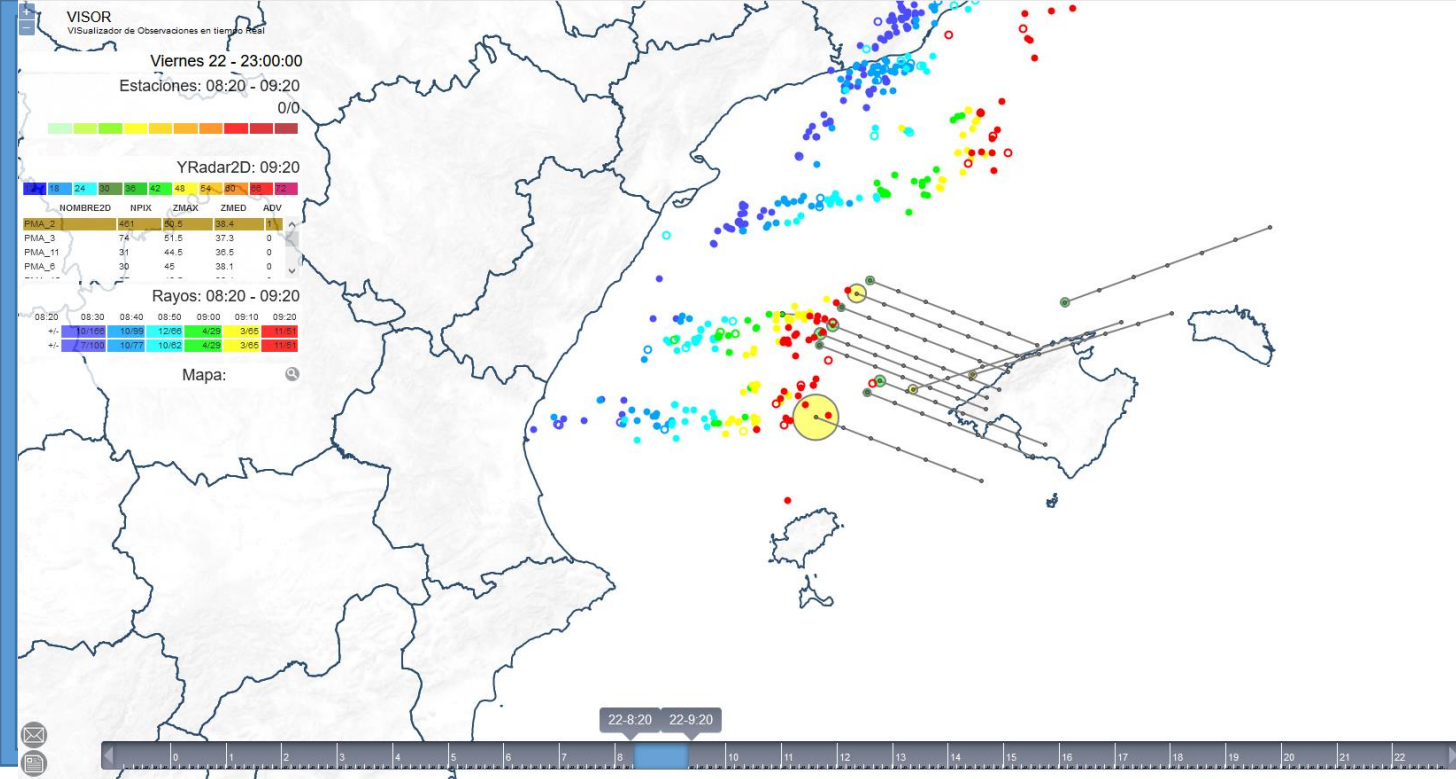


A line of convective cells, with little organisation, approaches the Balearics, from west

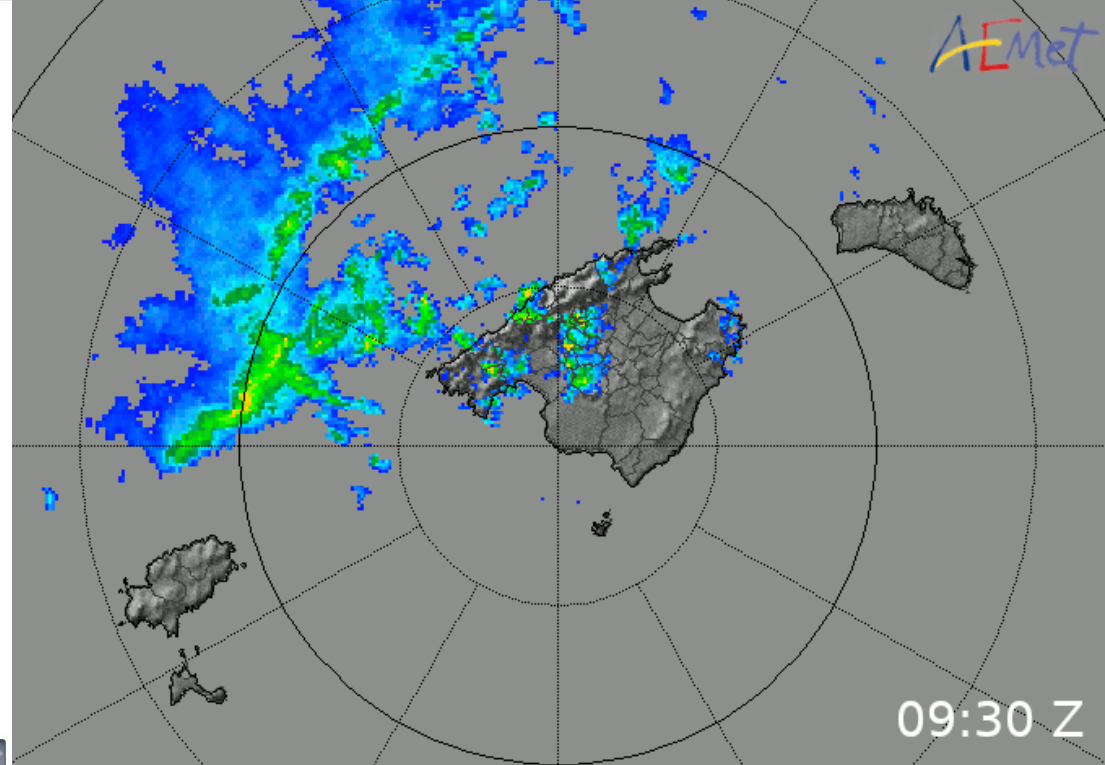
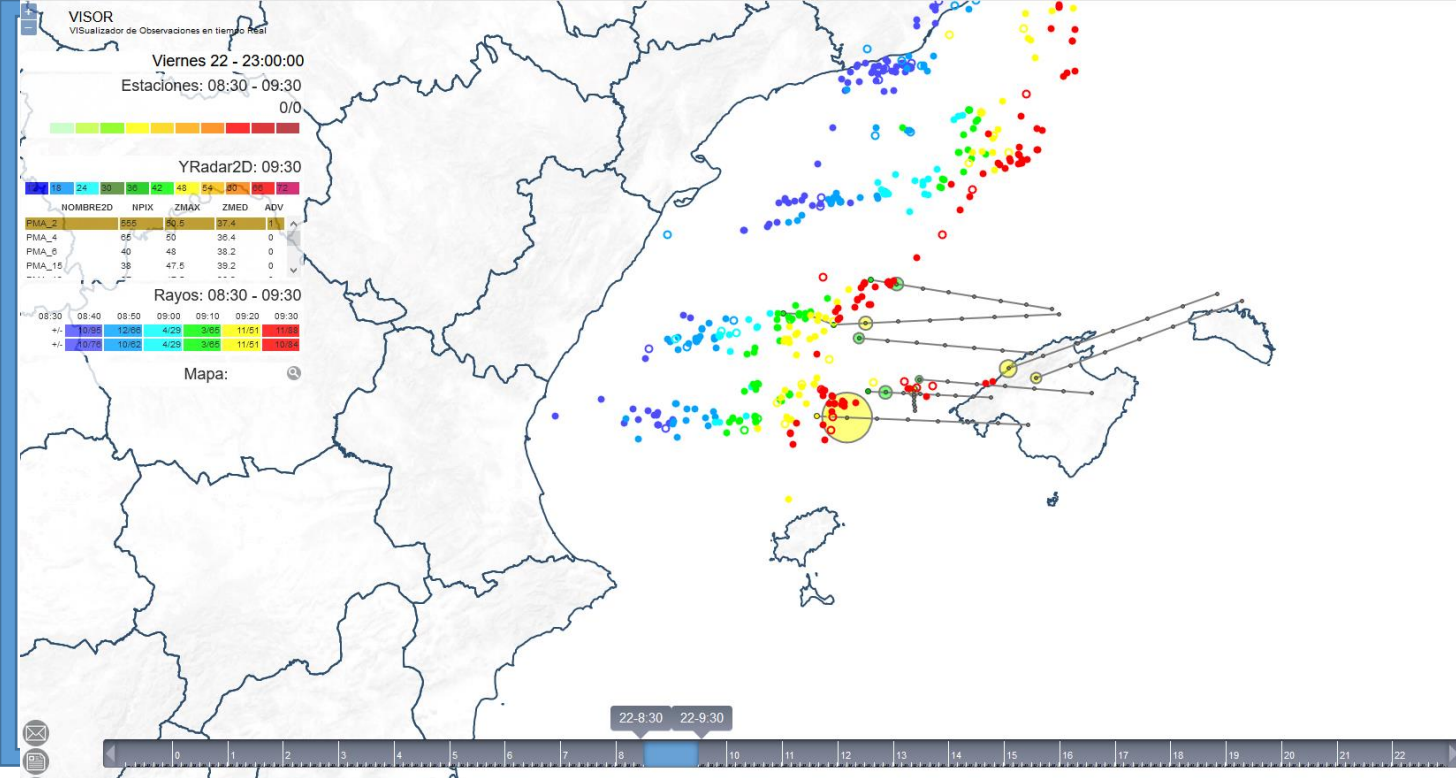


The line of convective cells gains intensity and organisation in its southern flank

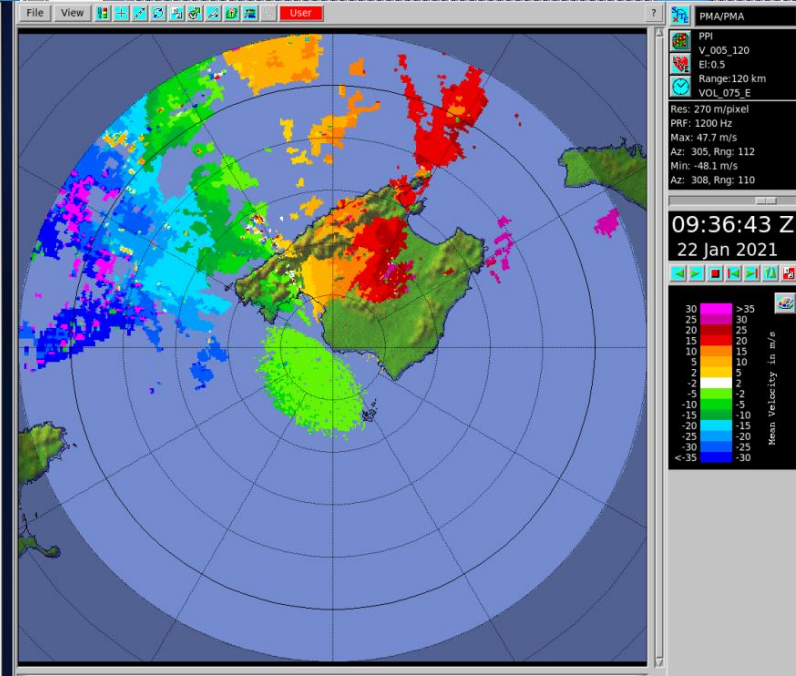
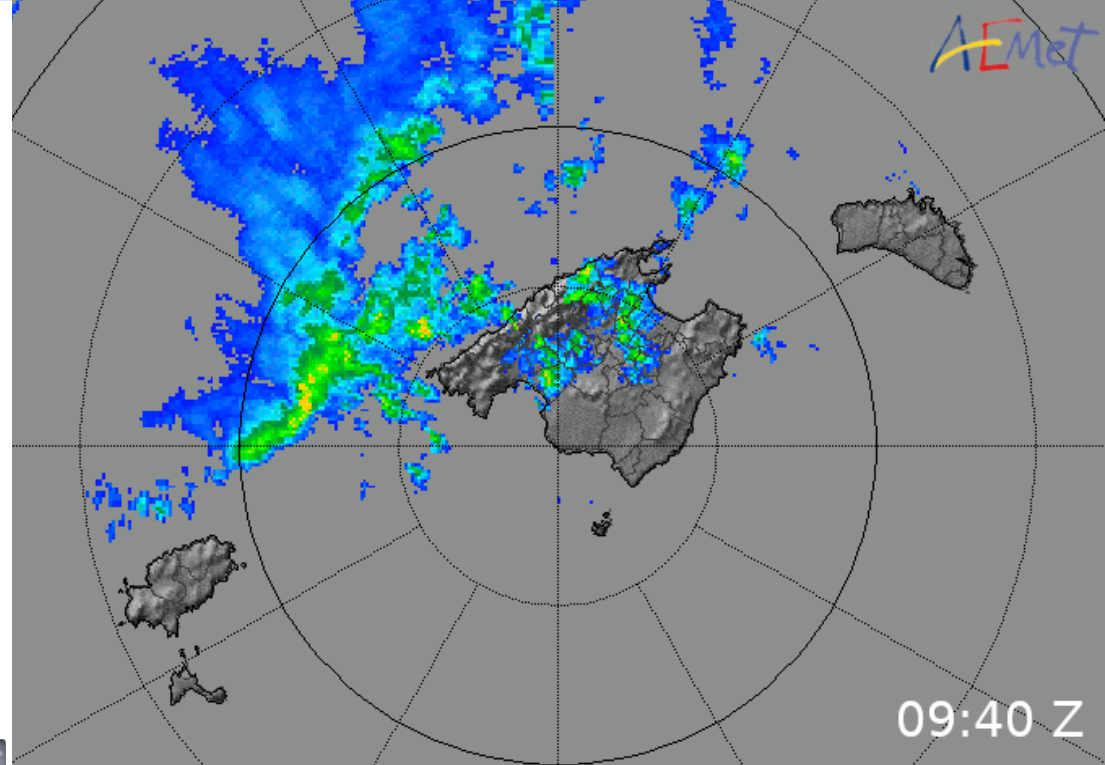
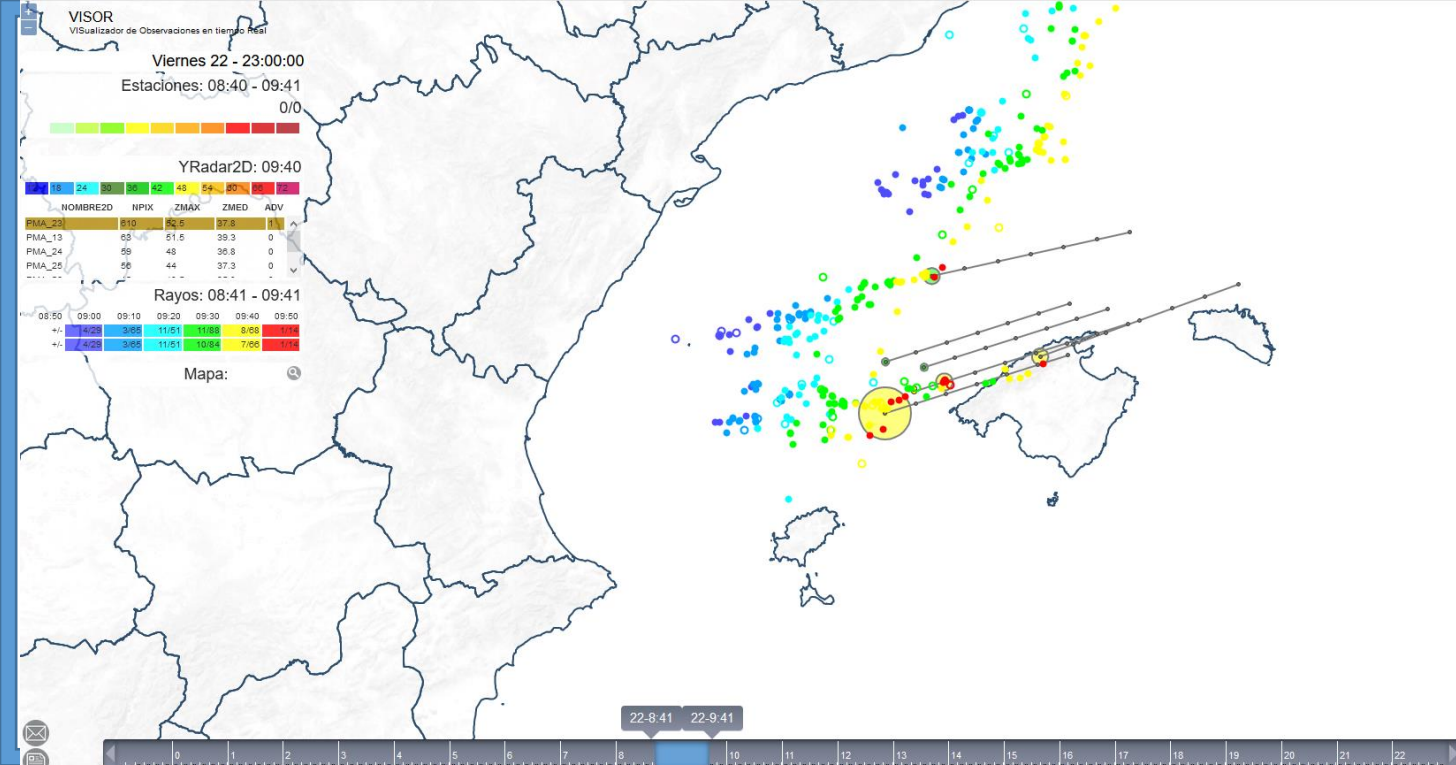




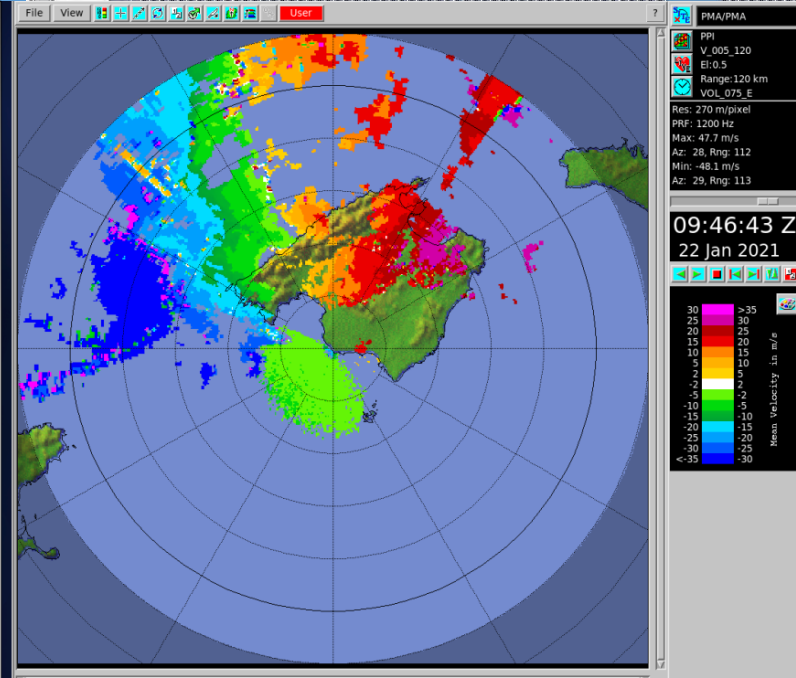
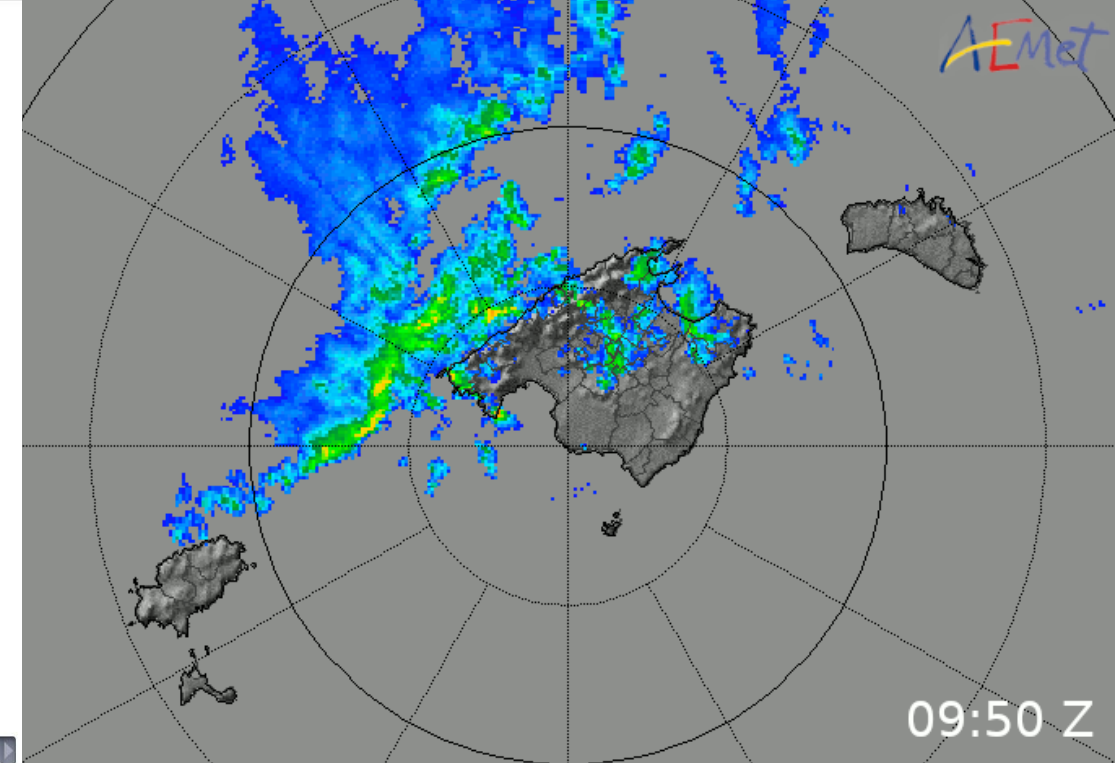
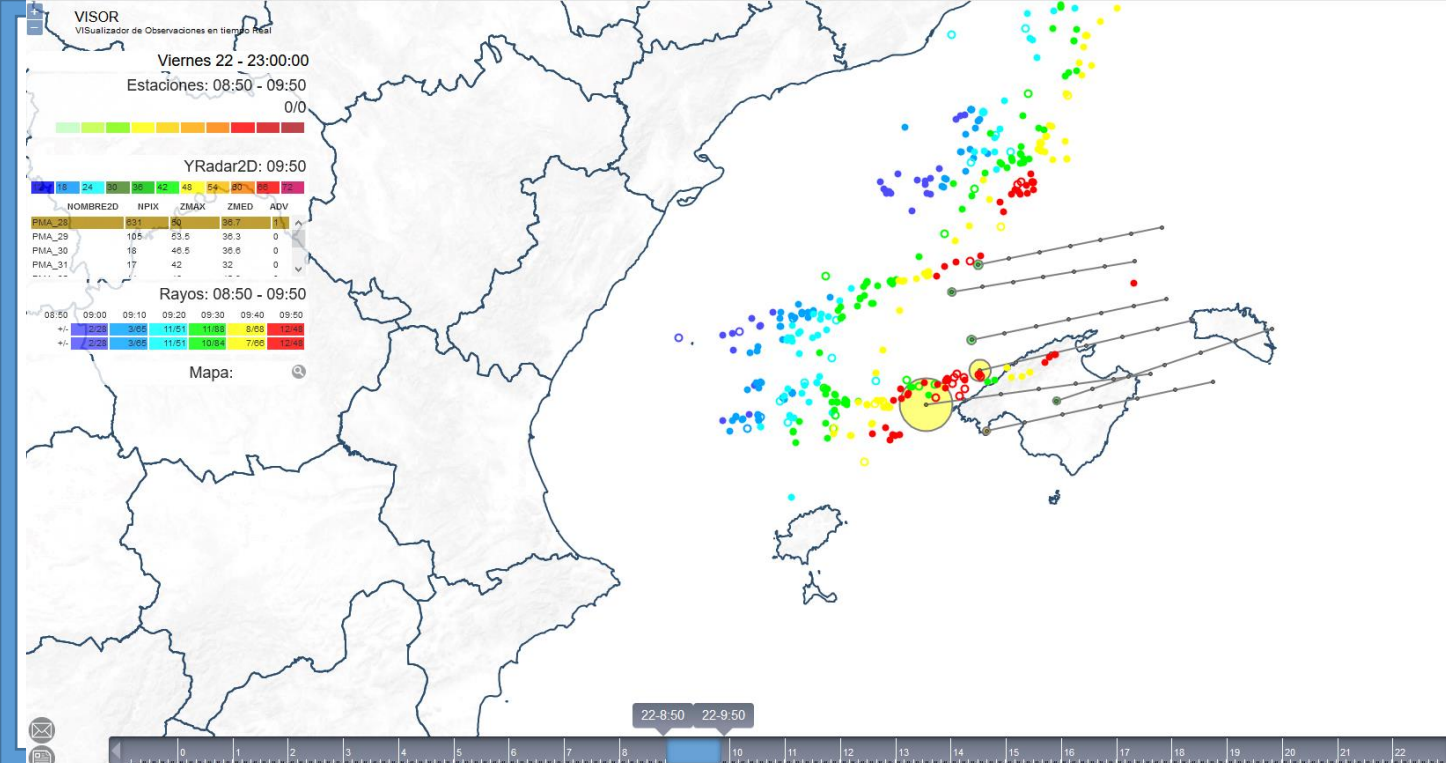
A compact line of radar echoes is already visible in the southern part of the large line of cells



Hints of curvature (bow echo) in the southern part of the line of convective cells

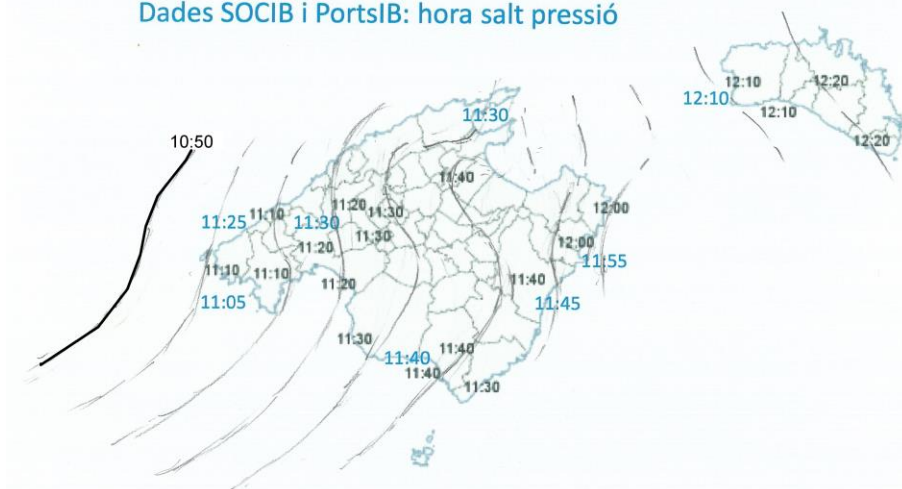


Bow echo progresses as it is approaching SW of Mallorca. The Doppler radar shows that it is moving towards the radar at a high speed (around 30 m/s)

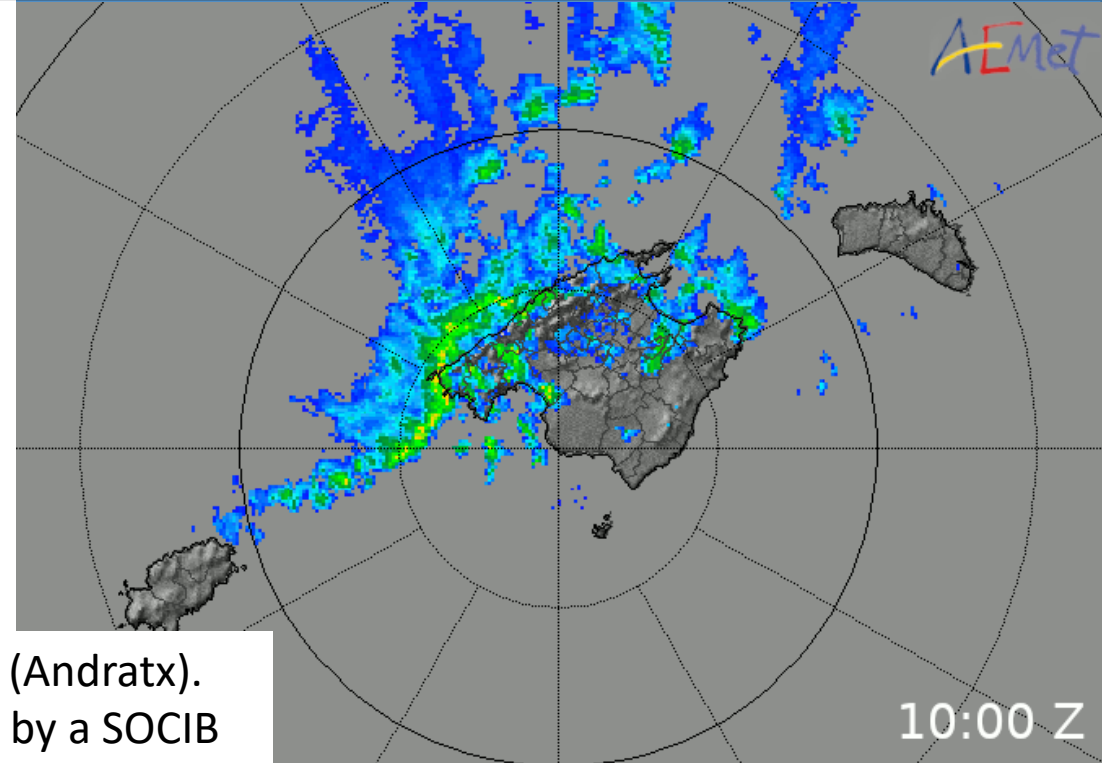
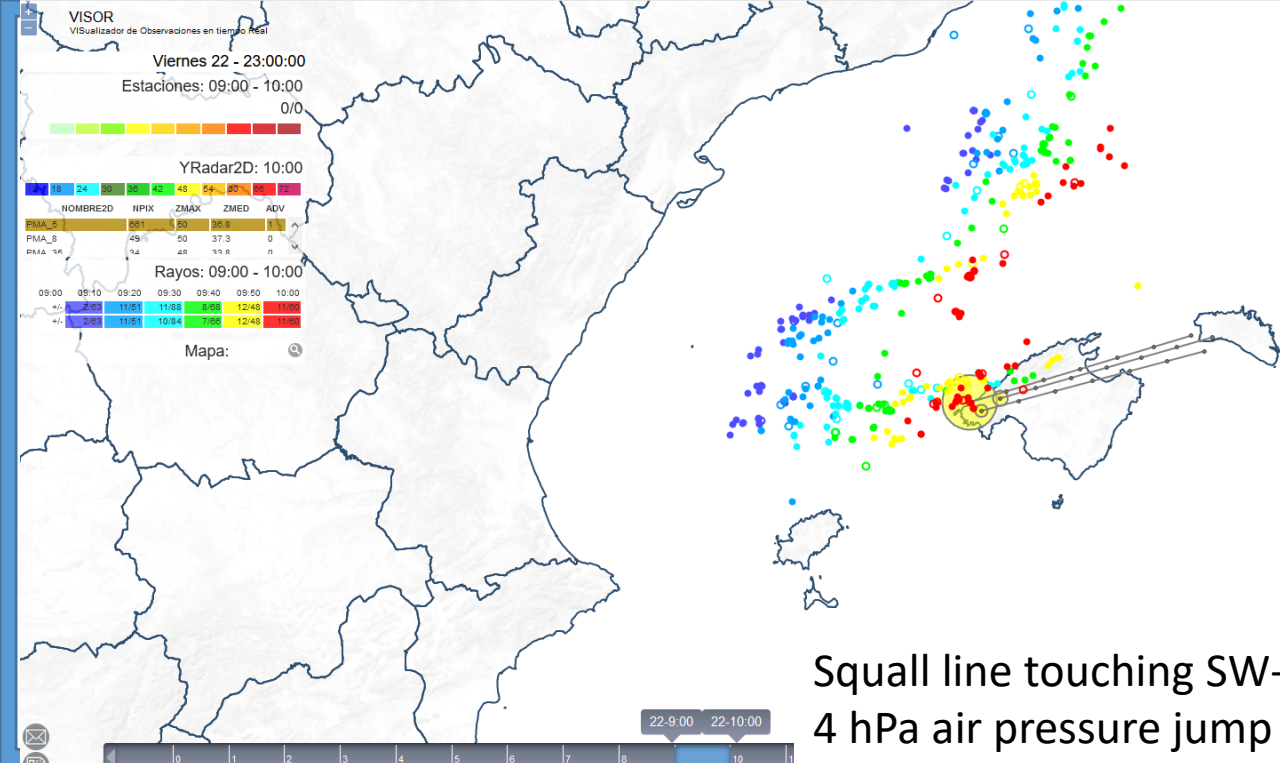


The bow echo –squall line- is approximately 50 km long and it is about the touch SW of Mallorca. The reflectivity is not extreme

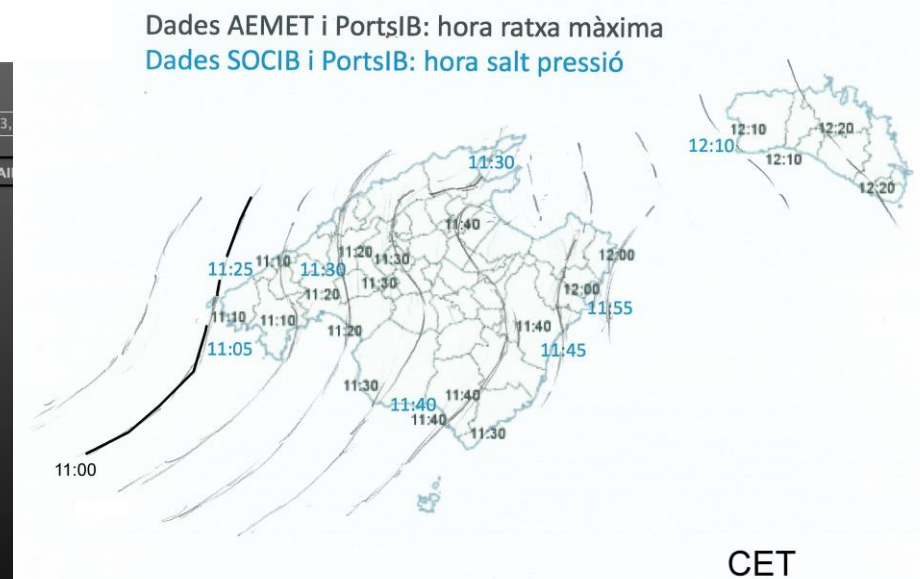
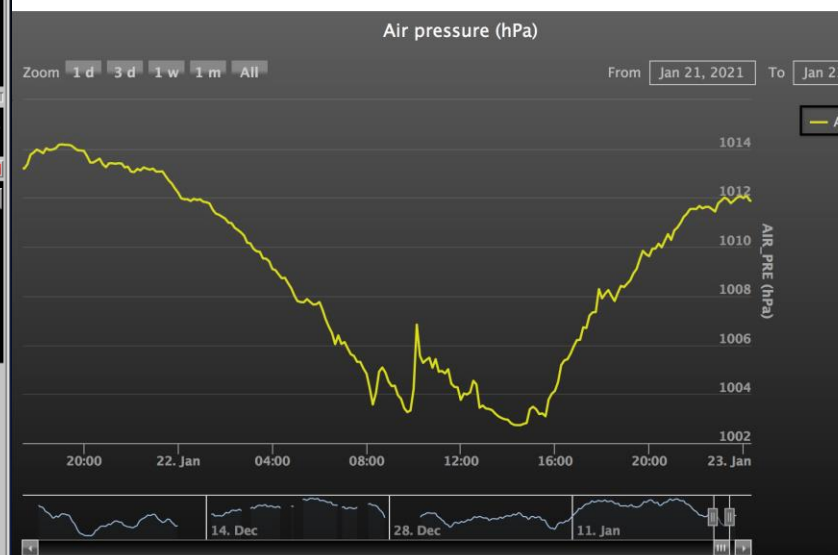
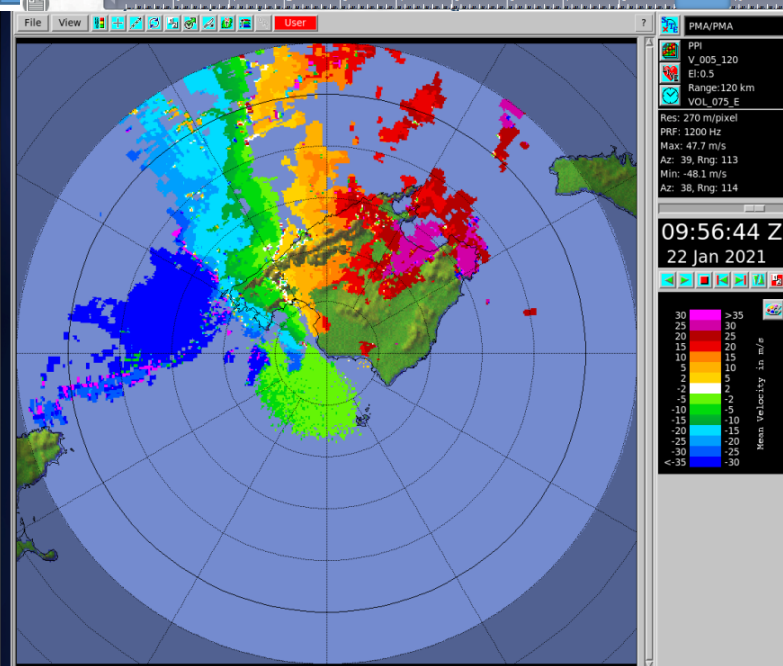
Dades AEMET i PortsIB: hora ratxa màxima
Dades SOCIB i PortsIB: hora salt pressió

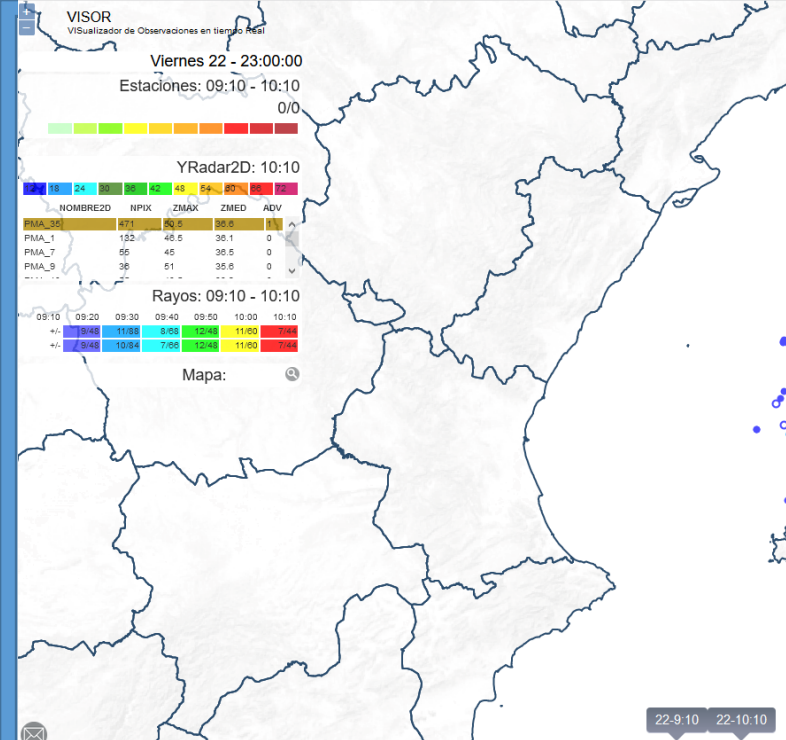


CET

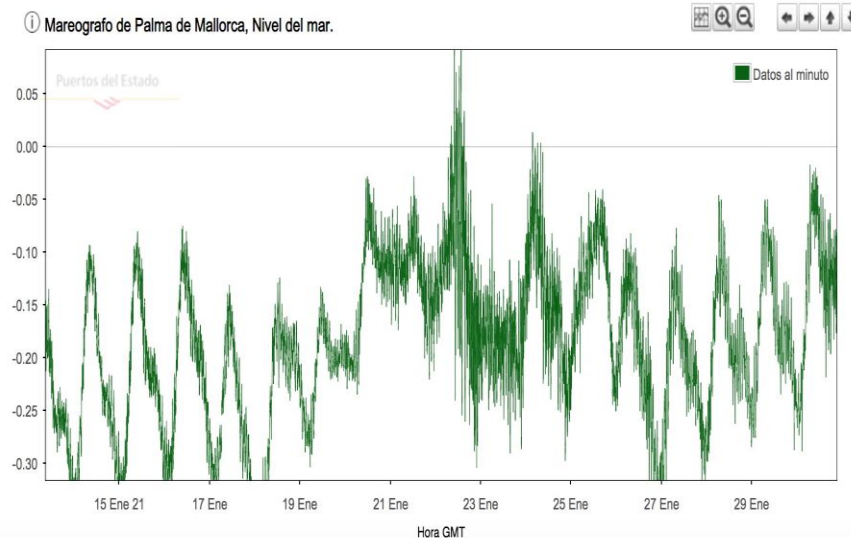
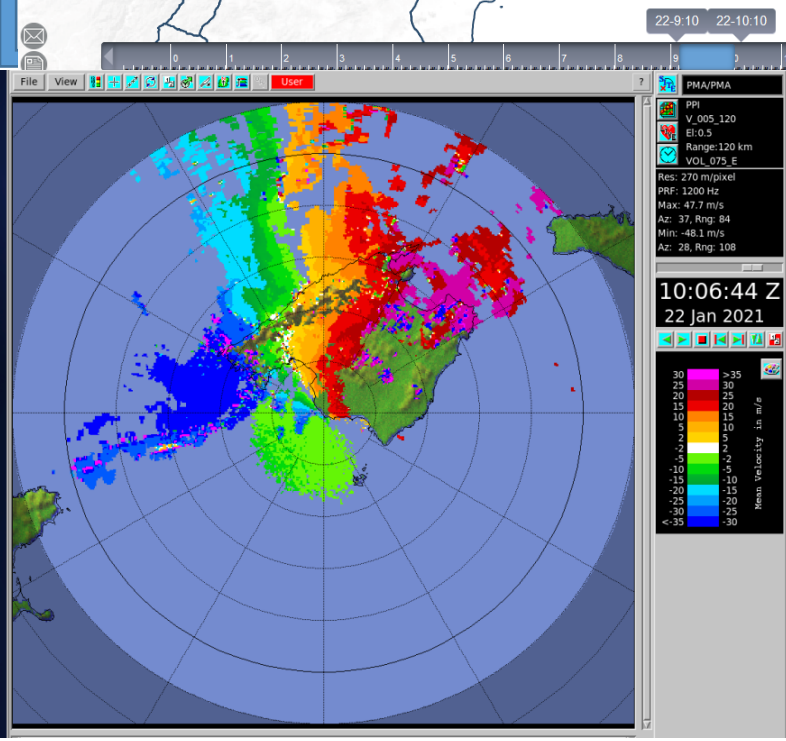
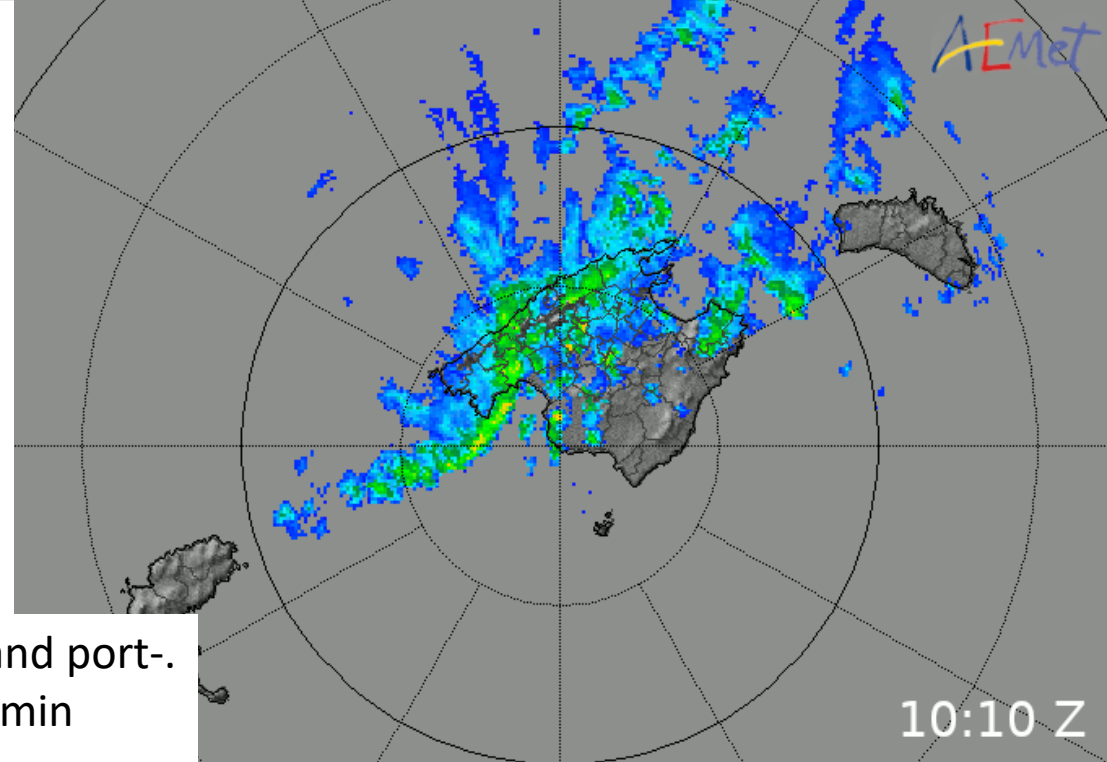


Squall line touching SW-Mallorca (Andratx).
 4 hPa air pressure jump detected by a SOCIB
 station. Sea level oscillation –not shown–
 reaching 25 cm (SOCIB)

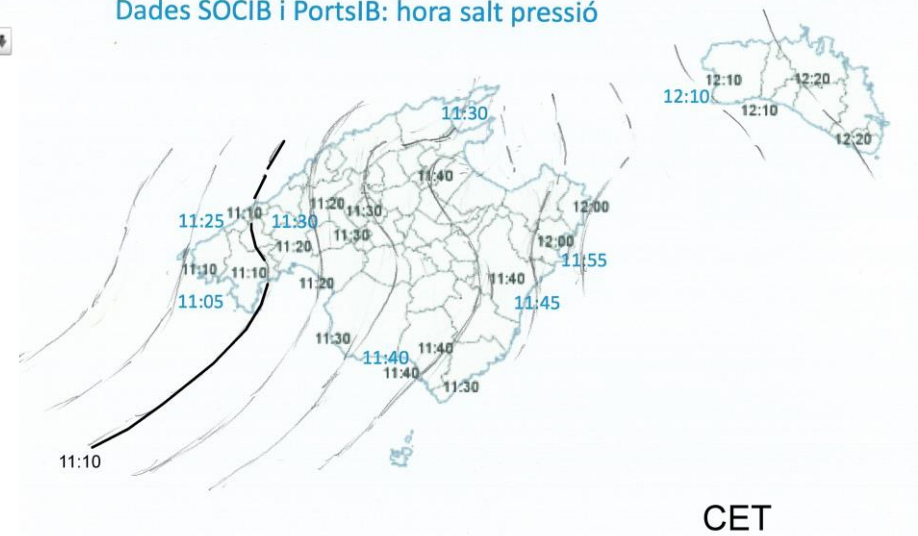


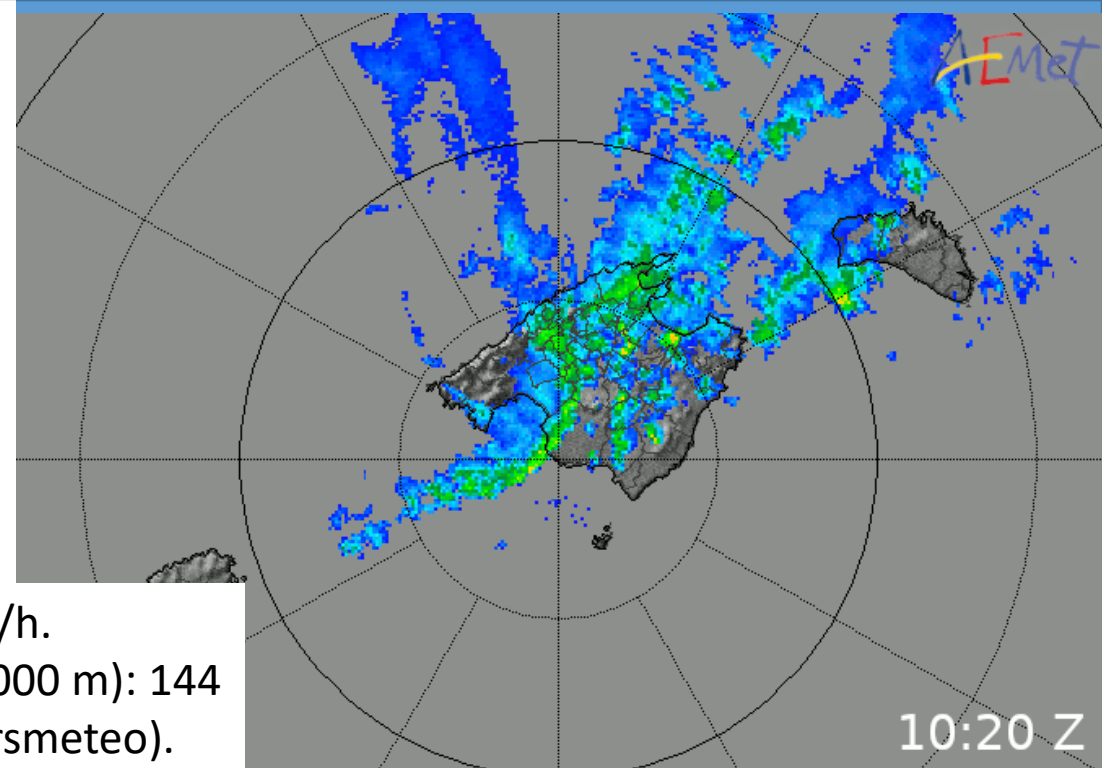
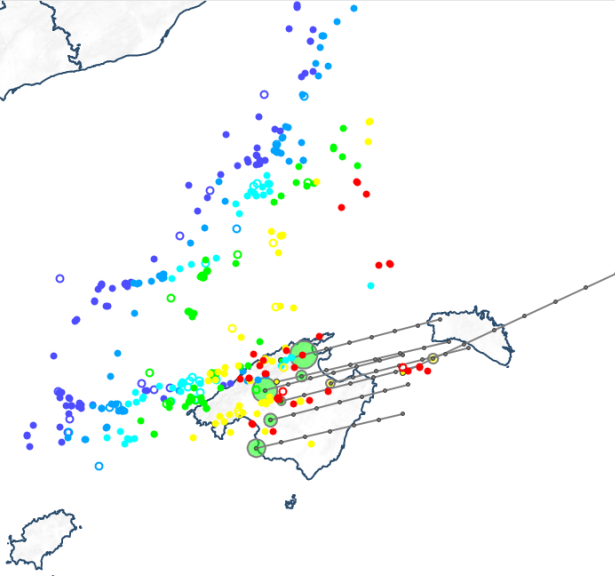
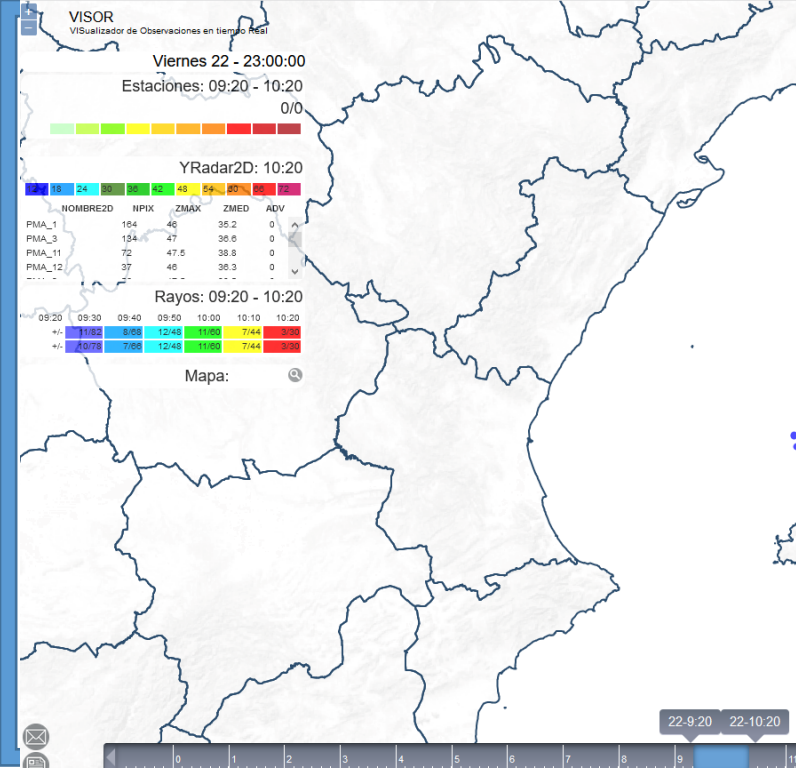


Squall line reaching Palma –city and port-
33 cm long wave height, with 25 min
period, at the PE tide gauge
111 km/h gust at Palma-port (AEMET)

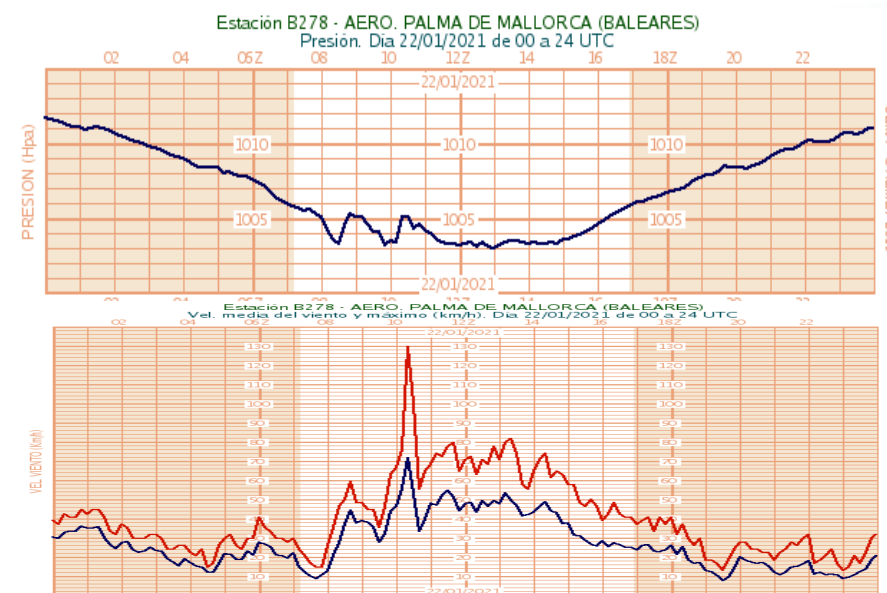
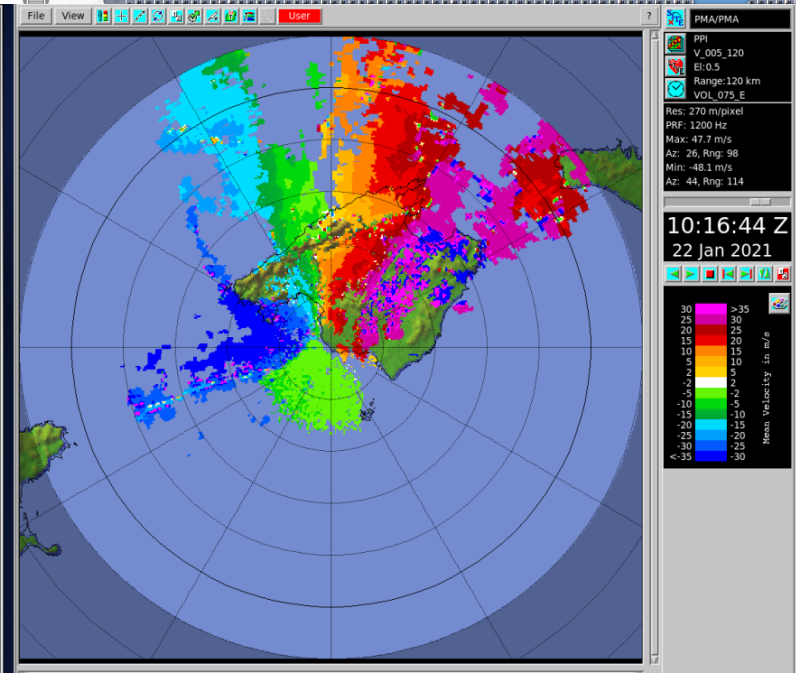


Dades AEMET i PortsIB: hora ratxa màxima
Dades SOCIB i PortsIB: hora salt pressió

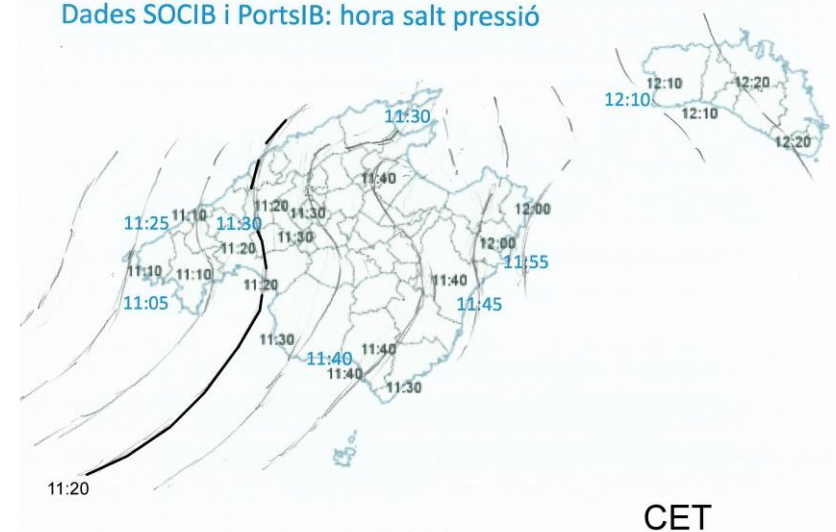


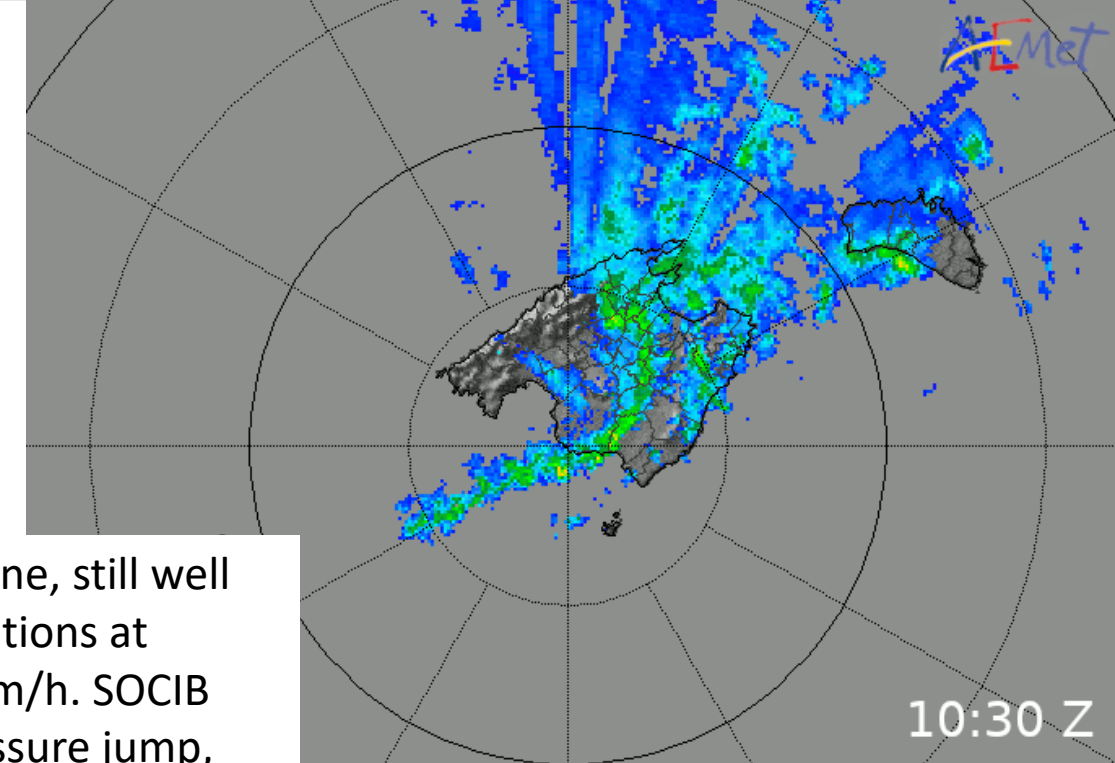
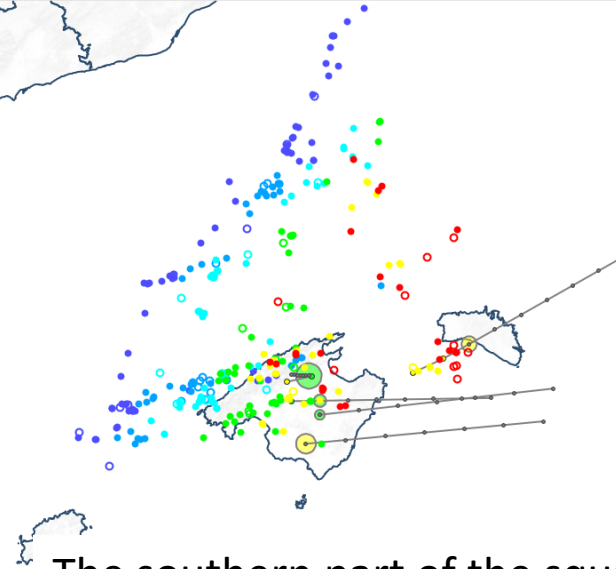
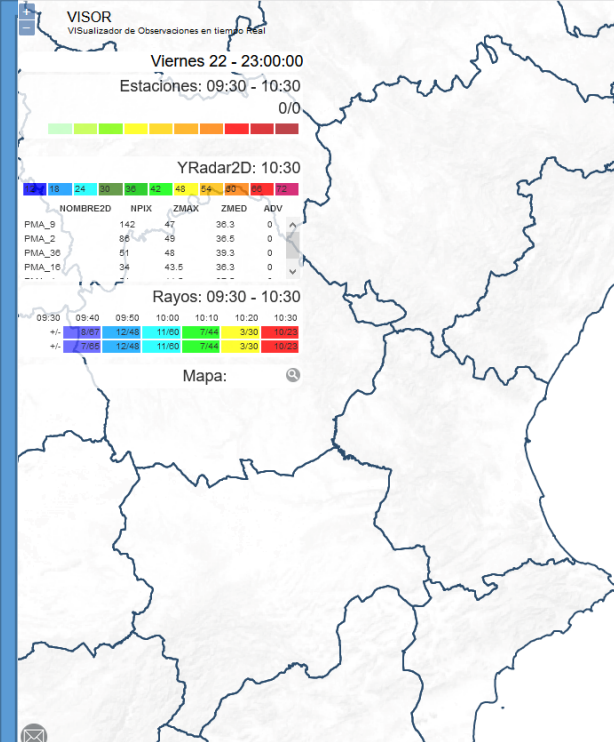


Palma-airport wind gust: 130 km/h.
Pressure jump, 2 hPa? Alfàbia (1000 m): 144 km/h (AEMET), 177 km/h (Balearsmeteo).
New cells at Pollença and inner Mallorca

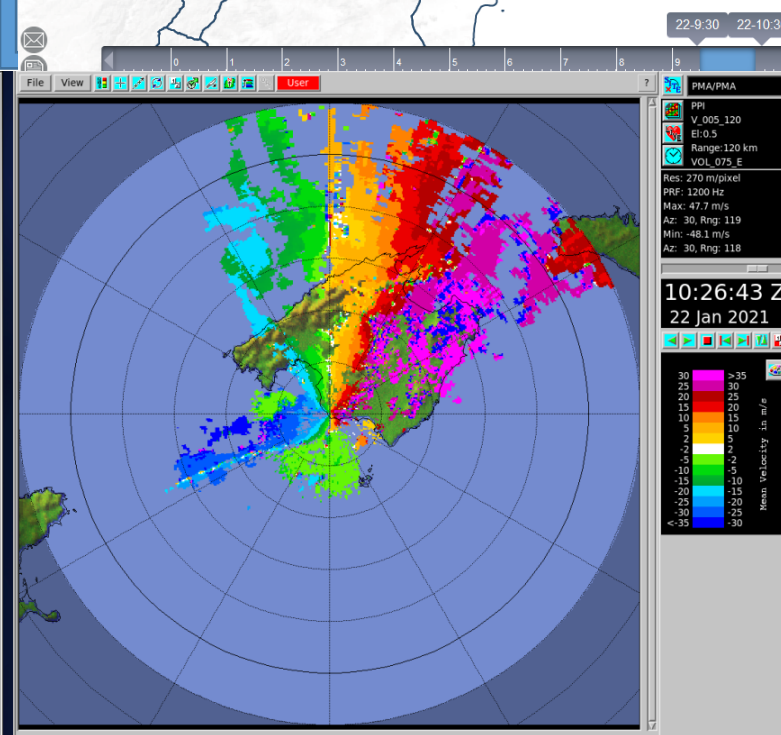


Dades AEMET i PortsIB: hora ratxa màxima
Dades SOCIB i PortsIB: hora salt pressió

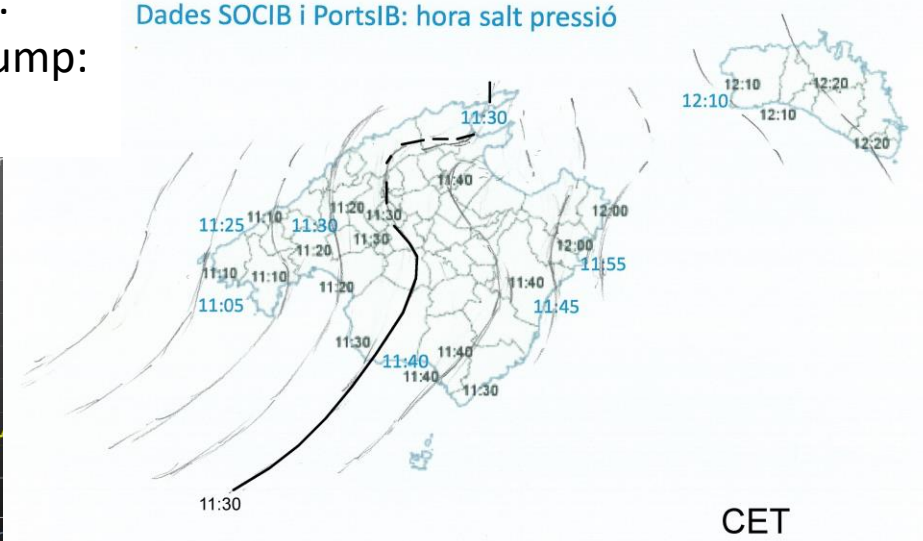


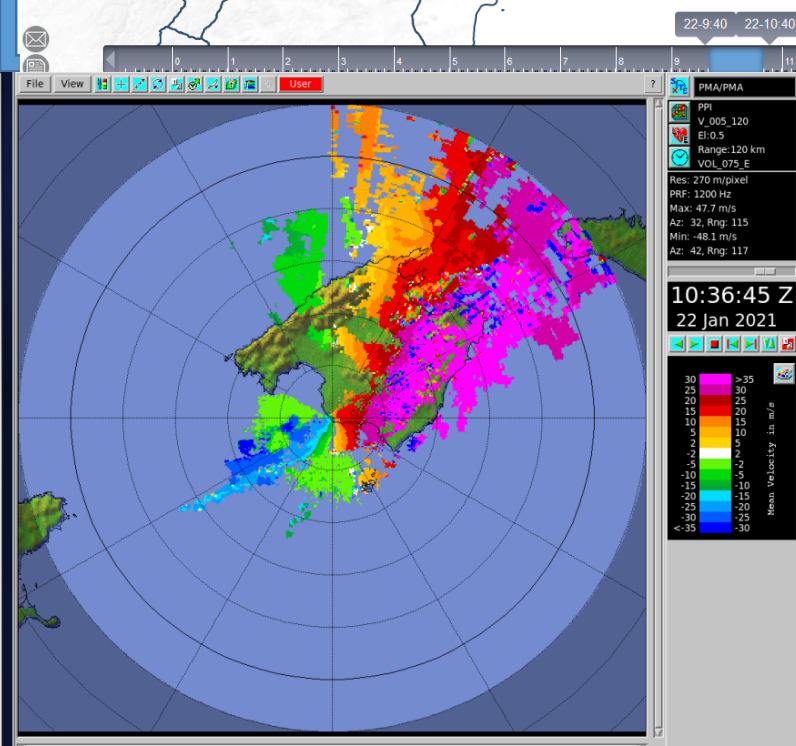
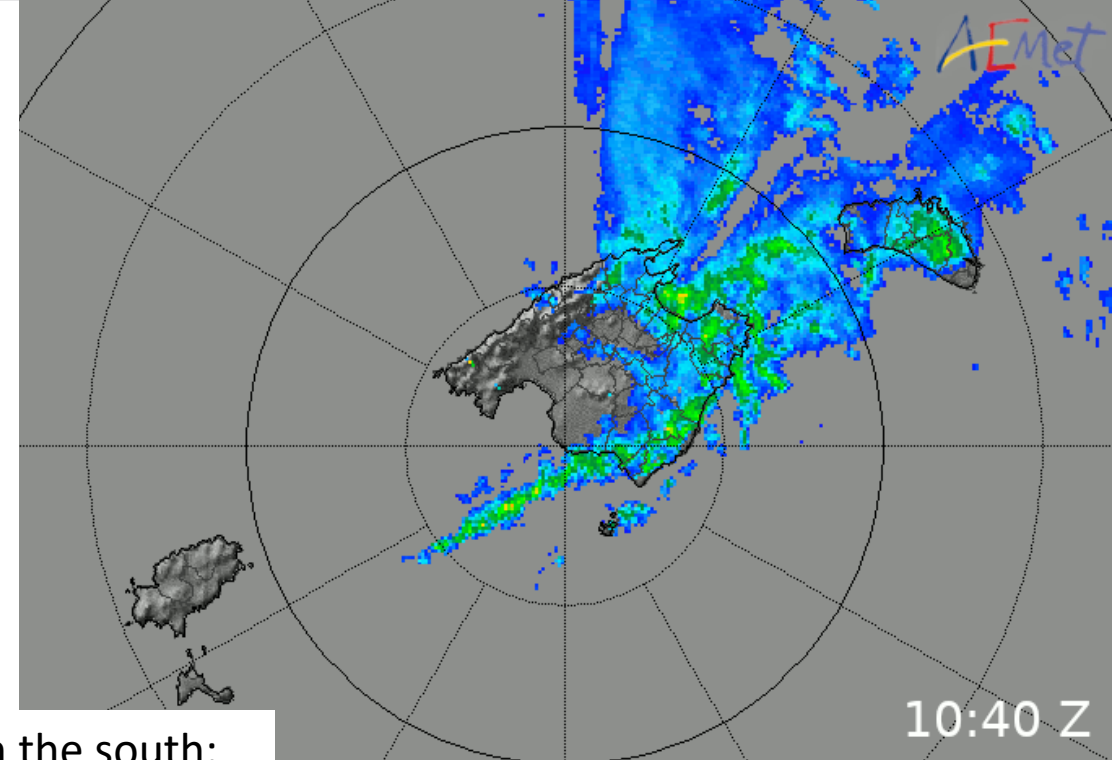
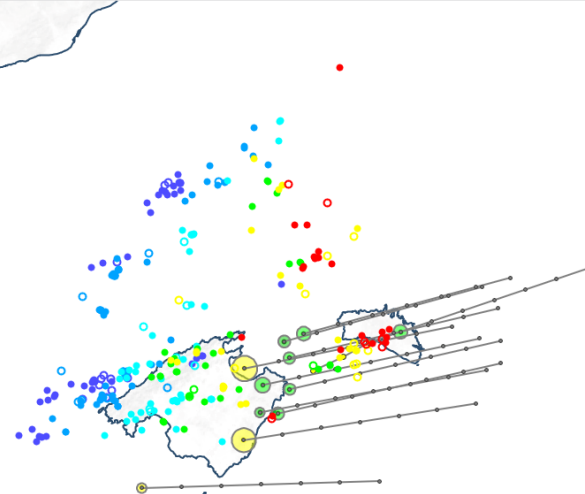
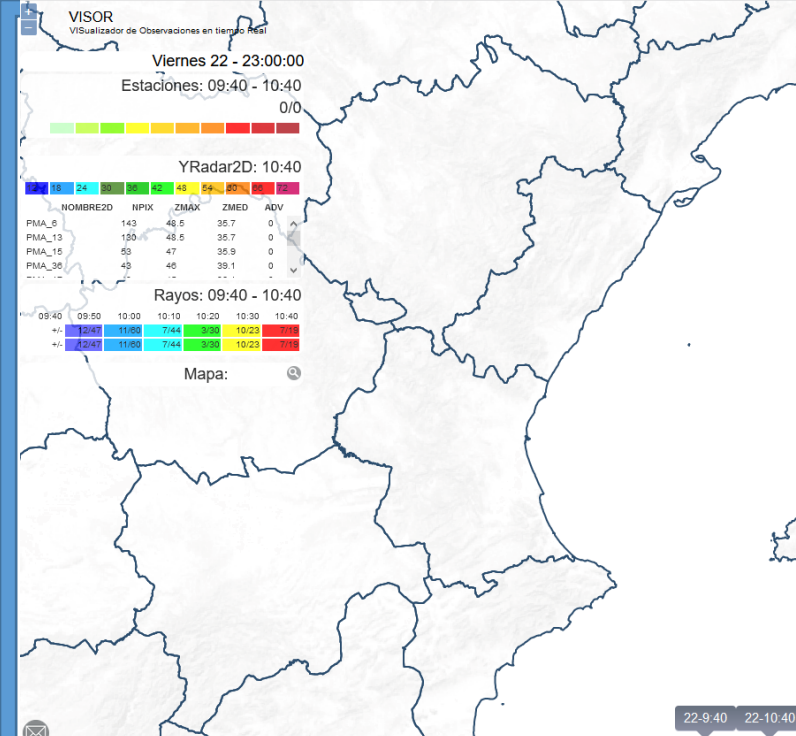


The southern part of the squall line, still well organised. Two Balearsmeteo stations at Campos reported 116 and 122 km/h. SOCIB sea level oscillations, 30 cm; pressure jump, 2.5 hPa. North/inner part, less organised, but the *inner Mallorca new cell* gains intensity. At port-Pollença (SOCIB), 2 hPa pressure jump: Is it separated from the squall line?



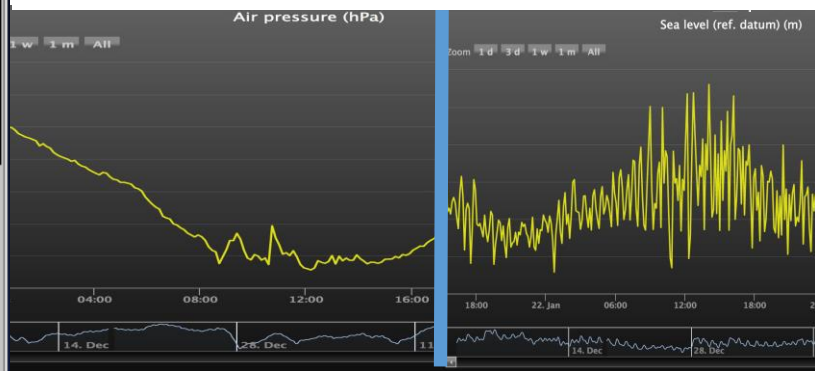
Dades AEMET i PortsIB: hora ratxa màxima
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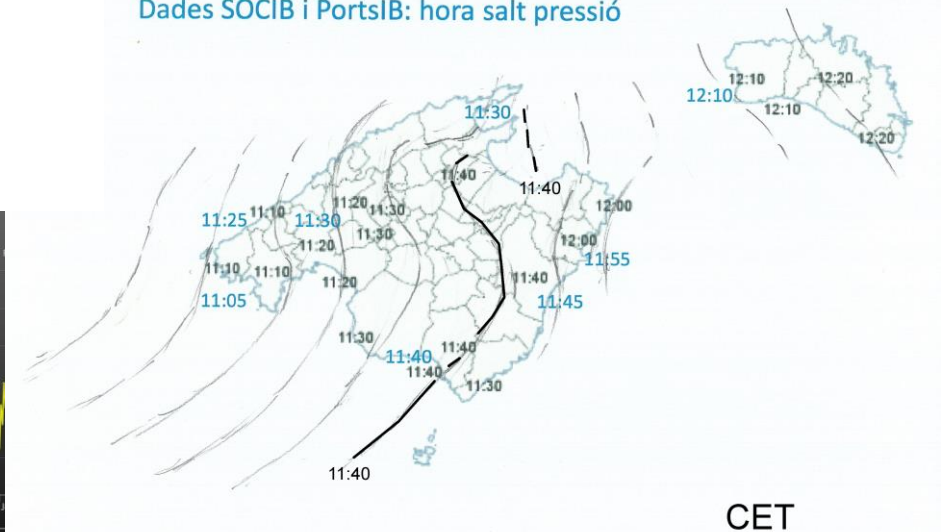


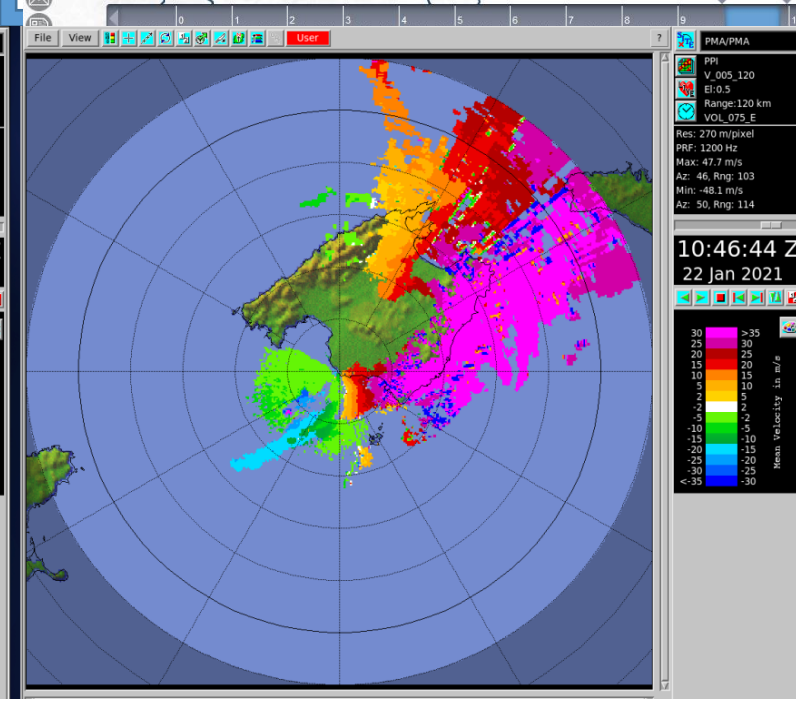
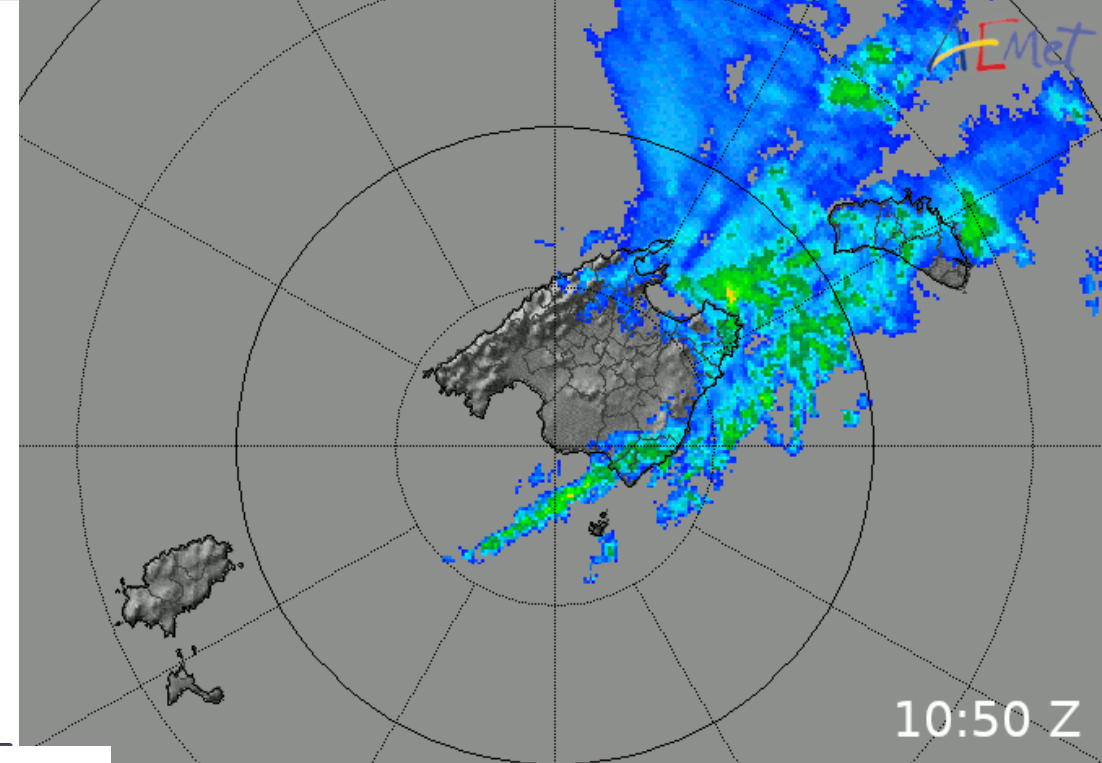
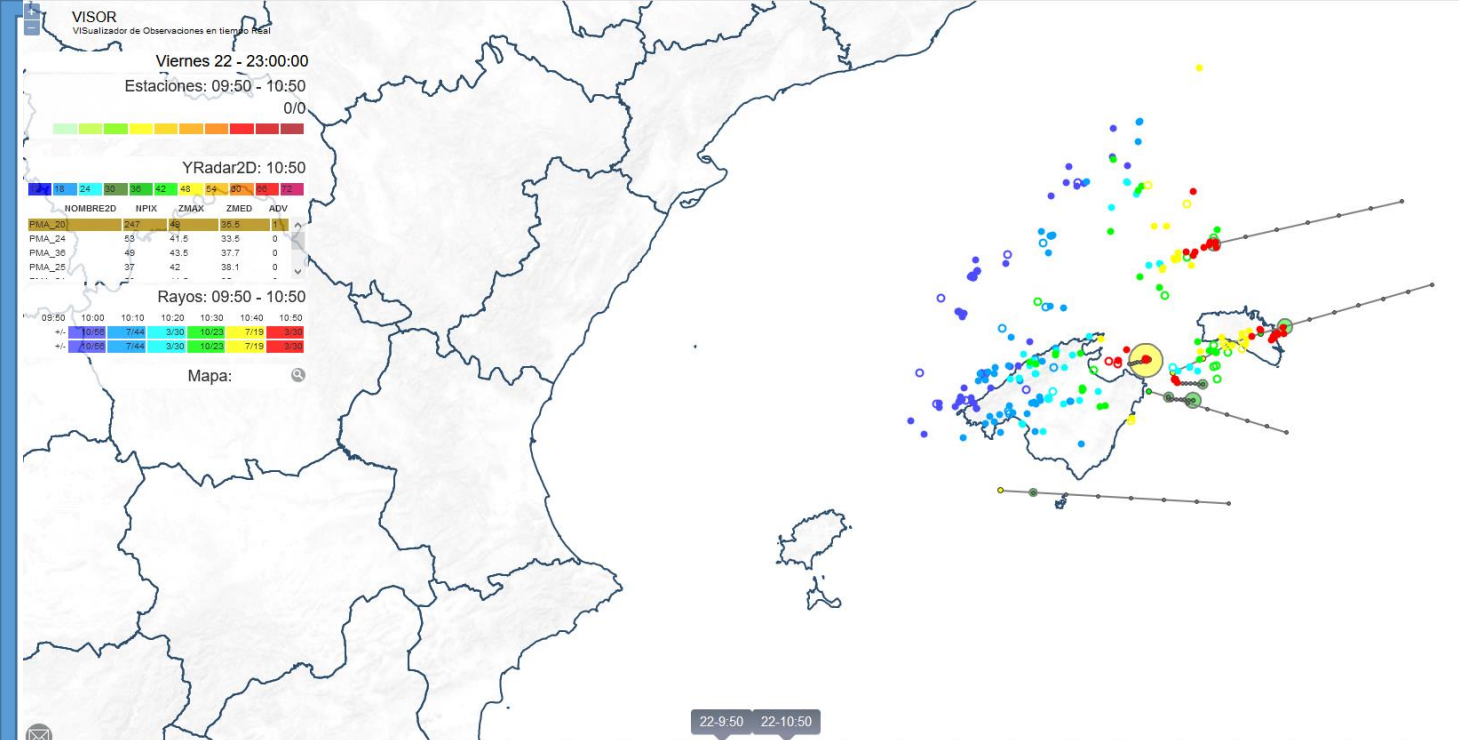
The quall line is still organised in the south; meanwhile the Mallorca *new cell* is at sea, moving towards Menorca and increasing intensity.

At Portocristo, pressure jump, 3 hPa; sea level oscillations, 25 cm

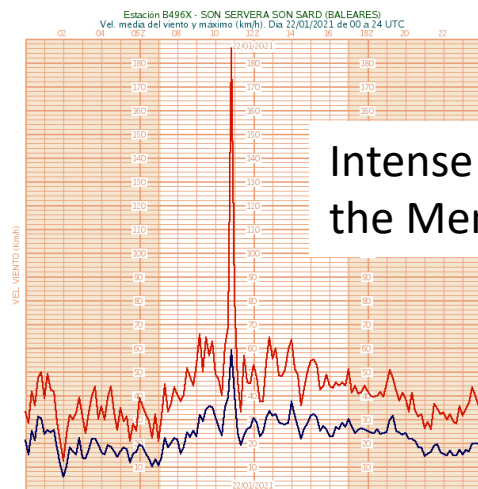


Dades AEMET i PortsIB: hora ratxa màxima
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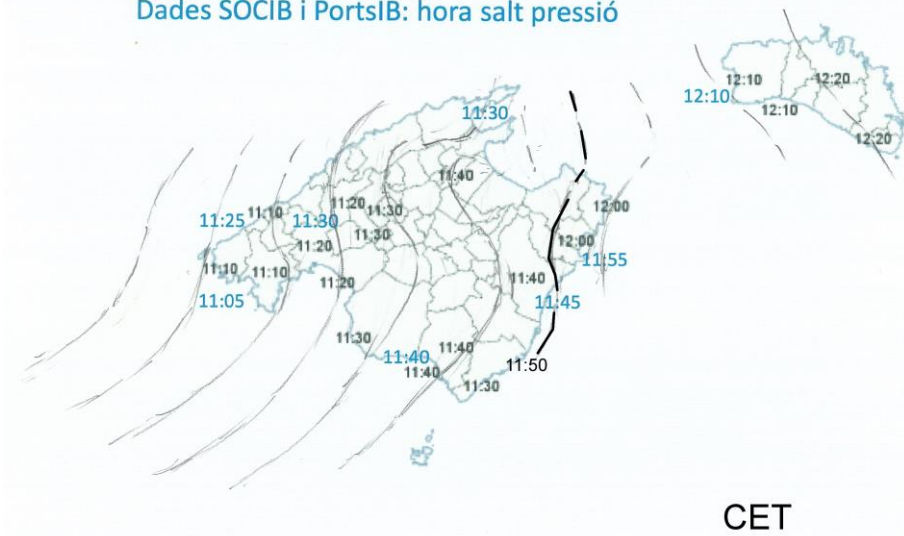


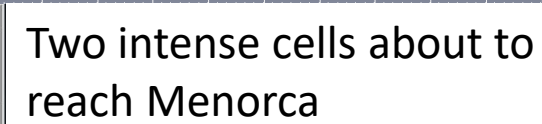
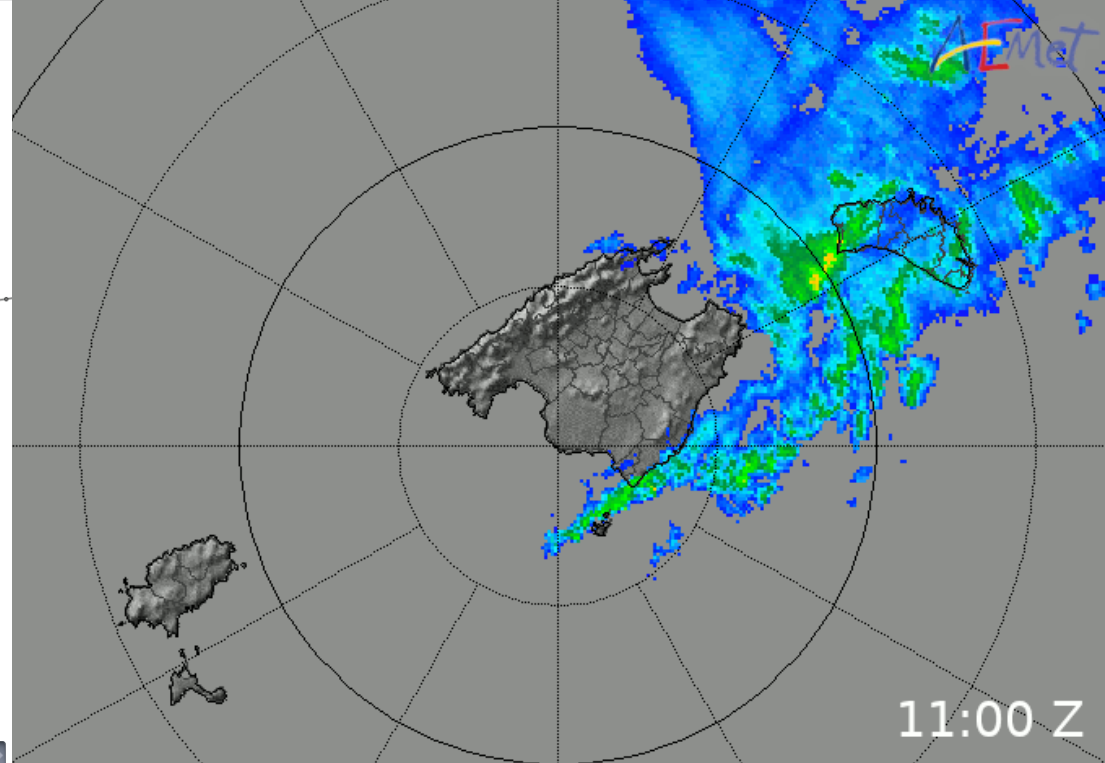
Surprise at Son Servera: 183 km/h.
Error? Ephemeral addition of a
tornado or a microburst?

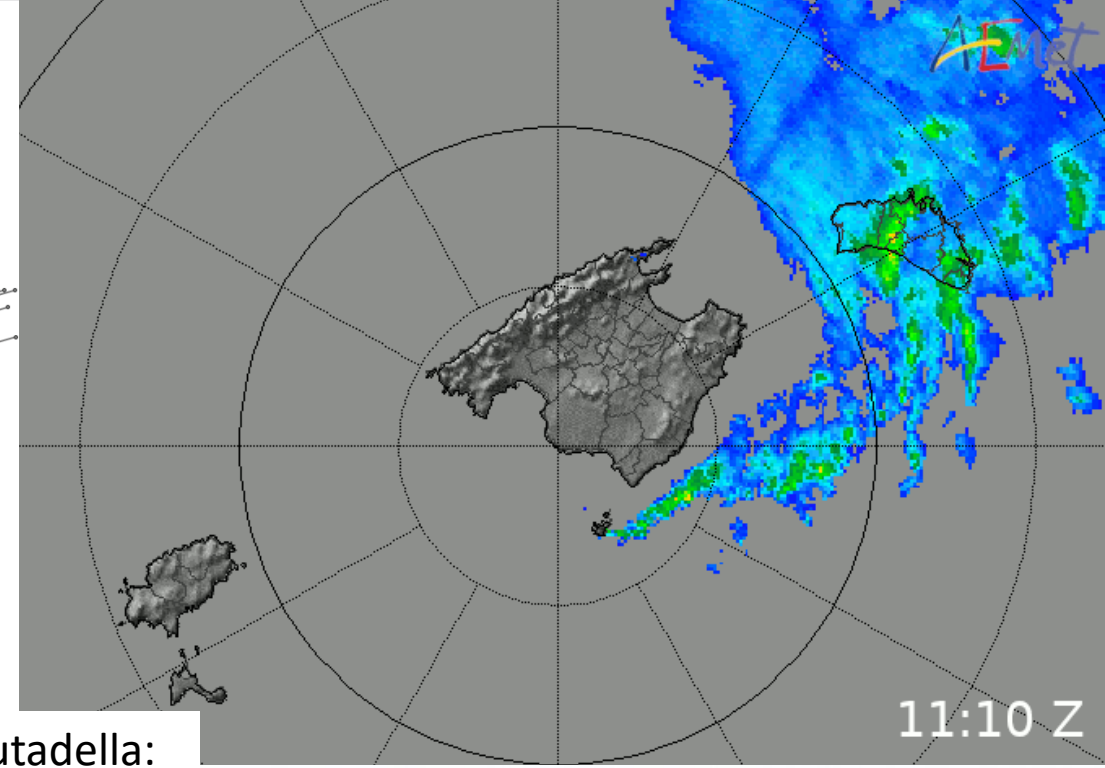
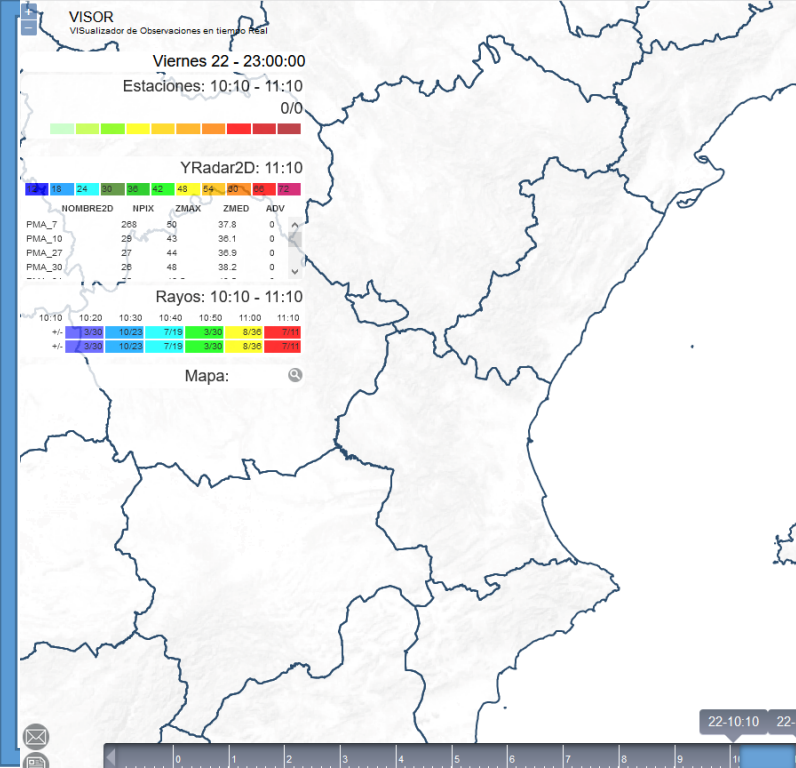


Intense cell crossing
the Menorca Chanel

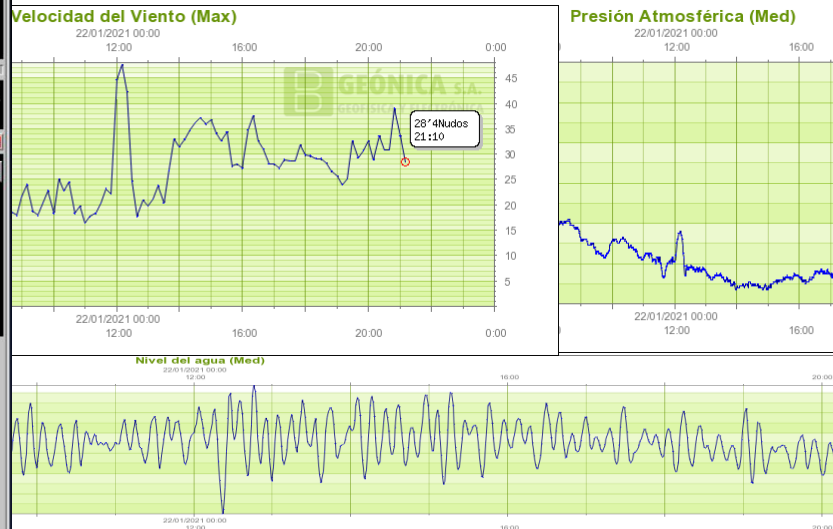
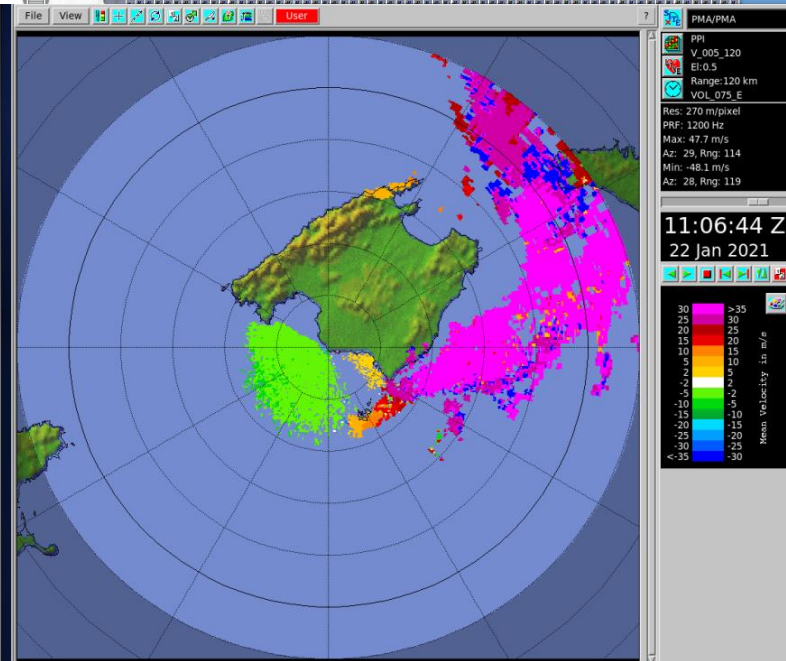
Dades AEMET i PortsIB: hora ratxa màxima
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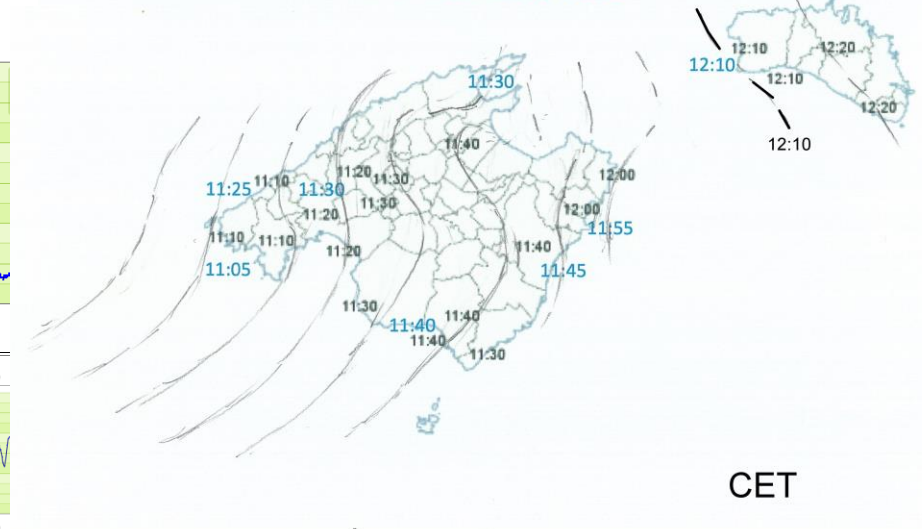


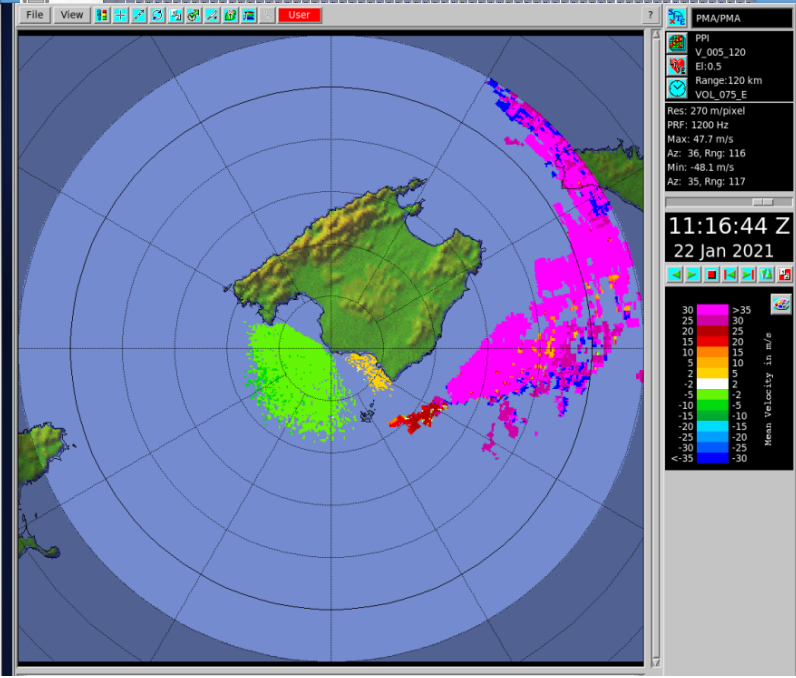
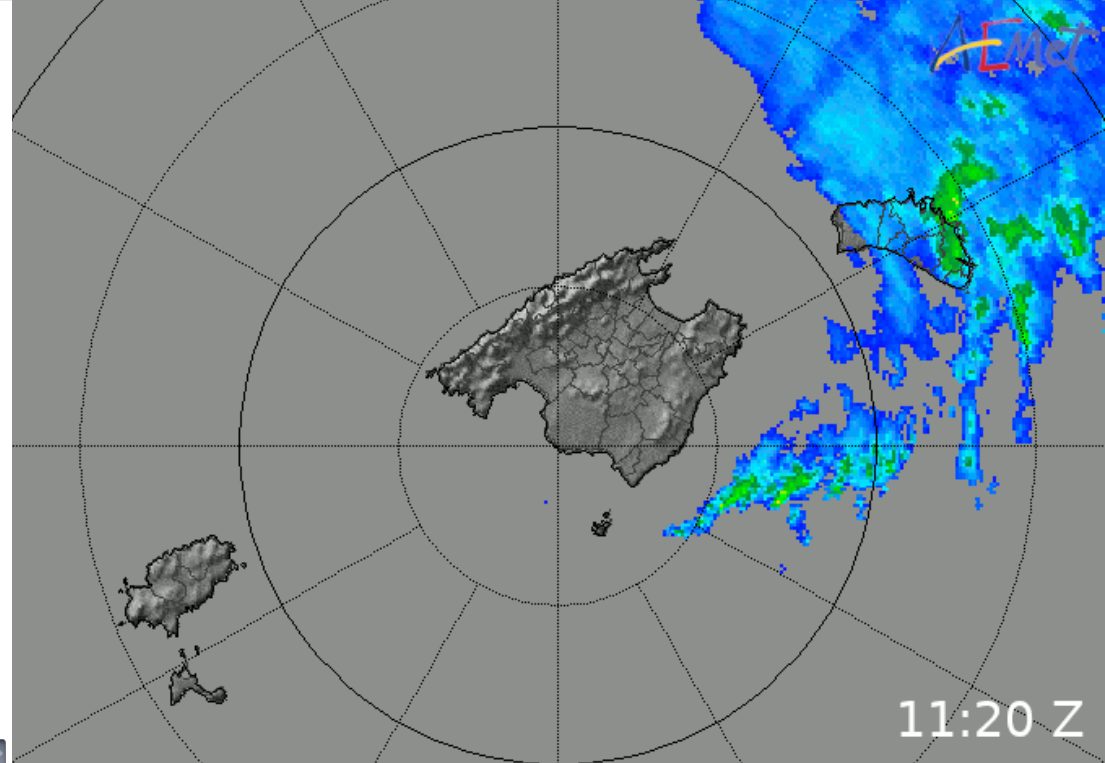
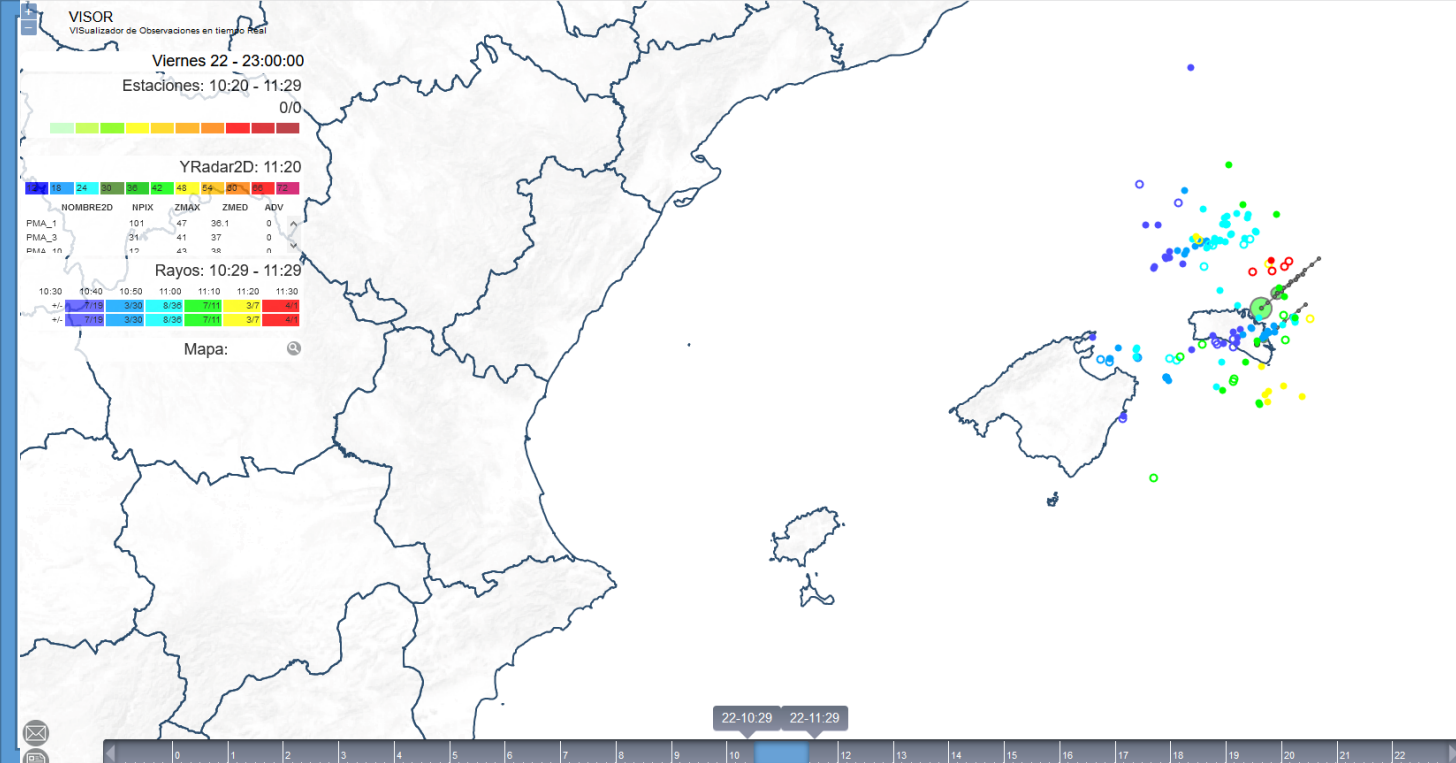


Intense cells just passed over Ciutadella:
wind gust: 88 km/h; pressure jump: 2.5
hPa; sea-level: 60 cm (Ports IB)

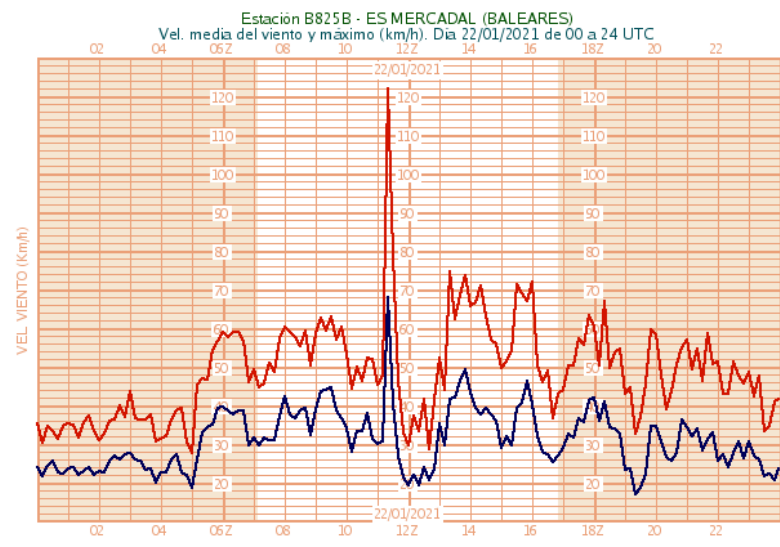


Dades AEMET i PortsIB: hora ratxa màxima
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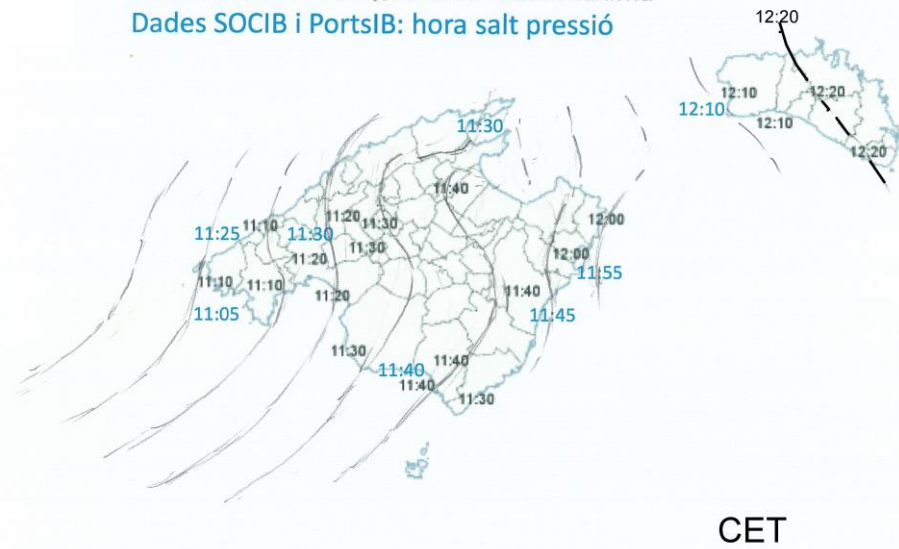




Wind gusts of 122 km/h at central Menorca and of 111 km/h in eastern Menorca



Dades AEMET i PortsIB: hora ratxa màxima
Dades SOCIB i PortsIB: hora salt pressió



Diagnosis

Meteorological diagnosis

Large scale



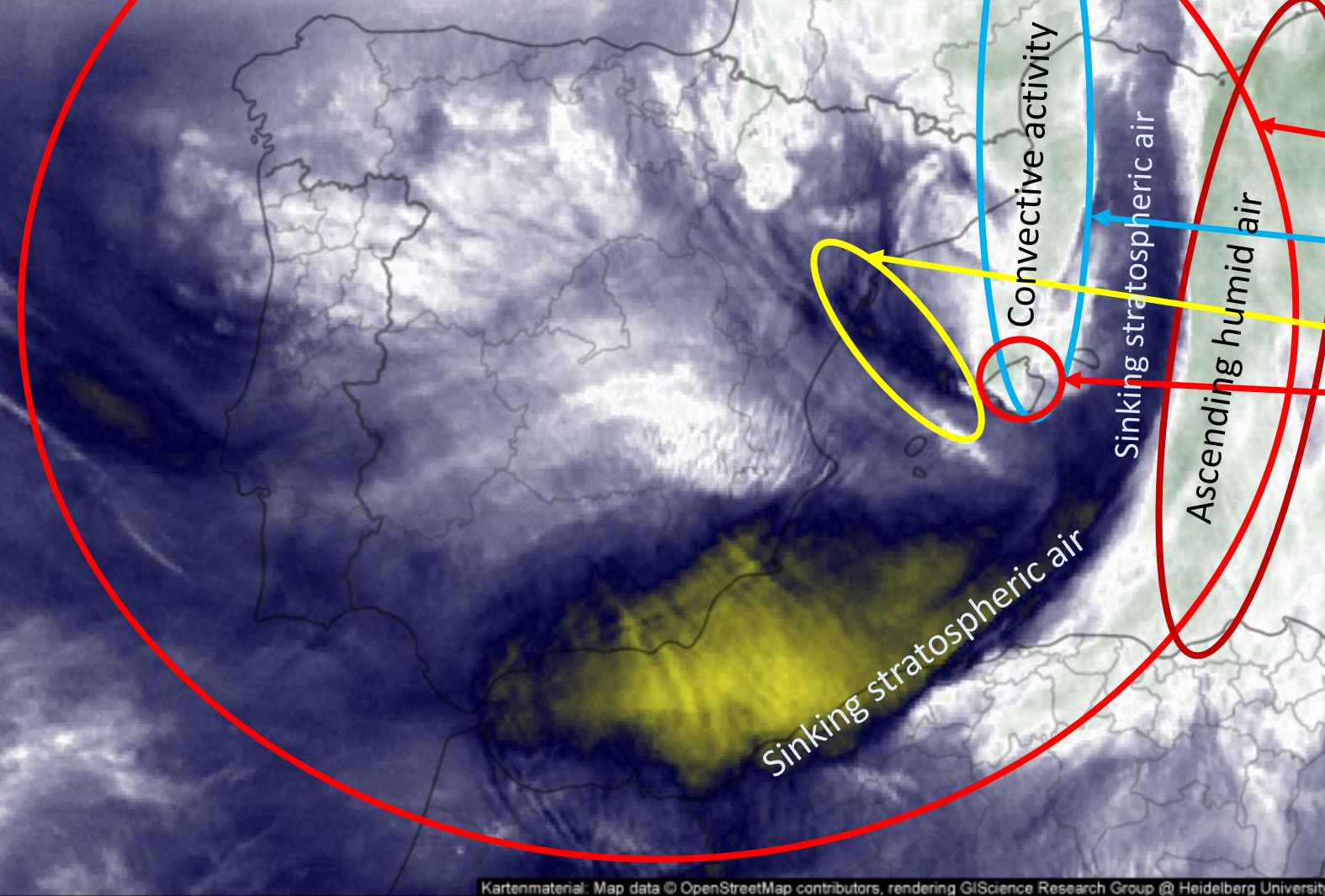
Mesoscale

Cyclone Hortense

Cold front - Line of convective cells - thunderstorms

Southern edge of the cold front + dry intrusion →
Severe multicell convective system

Squall line → Gust wind - pressure jump



Water vapour satellite images

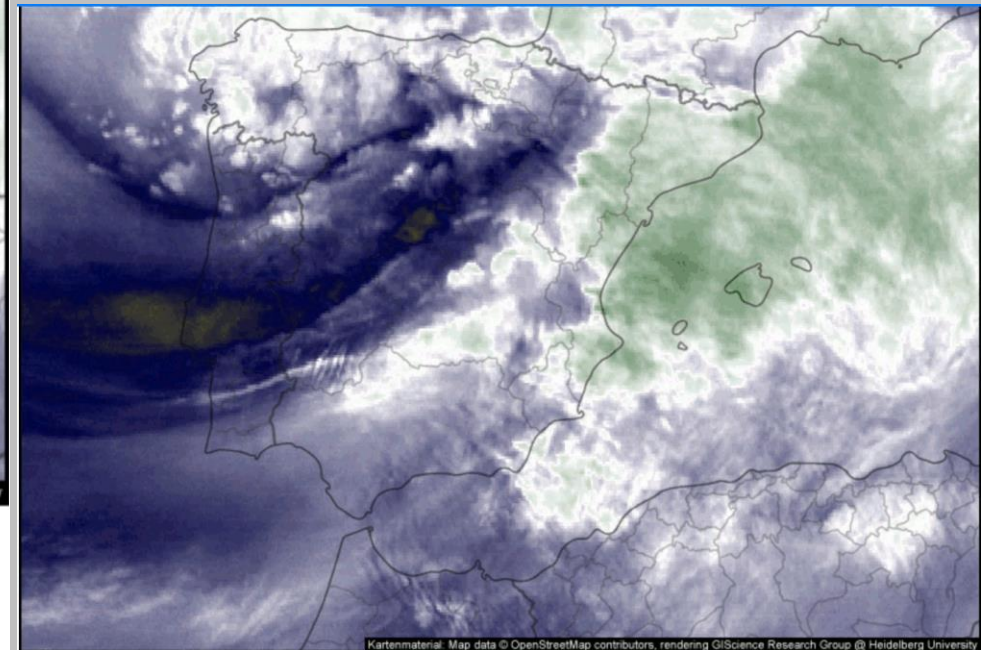
Cyclone Hortense

Warm conveyor belt – upper air front

Cold surface front – instability (cold dry air over warm humid air)

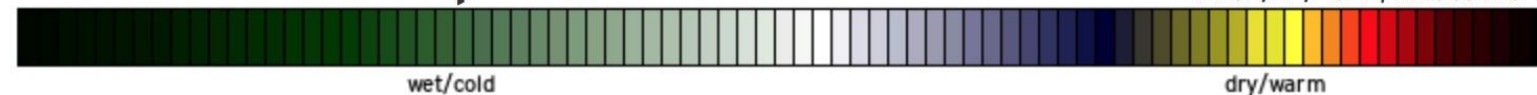
Dry intrusion – jet streak

Maximum upwards forcing - severe convective system – squall line



Satellite Water Vapor

Fri 01/22/2021, 11:00am CET



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meteologix.com

Satellite data: EUMETSAT

Satellite Water Vapor

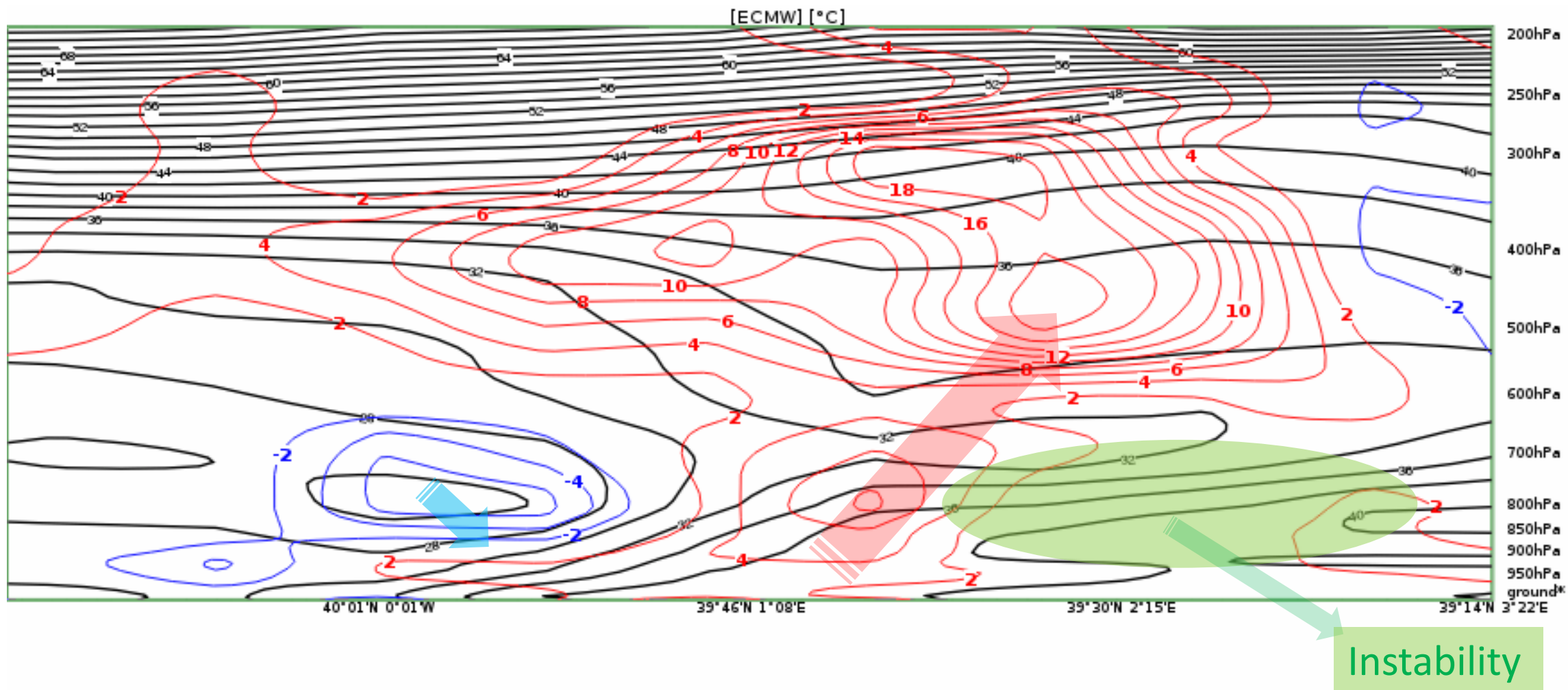
Fri 01/22/2021, 04:00am CET



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Satellite data: EUMETSAT



Cross-Section from map **Equivalent Potential Temperature** and **Vorticity Advection**
for 40°15'N 1°09'W - 39°14'N 3°22'E, valid 22.01.2021 09:00

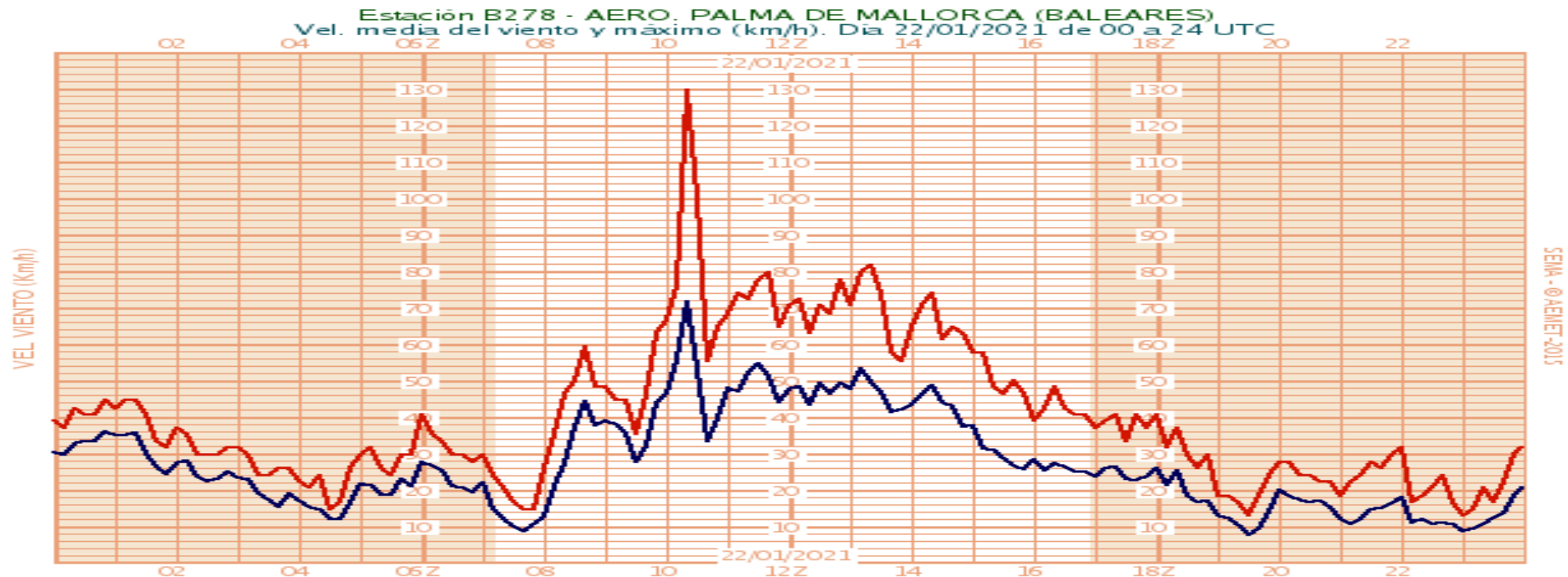
Section across dry-intrusion/jet-streak and and surface-cold-front
(obtained from the ZMAG – EumeTrain facilities – based on H+9 ECMWF forecasting)

Is there enough instability to explain convective gust speeds of 120-130 km/h in southern Mallorca and still 110-120 km/h in Menorca?

Probably not. Probably the strong cyclonic general wind has to be added to the convective contribution. In the case of Palma-airport it can be guessed:

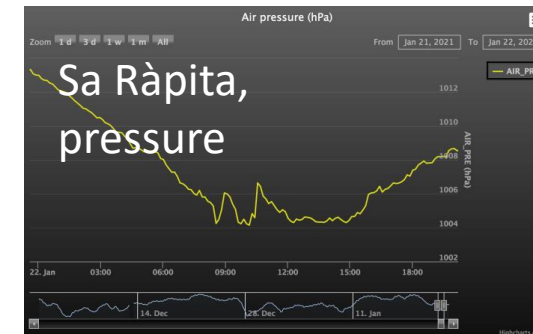
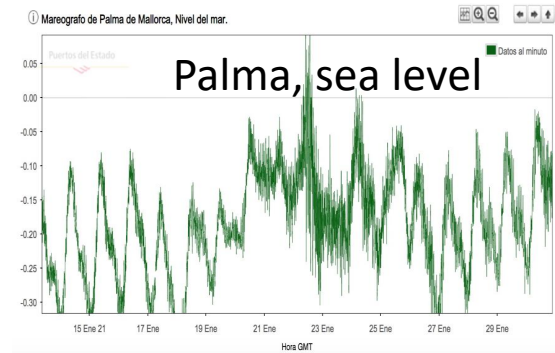
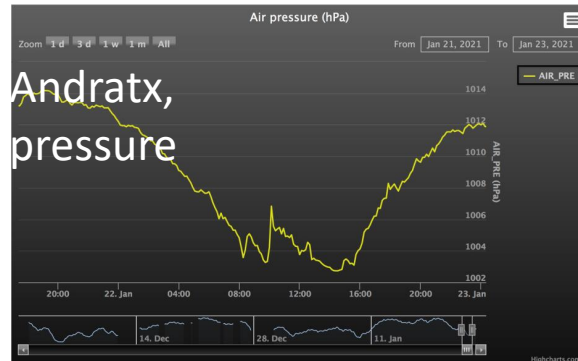
General wind: 50 km/h + Convective contribution: 80 km/h = Wind gust: 130 km/h

This is a wind speed record since 1961



Marine diagnosis from atmospheric forcing

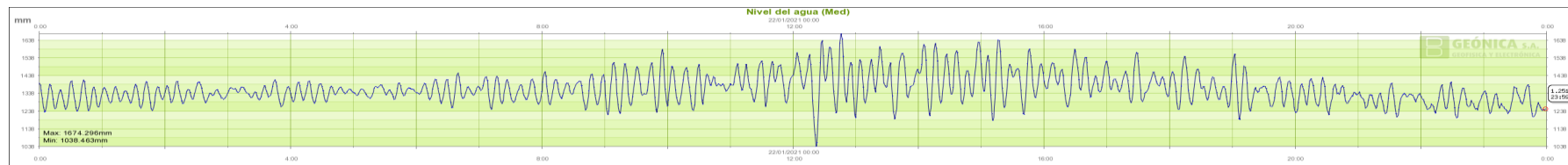
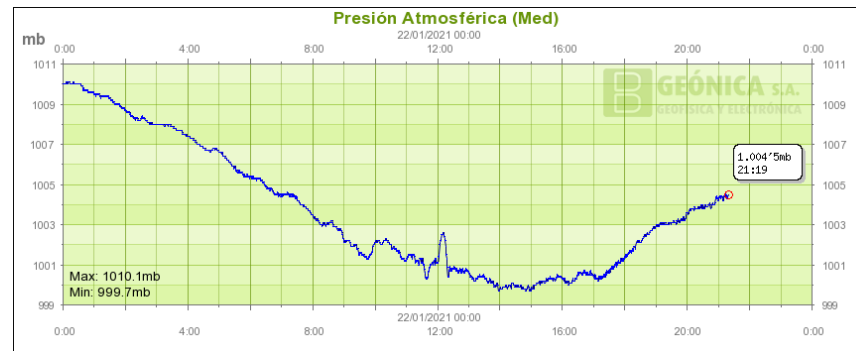
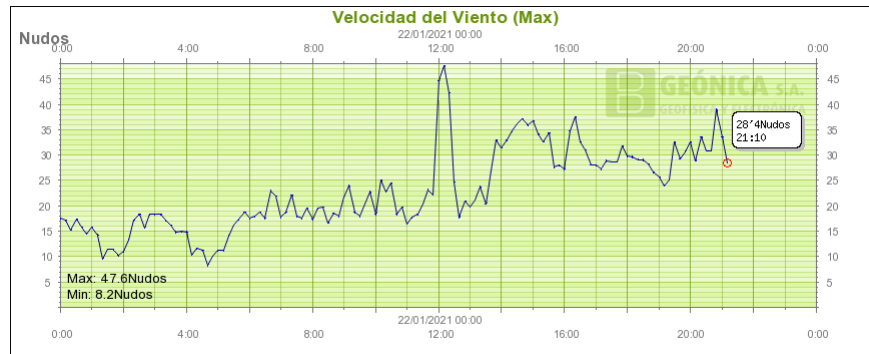
Squall line + previous pressure oscillations → Main pressure jump (3-4 hPa) + wind gusts (100-130 km/h) → initial marine waves: 3-4 cm high → Palma, 35 cm; Portocristo, 25 cm; ... → amplification mechanisms? Proudman resonance? shoaling effect? port/bay resonance?

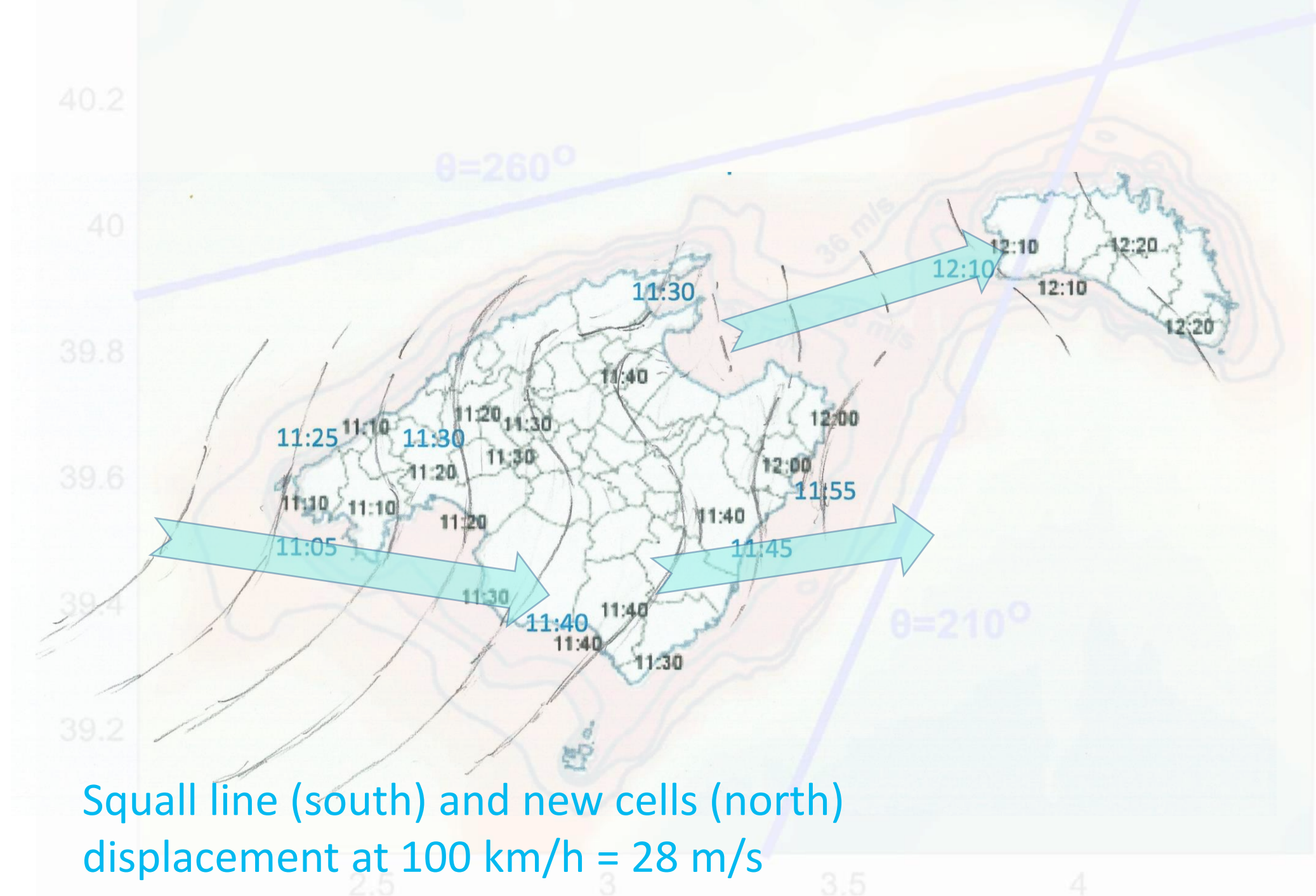


Ciutadella is a particular case →

Port of Ciutadella

Perhaps not the main squall line, but intense convective cells passed over Ciutadella, producing:
Wind gust: 88 km/h; pressure jump: 2.5 hPa; sea-level oscillation: 60 cm (data from *Ports IB*):
More than double amplification of the marine long waves than in other ports (Palma, Portocristo, ...)

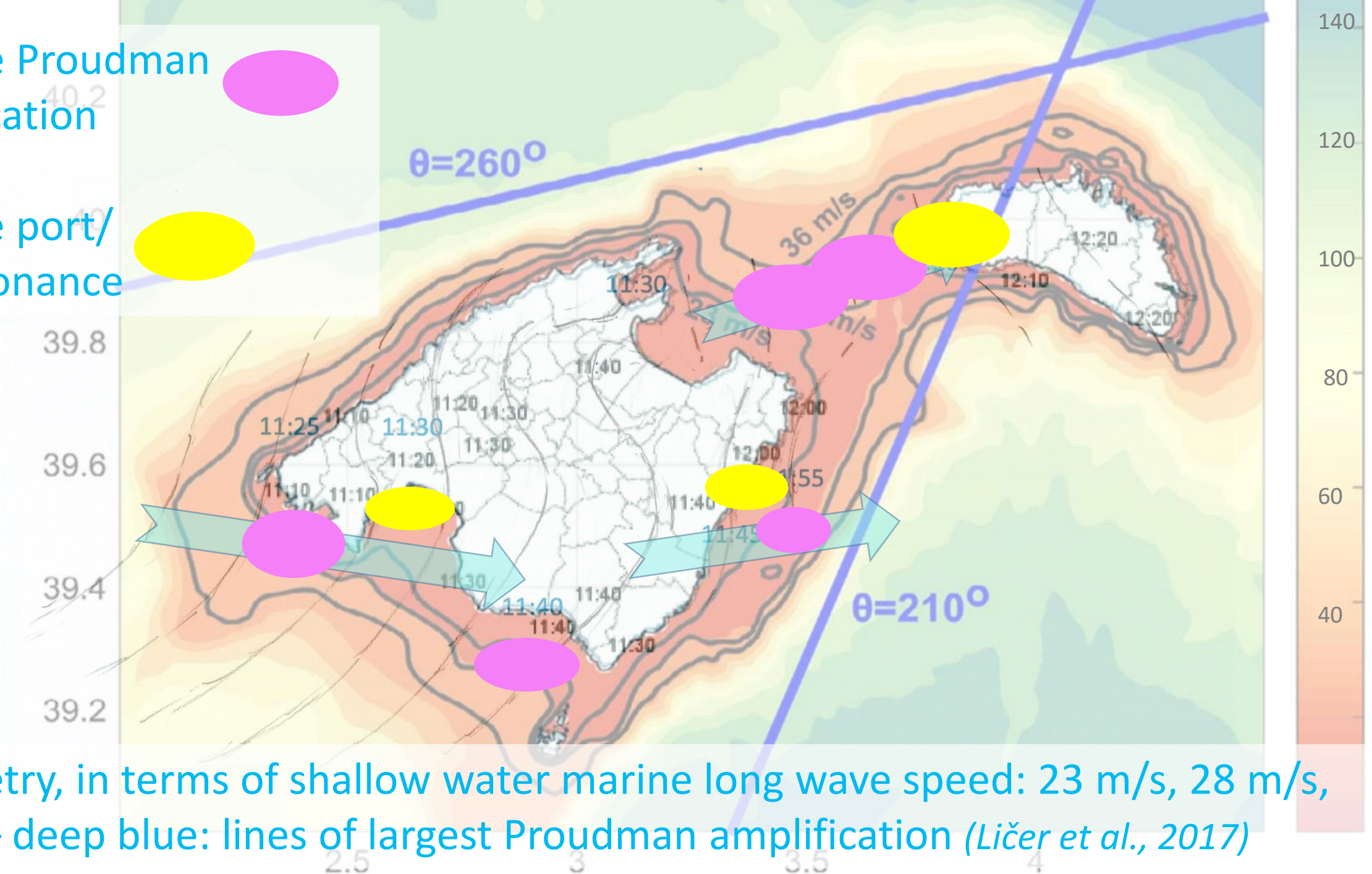




Squall line (south) and new cells (north)
displacement at 100 km/h = 28 m/s

Possible Proudman
amplification

Possible port/
bay resonance



Verification and Predictability

*From mesoscale meteorological models
and marine models*

The meteorological models (ROMS and TRAM models do forecast pressure oscillations, even convective squalls (strong pressure jumps), although the most intense convective cells and the convective squalls are badly located.

This means:

Squall line not in place

Rissaga event: underestimation

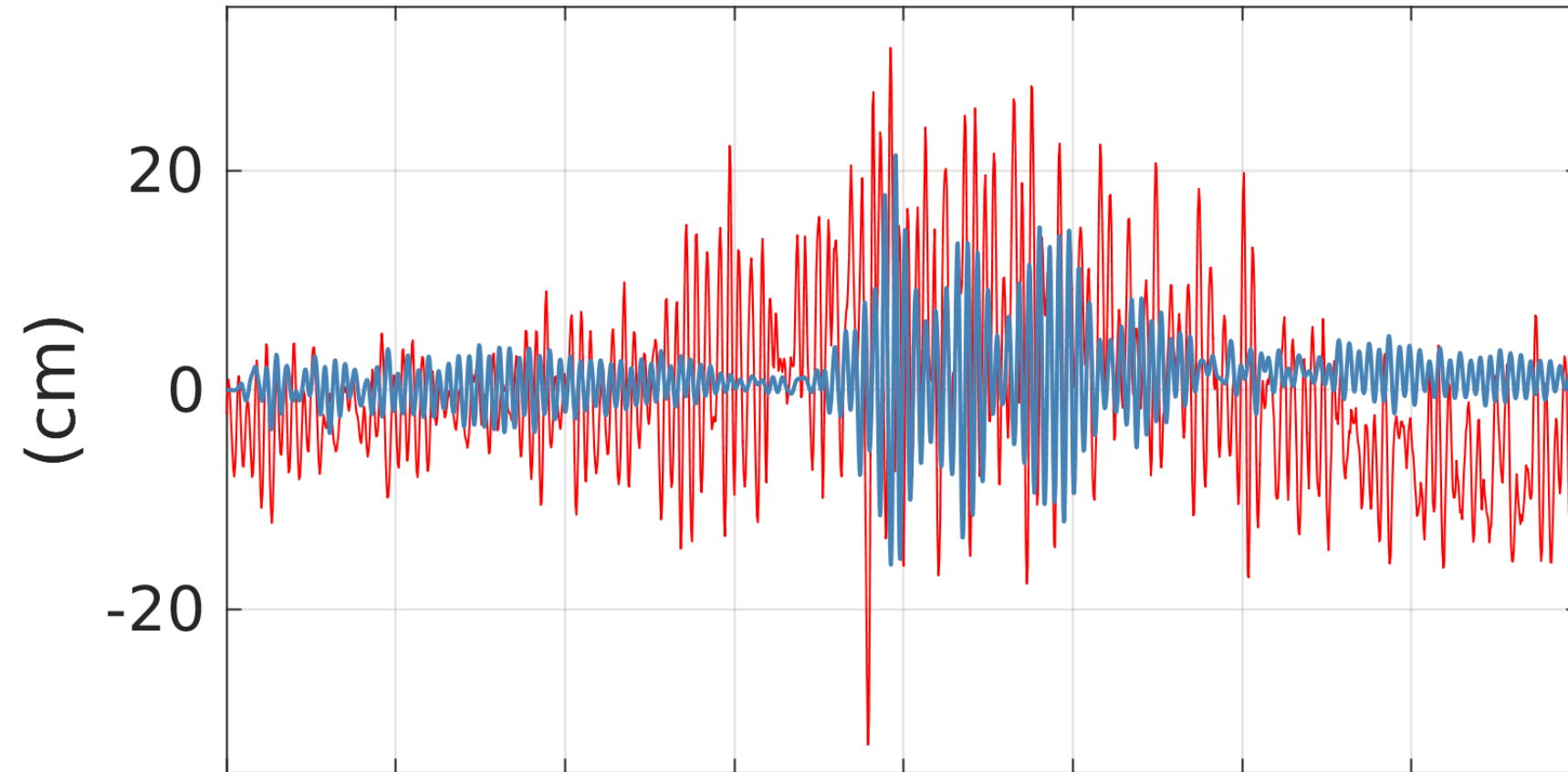
— OBS — BRIFS

(both curves at
mid-harbour point)

Sea level anomalies in Ciutadella

Geonica → 60cm magnitude
~11h25 UTC

BRIFS → 37cm magnitude
~11h55 UTC



22-Jan-2021
00:00 UTC

22-Jan
12:00 UTC

23-Jan
00:00 UTC

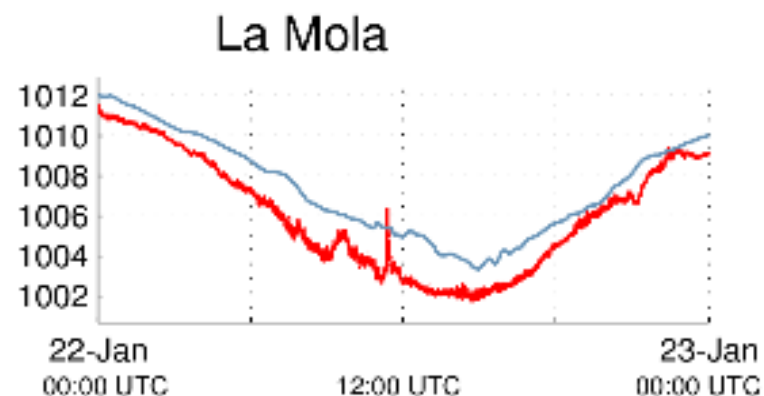
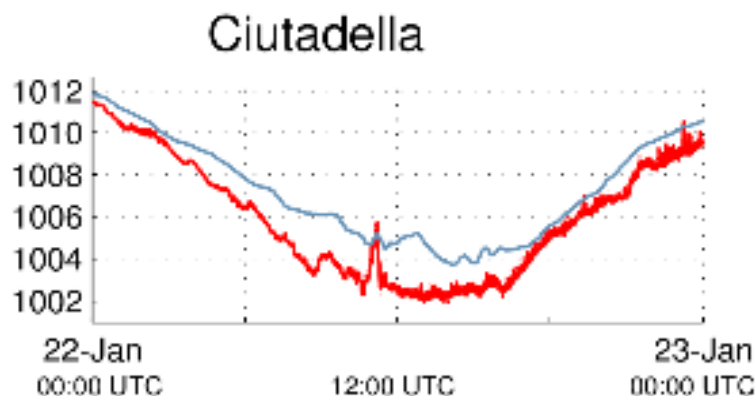
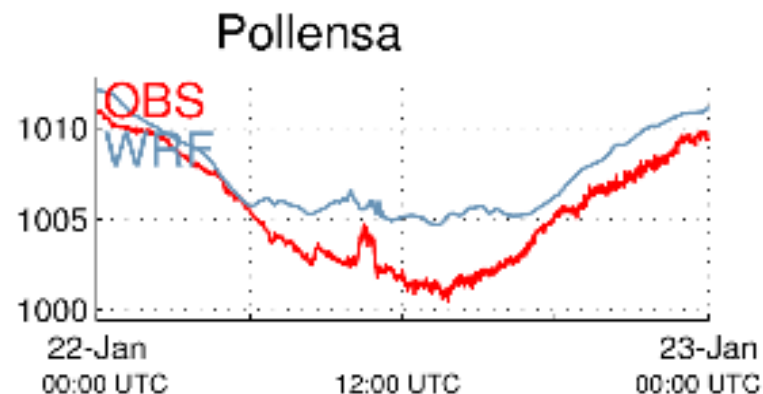
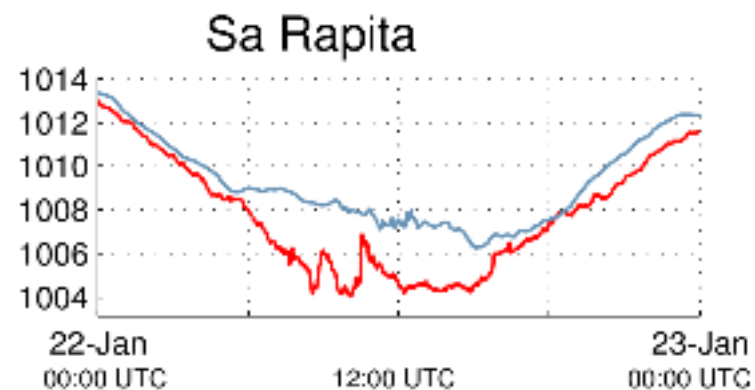
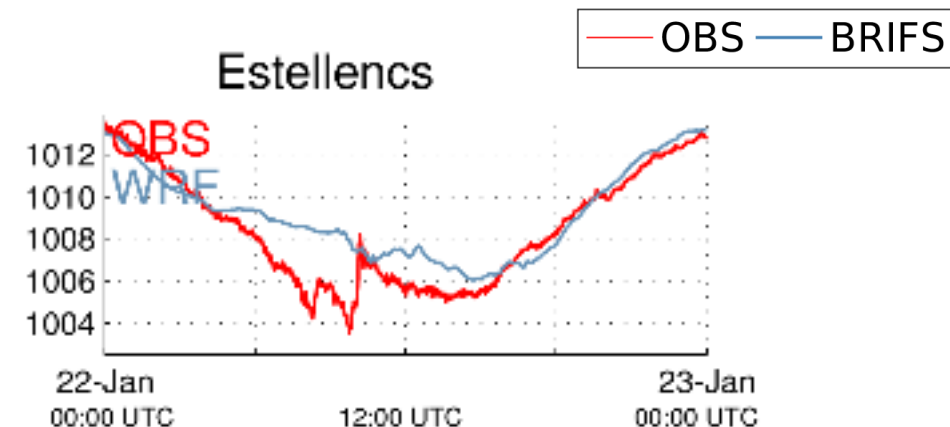
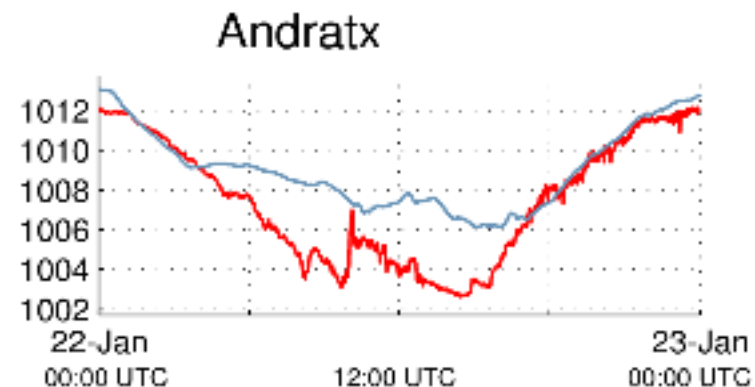
BRIFS produced a moderate rissaga, but with an underestimated magnitude compared to observations. The timing of the maximum oscillations is quite good, but the single pulse seen in the observations is not represented.

Atm. pressure

The overall pressure drop between ~06:00 and 18:00 over Mallorca-Menorca is underestimated in the model.

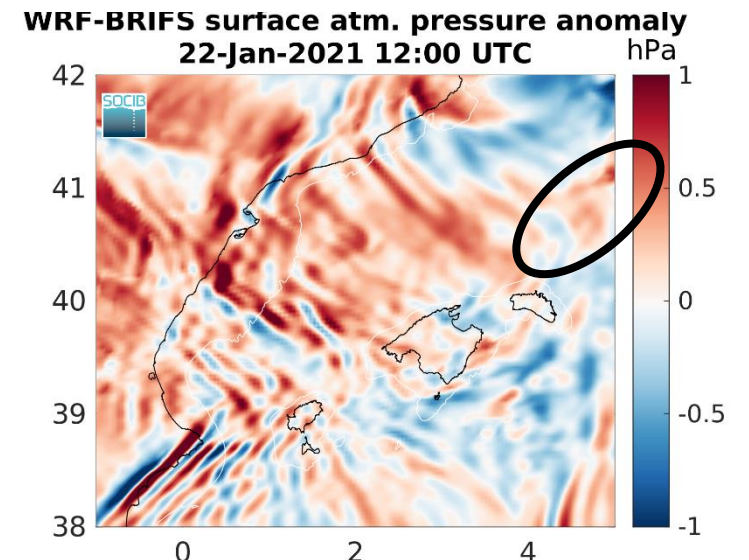
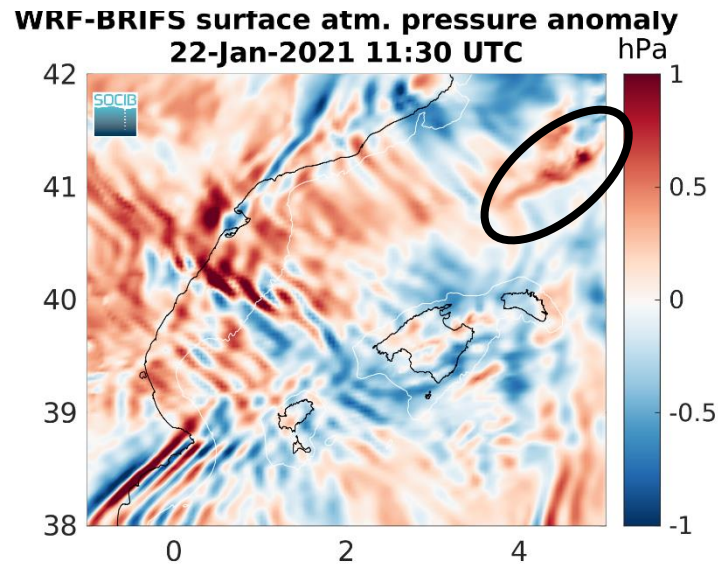
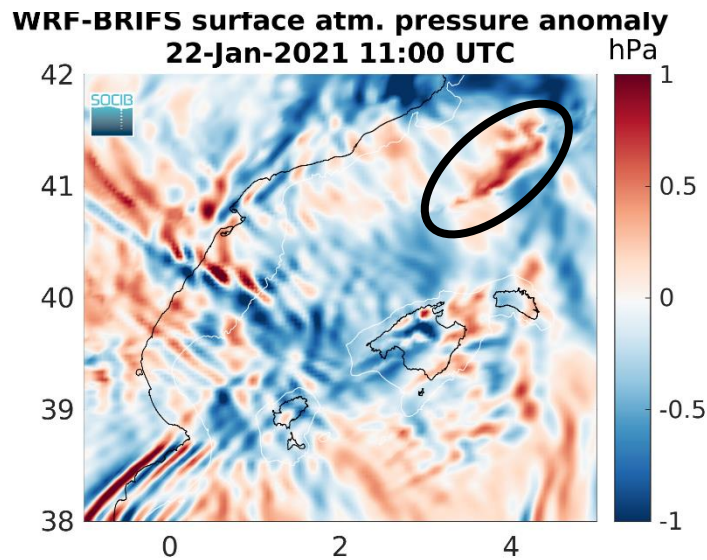
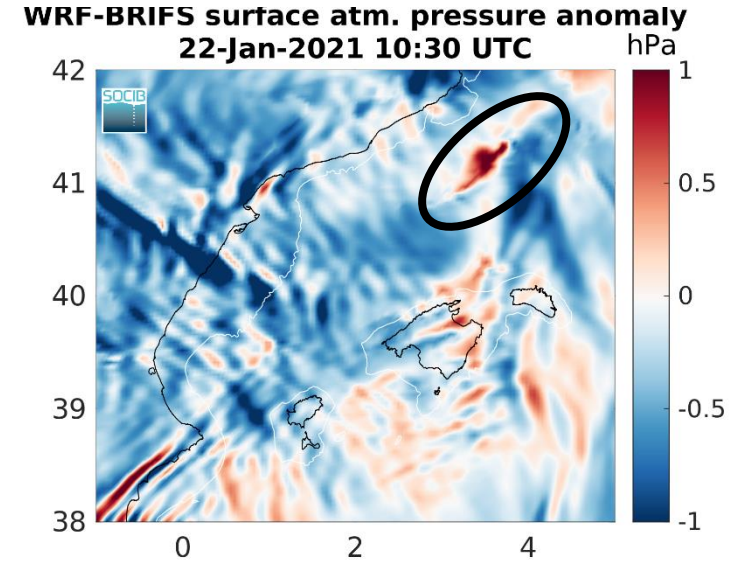
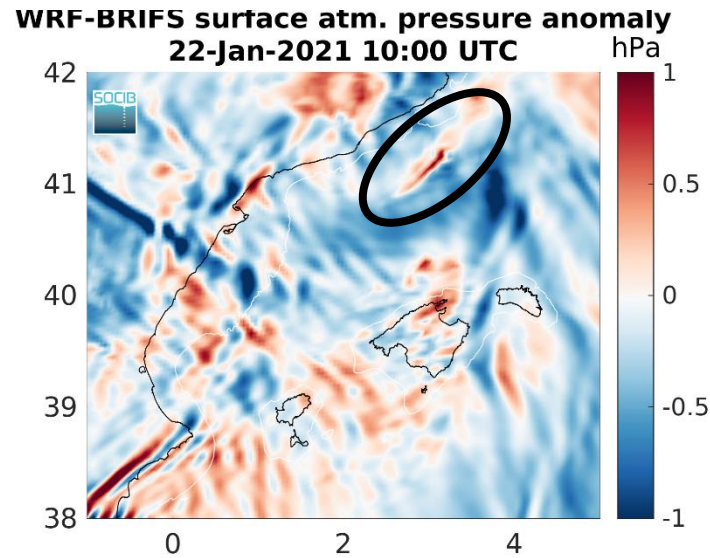
The ~3hPa sudden pressure jump observed from Andratx to Ciutadella is not represented in BRIFS (high-frequency oscillations exist but with a ~0.5hPa magnitude in the model).

Sea level pressure (hPa)



High-freq. atm. pressure

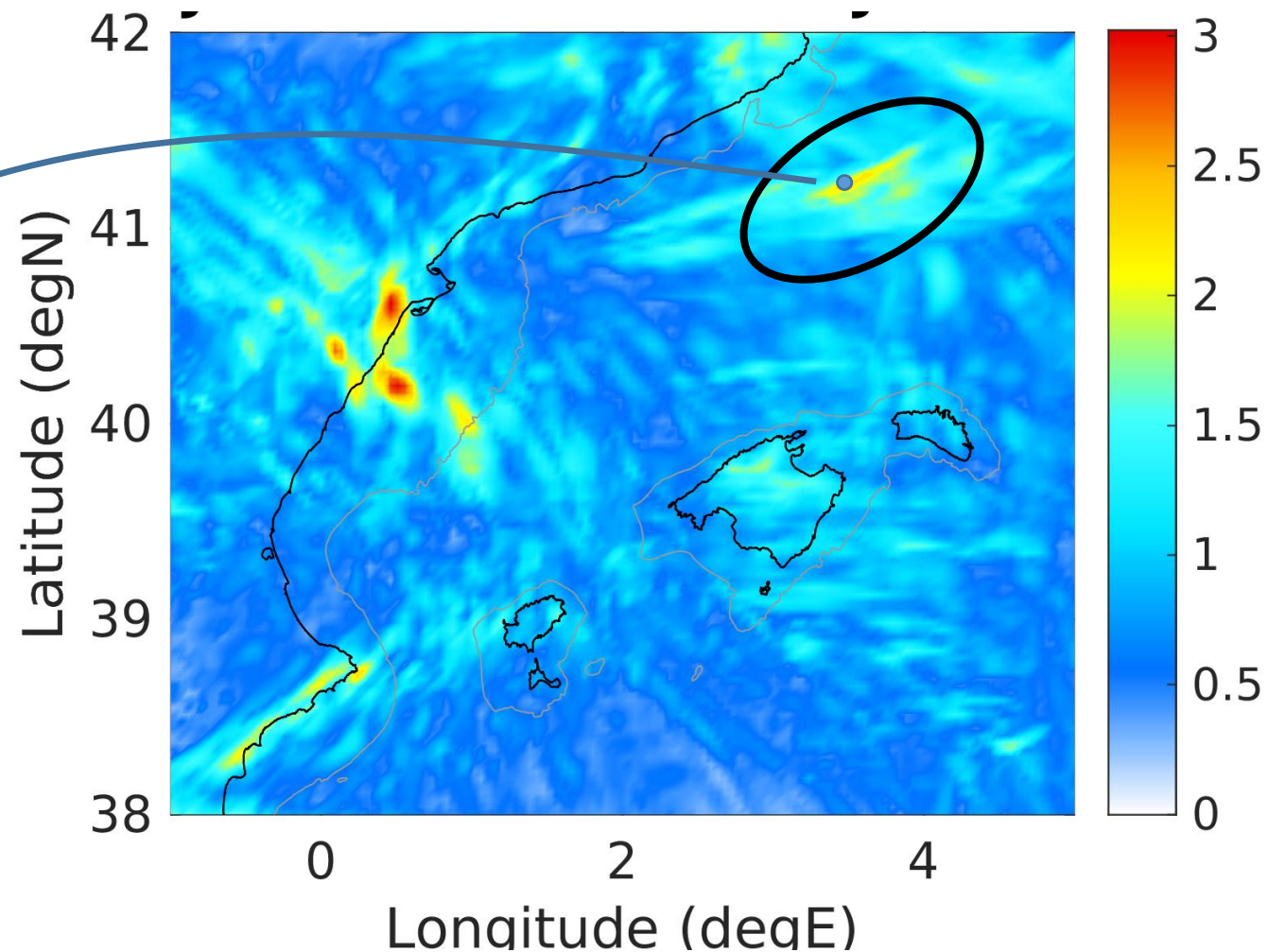
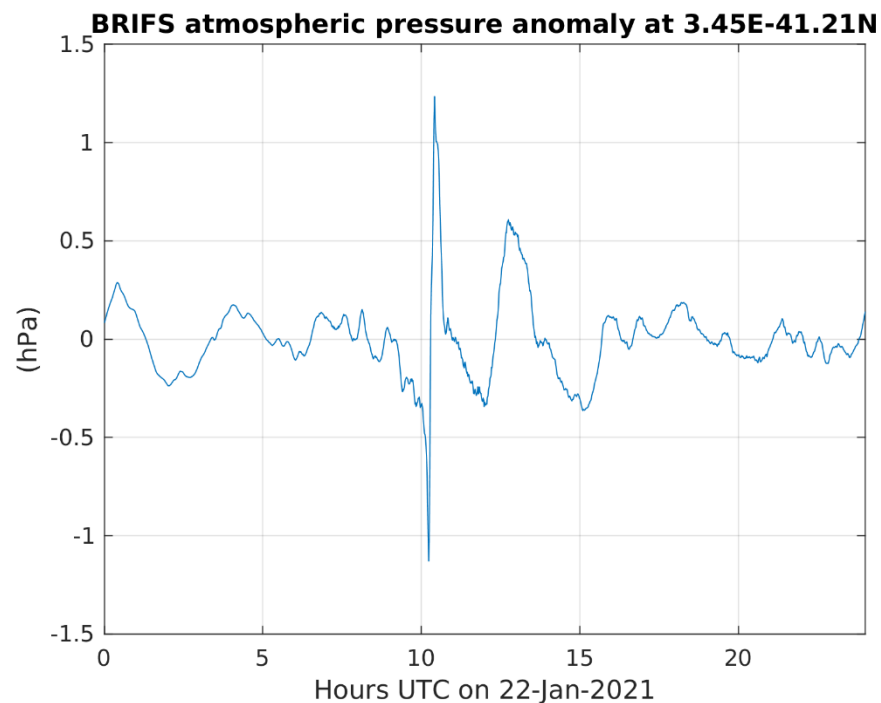
High-pass filtered surface pressure maps show the presence of $\sim 0.5\text{-}1\text{hPa}$ anomalies all over the region in the model. An eastward propagating squall-line-type feature is present in the model but it is located further north, so without effects on the model rissaga.



High-freq. atm. pressure

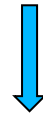
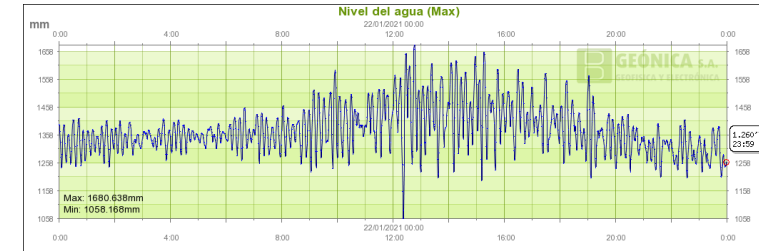
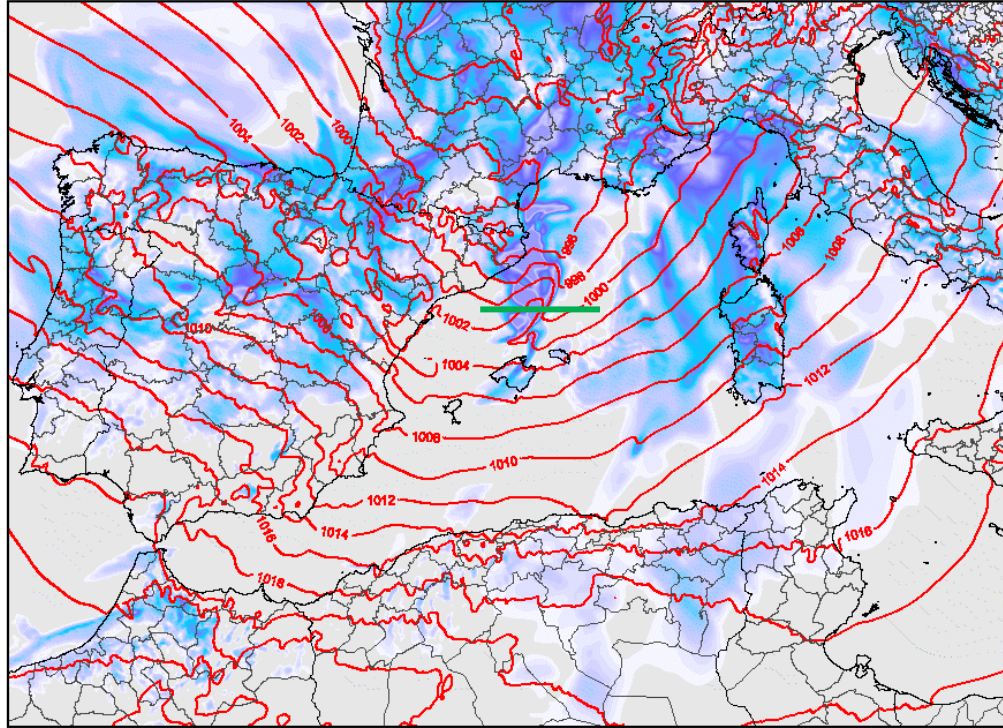
Maximum atmospheric pressure variations (hPa) in 25min intervals from 4:00 to 16:00 UTC on 22 Jan 2021

This squall line generates pressure jumps >2hPa!

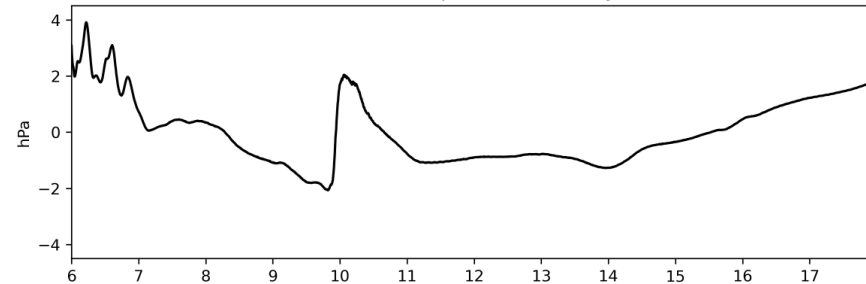


TRAM Atmospheric-Oceanic SIMULATION

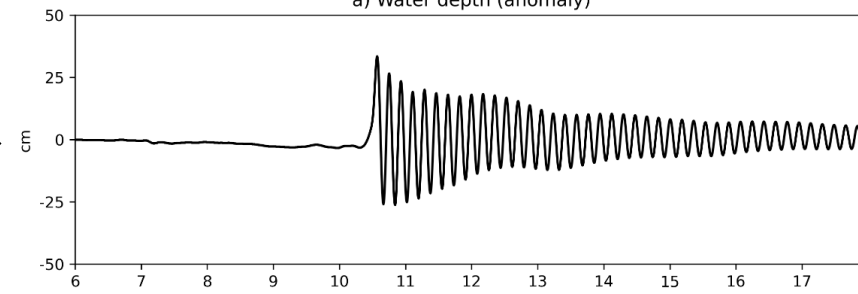
MSL PRESSURE (hPa) & CONDENSATE (kg/m³) Forecast: 04:30h / Valid: 10:30z Fri, 22 Jan 2021



a) Sea level pressure (anomaly)



a) Water depth (anomaly)



Thank you