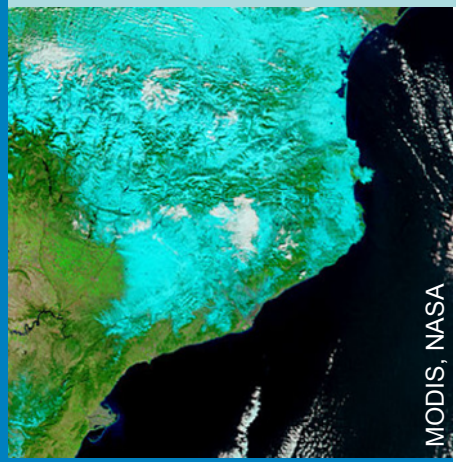
Remote sensing observations of a Mediterranean thundersnow and low-altitude heavy snowfall event

Palma de Mallorca,
Balearic Islands, Spain
3 - 7 October 2011



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1. Introduction (Thundersnow & low altitude snowfalls in Catalonia)
2. Synoptic conditions
3. Remote sensing observations (total lightning, radar)
4. Tower triggered lightning
5. Concluding remarks

Introduction

- **Heavy low altitude snowfalls:** in Catalonia are relatively rare events
  (16 cases in Barcelona from 1947 to 2009; 2 severe)

Pages et al (Plinius 2003), Pascual et al (AMS RAD2003), Aran et al (Plinius 2010)

- **Thundersnows**: thunderstorms with snowfall; relatively rare anywhere compared to snowfall & thunderstorm occurrence

Miyake et al (IEEE TPD1990), Market et al (WAF 2002), Schultz & Vavrek (Weather 2009), Becker (2007)

- Most studies over Japan and USA
- Low number of strokes compared to summer tx
- Typically CG correlated with heavy snow band

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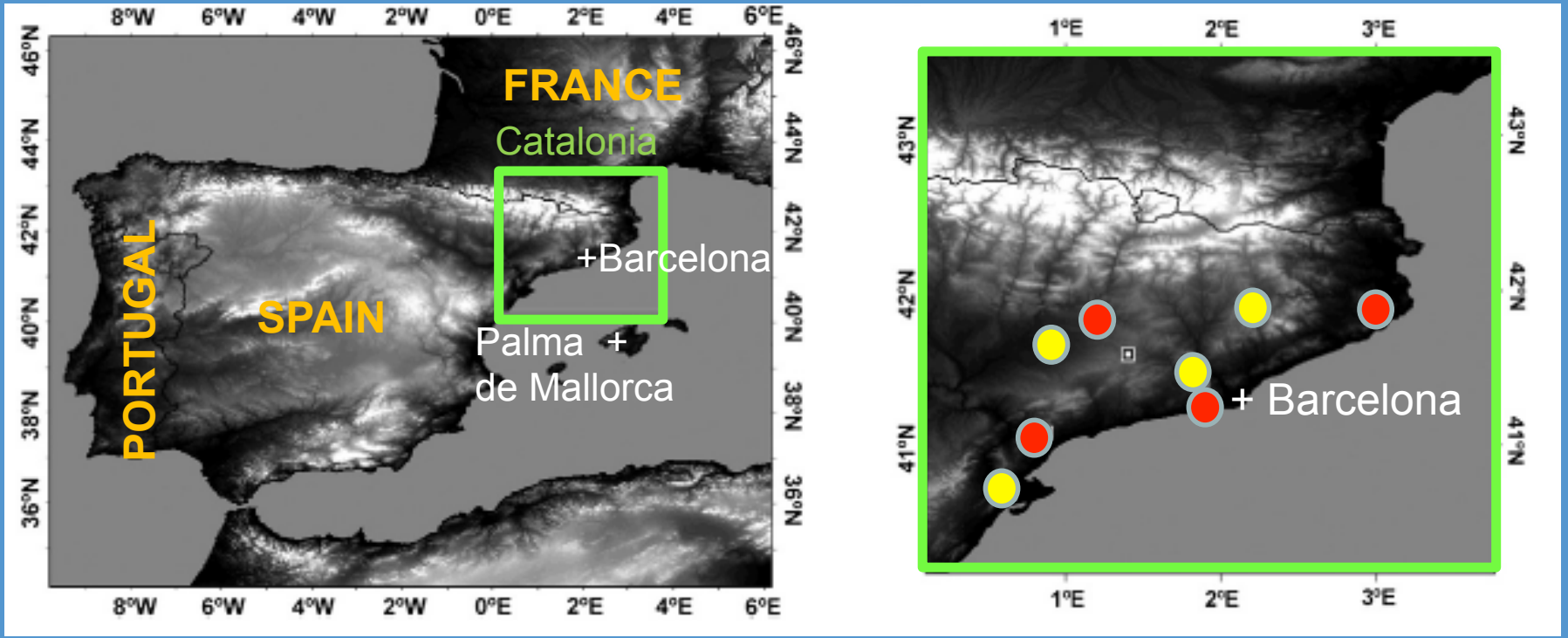
8 March 2010
Heavy low altitude Snowfall and thundersnow event in Catalonia

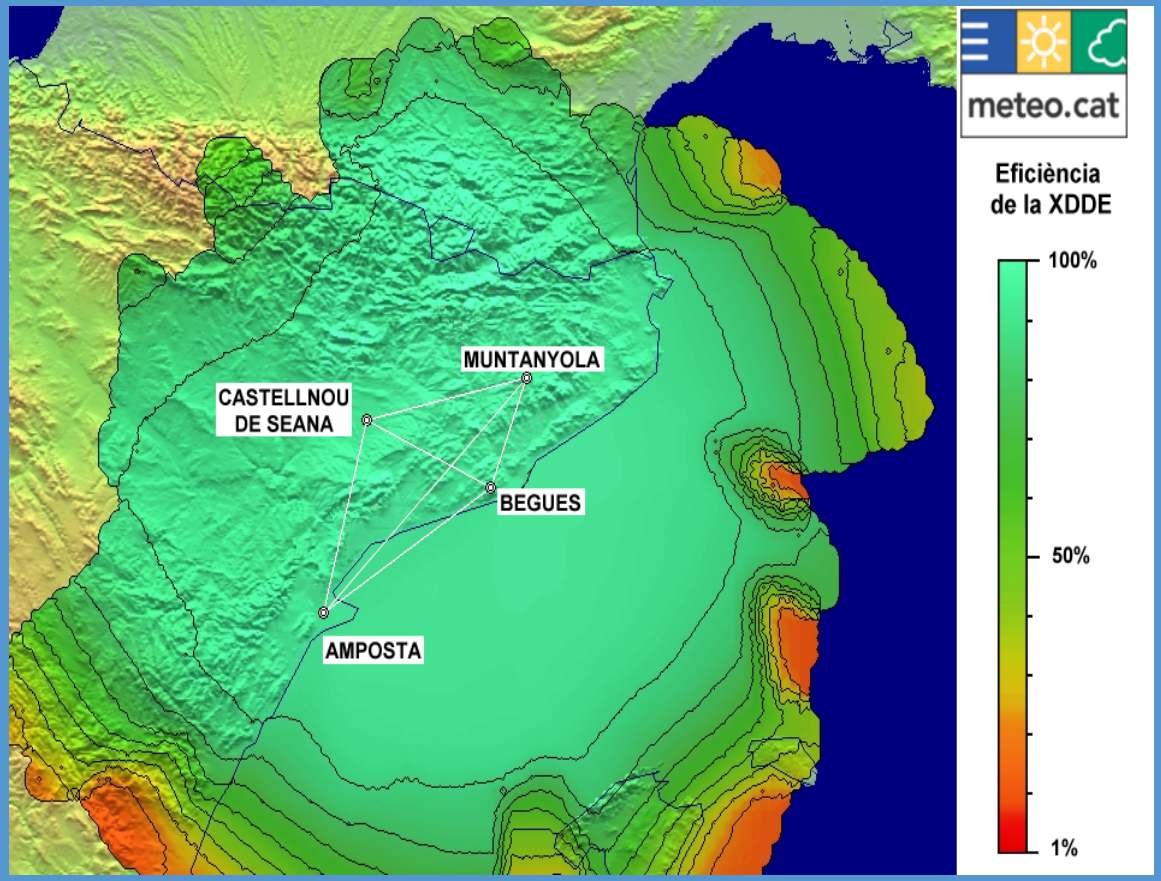
Introduction



Catalonia complex topography:
Pyrenees N (2000-300m)
Coastal (500 m) & pre-costal ranges (1000 - 1700 m)

- **C-band Doppler radar**
- **Total lightning sensor (IC & CG)**

Introduction



Total lightning sensor network efficiency

Damage overview

This episode caused very substantial disruption both in the area of Barcelona and in communications and transports at a regional level.

Moreover, it damaged large areas of low altitude forests, and also a number of power lines due to the combined effect of accumulation of wet snow (30-50 cm) and wind.

- **33 transmission towers** knocked down
- **220,000** customers without power
- **35,000** Ha of forests affected. A lot of trees were downed, causing an extra risk during the summer wildfire campaign (Amaro et al, 2010)

Synoptic conditions

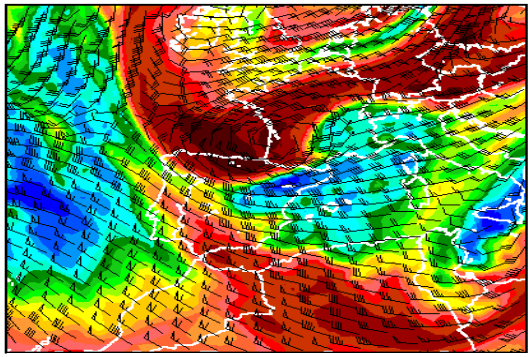
ECMWF-WRF analysis

500hPa: trough associated to a deep and cold depression in Central Europe extends in the N of Spain.

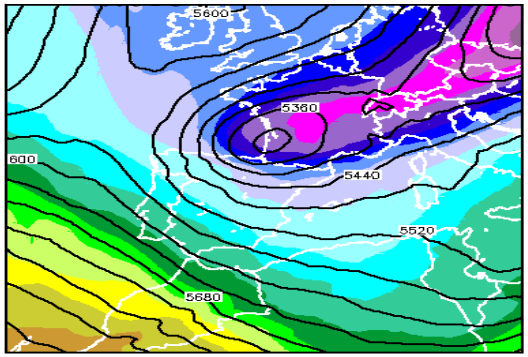
low levels: a depression located in the SE and a low deepens in the Balearic Sea. In this event, the cyclogenesis was very important and rapid

2010.3.8 00 UTC

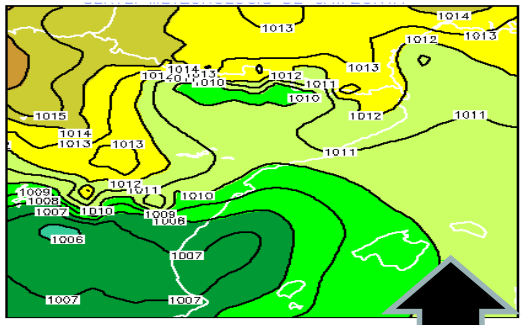
V (kts) & HR(%) 300 hPa



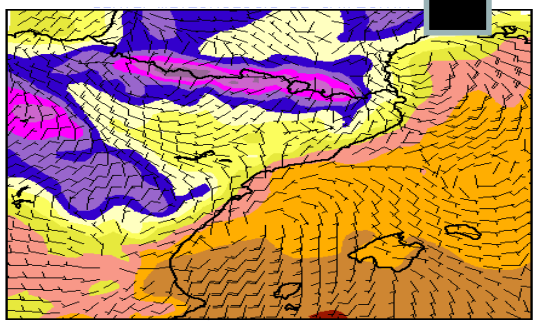
Z (mgp) & T(ºC) 500 hPa



MSLP (hPa)



T(ºC) & V(kts) SFC



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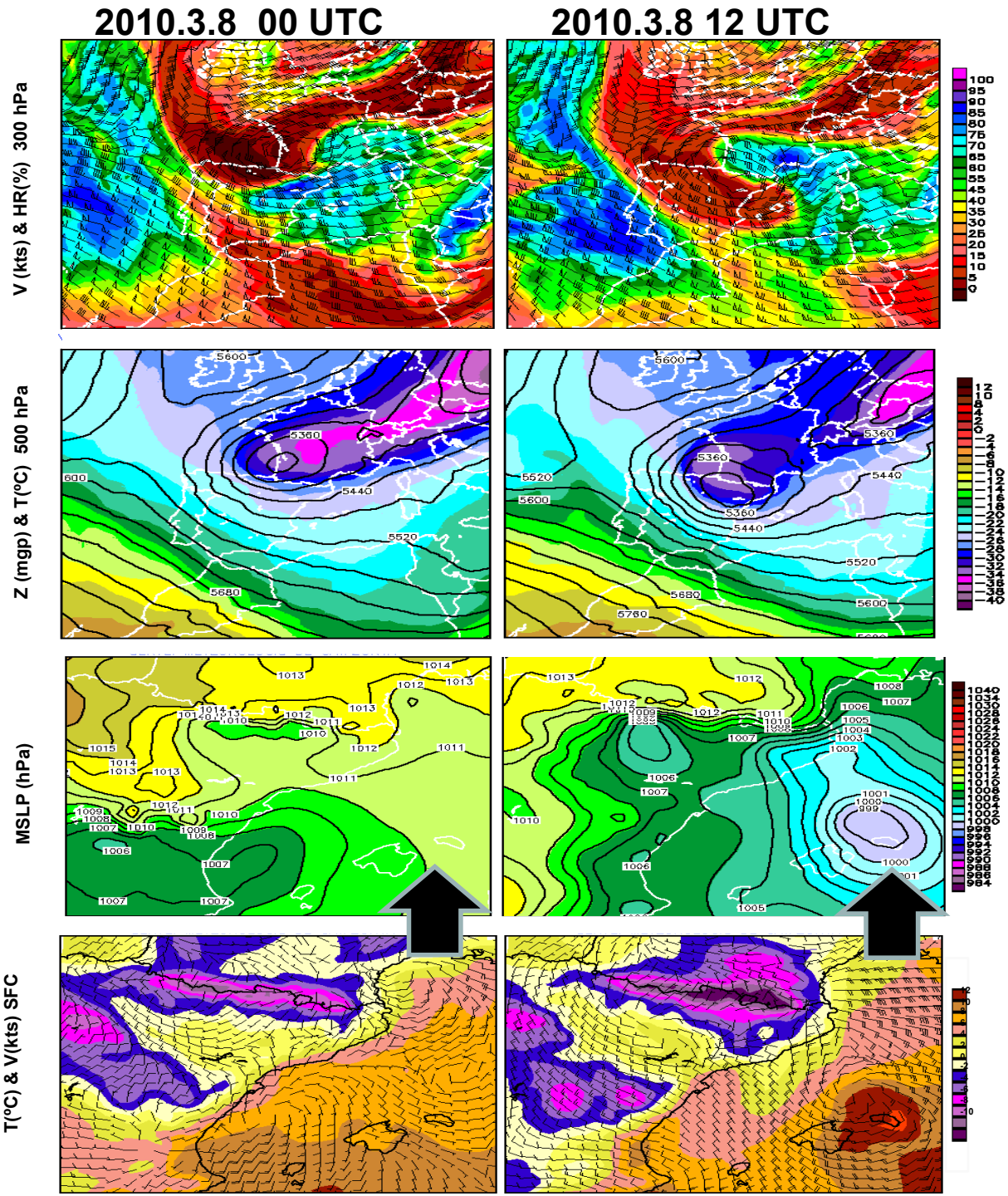
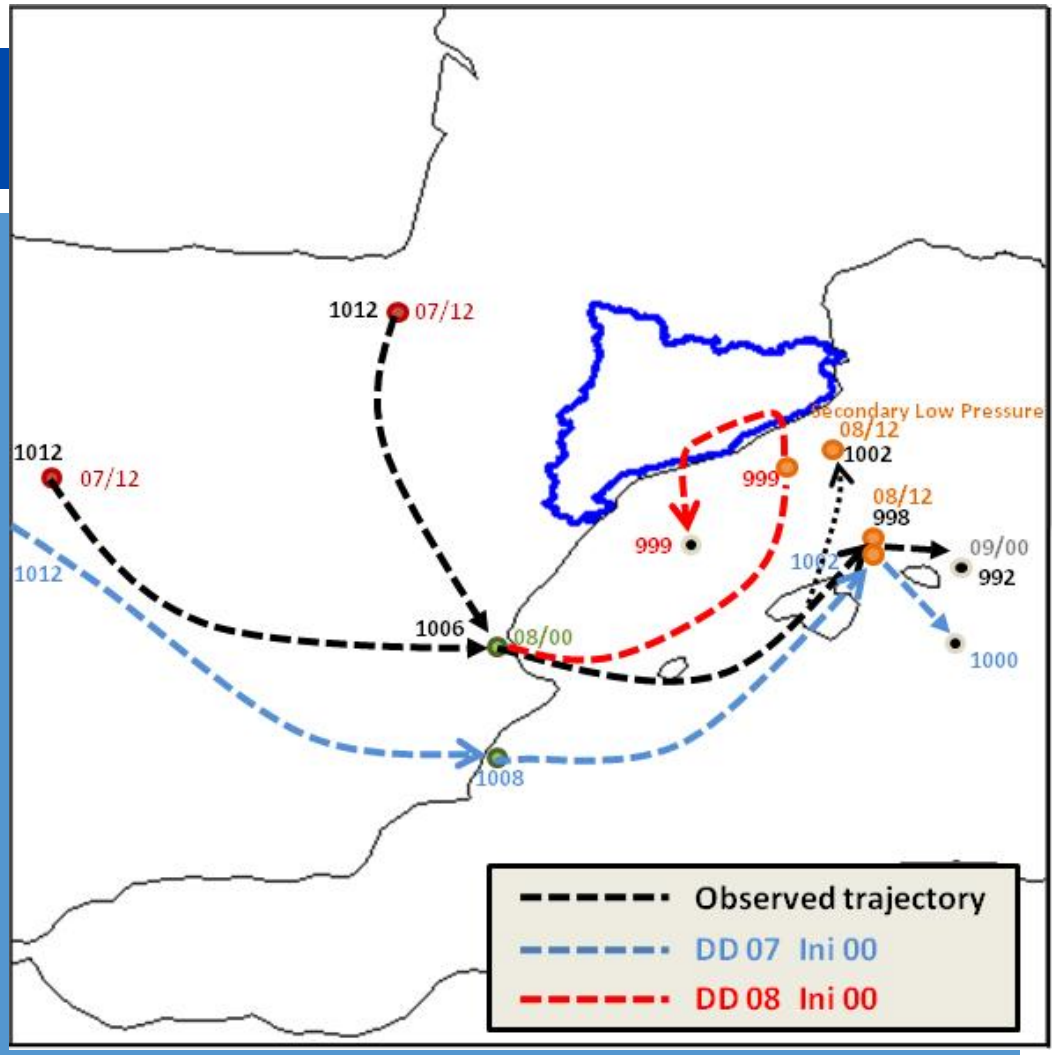
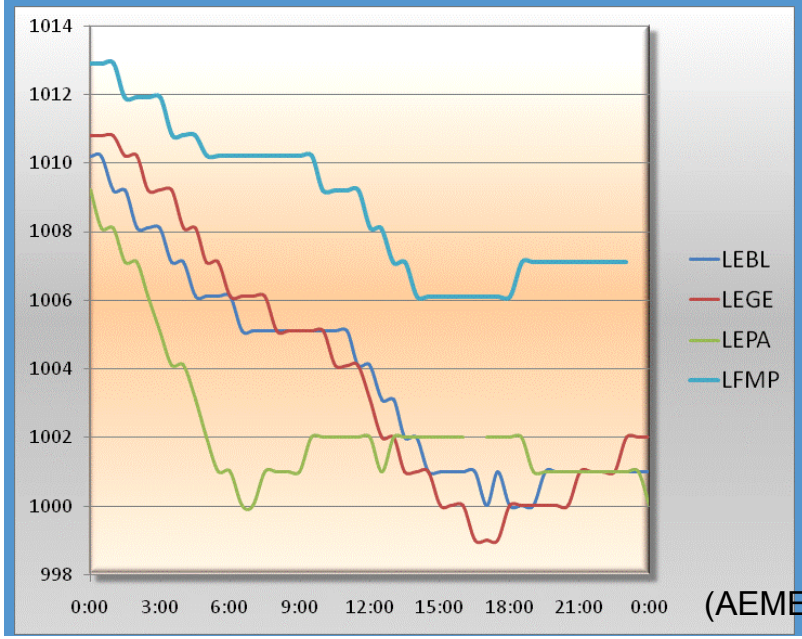


Synoptic conditions

Approximate location of the low centre: objective analysis (black), MM5 forecast run 7/03/2010 (cyan) and 8/02/2010 (red) at 00 UTC.





(AEMET data)

MSLP

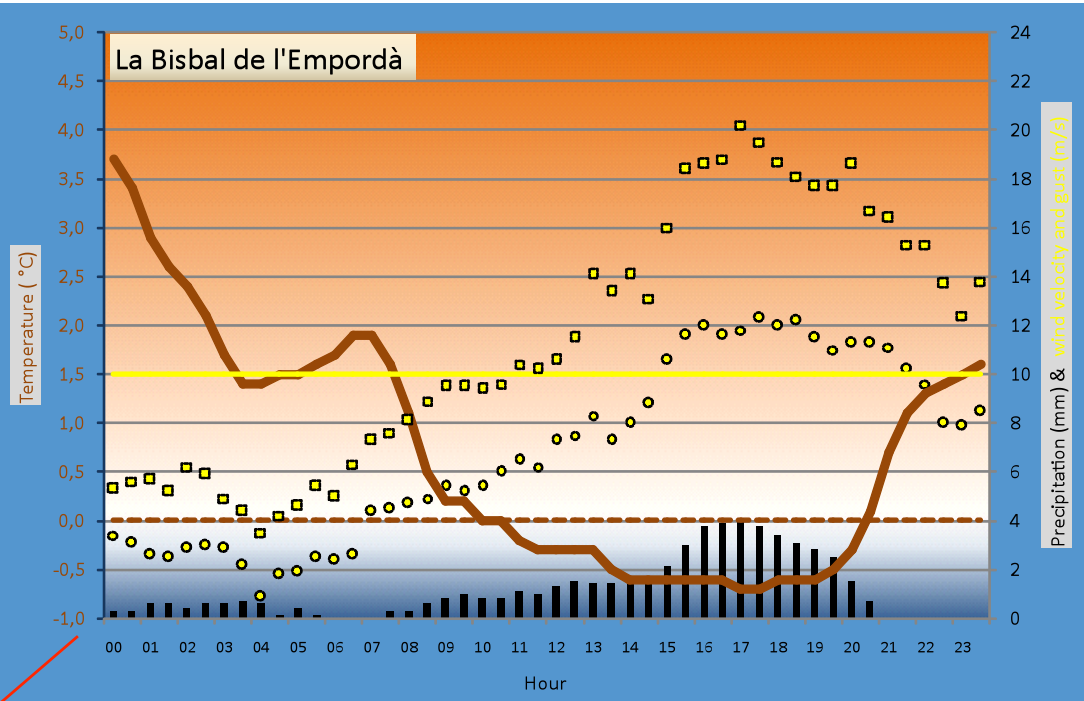
9,2 hPa/12h in **Barcelona** airport-LEBL

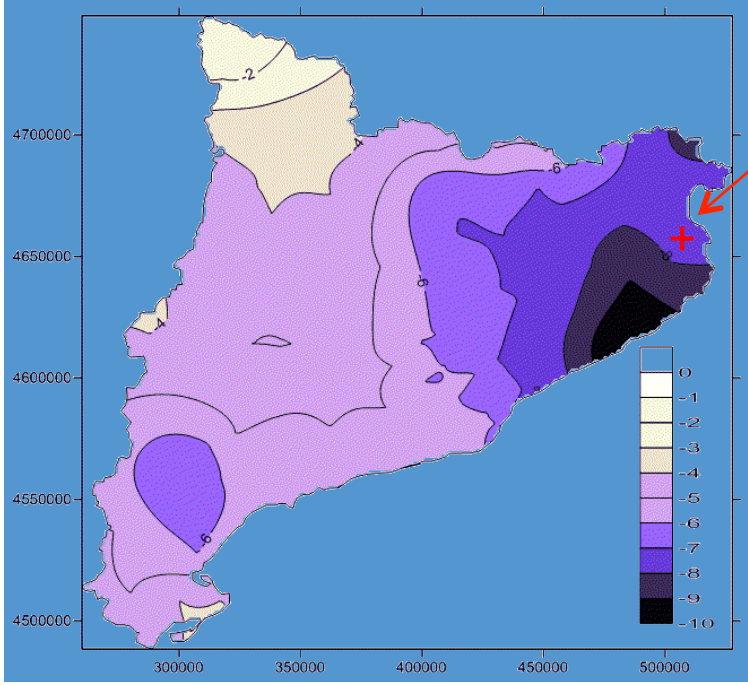
7,2 hPa/12 h in **Palma of Mallorca**-LEPA

Synoptic conditions

SAO (NE Catalonia)

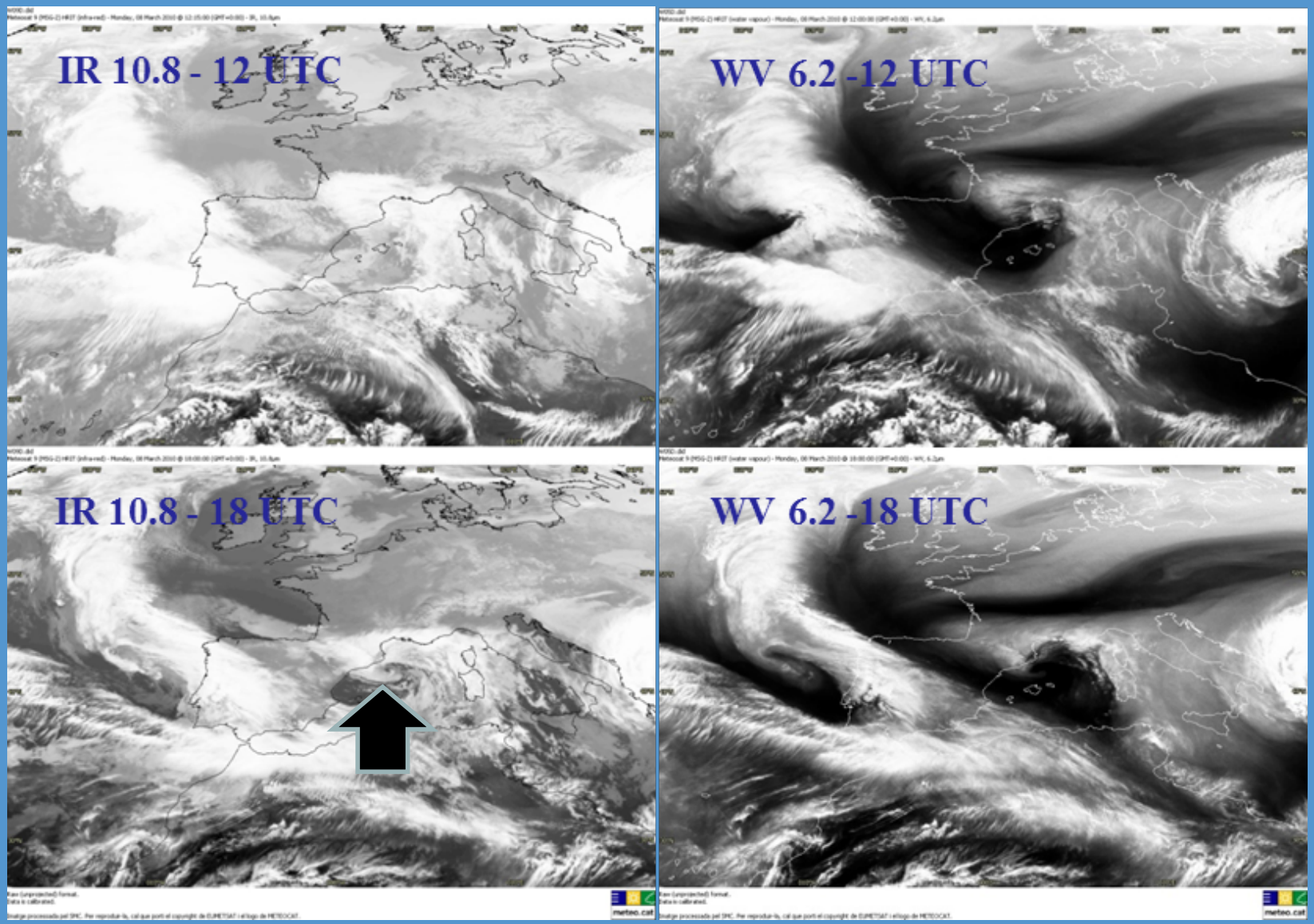
-Wet snow, with moderate wind
(snowpack formed over power lines)





Pressure fall between 00-15 UTC at surface obtained from AWS.

Synoptic conditions



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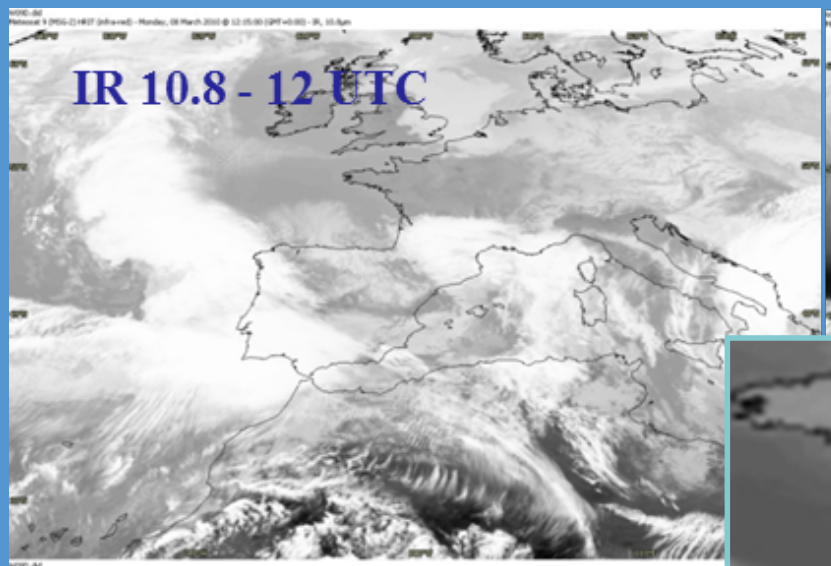
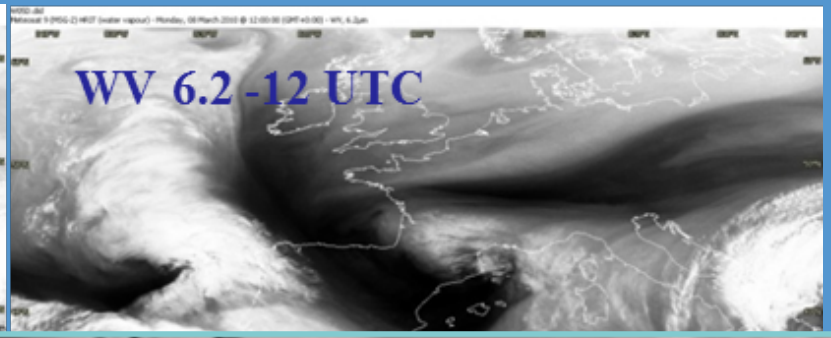
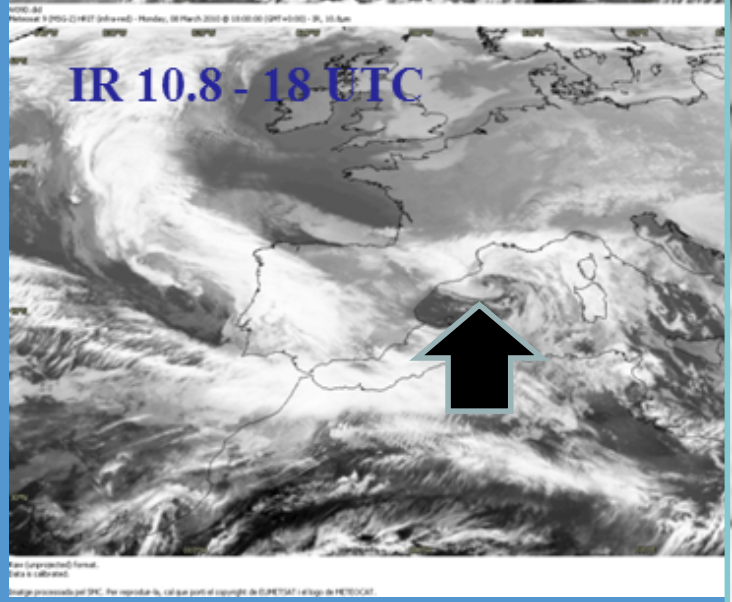
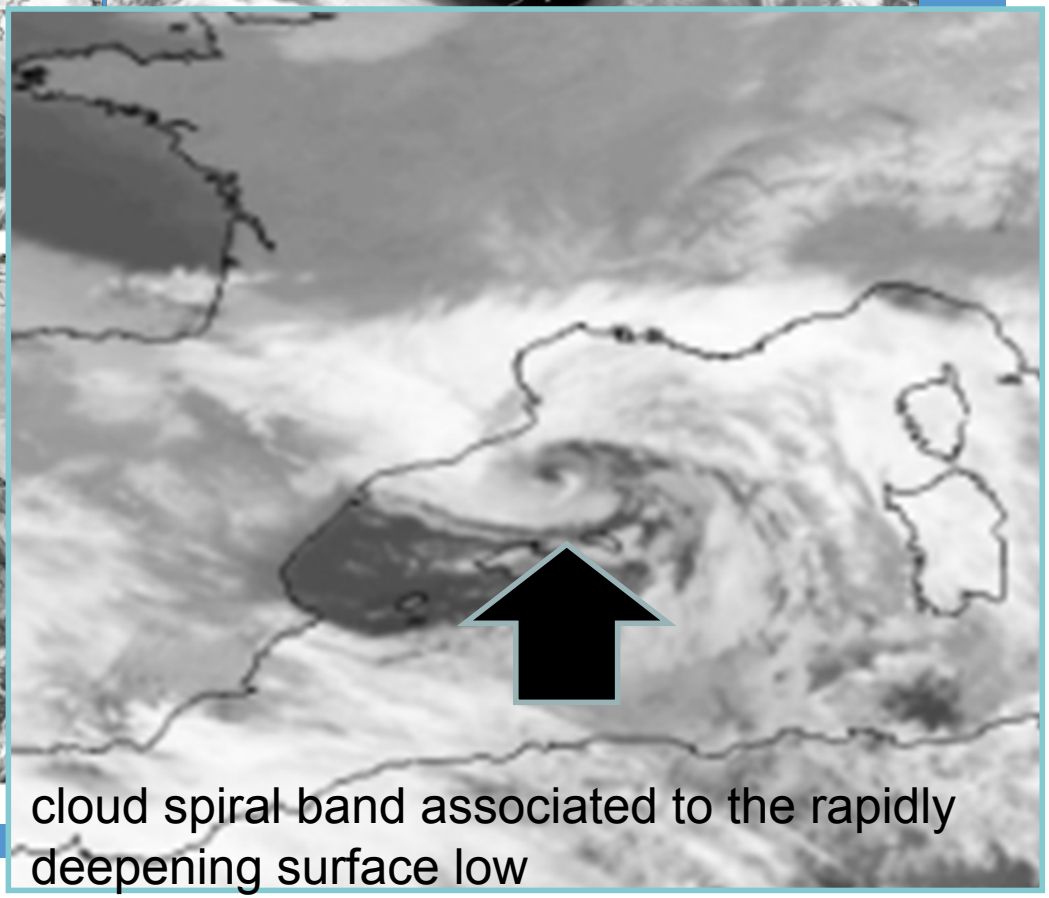
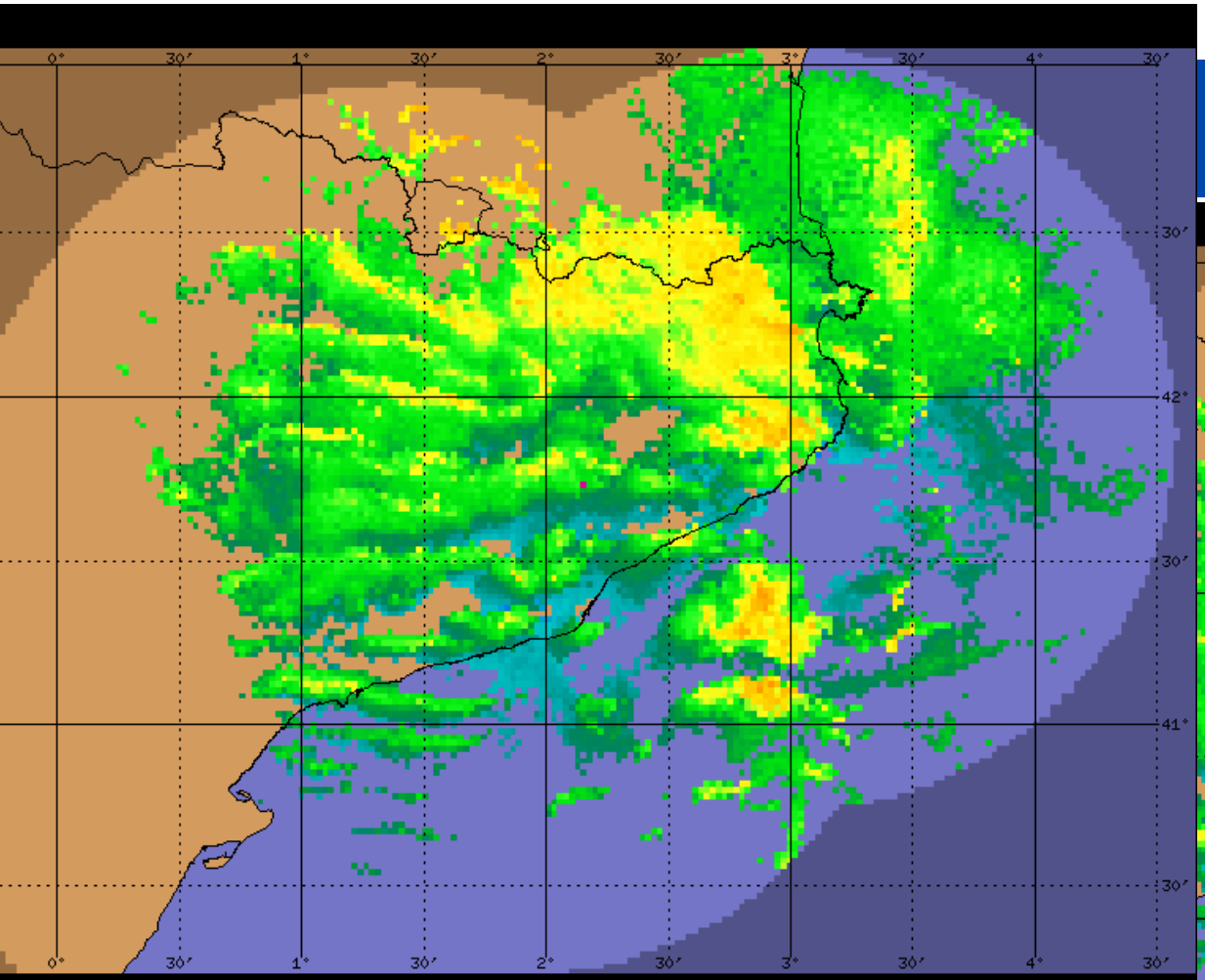


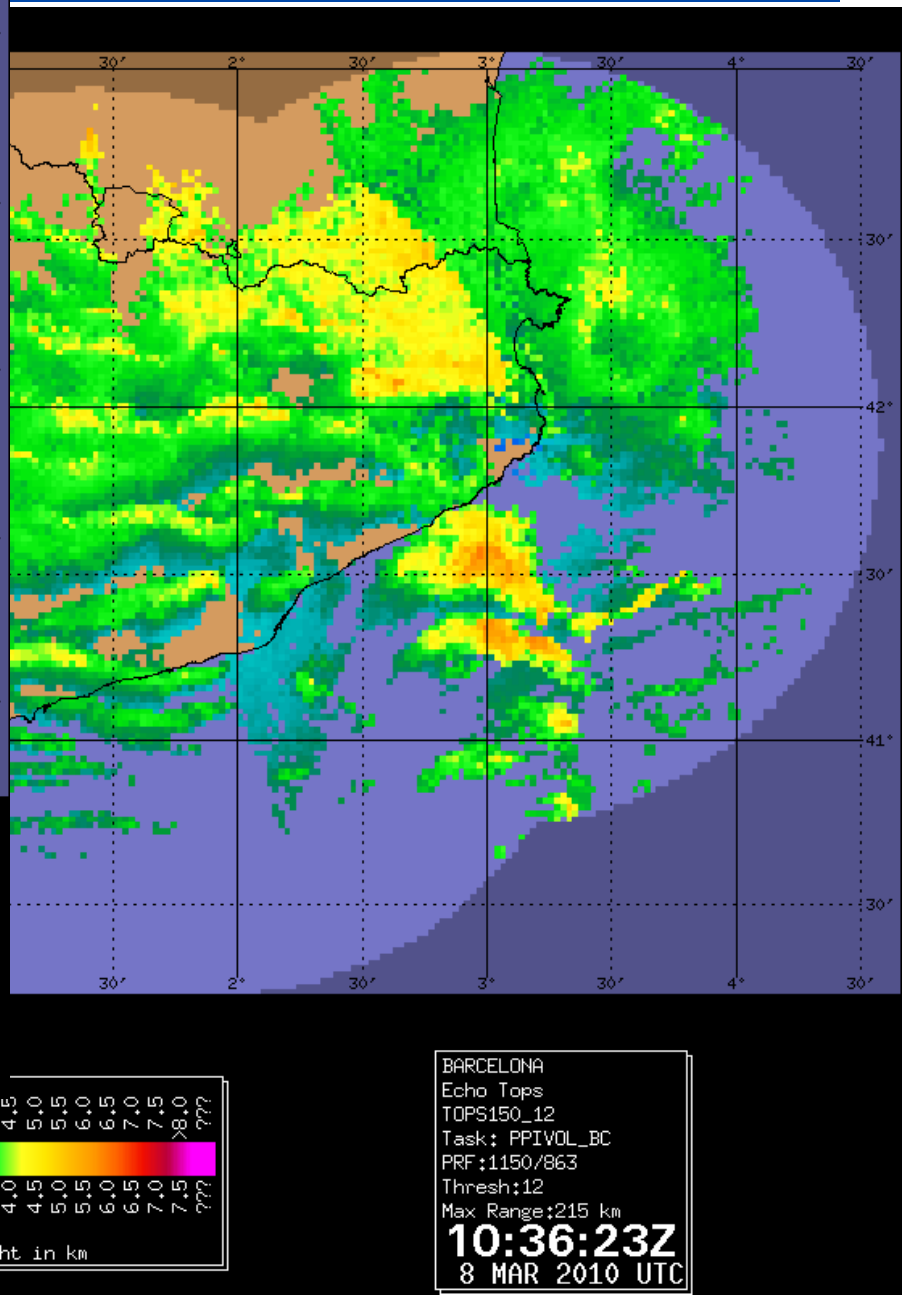






cloud spiral band associated to the rapidly deepening surface low


0° 30′ 1° 30′ 2° 30′ 3° 30′ 4° 30′
42°
41°
30′
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 >8.0 ???
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 ???
Height in km
BARCELONA
Echo Tops
TOPS150_12
Task: PPIVOL_BC
PRF:1150/863
Thresh:12
Max Range:215 km
10:00:22Z
8 MAR 2010 UTC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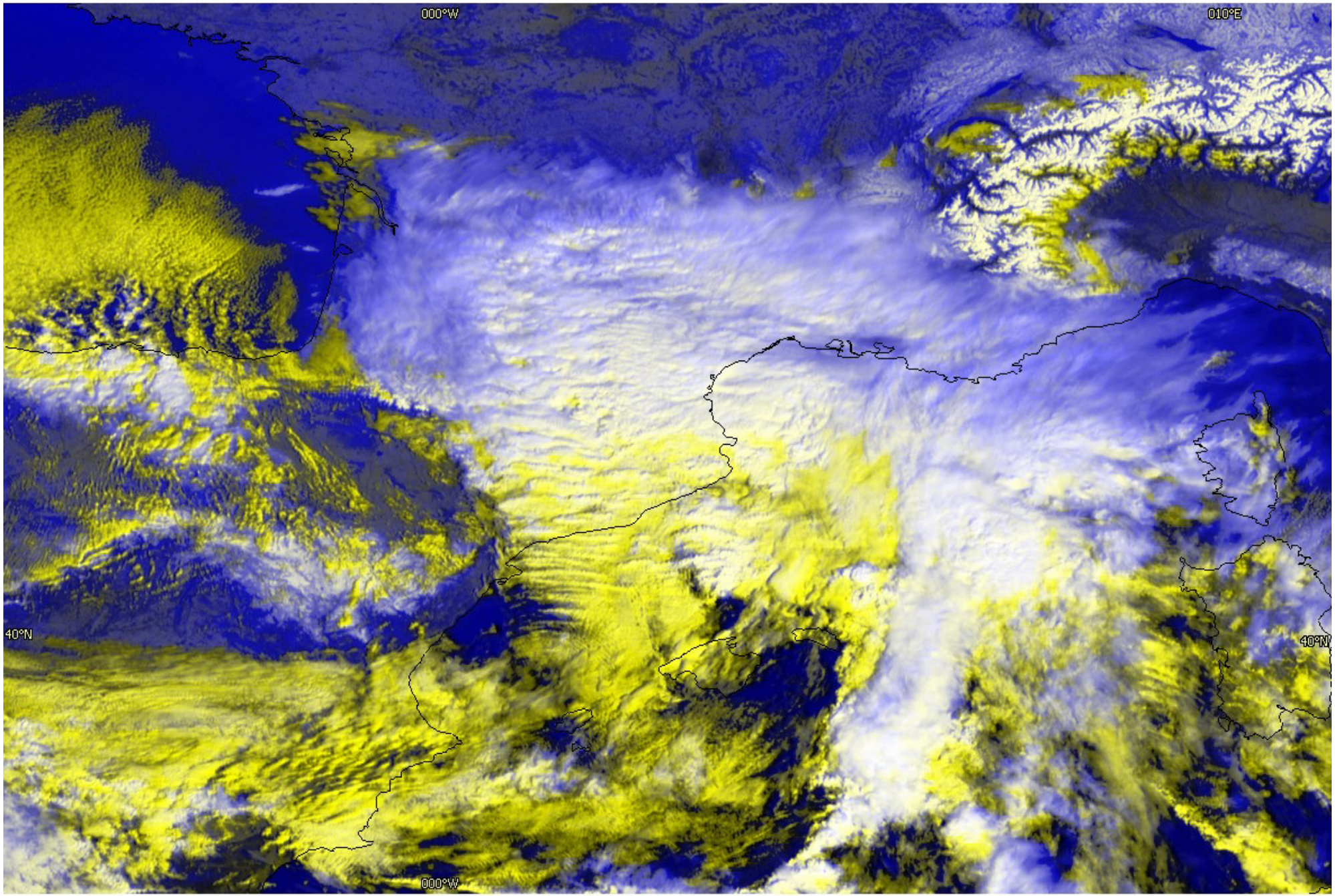
Height in km
BARCELONA
Echo Tops
TOPS150_12
Task: PPIVOL_BC
PRF:1150/863
Thresh:12
Max Range:215 km
10:36:23Z
8 MAR 2010 UTC

WRGB12D.did
Meteosat 9 (MSG-2) HRIT (multi-plane) - Monday, 08 March 2010 @ 10:00:00 (GMT+0:00) - Red=Visible (0.7µm), Green=Visible (0.7µm), Blue=IR (3.9µm)



Raw (unprojected) format.
Data is calibrated.

HVIS:HVIS:MIR(3.9micrometer)

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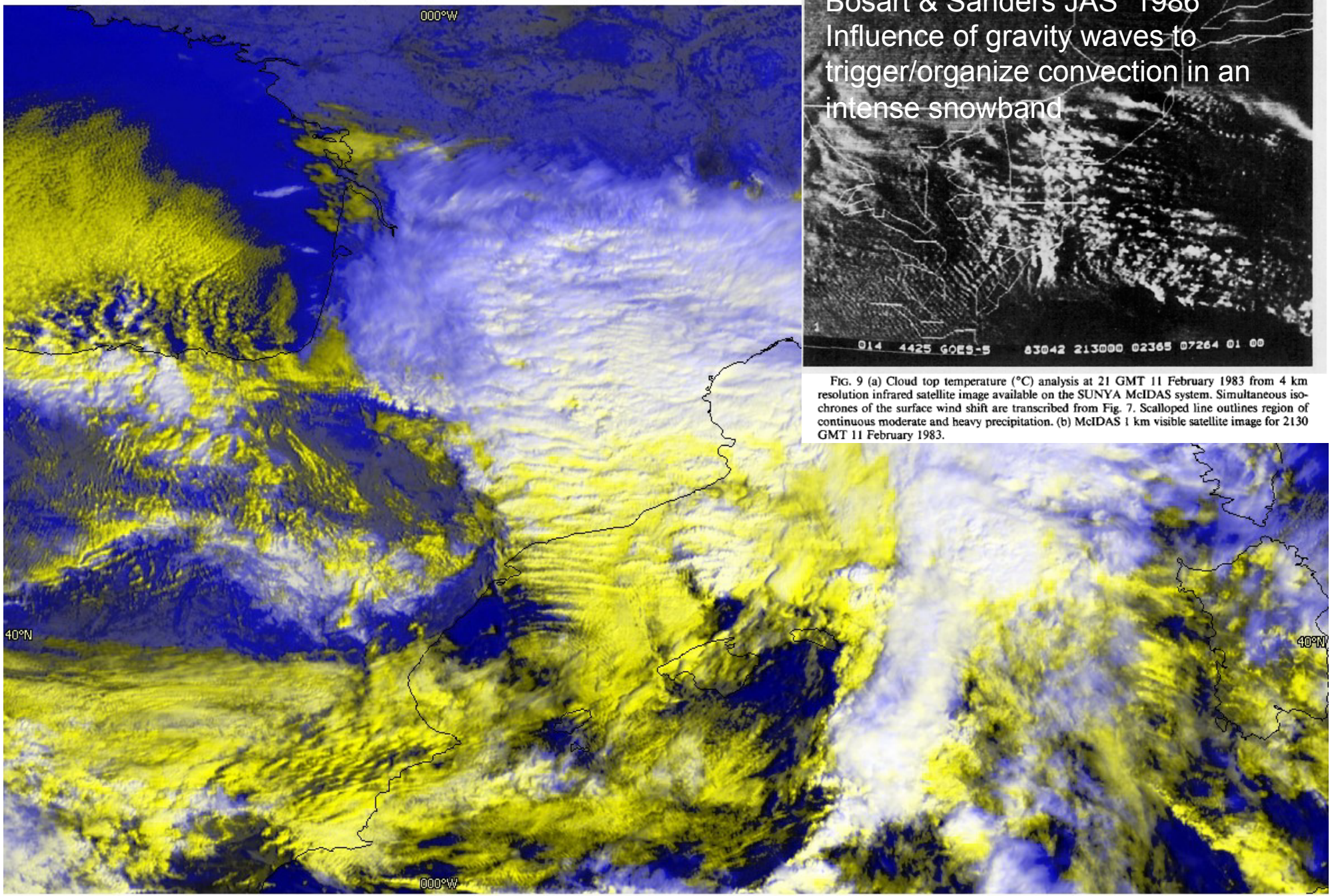
Meteosat 9 (MSG-2) HRIT (multi-plane) - Monday, 08 March 2010 @ 10:00:00 (GMT+0:00) - Red=Visible (0.7µm), Green=Visible (0.7µm), Blue=IR (3



Bosart & Sanders JAS 1986
Influence of gravity waves to trigger/organize convection in an intense snowband

FIG. 9 (a) Cloud top temperature (°C) analysis at 21 GMT 11 February 1983 from 4 km resolution infrared satellite image available on the SUNYA McIDAS system. Simultaneous isochrones of the surface wind shift are transcribed from Fig. 7. Scalloped line outlines region of continuous moderate and heavy precipitation. (b) McIDAS 1 km visible satellite image for 2130 GMT 11 February 1983.

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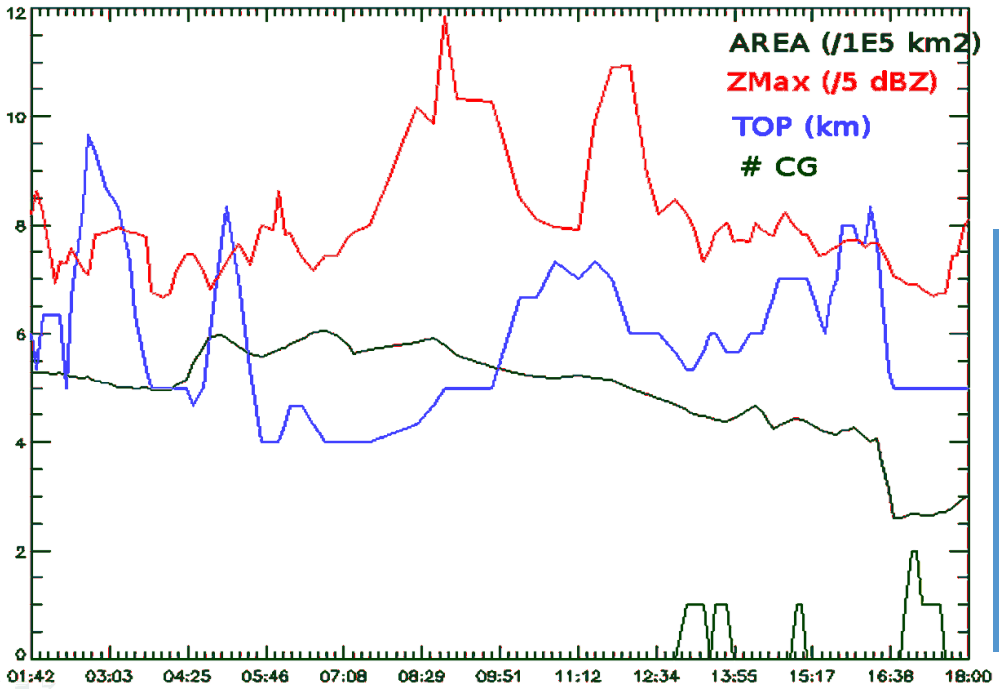
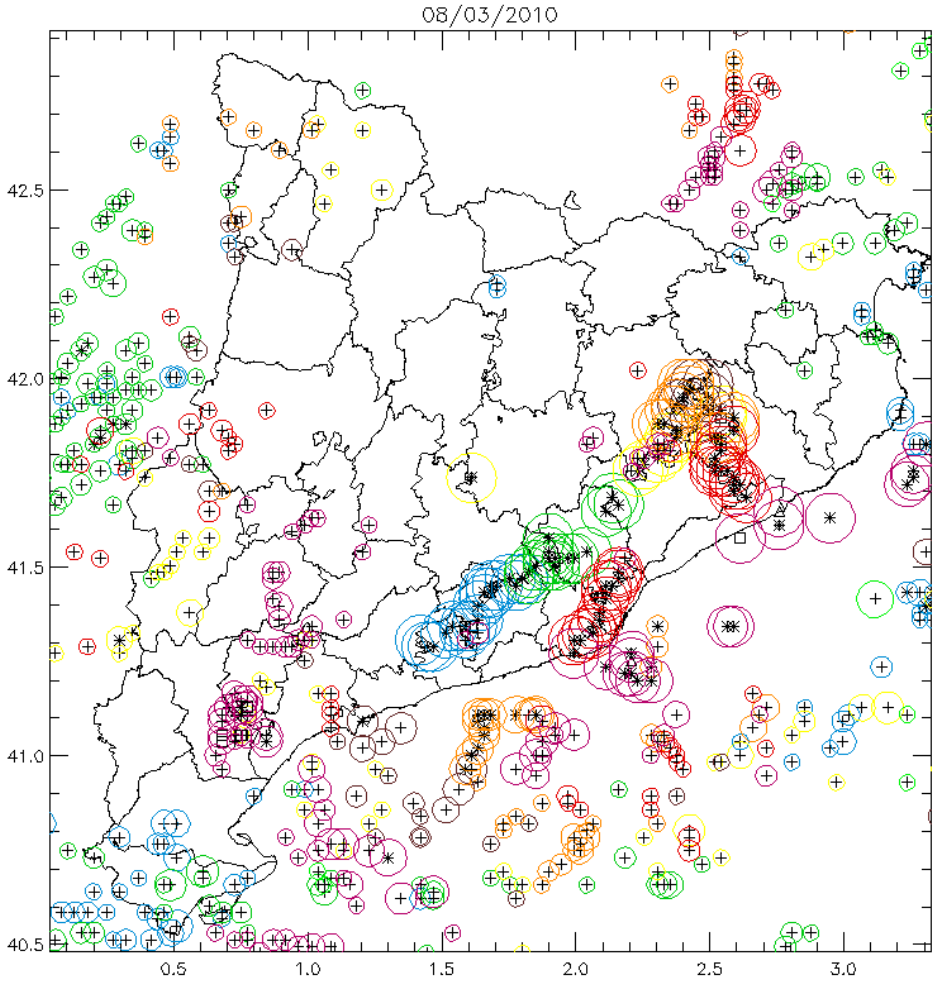
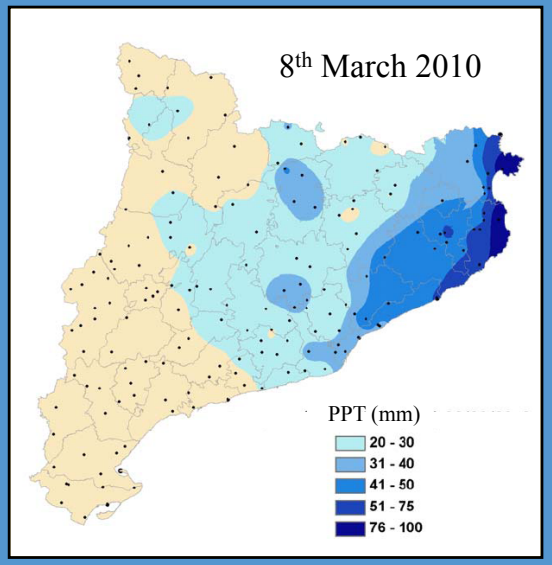
Radar observations

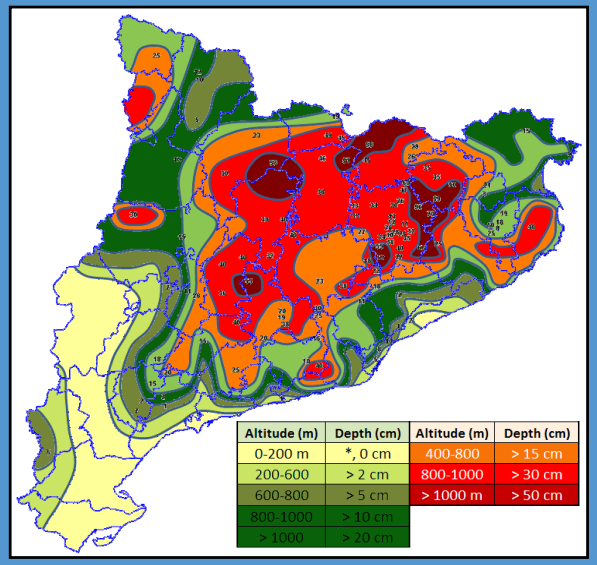


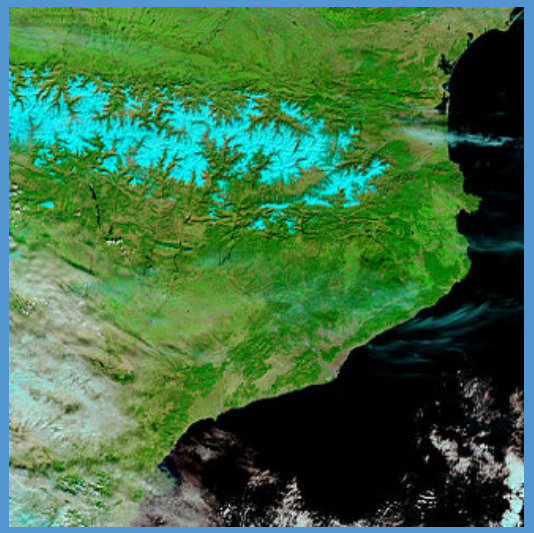


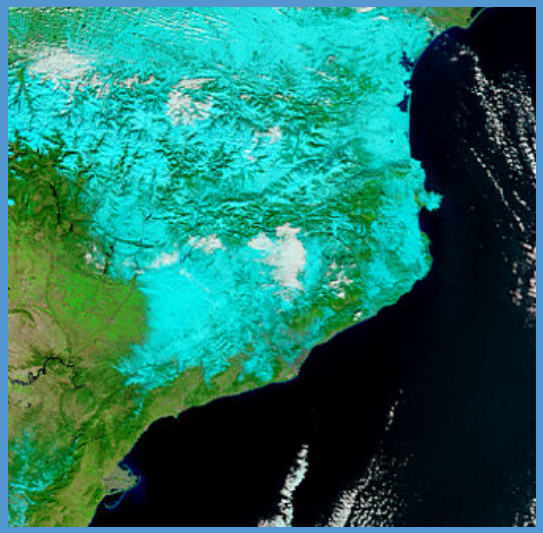
Rigo et al (NHESS 2010)
Bech et al (Atmos.Res. 2011)

24 h Precipitation (100 mm, snow depth > 50 cm)



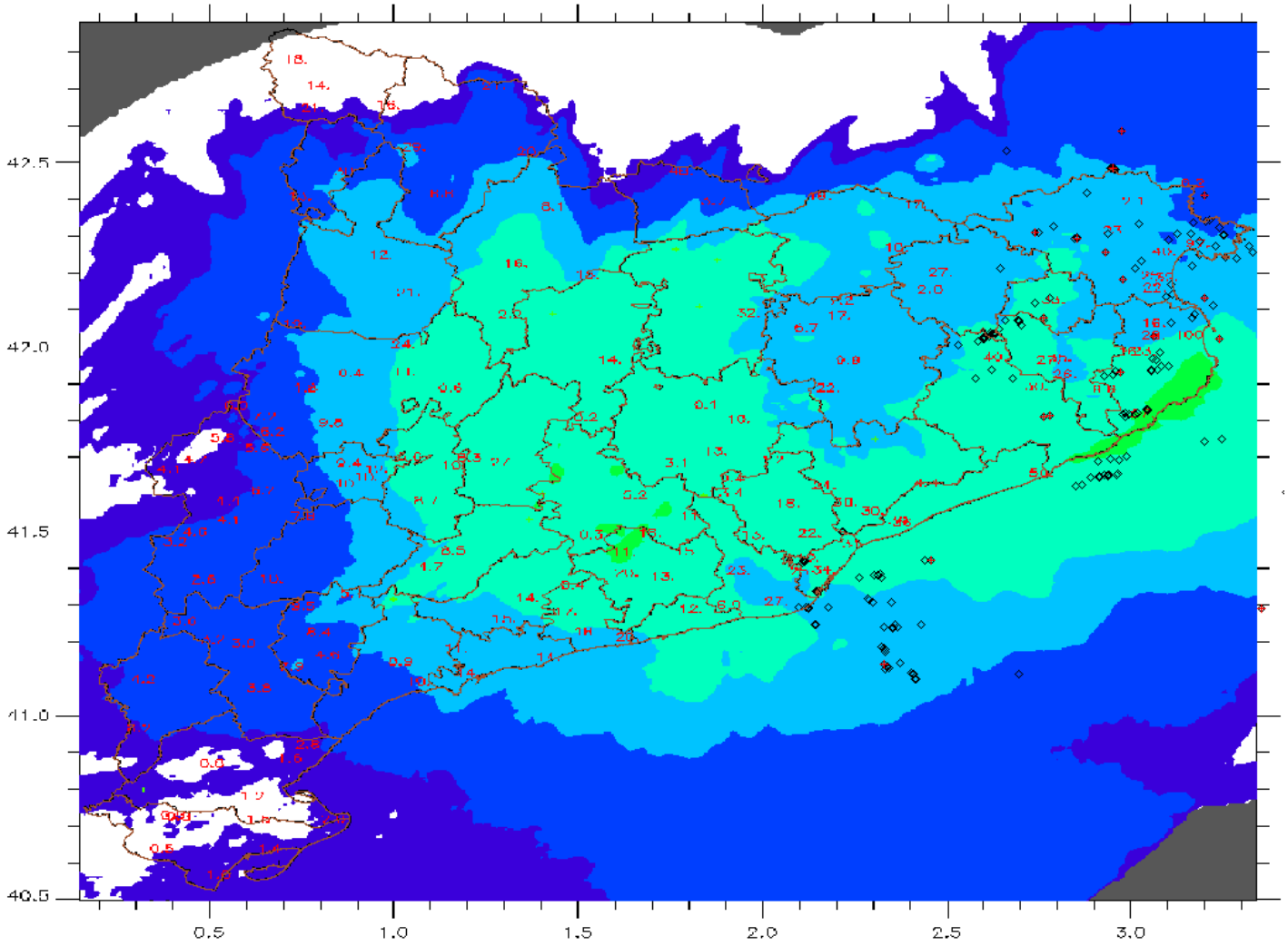






MODIS, NASA.

24h Radar Quantitative Precipitation Estimation & CG observations



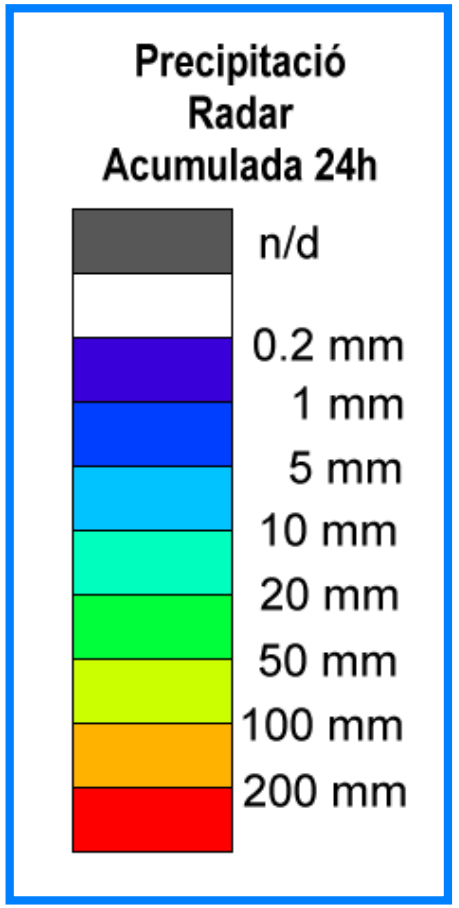
CG and QPE not colocated!!!

QPE 24h

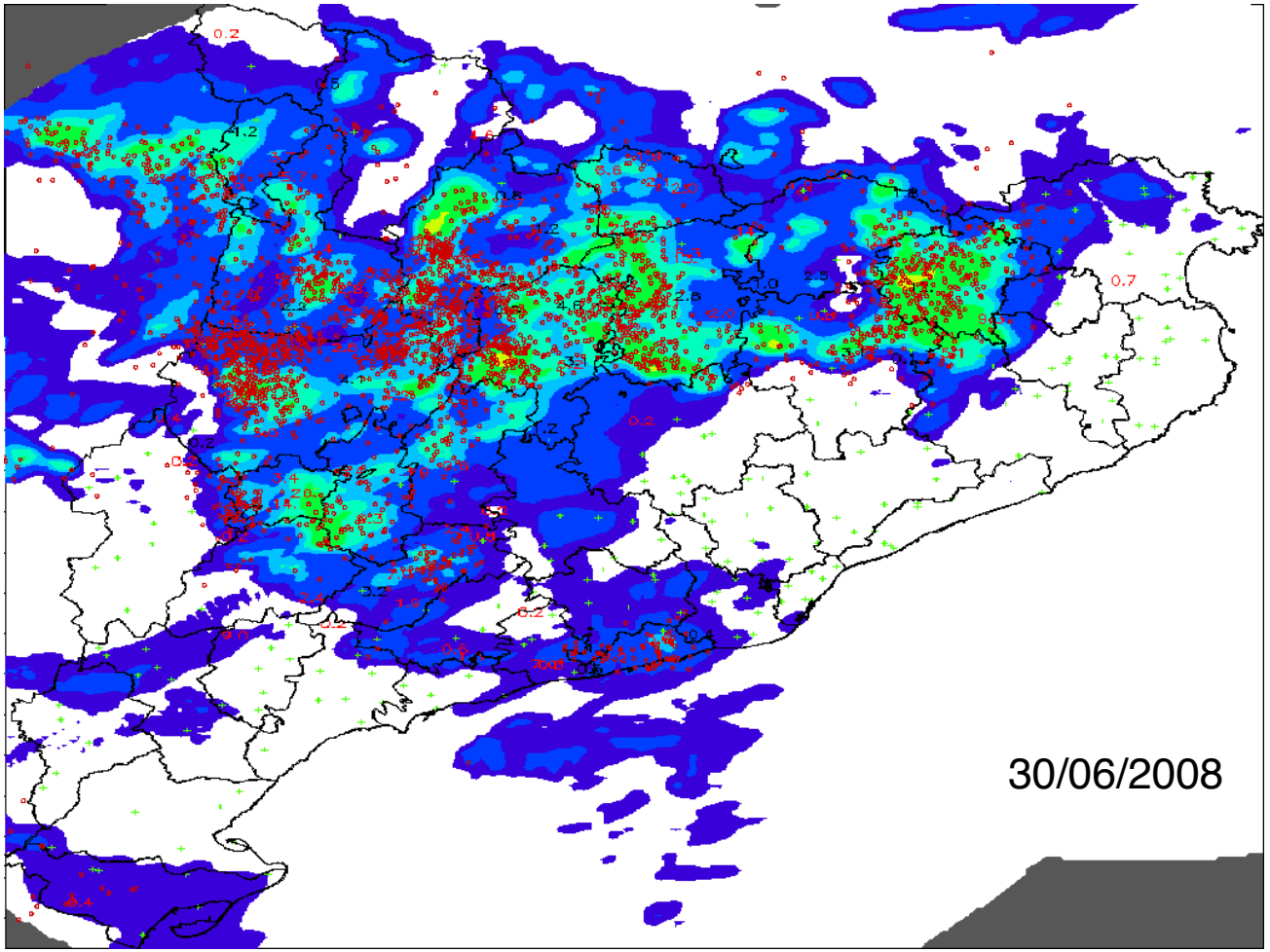
- CG

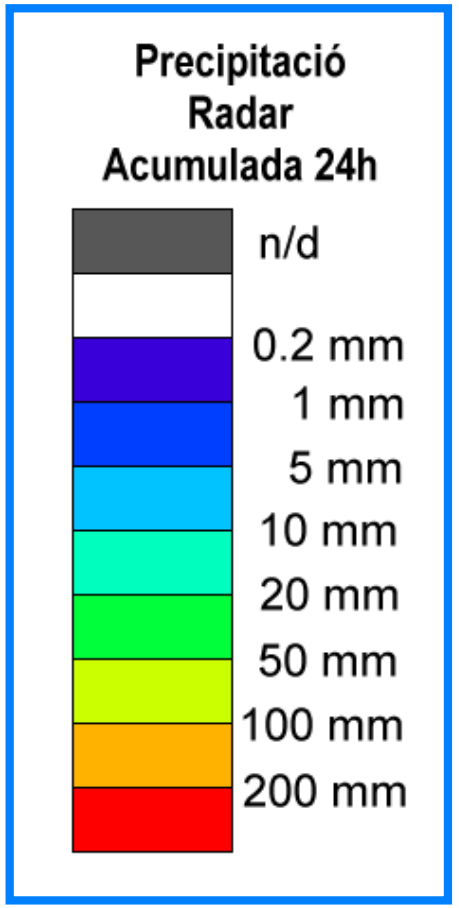
+CG

AWS 3.1

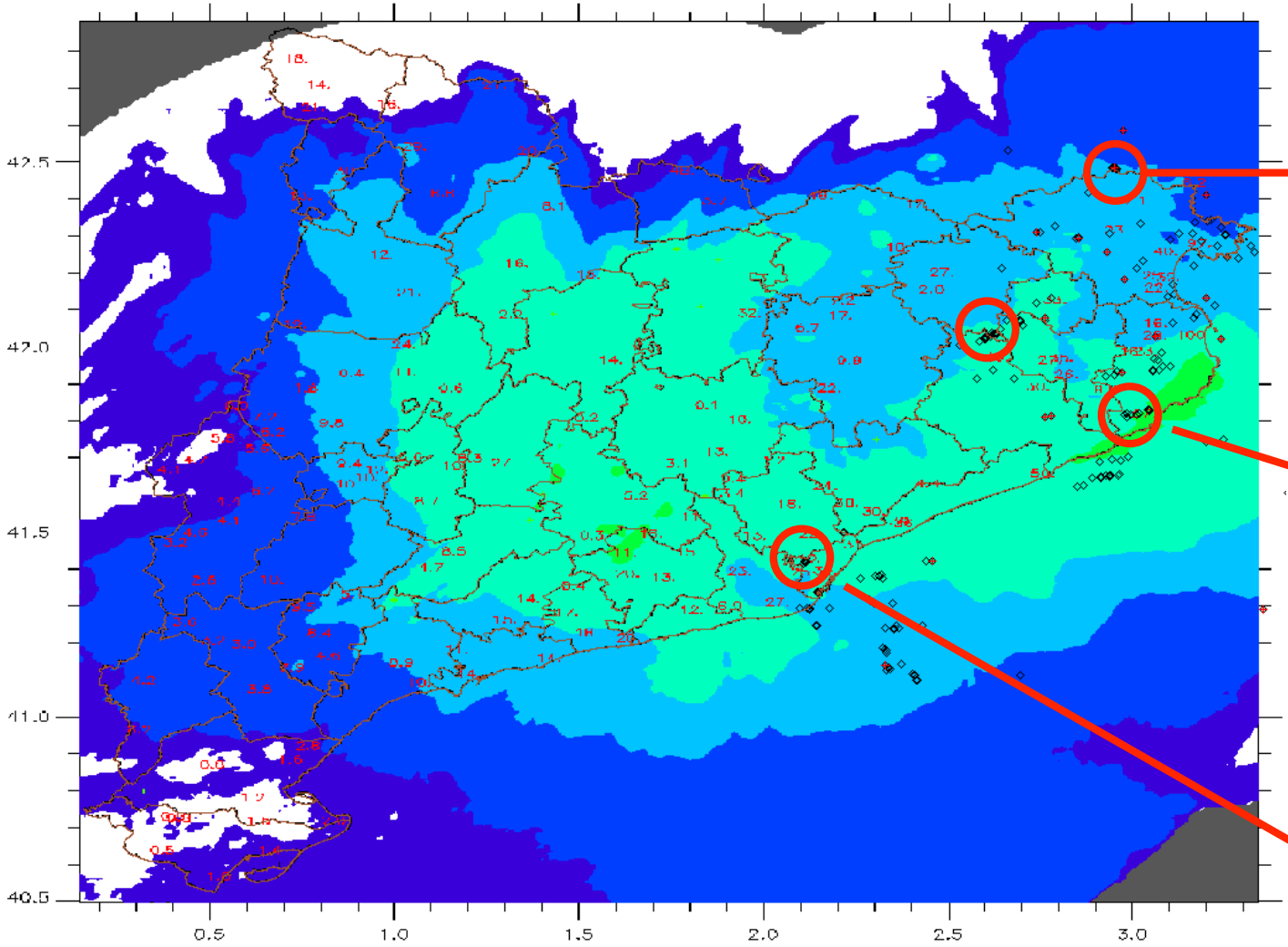


24h Radar Quantitative Precipitation Estimation & CG observations

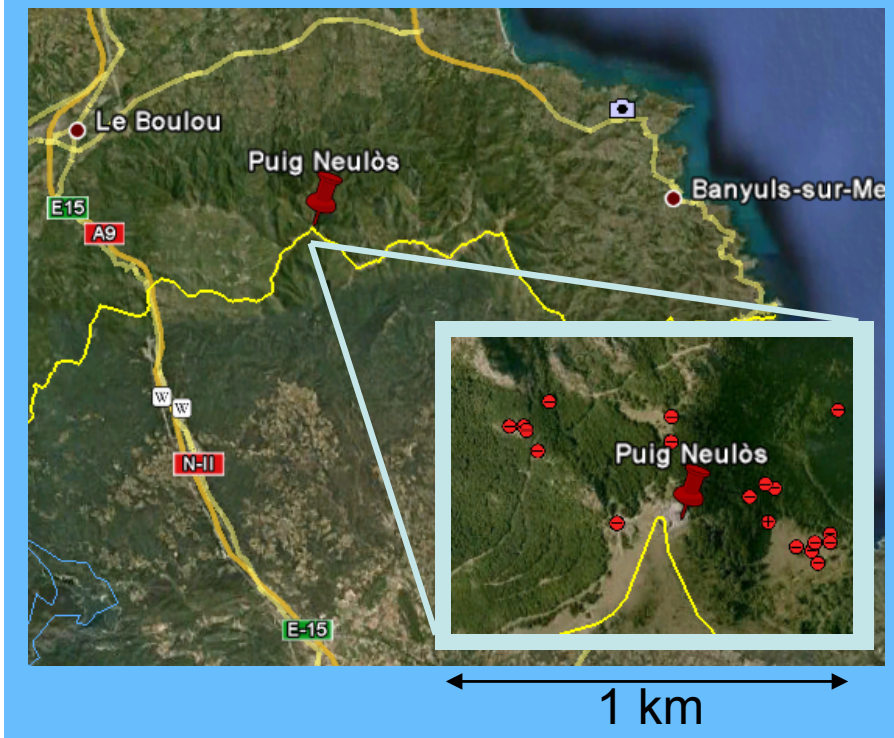


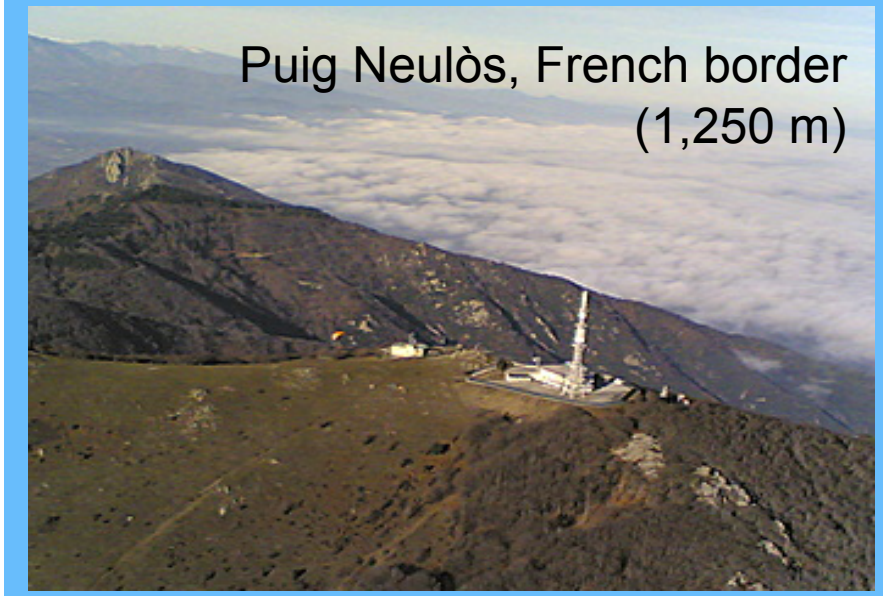


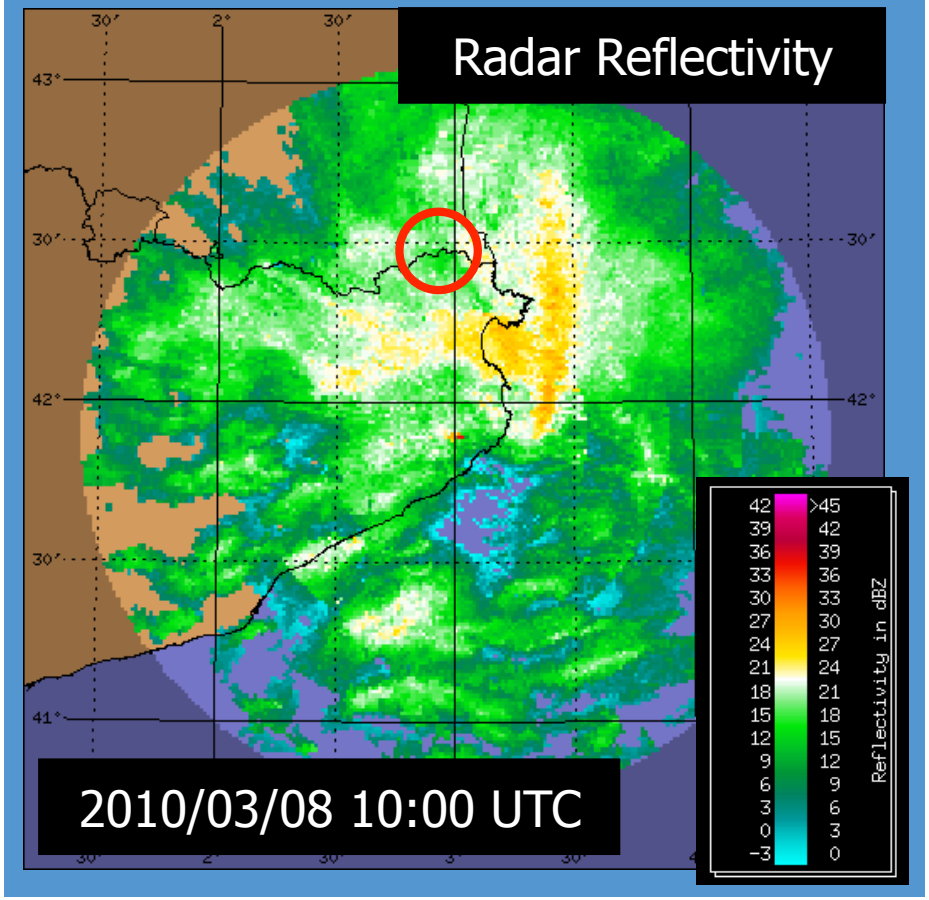
CG and QPE approximately colocated.



- Bunch of lightning in some spots (tall structures)
- Lightning density not related to radar QPE!!



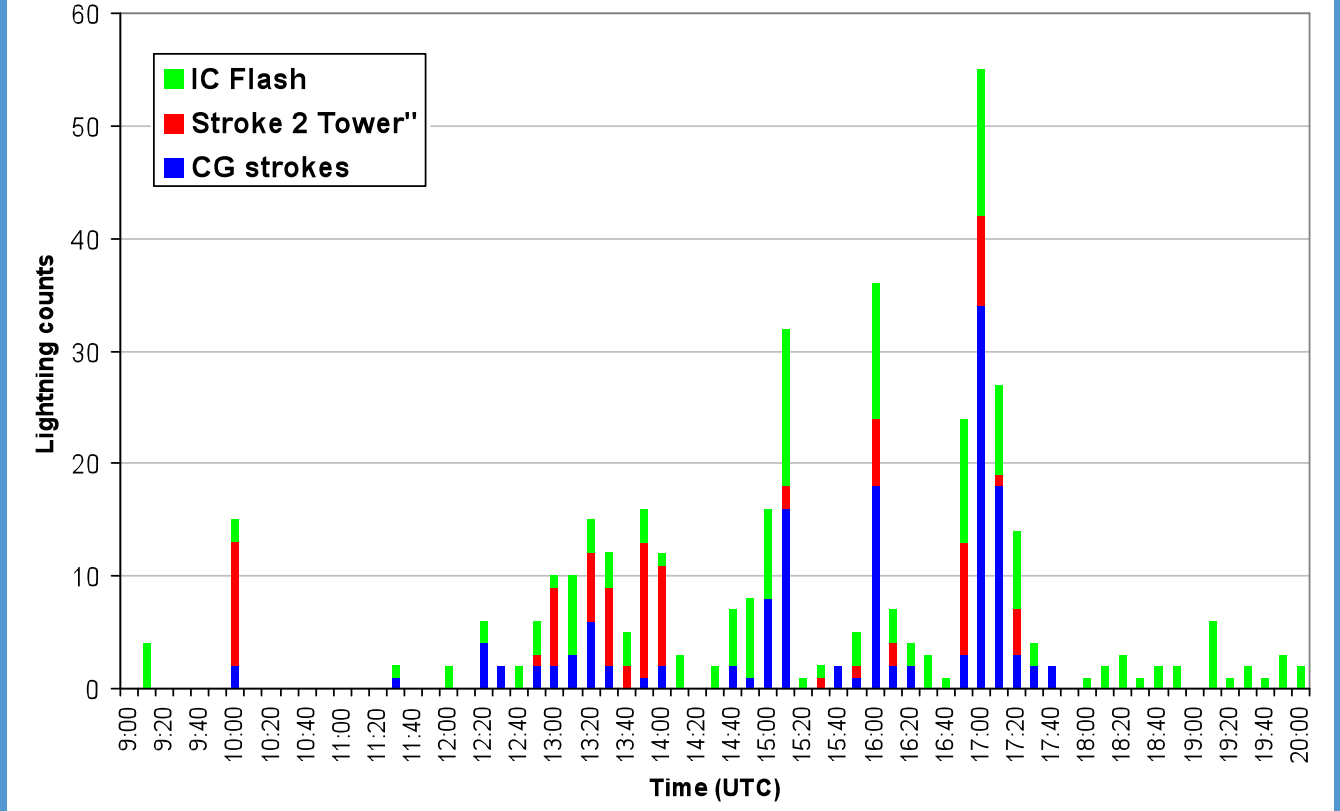




Lightning strikes in tall structures:

- No relation to high reflectivity areas, neither to high echo-tops
- Tower triggering?

Lightning activity during thundersnow episode



169 IC Flashes

231 CG strokes

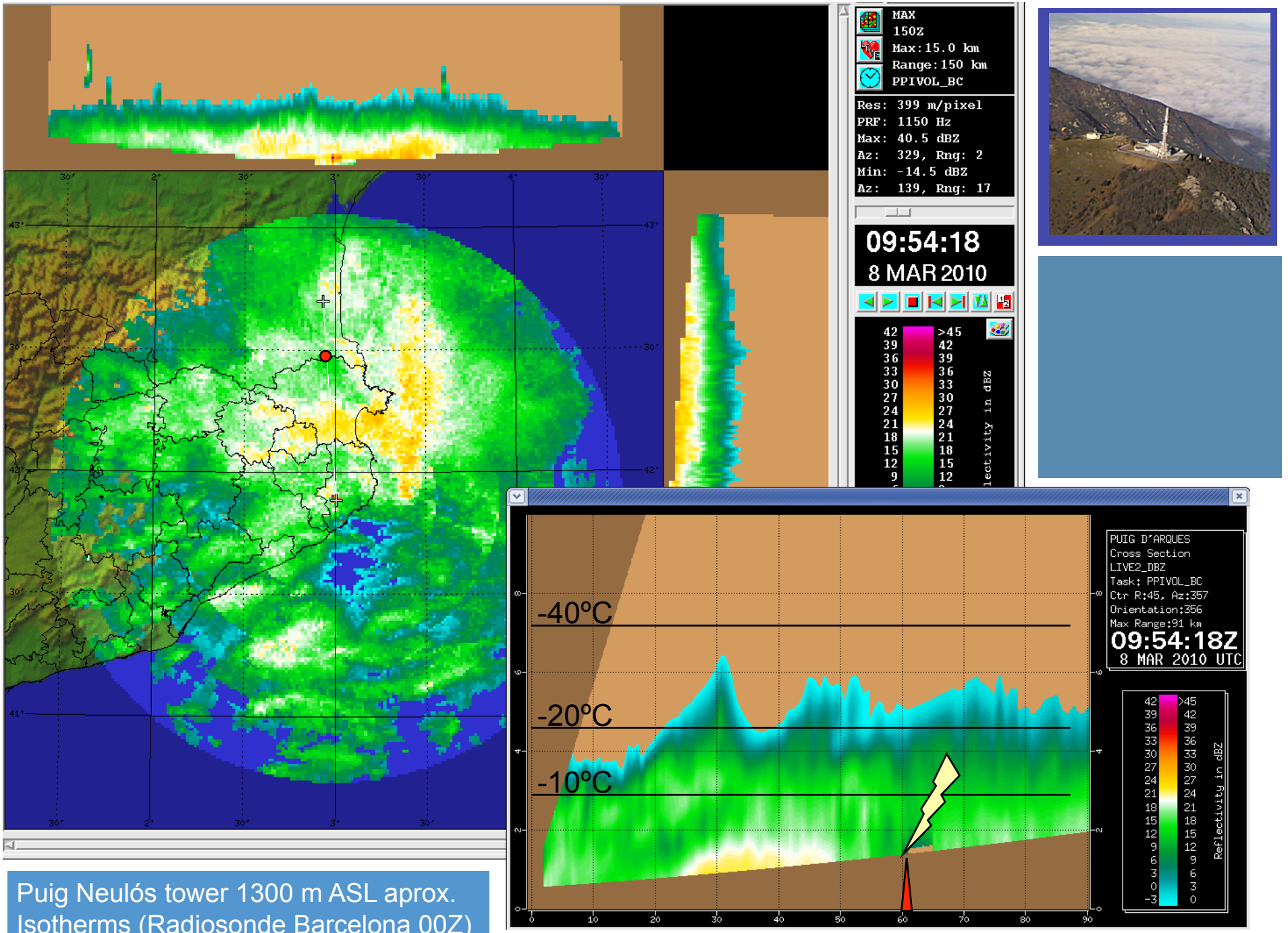
90 CG (39%) tower striking

67% CG nearby towers
(almost no IC activity!!)

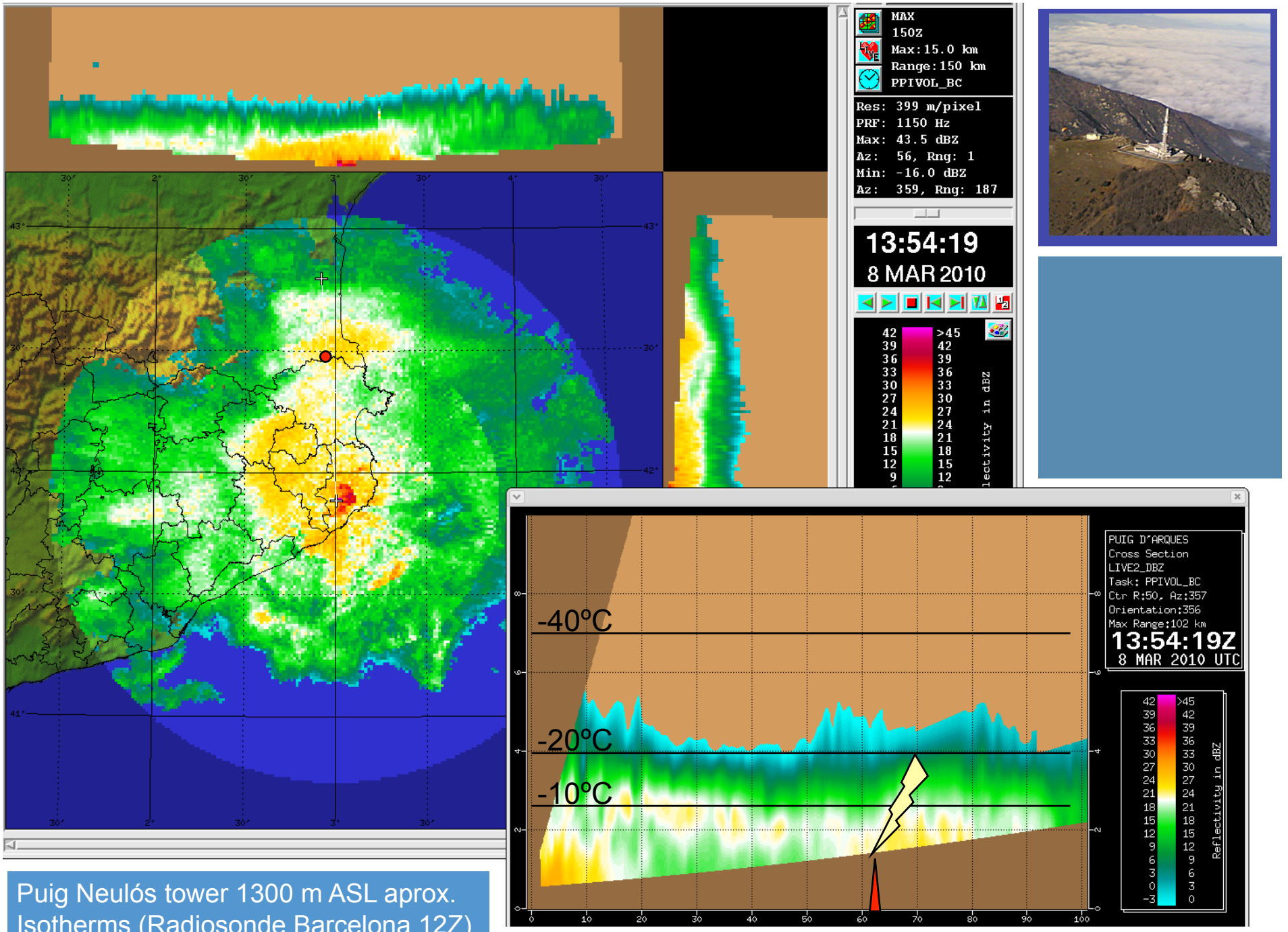
Lightning activity during thundersnow episode

	Lightning to Ground		Lightning to Tower	
	Neg	**Pos**	**Neg**	**Pos**
Stroke count	123	18	89	1
%	87%	13%	99%	1%
Peak Current (Ave)	-22.1	36.0	-11.0	8.9
(Median)	-16.3	31.5	-10.1	8.9
Rise Time (Ave)	75	156	42	44
Multiplicity	2.5	1.5	3.1	1

- Lower peak currents in L2T, almost all negative strokes
- Lower rise time in L2T (microseconds)
- Higher multiplicity in L2T, but not significative

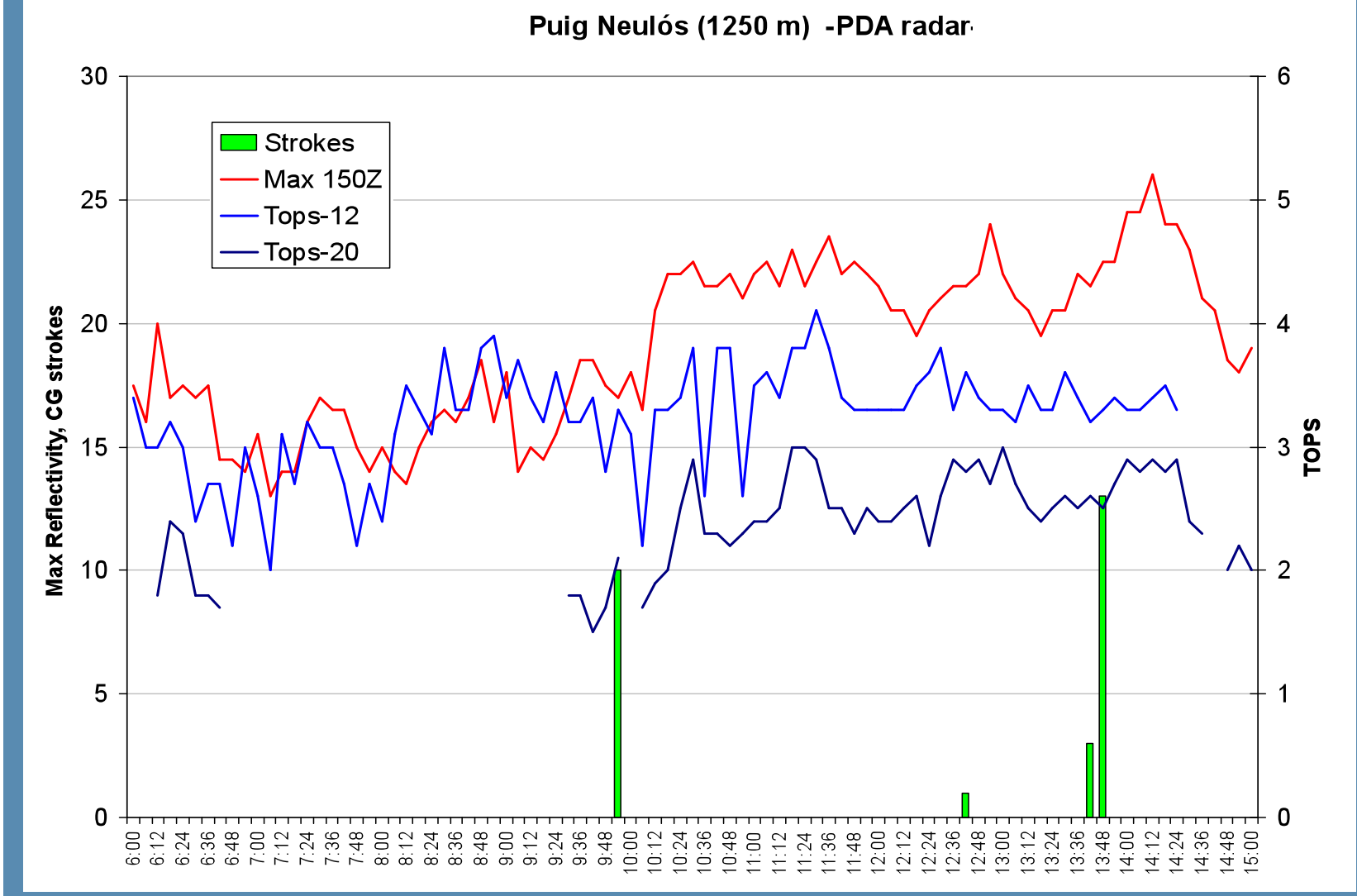


Puig Neulós tower 1300 m ASL aprox.
Isotherms (Radiosonde Barcelona 00Z)

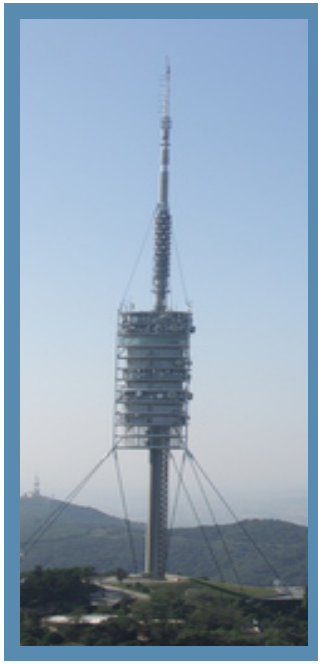


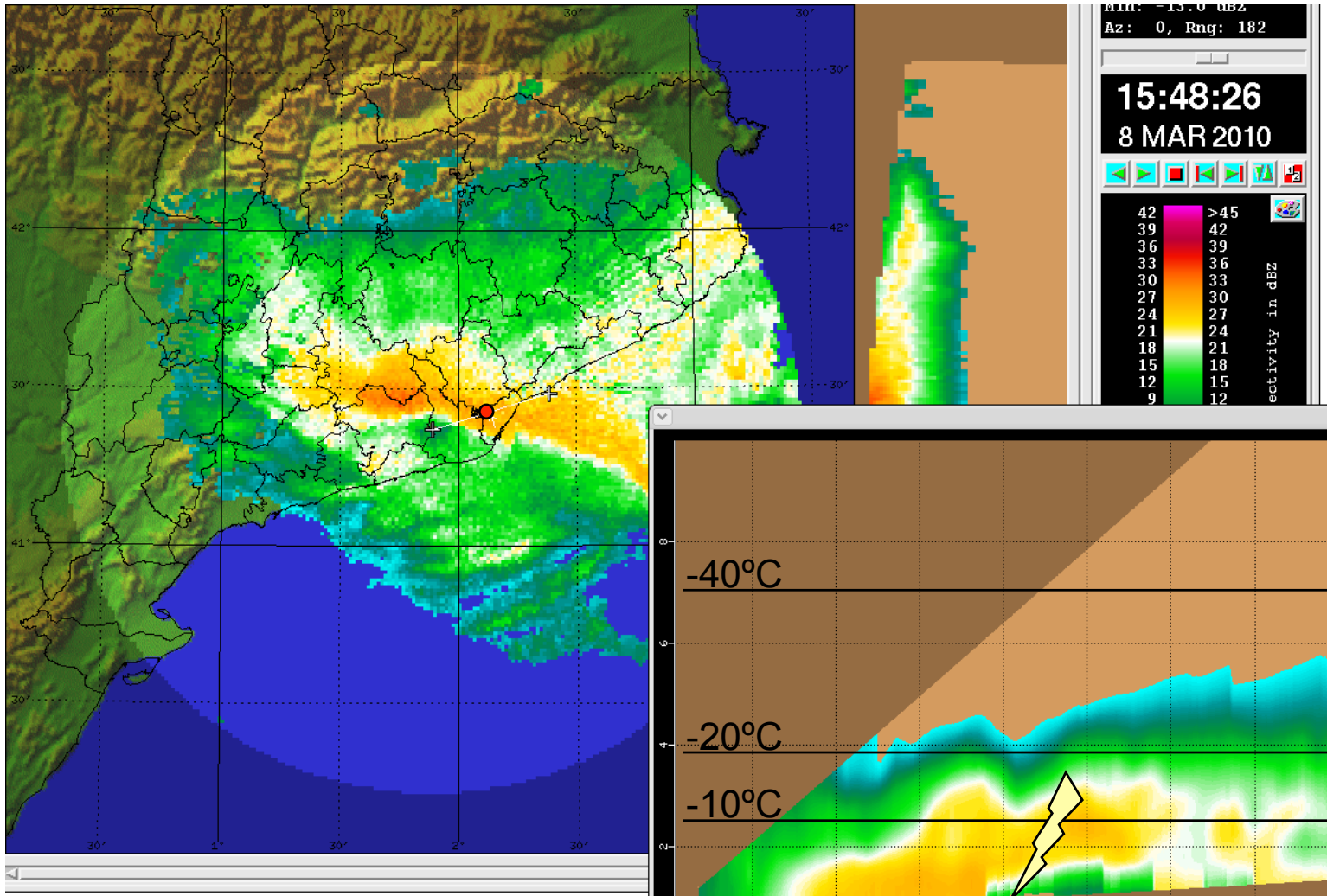
Puig Neulós tower 1300 m ASL aprox.
Isotherms (Radiosonde Barcelona 12Z)

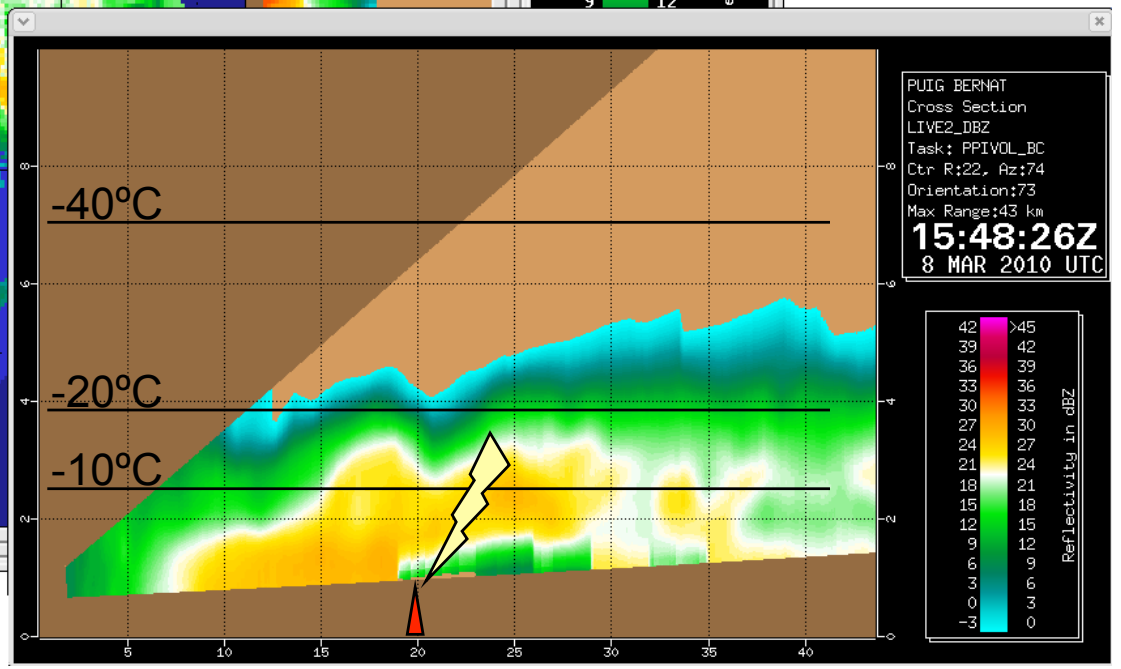
Radar parameters evolution above the tower



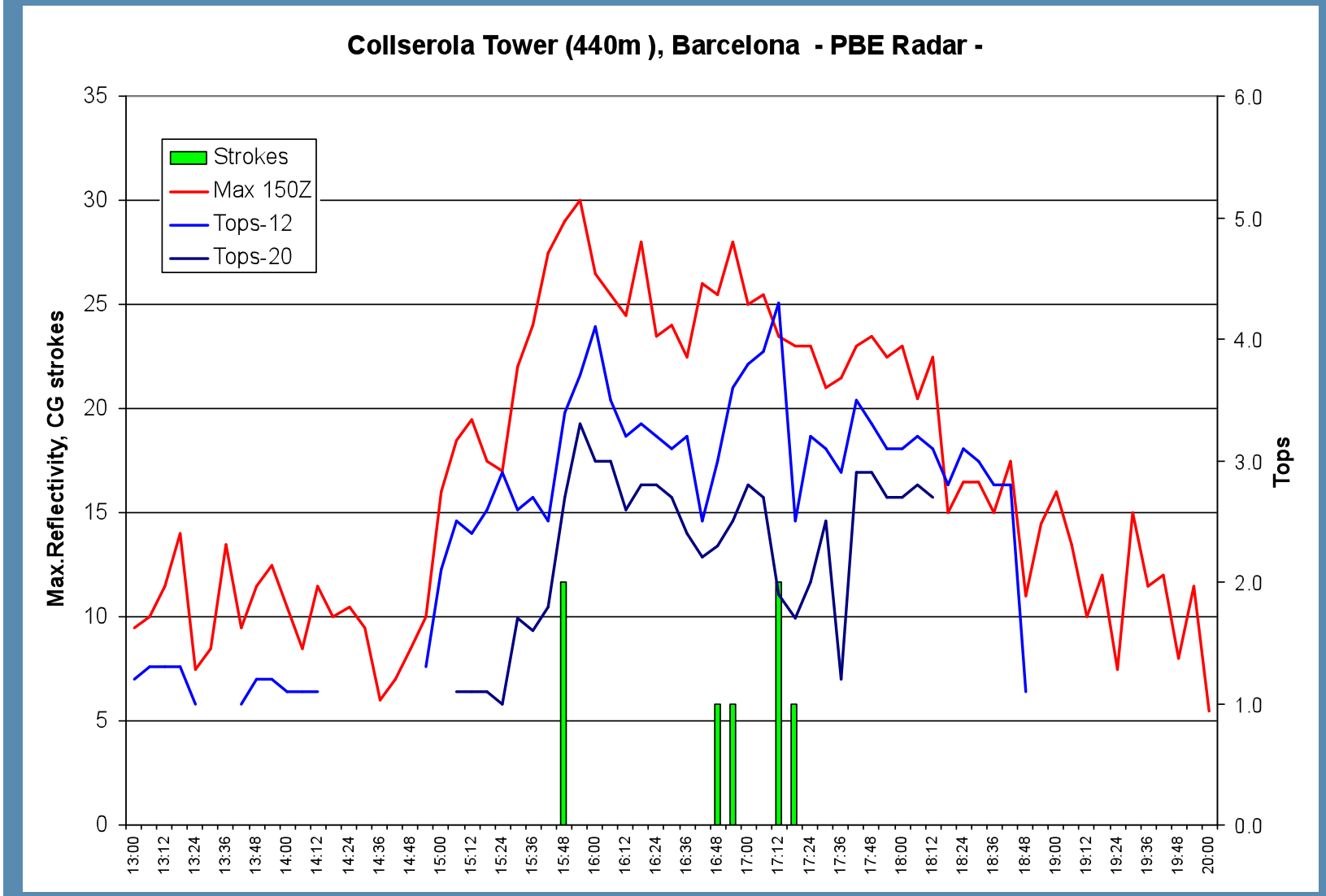
Collserola tower 750 m ASL aprox.
Isotherms (Radiosonde Barcelona 12Z)

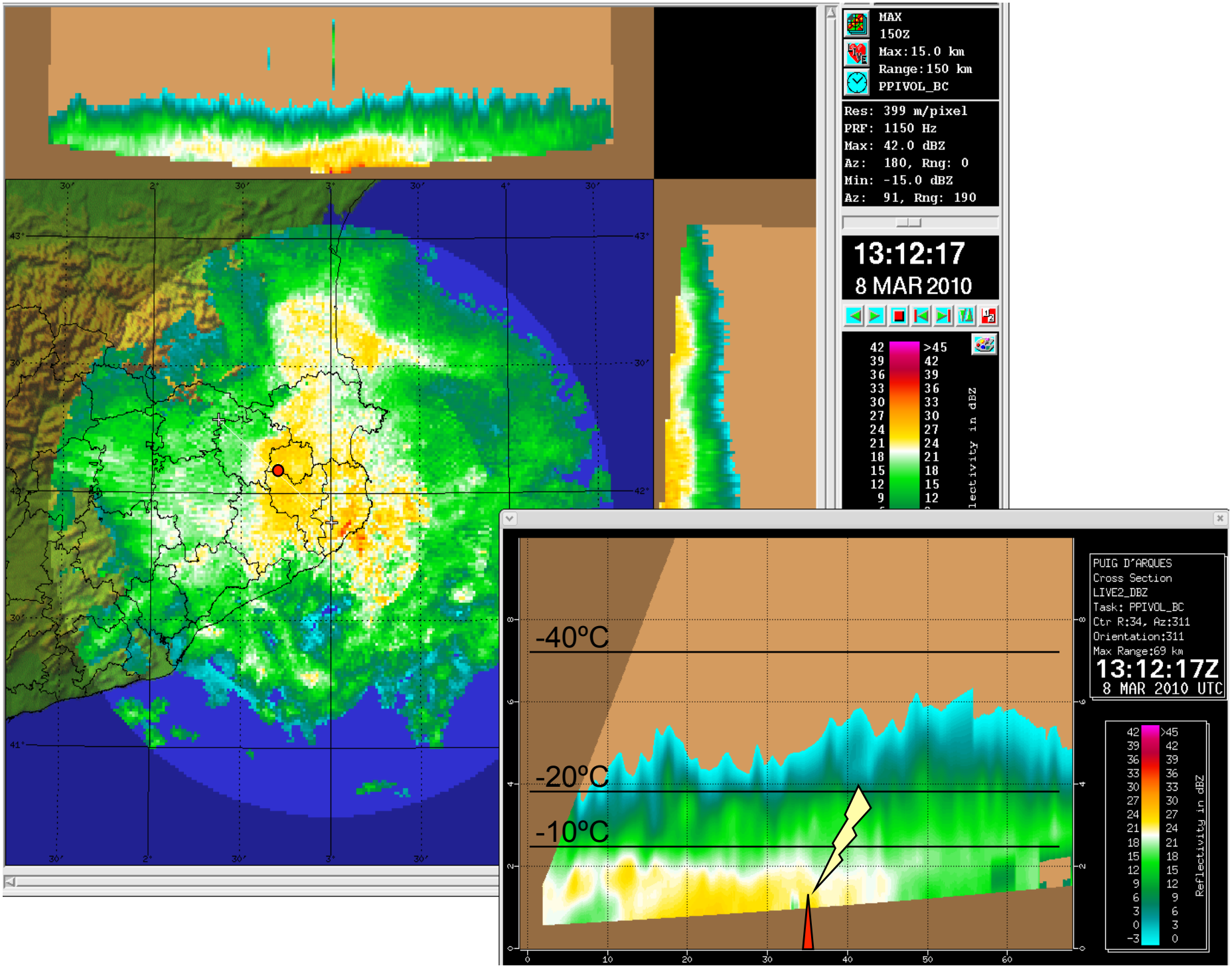




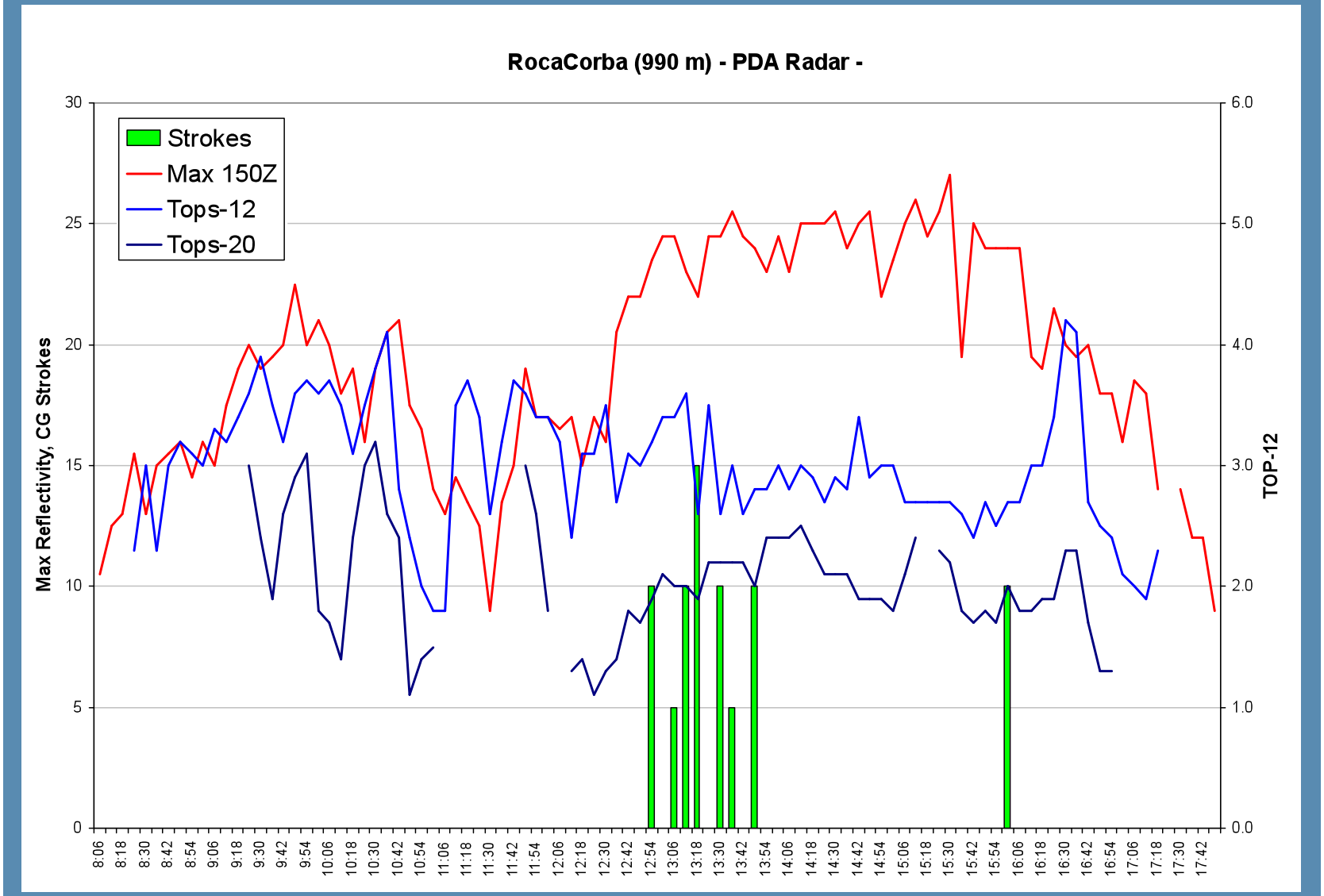


Radar parameters evolution above the tower

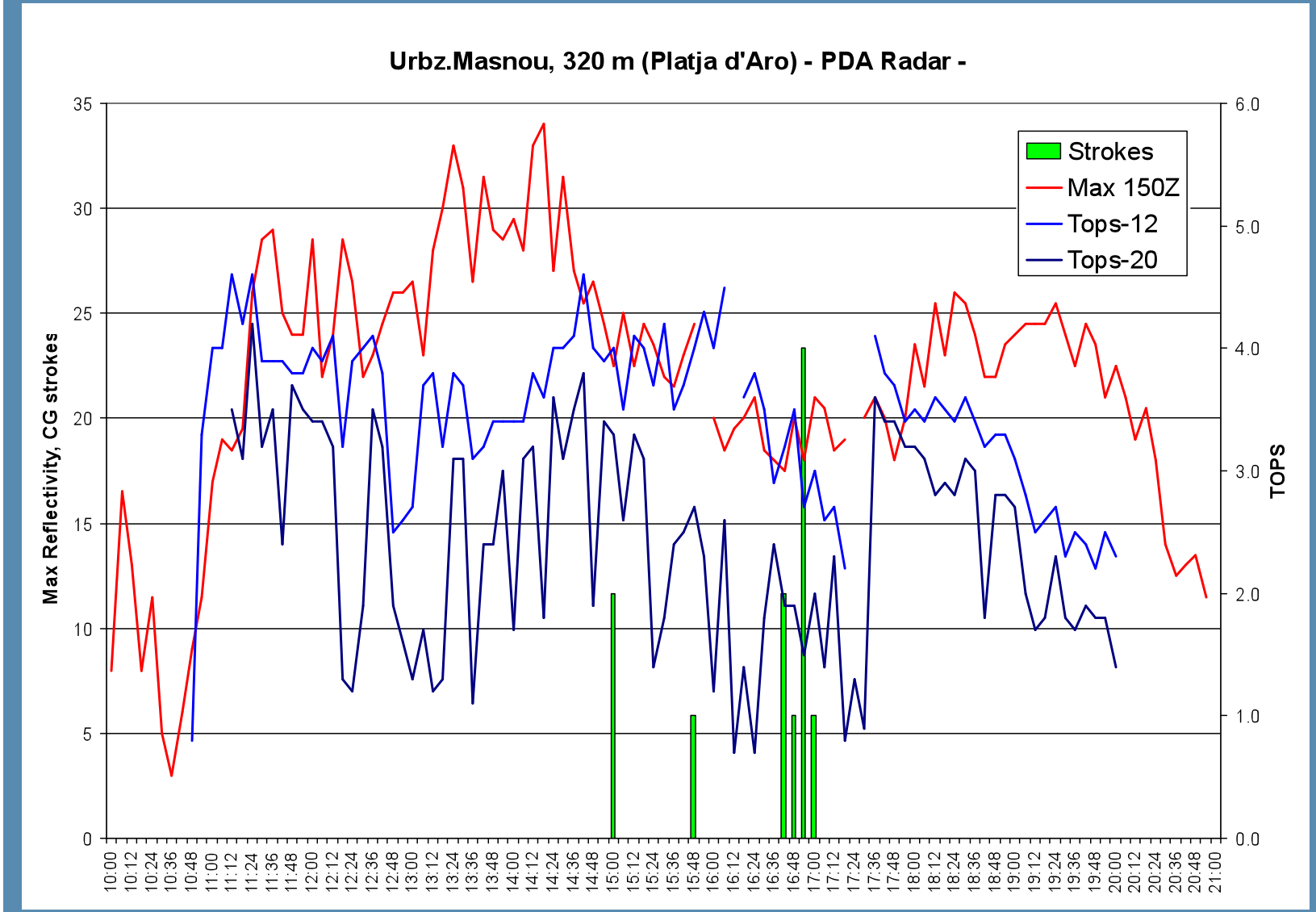


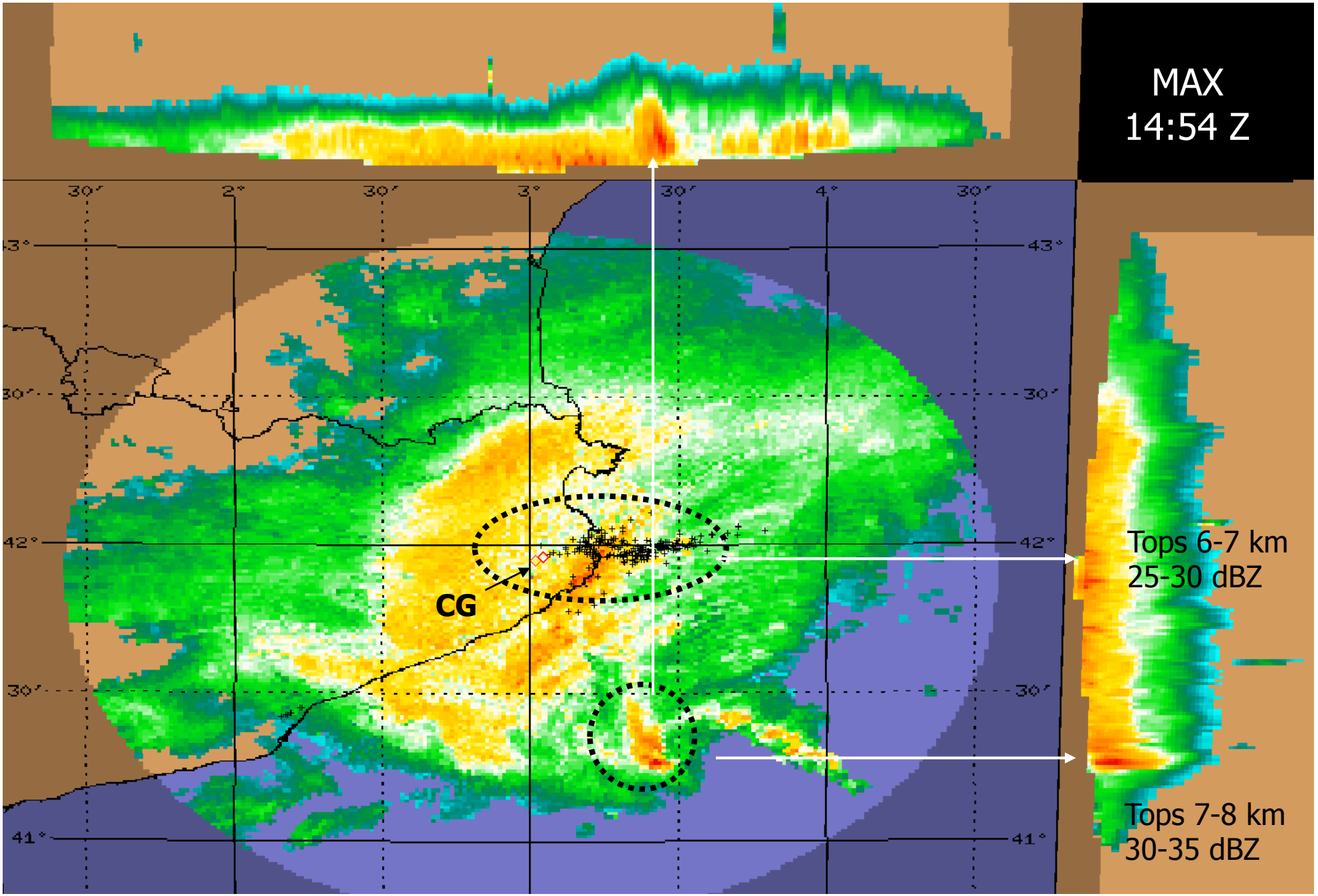

MAX
150Z
Max:15.0 km
Range:150 km
PPIVOL_BC
Res: 399 m/pixel
PRF: 1150 Hz
Max: 42.0 dBZ
Az: 180, Rng: 0
Min: -15.0 dBZ
Az: 91, Rng: 190
13:12:17
8 MAR 2010
42 >45
39 42
36 39
33 36
30 33
27 30
24 27
21 24
18 21
15 18
12 15
9 12
lectivity in dBZ
PUIG D'ARQUES
Cross Section
LIVE2_DBZ
Task: PPIVOL_BC
Ctr R:34, Az:311
Orientation:311
Max Range:69 km
13:12:17Z
8 MAR 2010 UTC
-40ºC
-20ºC
-10ºC
42 >45
39 42
36 39
33 36
30 33
27 30
24 27
21 24
18 21
15 18
12 15
9 12
6 9
3 6
0 3
-3 0
Reflectivity in dBZ
0 10 20 30 40 50 60

Radar parameters evolution above the tower

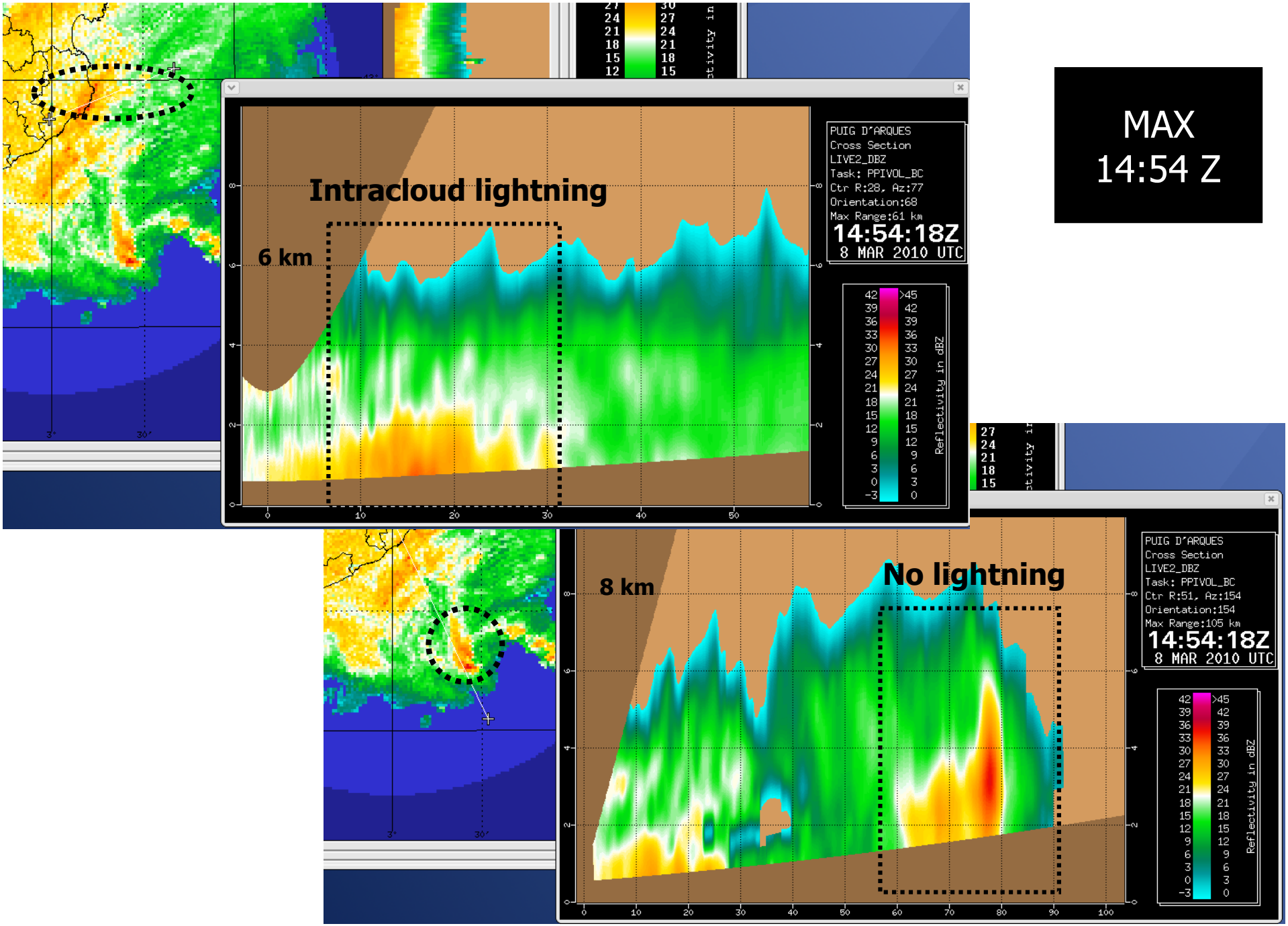


Radar parameters evolution above the tower

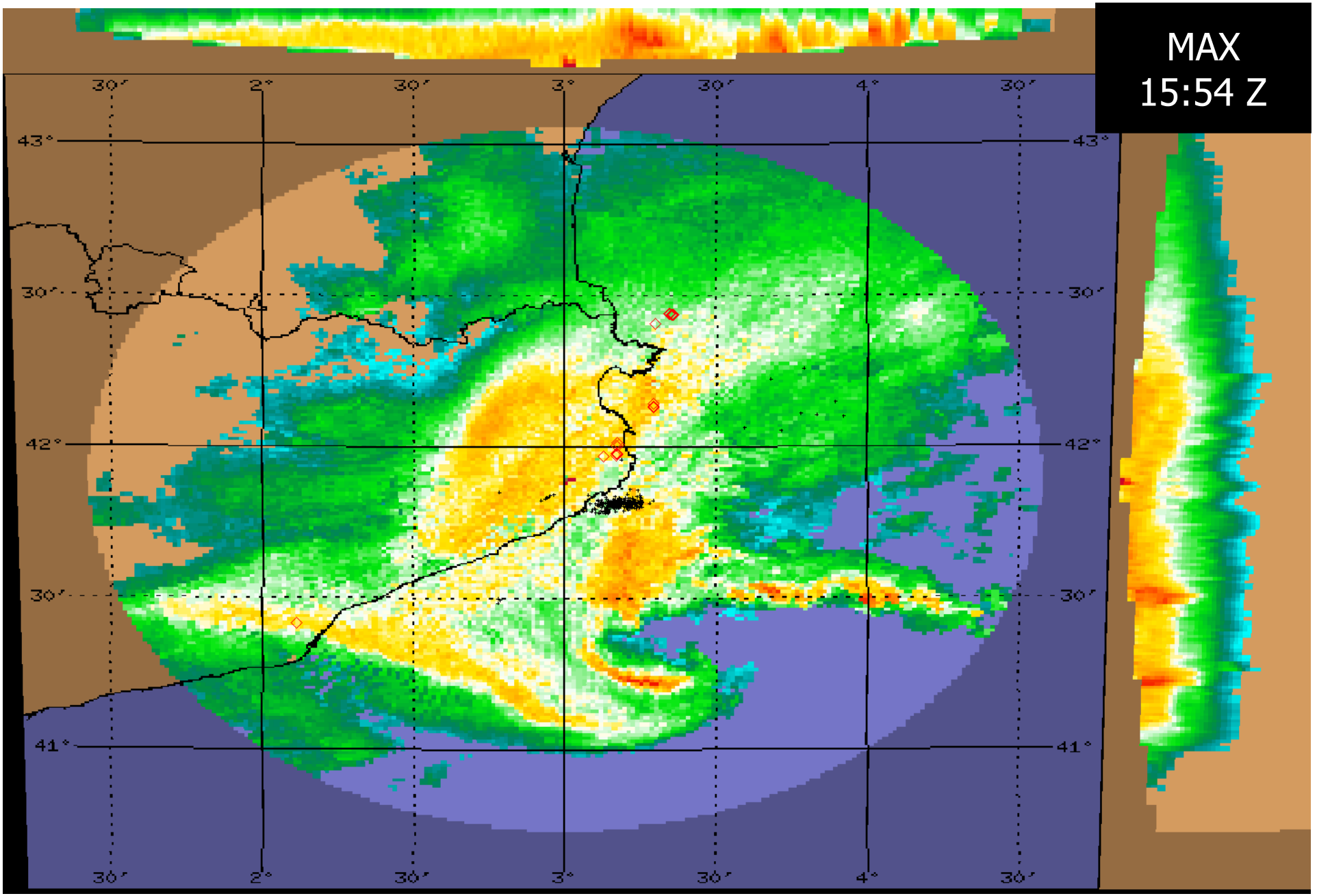




Intracloud activity not related to higher reflectivity and radar tops (triggering CG?)

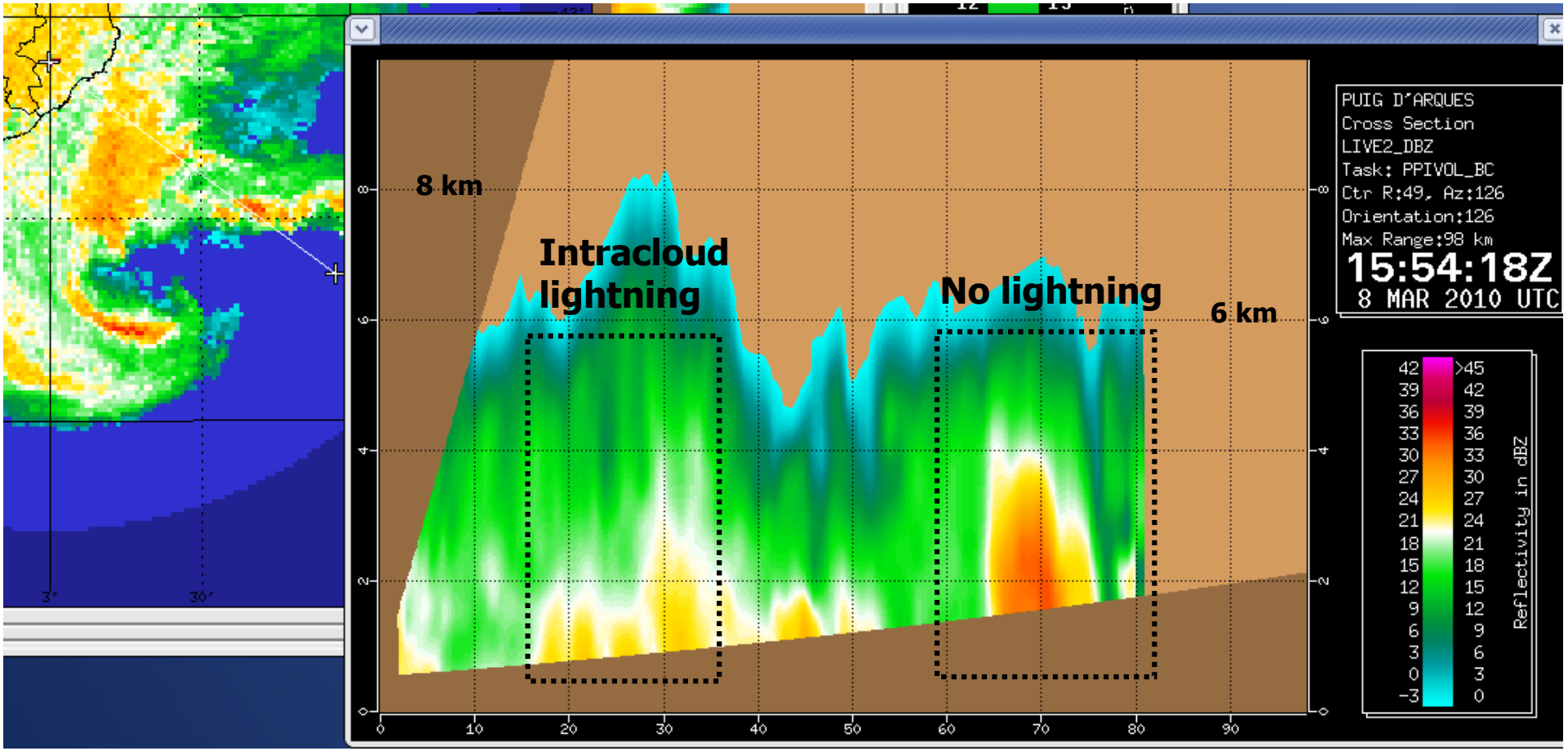


Intracloud activity not related to higher reflectivity and radar tops (triggering CG?)



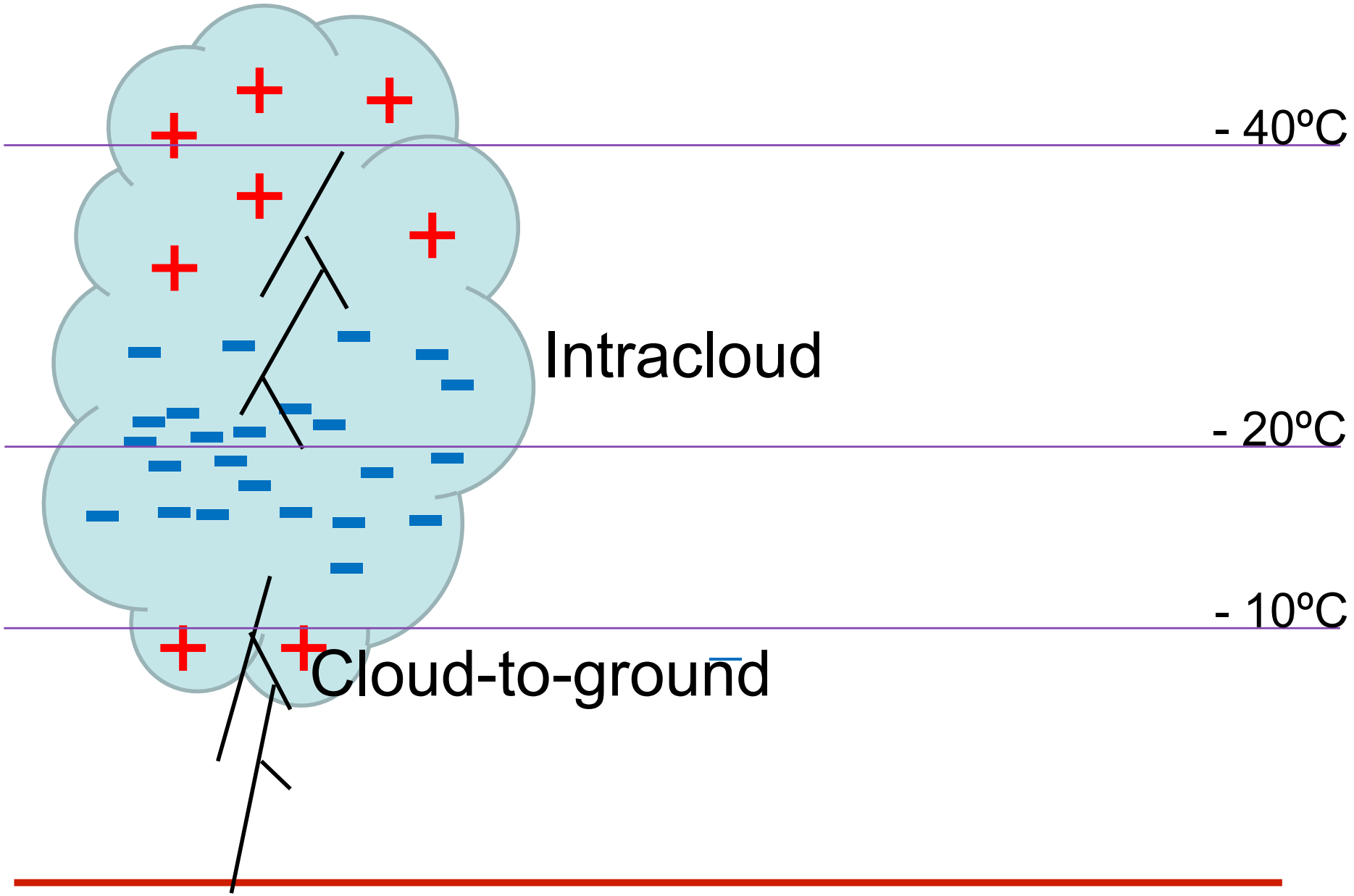
Intracloud activity not related to higher reflectivity and radar tops (triggering CG?)

MAX
15:54 Z

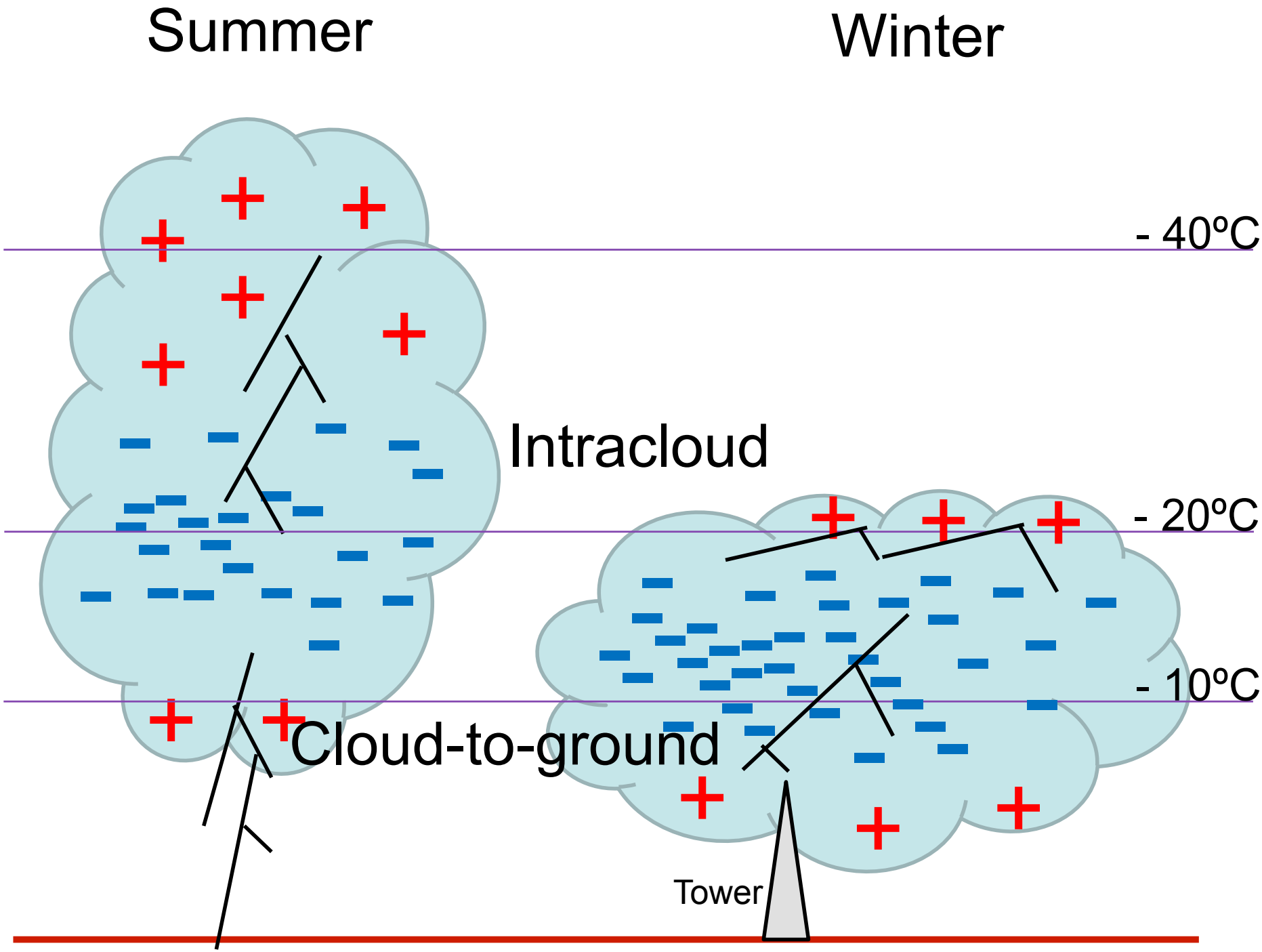


Intracloud activity not related to higher reflectivity and radar tops (triggering CG?)

Summer



Williams JGR 1989


Summer
Winter
- 40ºC
- 20ºC
- 10ºC
Intracloud
Cloud-to-ground
Tower
Williams JGR 1989
Goshima et al Trans EE Japan 2000

Summary & concluding remarks

- Analysis of a thundersnow in Catalonia (BCN radiosonde, total lightning, MSG and radar data)
- Intense and rapid developing Mediterranean cyclone
- Possible role of gravity waves
- Anomalous lightning features:
  - Spatial distribution (disconnected from radar convective structures)
  - IC/CG ratio, precip/CG
- Tower triggering caused CG local density maxima not related to snowband
- Practical results for forecasters in similar situations

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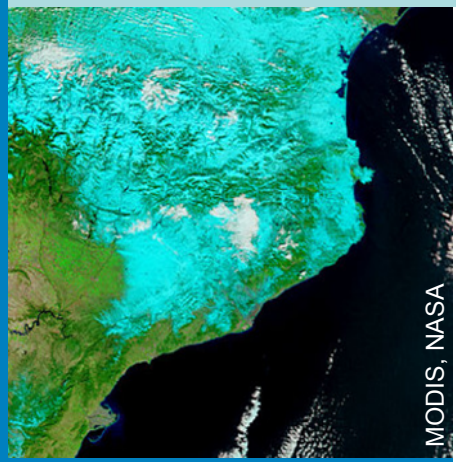
Palma de Mallorca,
Balearic Islands, Spain
3 - 7 October 2011



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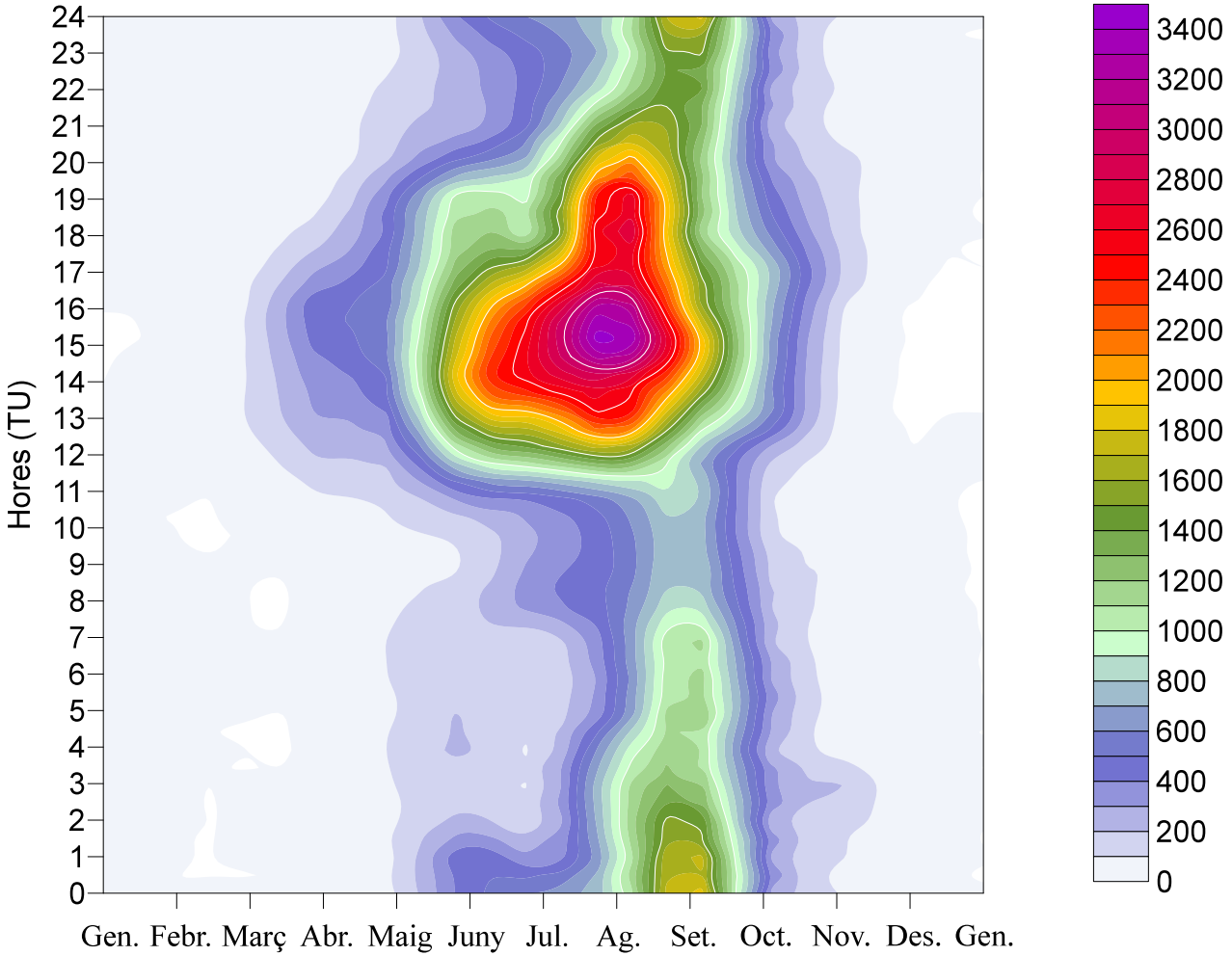

Pineda et al. 2011

Figura 29. Mitjana anual (període 2004-2008) de llamps NT per mes (abscisses) i hora (ordenades) (a) zona d'estudi representada a la figura