

A STUDY OF THE 21 MARCH 2012 TORNADIC QUASI LINEAR CONVECTIVE SYSTEM IN CATALONIA

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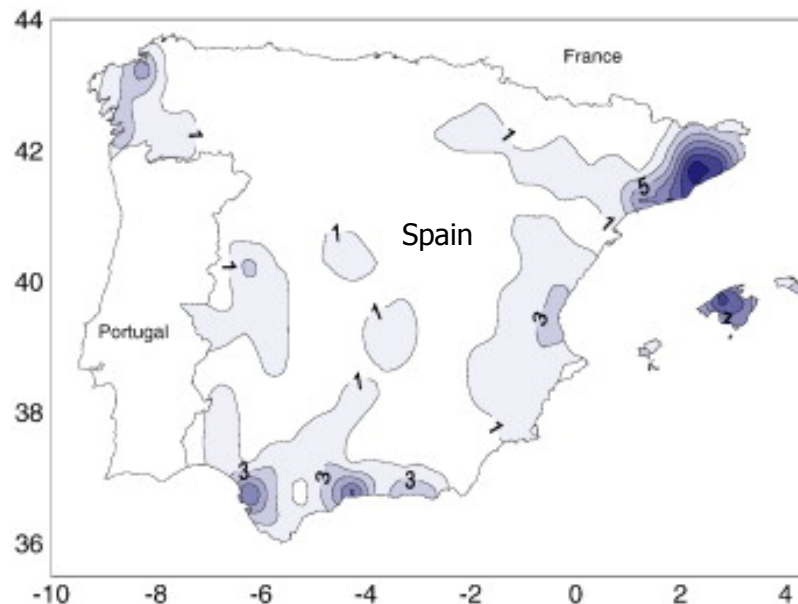
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Introduction



Tornado density contours (cases per $0.5^\circ \times 0.5^\circ$) in the period 1976–2009, considering 338 tornadoes. Mostly F0 (35%), F1 (46%), F2 (17%), F3 (2%) (Gayà, 2011)

Monthly Distribution 1950-2009

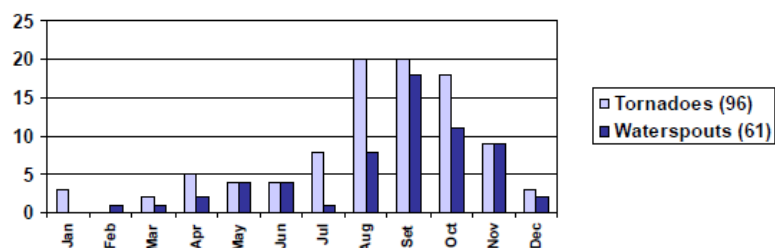


Fig. 5. Monthly distribution for tornadoes and waterspouts in the complete period 1950–2009 in Catalonia. One tornado and one waterspout from the total sample cannot be classified due to the lack of information.

Hourly Distribution 1950-2009

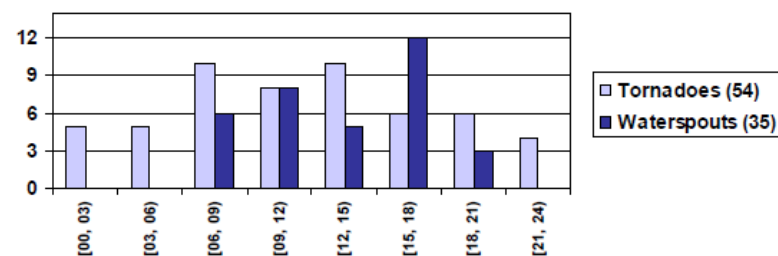
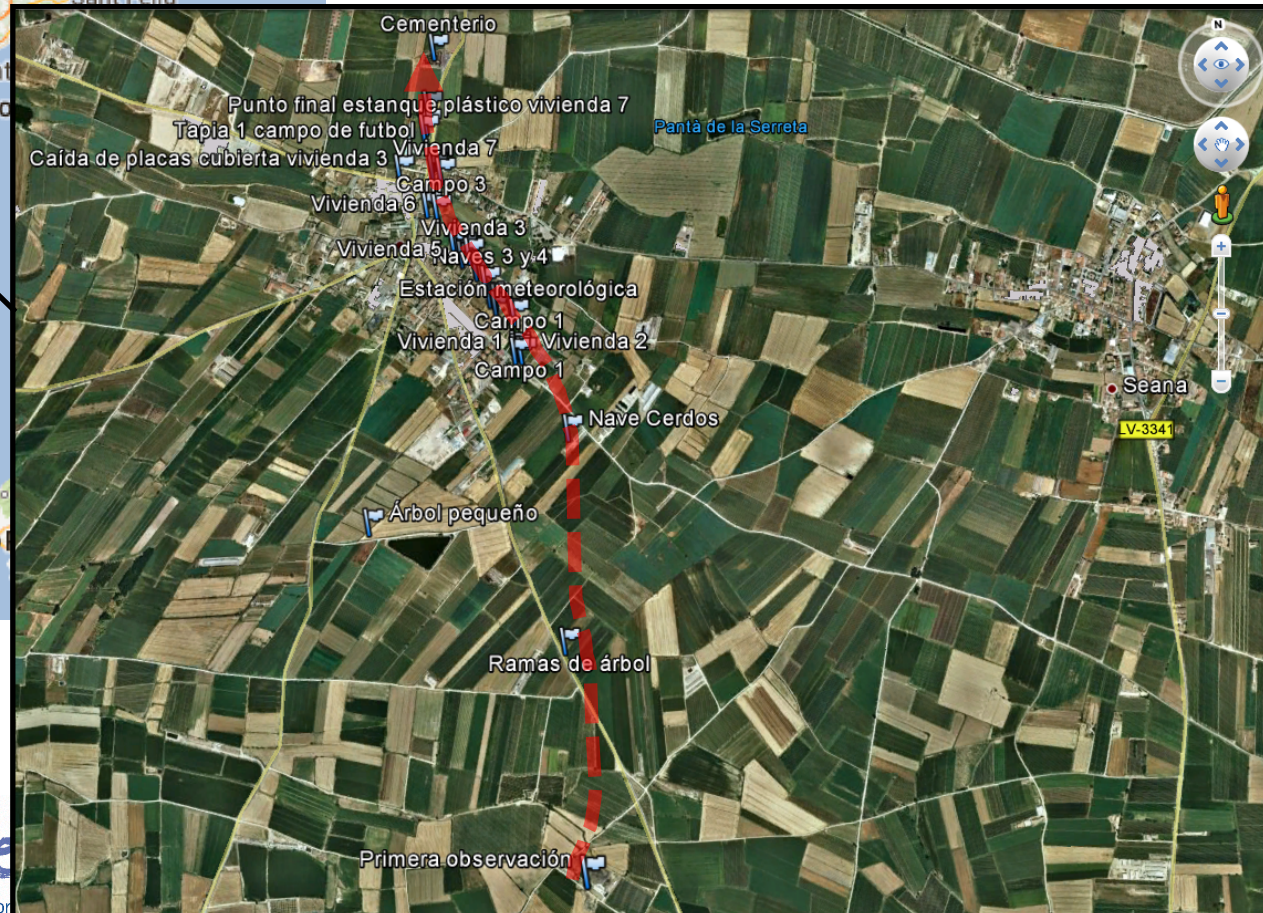


Fig. 6. Hourly distribution of tornadoes and waterspouts for which this information is available (1950–2009). (Gayà et al 2011)

Damage Survey

- **Nocturnal event (ca. 19Z)**
- **Rural Area (open fields & village)**
- **Location: Ivars d'Urgell**
- **Path Length: 3.6 km**
- **Path Width: 20 m (very narrow)**
- **Damage: EF1**
- **No injuries**
- **Insurance claims: ca. 65 kEur**



Damage Survey



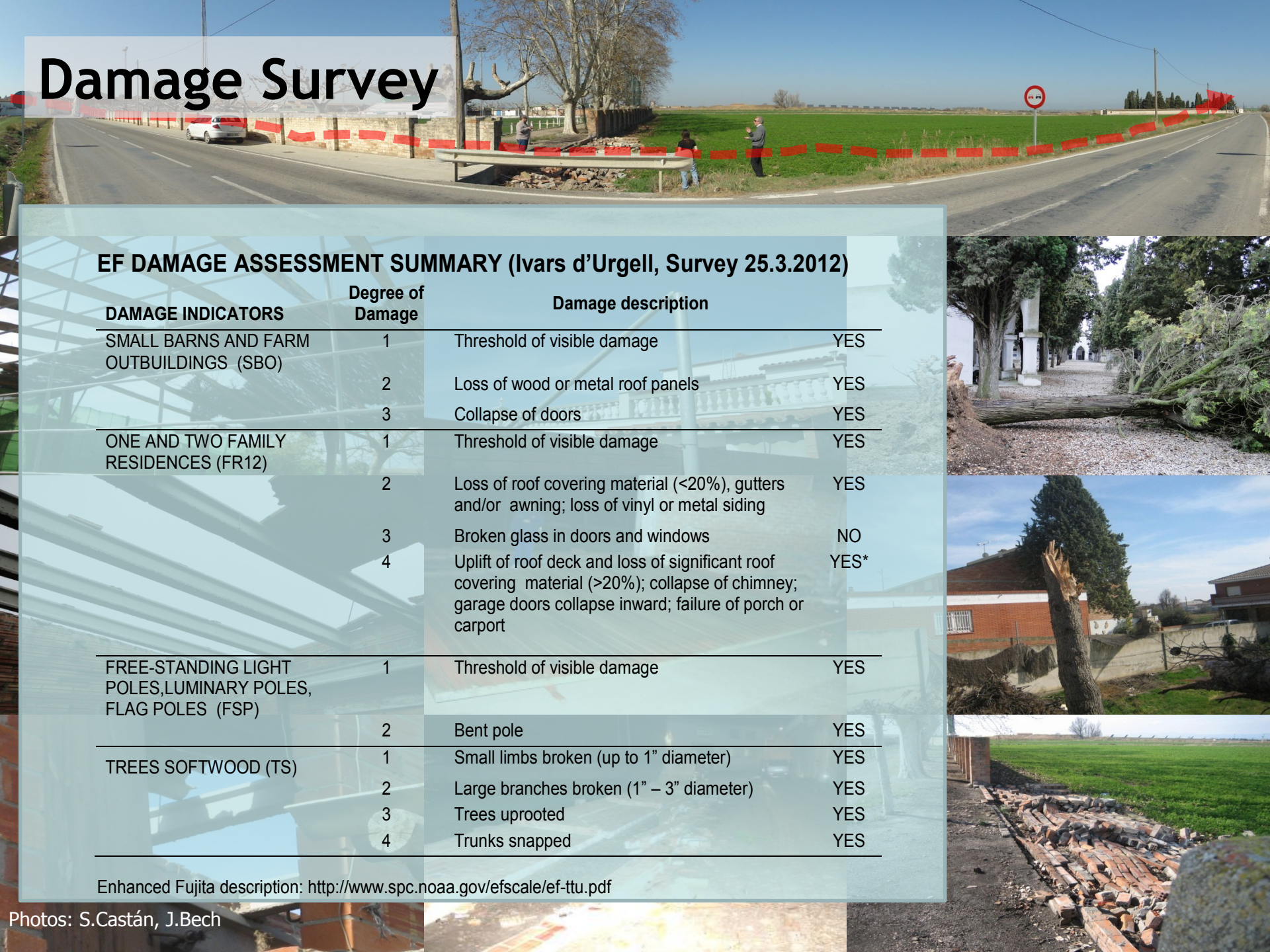
Damage Survey

EF DAMAGE ASSESSMENT SUMMARY (Ivars d'Urgell, Survey 25.3.2012)

DAMAGE INDICATORS	Degree of Damage	Damage description	
SMALL BARNs AND FARM OUTBUILDINGS (SBO)	1	Threshold of visible damage	YES
	2	Loss of wood or metal roof panels	YES
	3	Collapse of doors	YES
ONE AND TWO FAMILY RESIDENCES (FR12)	1	Threshold of visible damage	YES
	2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	YES
	3	Broken glass in doors and windows	NO
	4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	YES*
FREE-STANDING LIGHT POLES, LUMINARY POLES, FLAG POLES (FSP)	1	Threshold of visible damage	YES
	2	Bent pole	YES
TREES SOFTWOOD (TS)	1	Small limbs broken (up to 1" diameter)	YES
	2	Large branches broken (1" – 3" diameter)	YES
	3	Trees uprooted	YES
	4	Trunks snapped	YES

Enhanced Fujita description: <http://www.spc.noaa.gov/efscale/ef-ttu.pdf>

Photos: S.Castán, J.Bech

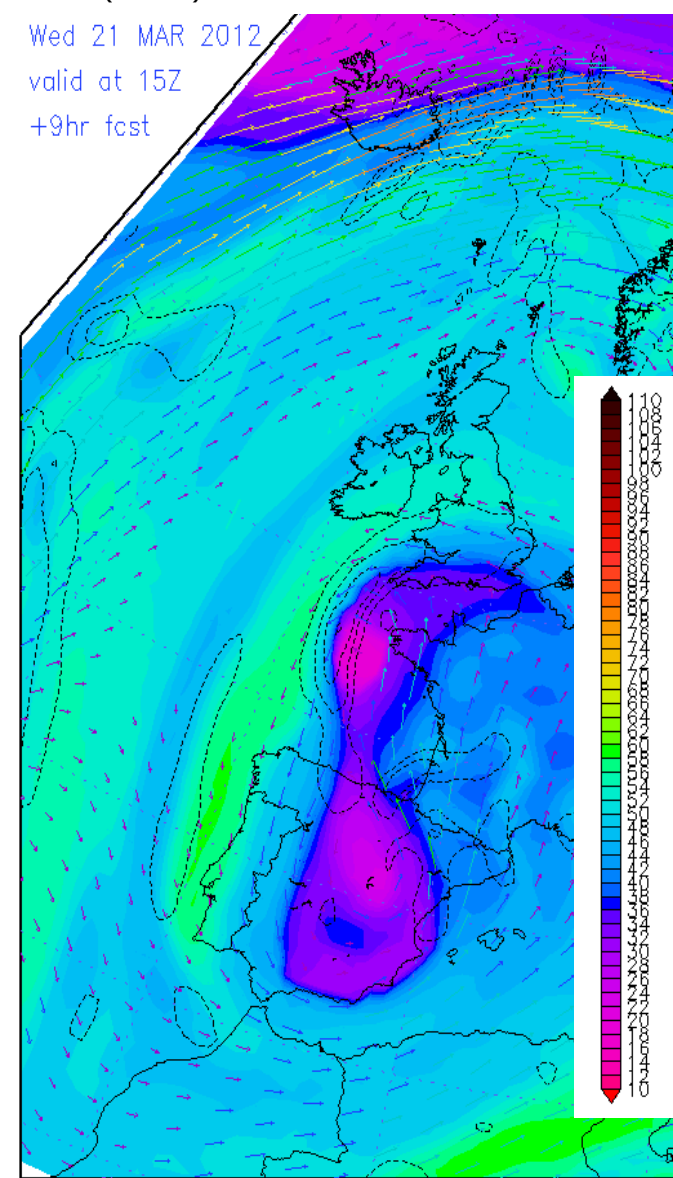
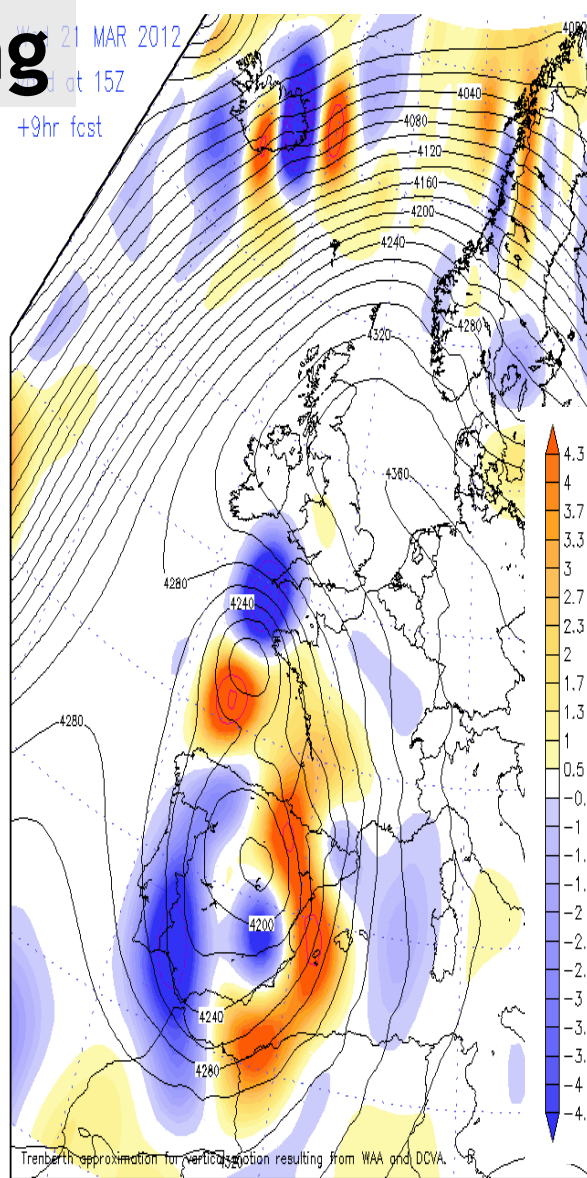
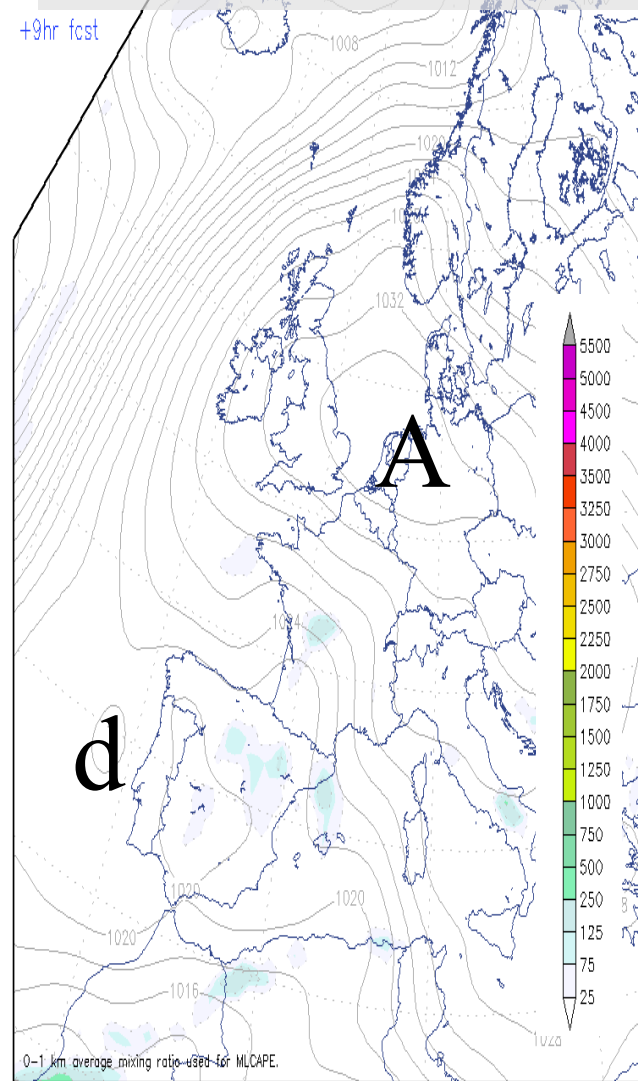


MSL Pressure [hPa] | Mixed Layer CAPE [J/kg]

Adv 600 hPa Geostrophic Vorticity by
900-300 hPa Thermal Wind Vector

Dyn Trop (Lowest 2.5 PVU level) Pot Temp [°C] |
Wind (arrows)

Synoptic setting



LightningWizard.com

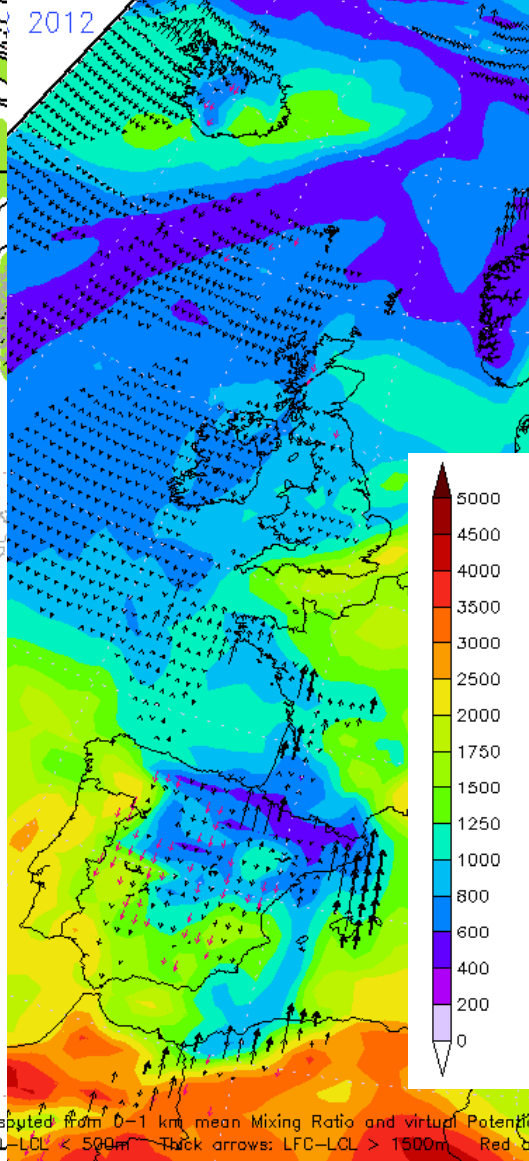
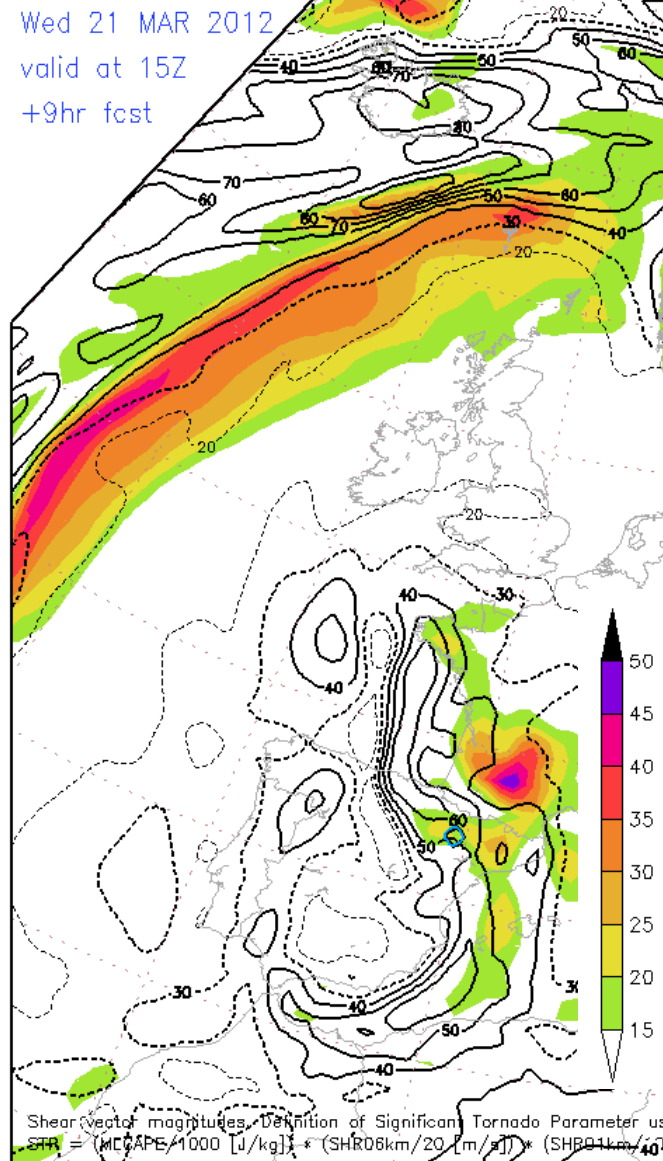
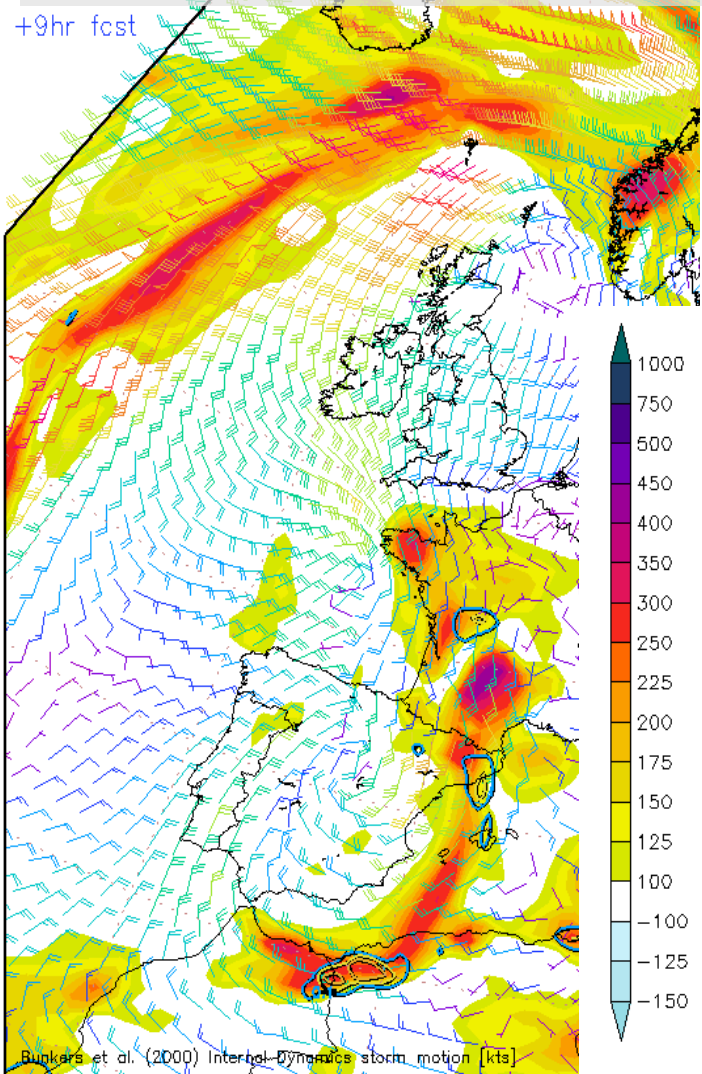
Blocking pattern Europe, ridge from N Africa to C. Europe – cut-off low over Iberia - Strong convergence line over sea and at mid levels, a steep PV gradient causing linear lifting, at 500-700 hPa theta-e difference (cold front)

Rightmover: 0-3 km Storm-relative Helicity [m^2/s^2]

0-6 km Shear (black) [kts] | 0-1 km Shear+ τ_h

ML Lifting Condensation Level (shaded) | Level of Free Convection - LCL difference

Synoptic setting



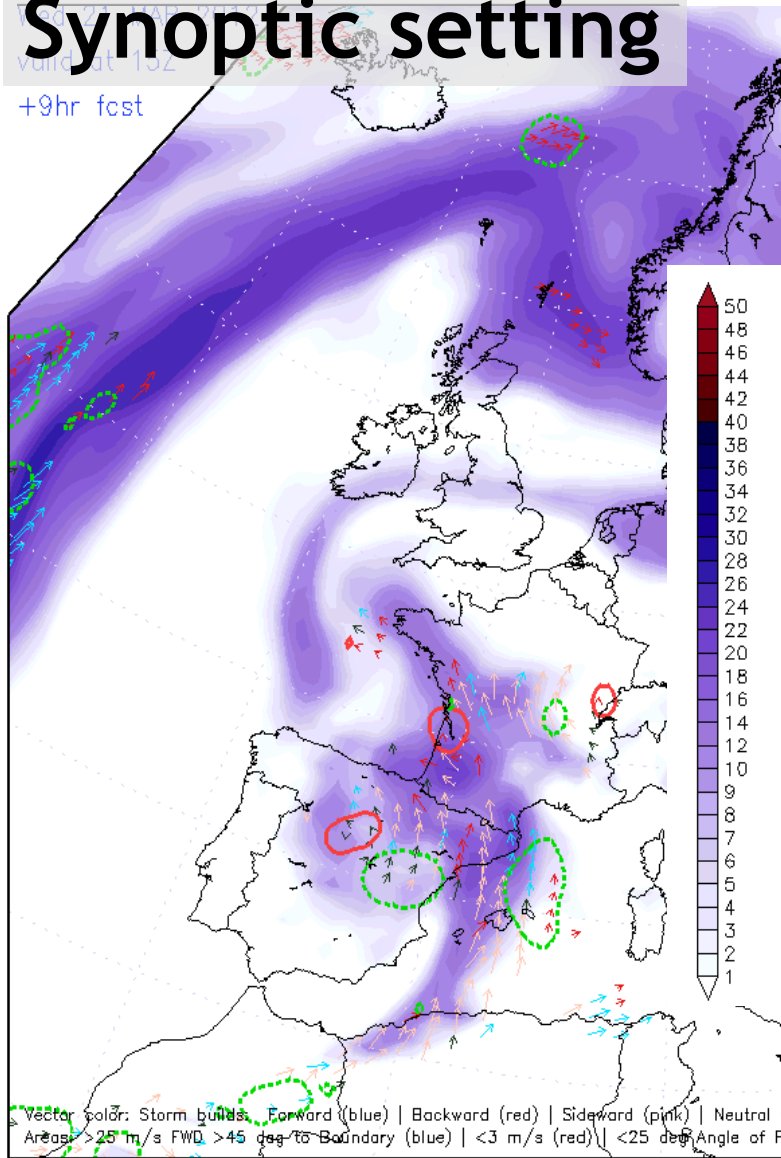
good 0-1 km shear and 0-6 km shear, and 0-3 km SREH, together with low LCL

Favourable conditions for organized convection, possibility of tornadoes

MCS Propagation Vector | Effective Precipitable Water (PW-SD, SFC-300 hPa) [mm]

Synoptic setting

+9hr fcst

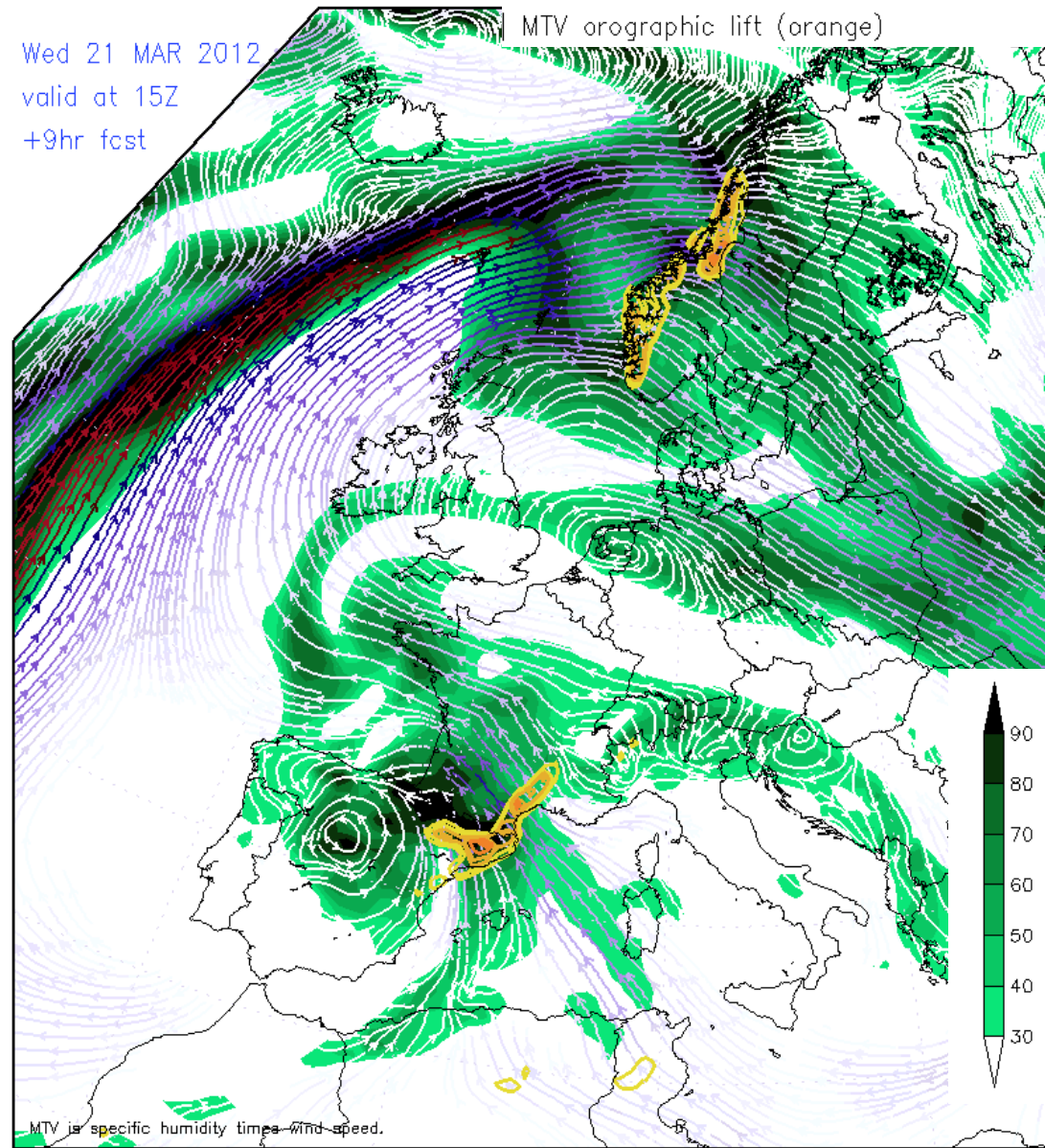


0-2km Moisture Transport Vectors | 1000-600 hPa Min RH (shaded)

Wed 21 MAR 2012

valid at 15Z

+9hr fcst



LightningWizard.com

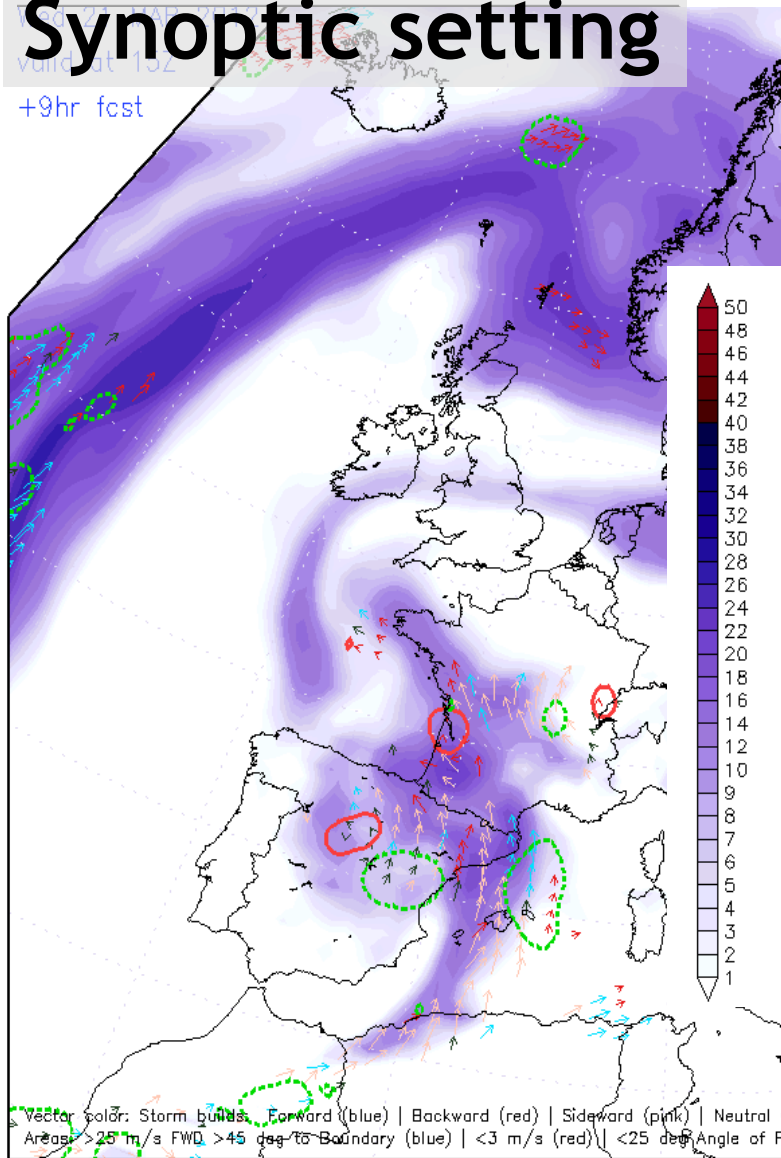
Precipitable water avail. – moisture transport - MCS propagation along boundary & orographic effect enhancement likely *Favourable conditions for heavy rainfall*

MCS Propagation Vector | Effective Precipitable Wa

Effective Precipitable Water (PW-SD, SFC-300 hPa) [mm]

Synoptic setting

+9hr fcst

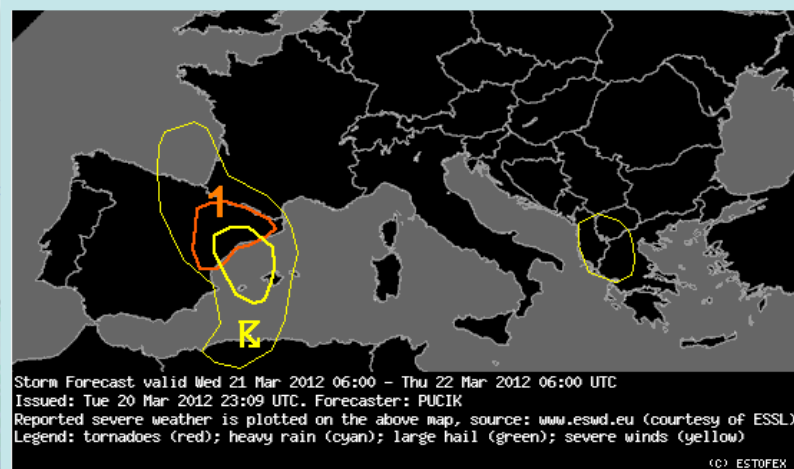


NCEP GFS 0.5°

Wed 21

valid at

+9hr f



Storm Forecast valid Wed 21 Mar 2012 06:00 - Thu 22 Mar 2012 06:00 UTC
Issued: Tue 20 Mar 2012 23:09 UTC. Forecaster: PUCIK
Reported severe weather is plotted on the above map, source: www.eswd.eu (courtesy of ESSL)
Legend: tornadoes (red); heavy rain (cyan); large hail (green); severe winds (yellow)
(C) ESTOFEX

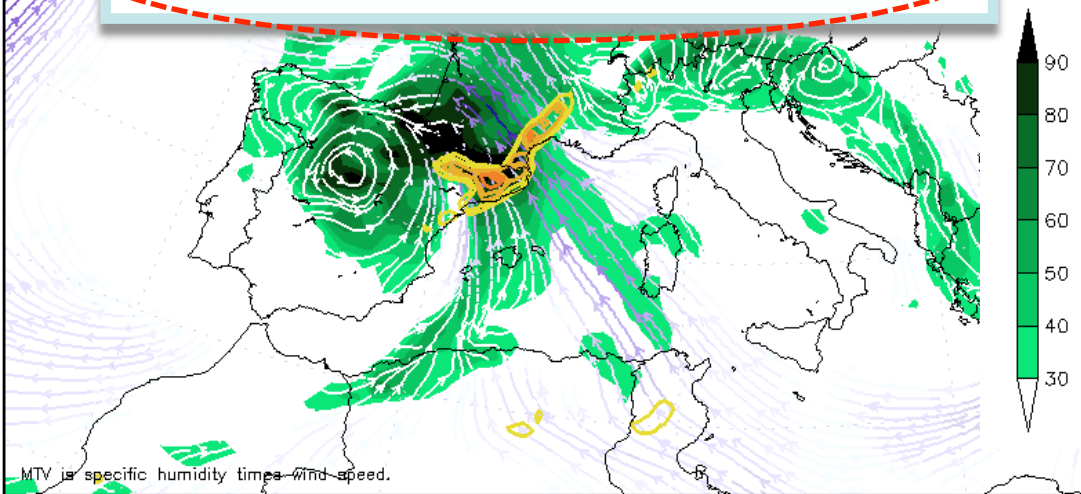
Storm Forecast

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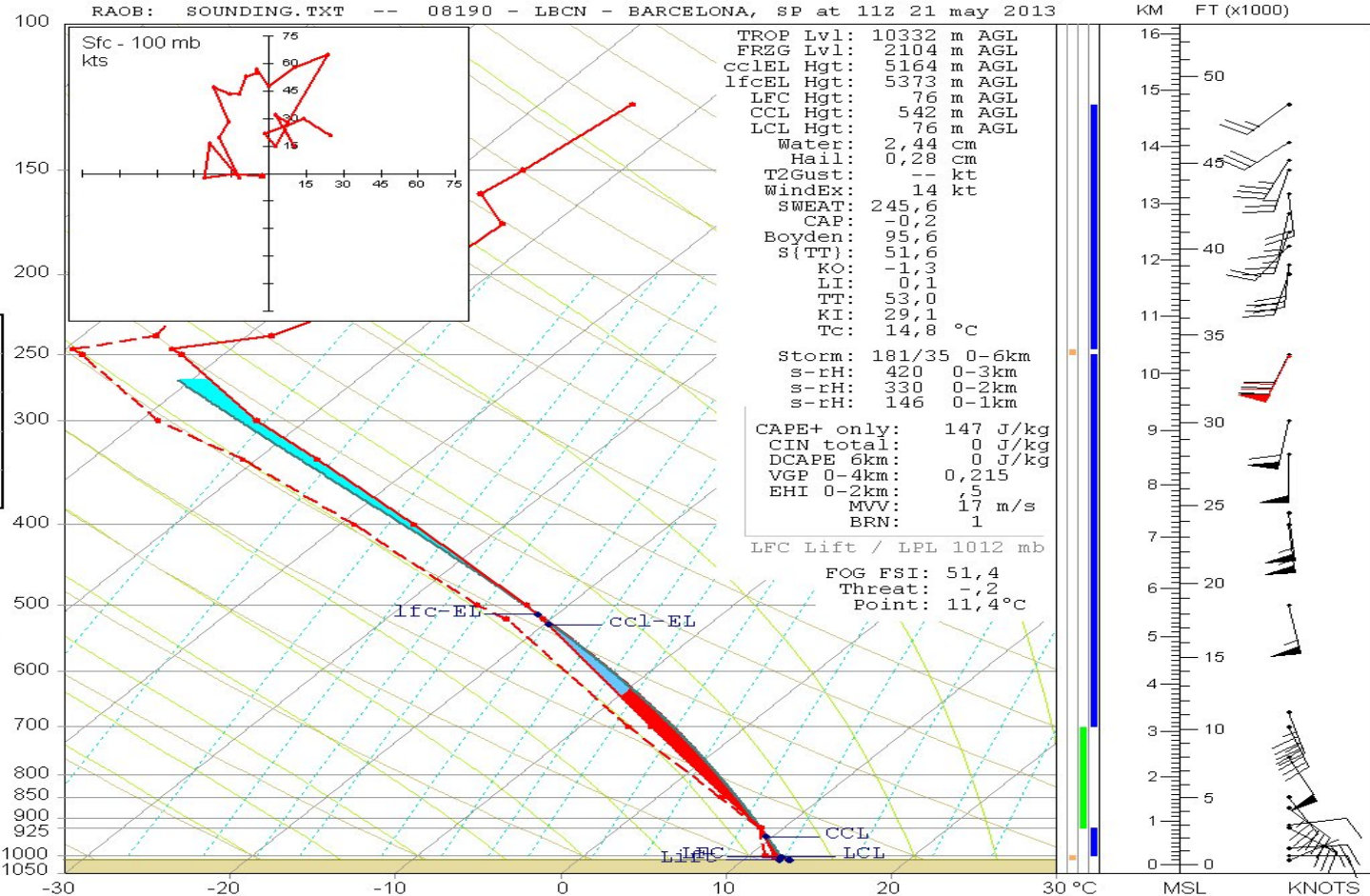
A level 1 was issued for Northeastern Spain mainly for excessive rainfall and tornadoes.



NCEP GFS 0.5°

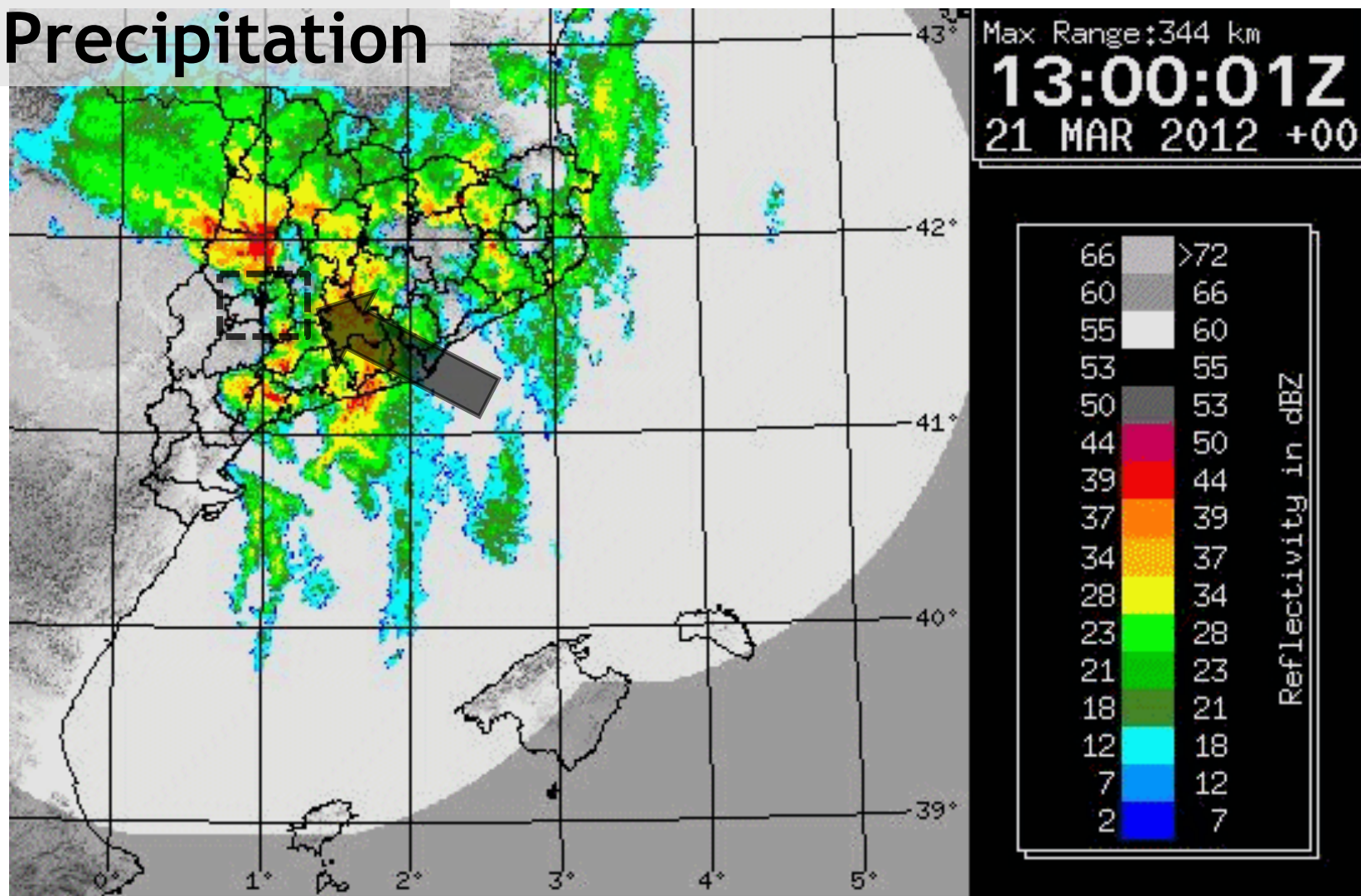
LightningWizard.com

Precipitable water avail. – moisture transport - MCS propagation along boundary & orographic effect enhancement likely *Favourable conditions for heavy rainfall*



EVENT	CAPE [Jkg ⁻¹]	0-3km SRH [m ² s ⁻²]	Severe Weather (Location)	Reference
21-03-2012 12Z	147	420	F1 Tornado (Ivars d'Urgell)	
02-11-2008 00Z	80	284	F2 Tornado (Cabra del Camp)	Bech et al AtRes 2011
18-10-2006 12Z	768	267	F2 Tornado (Castellcir)	Aran et al AtRes 2009
07-09-2005 12Z	669	250	T. Outbreak (F2, F1, ..) (Delta Llobregat)	Bech et al NHESS 2007

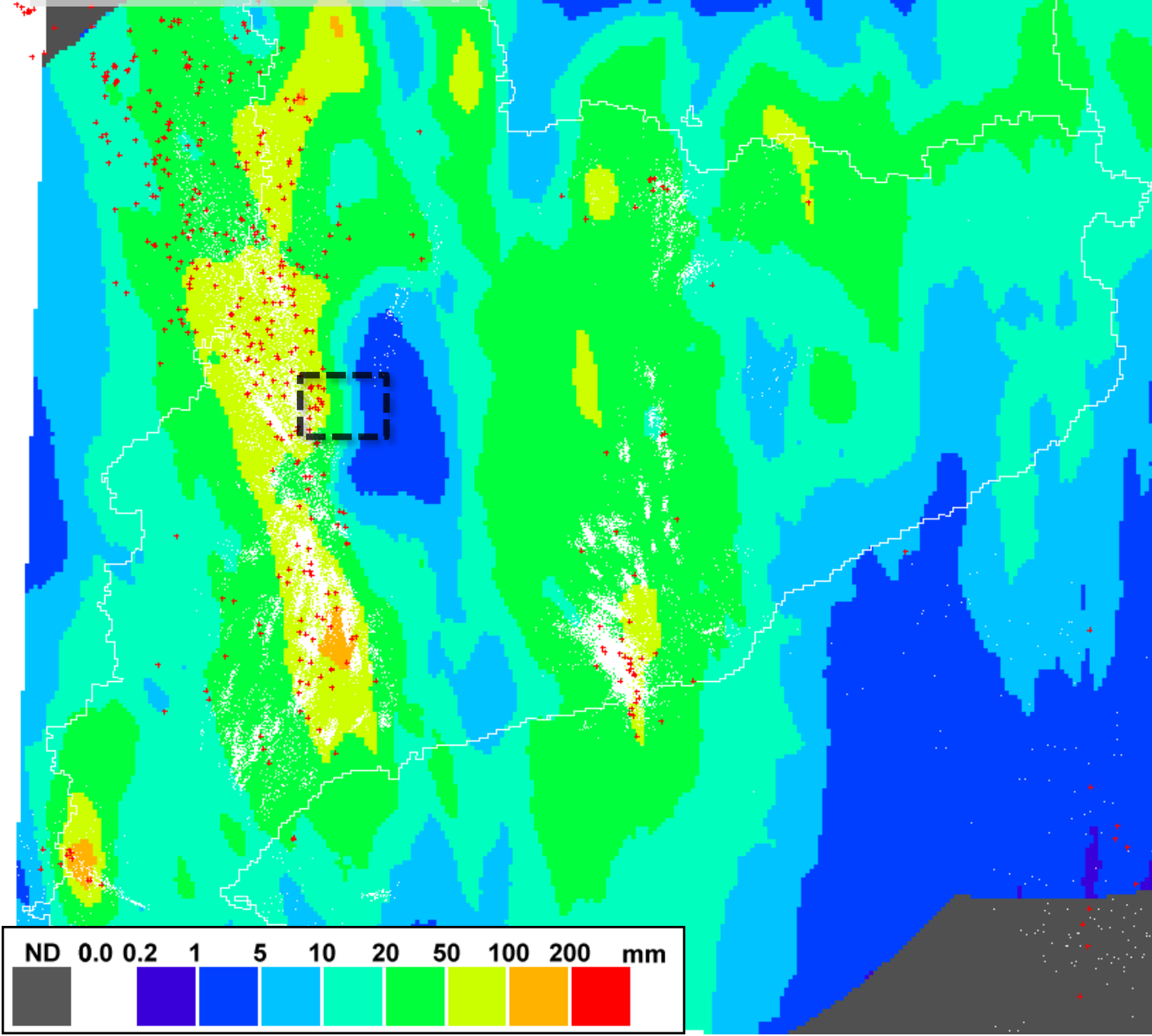
Precipitation



SMC XRAD radar reflectivity composite (real-time corrected 0 km CAPPI)

Precipitation

2012.03.21 00:00-23:59Z



Precipitation

2012.03.21 00:00-23:59Z

SMC Daily precipitation analysis

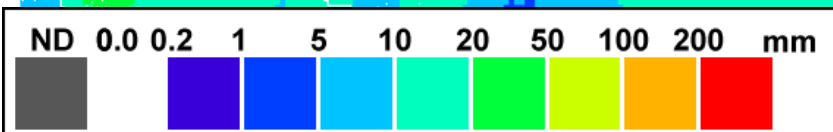
XRAD 4 C-band Doppler radar systems

XEMA 165 ASOS

Total lightning CG red, IC white

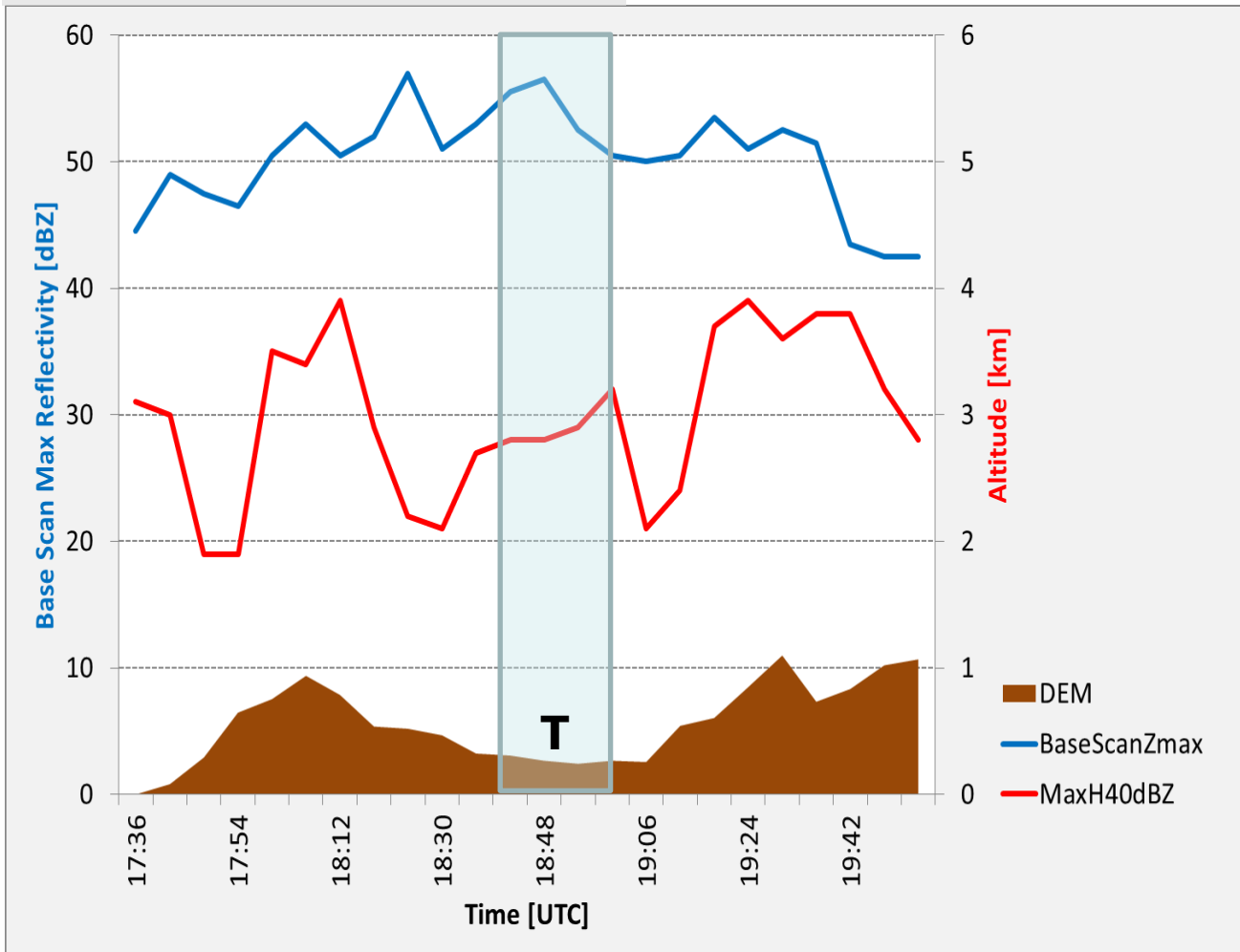
24hPP [mm]	ID	Station	Height [m]
113.6	Z2	Boí	2535
109.8	U5	Prades	969
108.9	Z1	Bonaigua	2266
108.3	X5	Ports	1055

30'PP [mm]	ID	Station	Height [m]
17.4	D3	Vallirana	252
13.0	XL	El Prat de Llobregat	8
12.9	D8	Horta de Sant Joan	515
11.6	C6	Castellnou de Seana	264



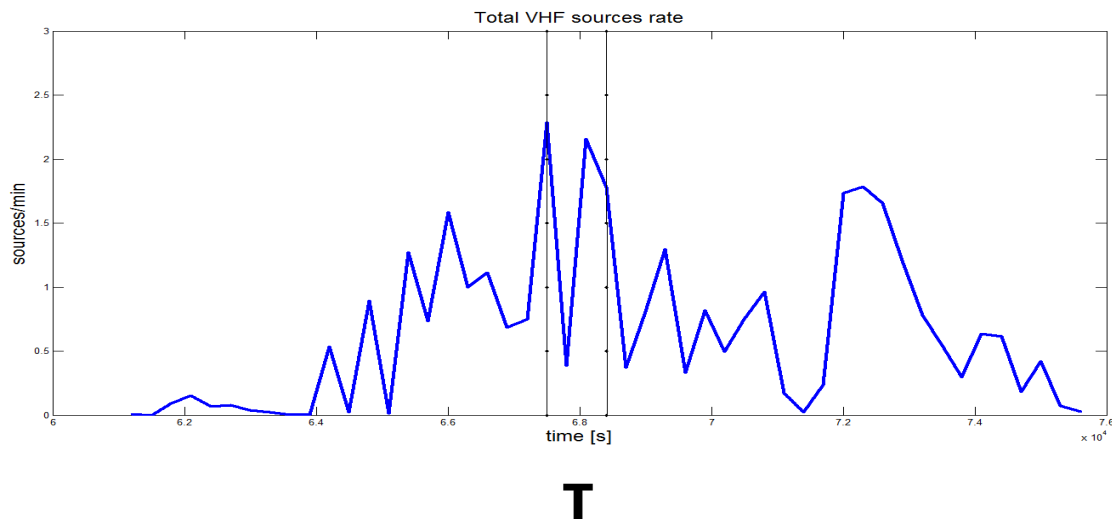
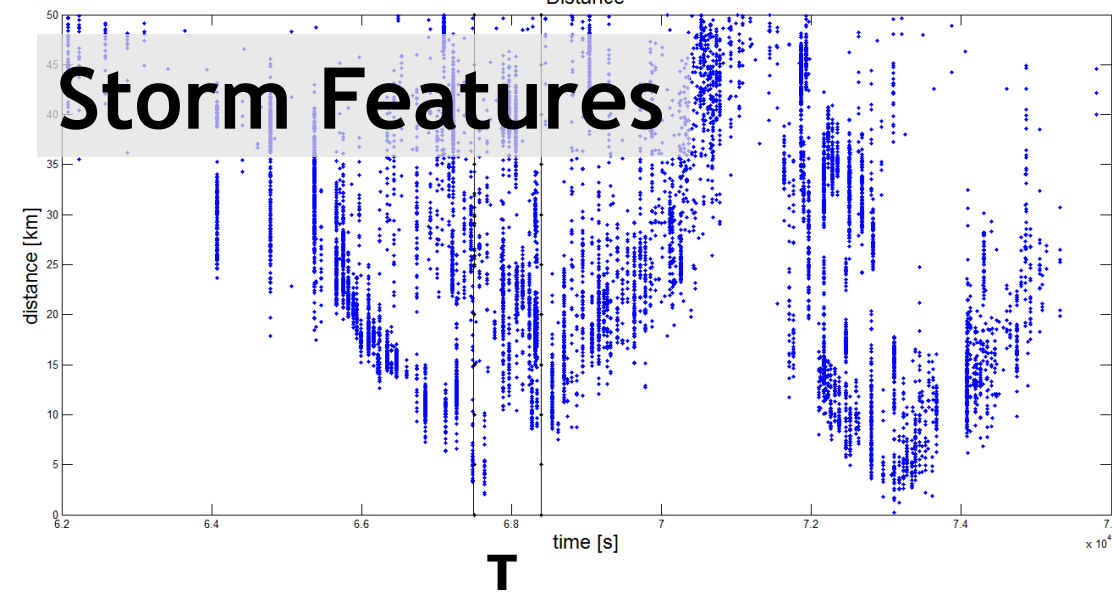
Storm Features

Radar Characteristics (Av. Speed: 56 km/h)



- Increase of Zmax with topogr. (orog. Enhancement)
- During T increase & decrease Zmax base scan
- During T increase of TOP40

Storm Features



Lightning activity

- Generally modest

Intra-cloud

- peak (2.4 flash/min) just before 18:45Z
- Later sharp decrease for 5'

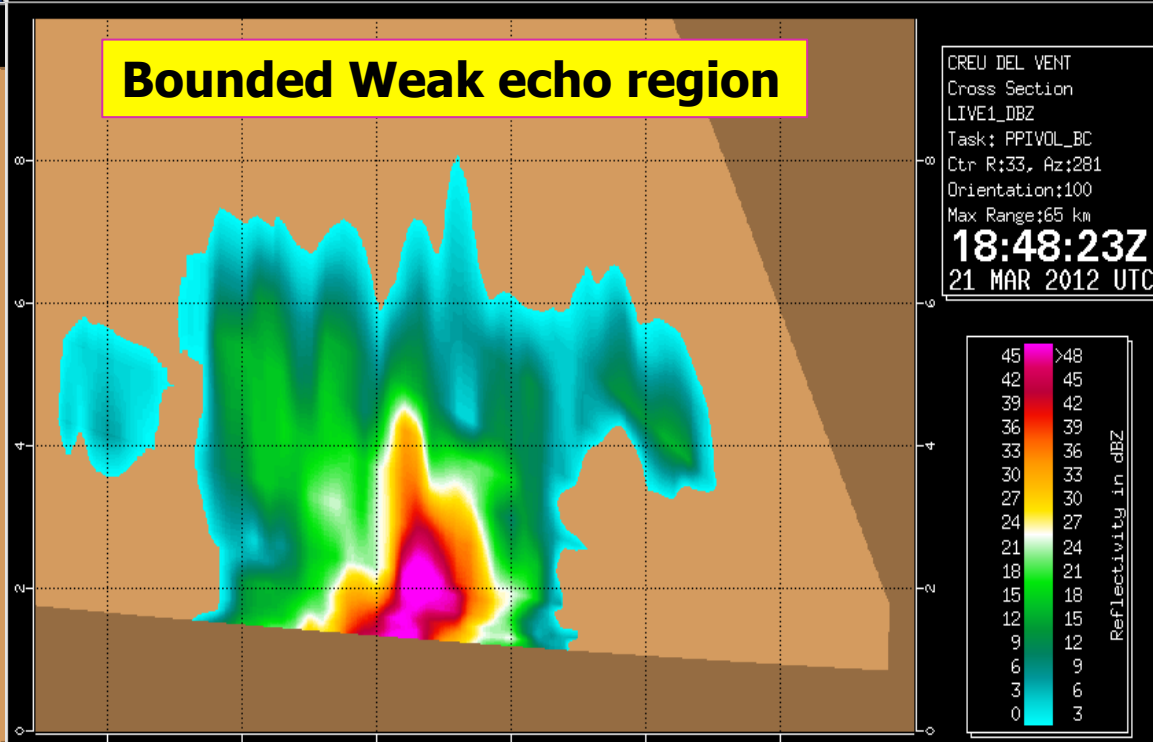
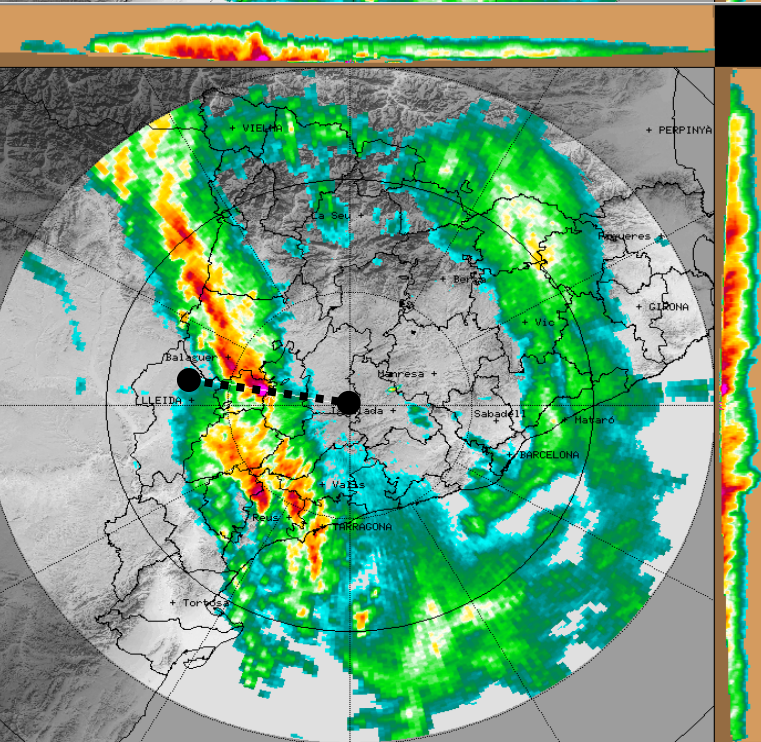
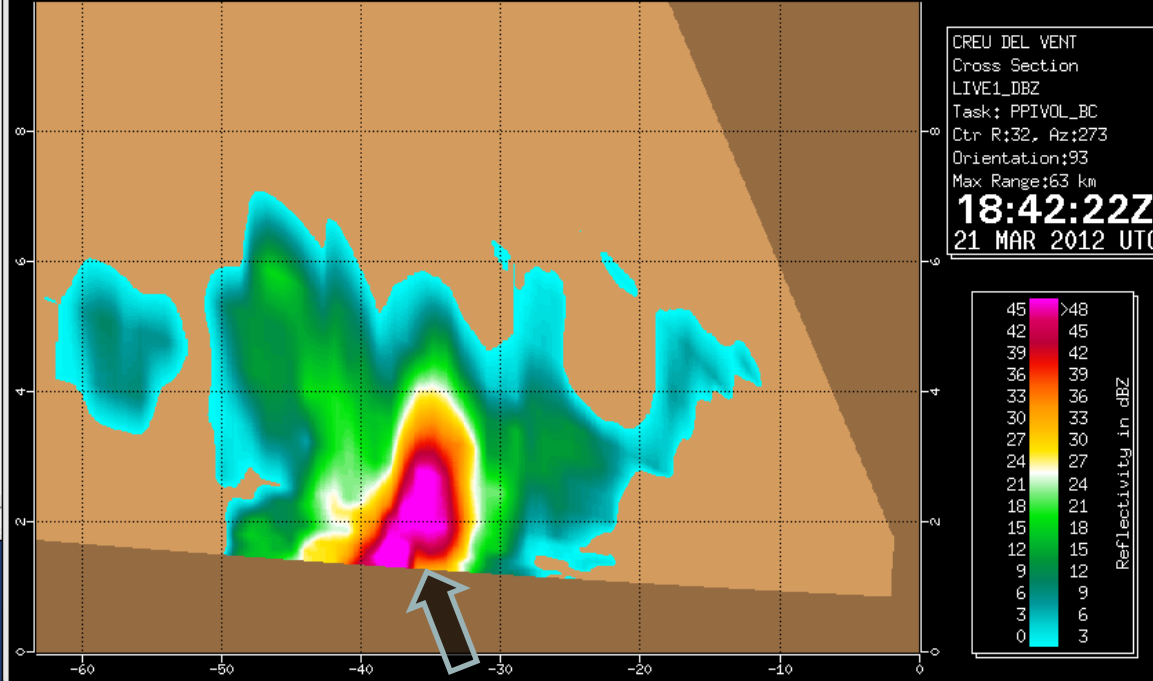
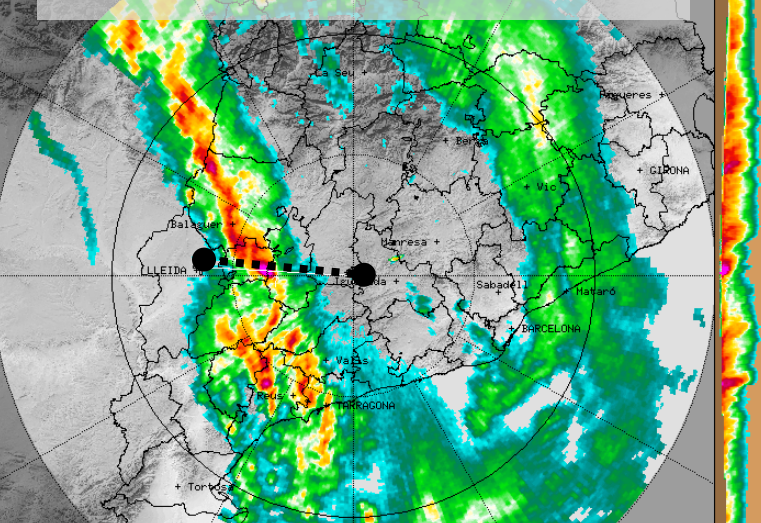
Cloud-to-ground

- Low rates (<0.1 flash/min)
- -CG no particular features
- +CG during 18:45-19:00Z

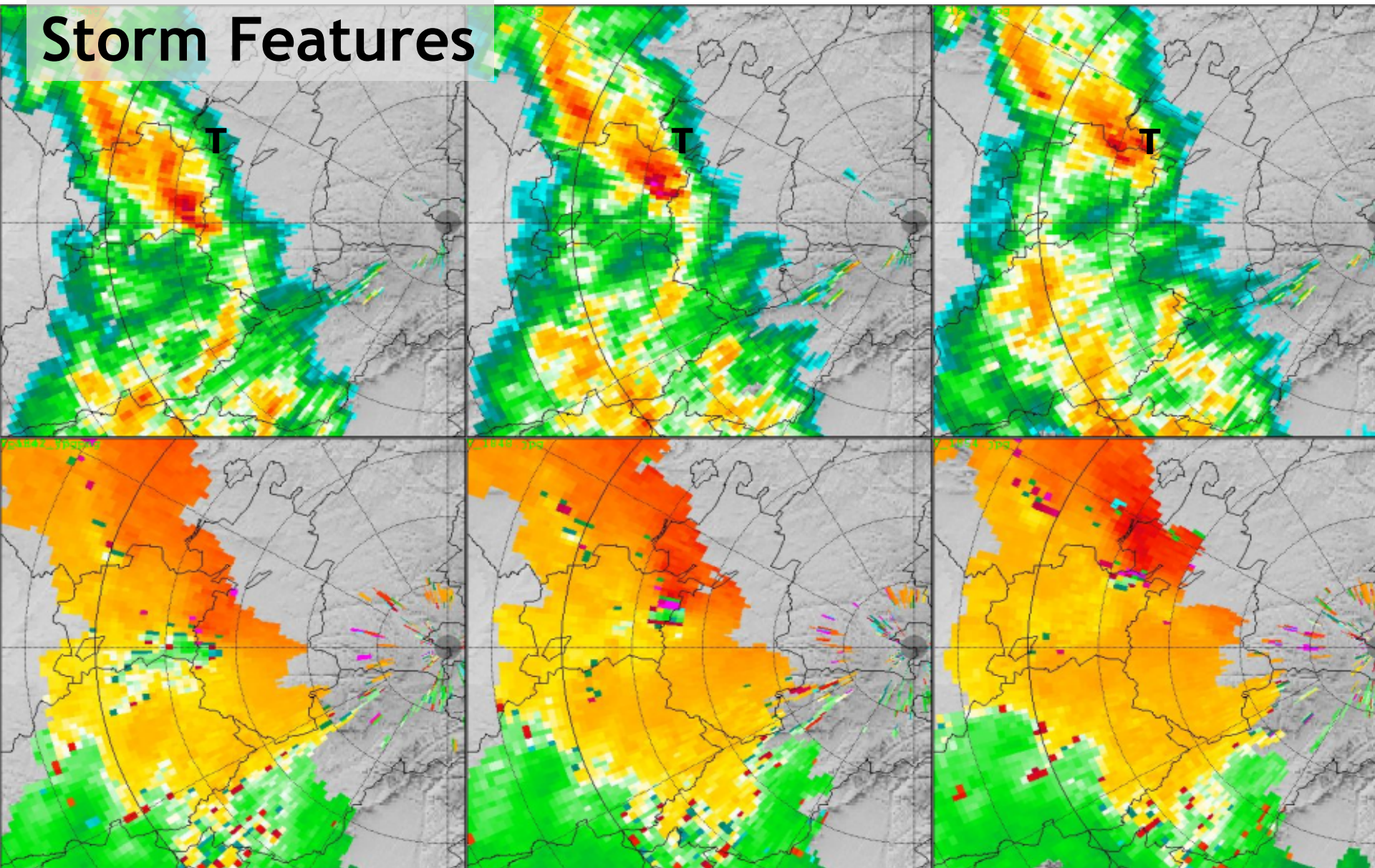
Marginal total lightning
18:45-19:00Z within 20 km
radius of reported damage

- Increase of IC possibly associated to a strong updraft [Elevated charge model, MacGorman et al JAS 1989, Carey et al JGR 2003]

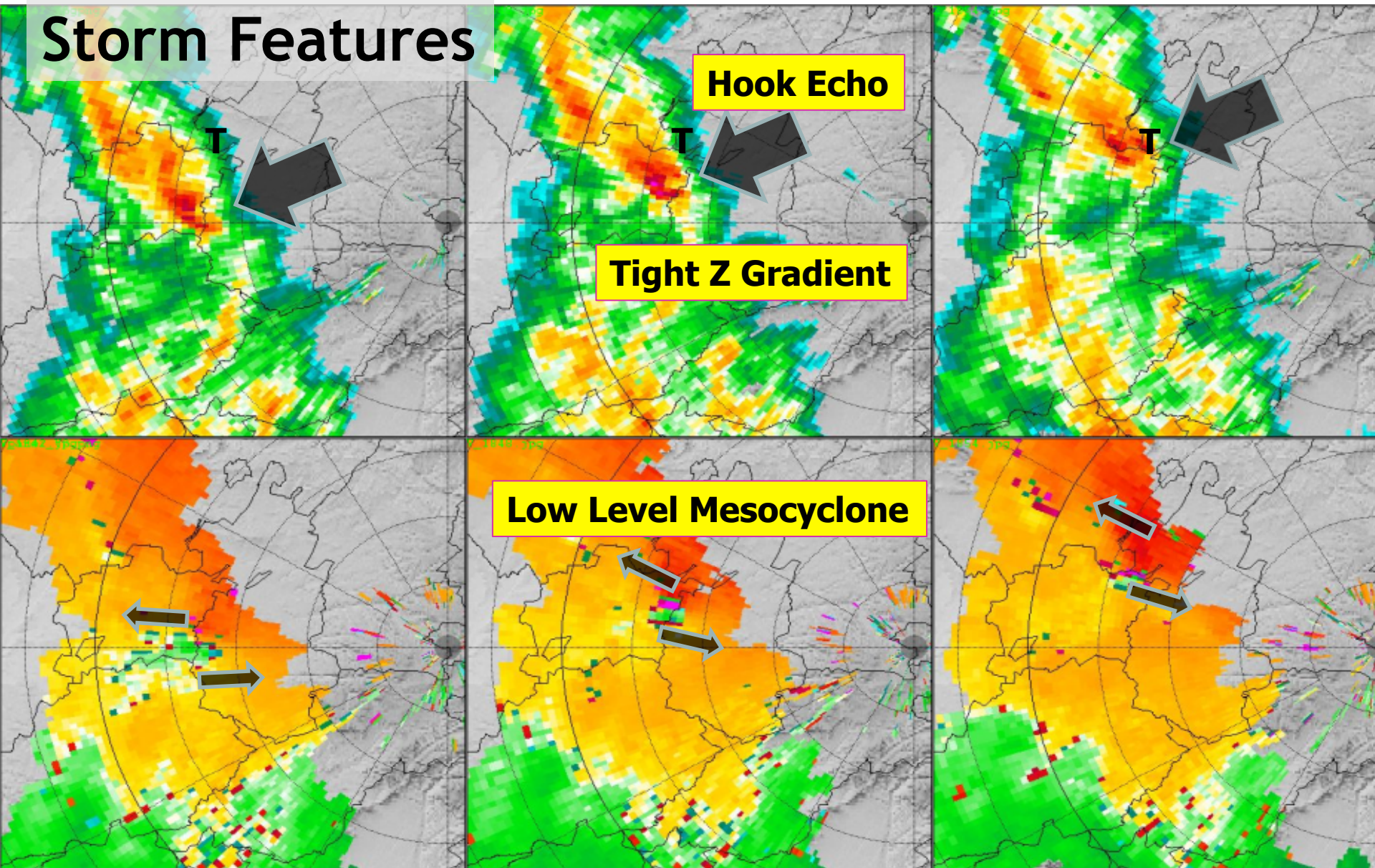
Storm Features



Storm Features



Storm Features

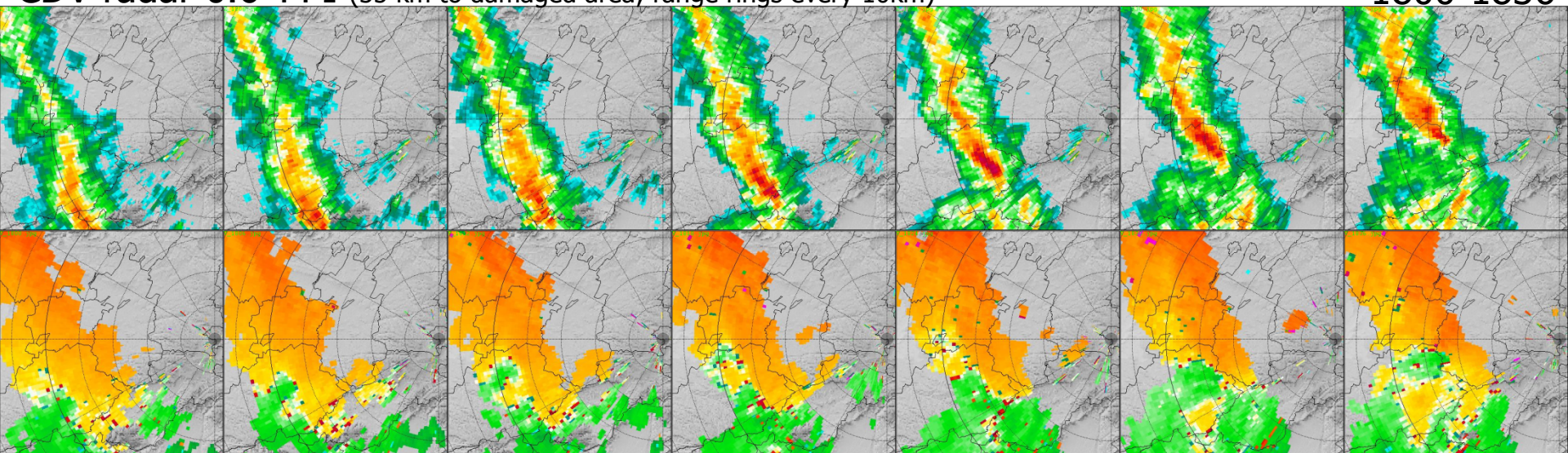


Summary and Conclusion

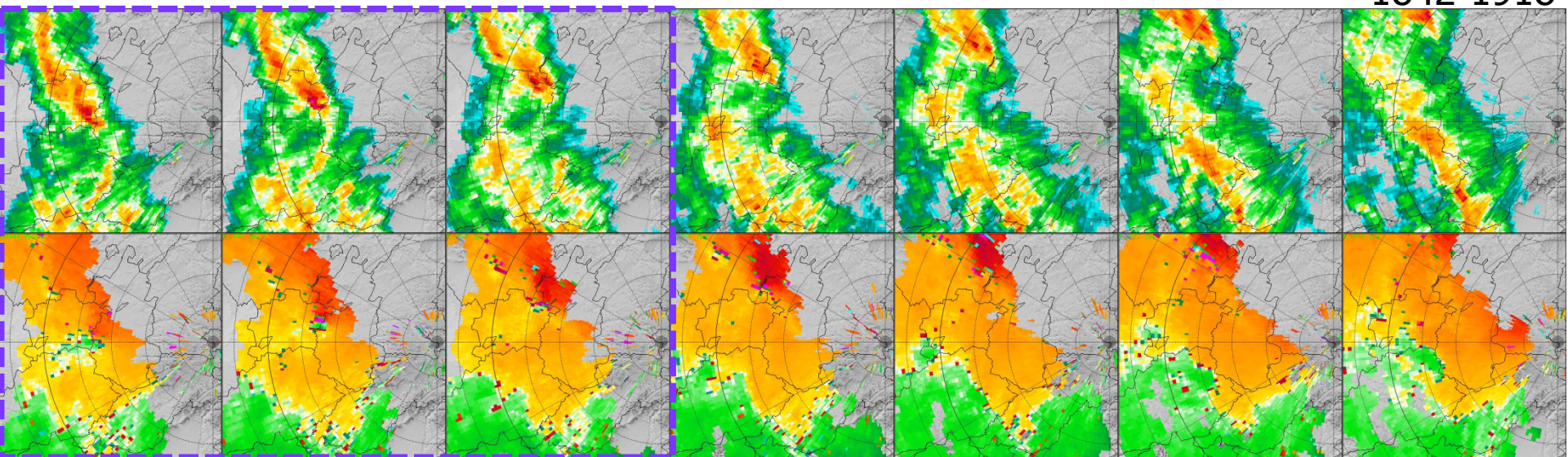
- **Ivars d'Urgell case study**
 - 2012.03.21 cool season, late evening, severe wind damage
 - EF1 tornado, 3.6 km long, 50 m wide, no injuries
- **Synoptic setting**
 - SLP blocking – ridge over C Europe – cut-off low aloft
 - Low Cape, but high 0-6 km SH & 0-3 SRH [highest in recent tornadic cases]
 - Heavy & intense precipitation, orogr. enhanc. (24h > 100mm, 1h>17mm)
- **Thunderstorm features**
 - Parent storm enbeded in QLCS ([Weisman & Davis 1998](#), [Trapp et al 2005](#))
 - Modest Lightning activity (no jump)
 - Possible updraft before tornadogenesis
 - Relevant features (LLME, HE, BWER,..) – not a classical isolated SPC
- **To-do list**
 - Continue radar analysis (upper PPIs..)
 - Compare IR satellite with radar data

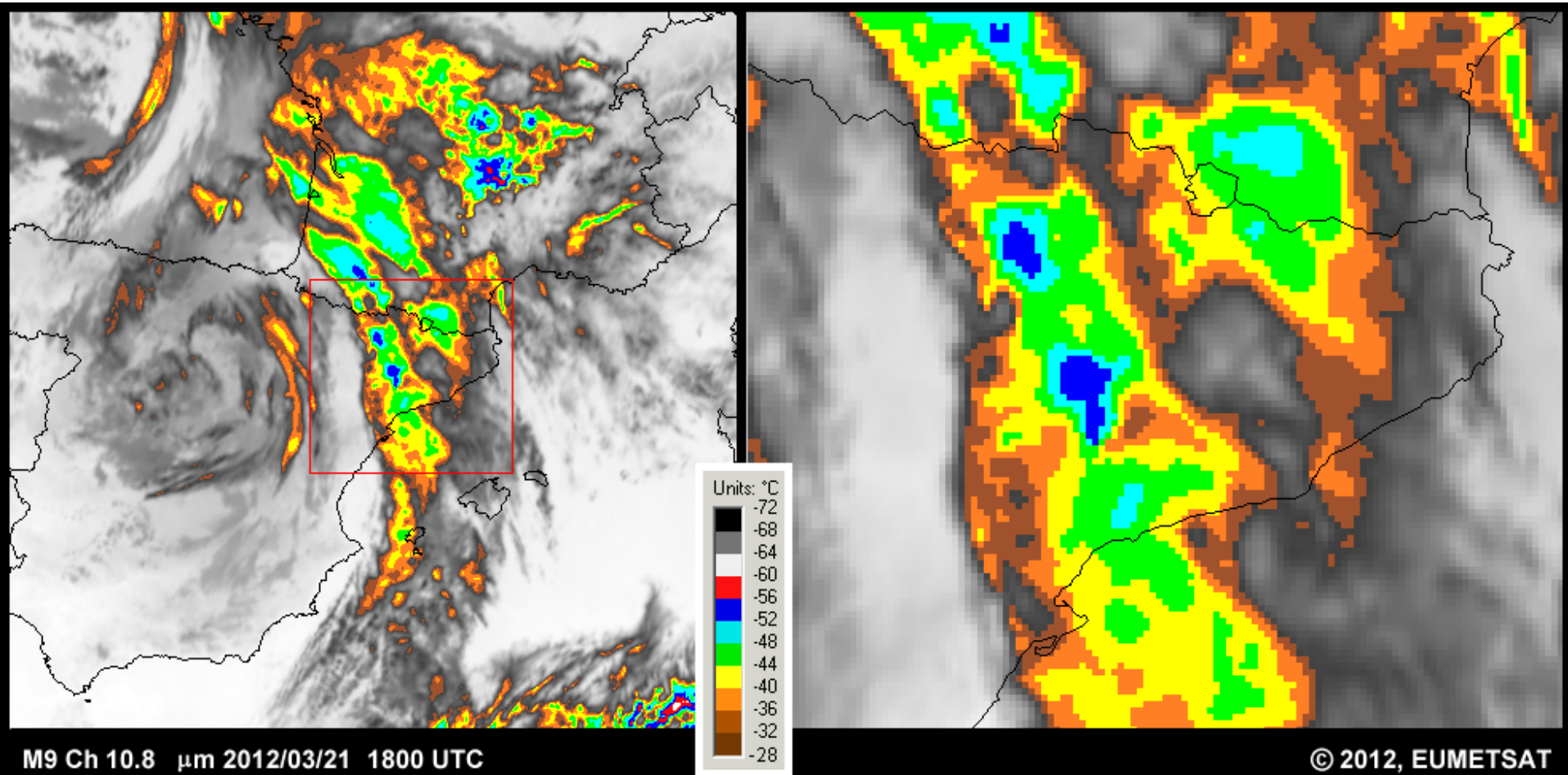
CDV radar 0.6°PPI (35 km to damaged area; range rings every 10km)

1800-1836

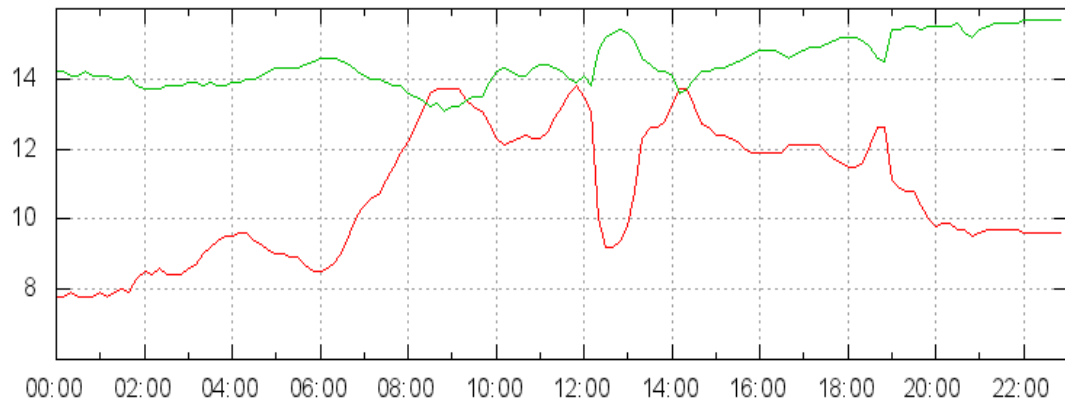


1842-1918



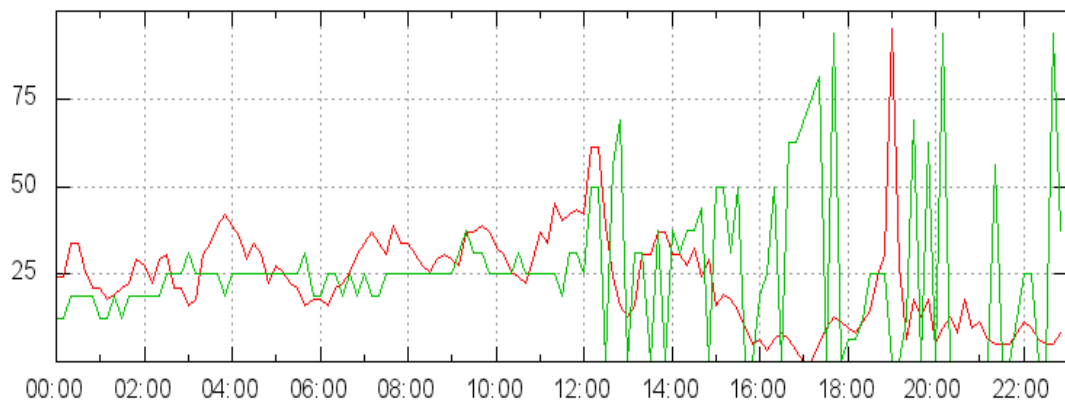


Temperature [Celsius]



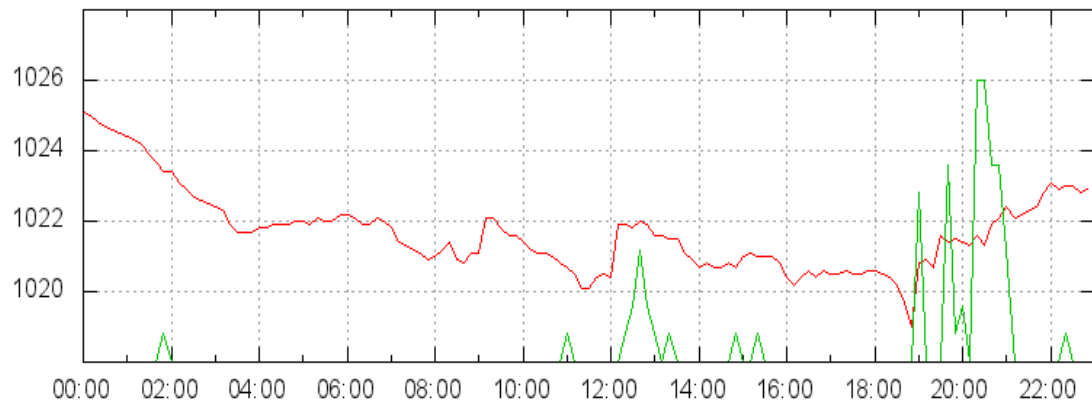
Relative Humidity [%]

Gust Speed [km/h]



Gust Direction [deg]

Pressure [hPa]

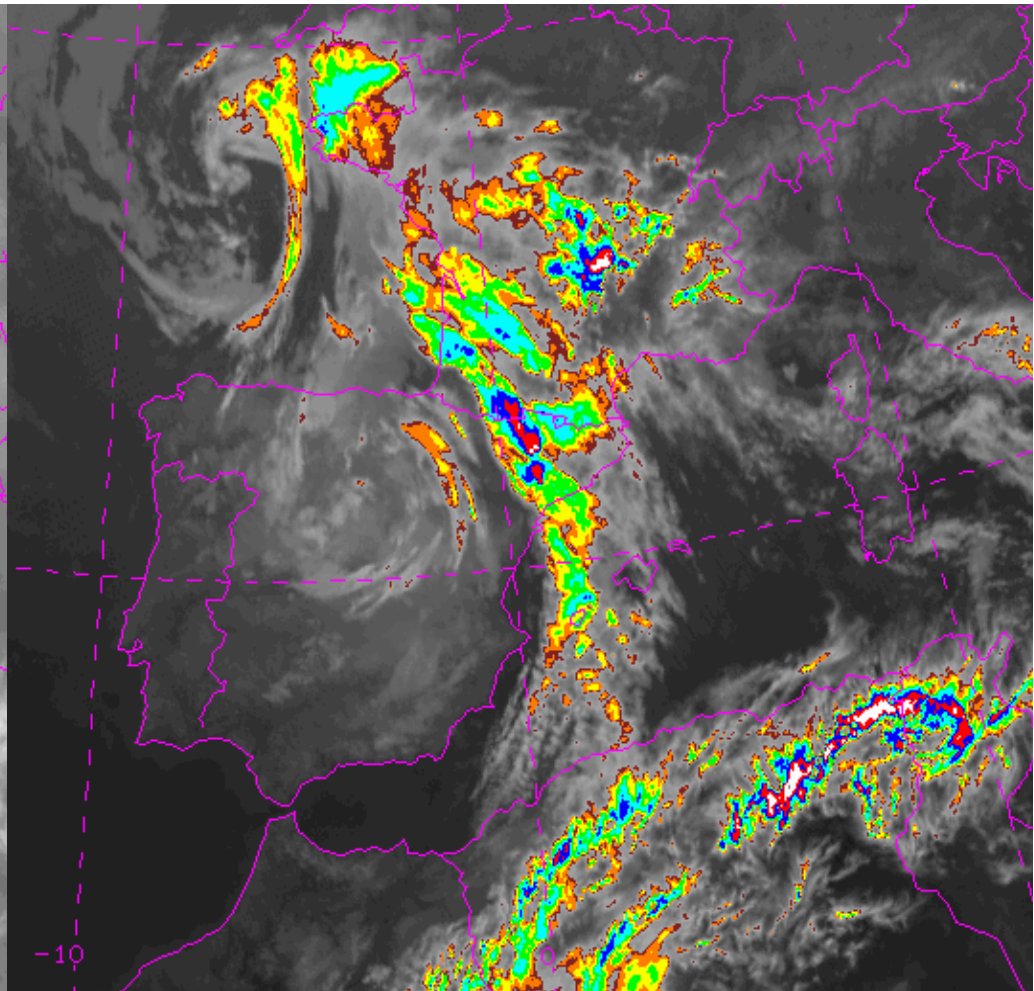
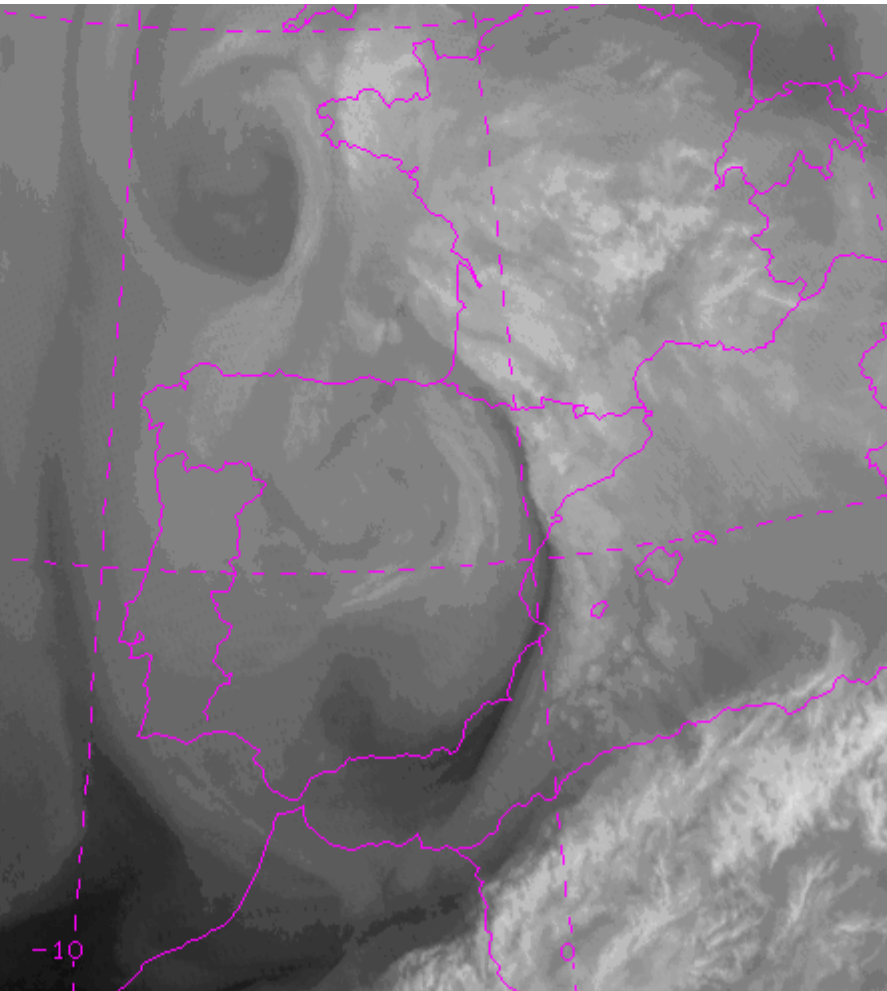


10' Rainfall [mm]



Wind gust 95 km/h
Press. 1.8 hPa / 10'

Data courtesy Xavier Coll



WV 19Z

IR 19Z Cloud tops red : (-60,-63°C)
white: (-64,-68°C)