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DOPPLER RADAR OBSERVATIONS OF THE 7 SEPTEMBER 2005 TORNADIC THUNDERSTORM NEAR BARCELONA, SPAIN

Castelldefels ca. 1730 UTC. Courtesy of J.M. Fernández.

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Contents

- Introduction
  - Background
  - Visual observations & site survey
- General setting
  - Synoptic situation
  - Satellite & lightning observations
- Radar observations
  - General features
  - Fine scale details (Z)
  - Fine scale details (RV)
- Concluding remarks

Background

Tornadoes and Tornadic Thunderstorms

Davies-Jones et al. 2003, AMS MM 28

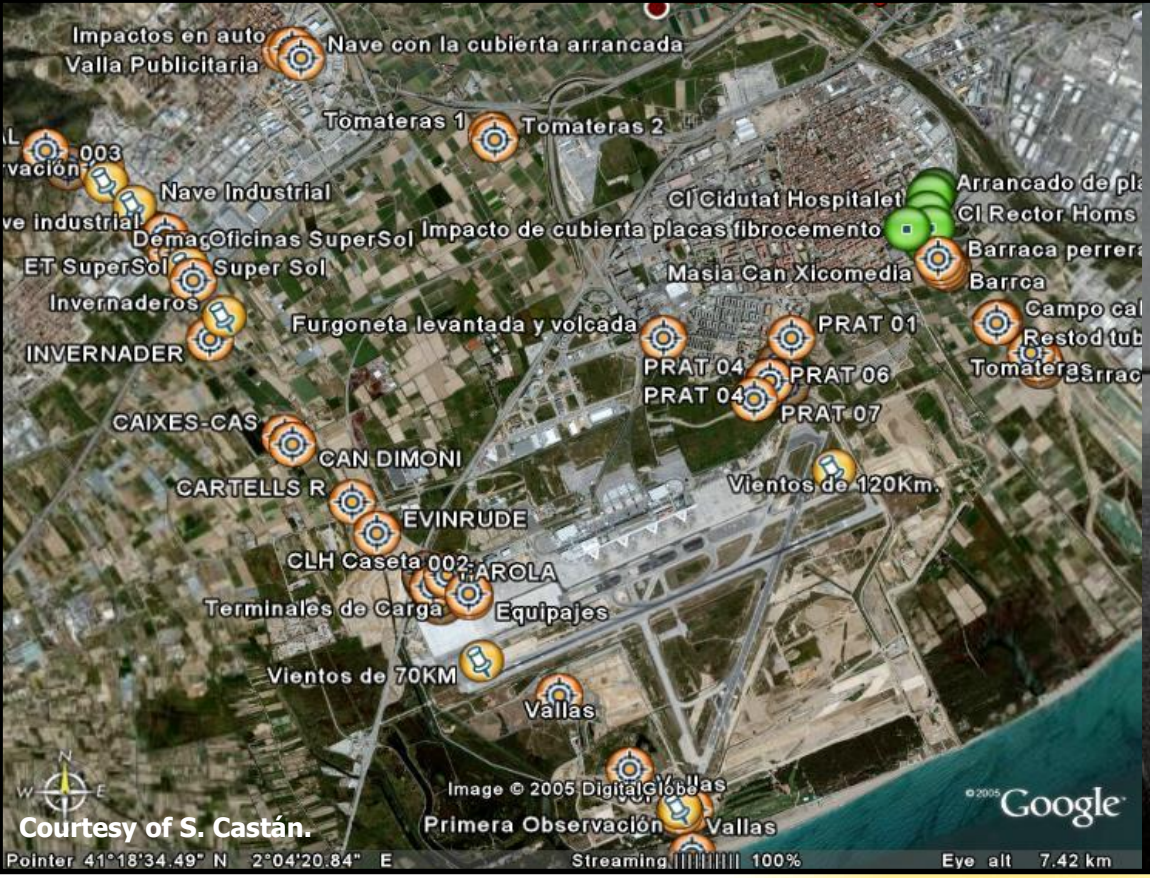
	Doppler Signatures ME	TVS
■ Type I tornadoes (form within a ME) - Isolated SC (HP, Classic, LP) Browning 1965, JAS - SC in a line of thunderstorms - mini SC (small ME) Suzuki et al. 2000, MWR	✓	✓
■ Type II tornadoes (no ME, but CL) Brady & Szoke 1989, MWR; Wakimoto & Wilson 1989, MWR - Landspout - Gustnado (along gust front, no condensation-funnel)	X	✓

Introduction

- A series of waterspouts & tornadoes (largest local outbreak) were observed in the afternoon of 7 September 2005. Most of them started as waterspouts and moved inland (to NW) a few km.

- They affected the SW Barcelona metropolitan area (including the airport), a densely populated zone (many pictures & videos).

The first Castelldefels tornado (ca. 1700 UTC) damaging the railway power lines. Photograph courtesy of M. Ribera & C.W.Chiu.



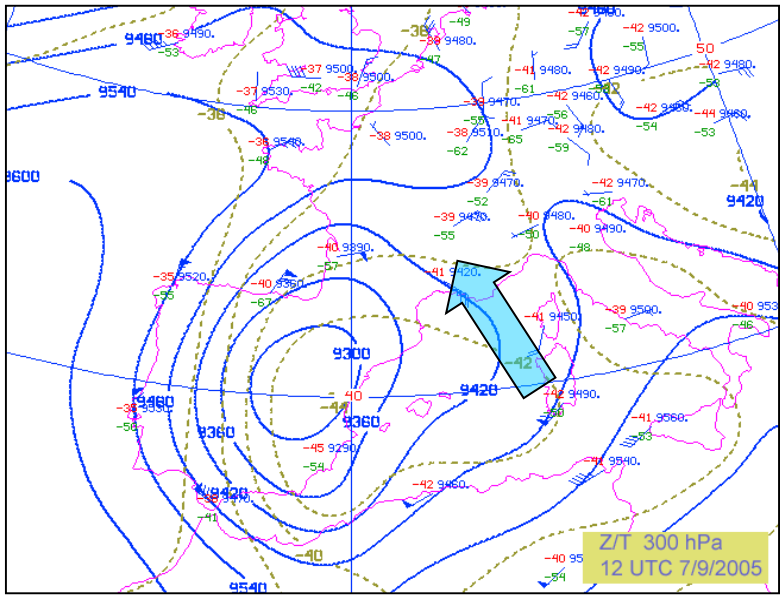
Courtesy of S. Castán.

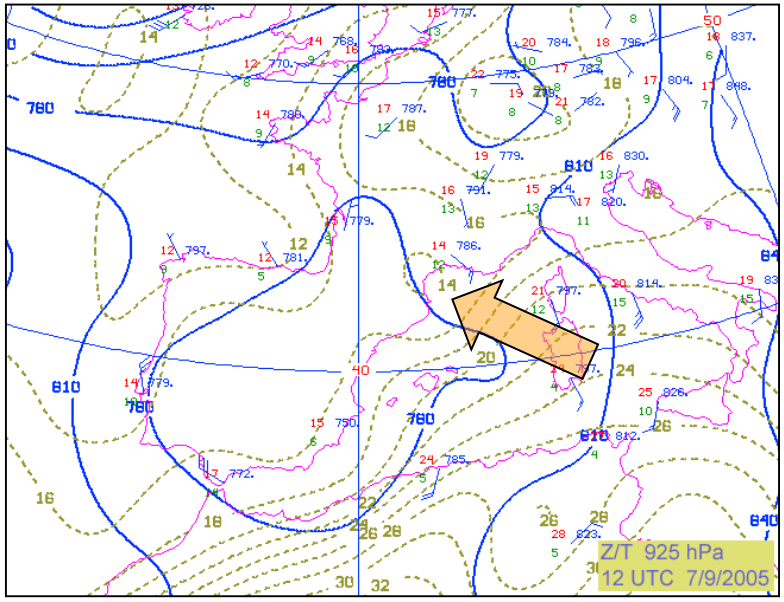

View from the Barcelona airport runways (1751Z). Photograph courtesy of R. Romero.

■ The site survey identified four different tracks. Some visual reports indicate up to 11 funnel-clouds.

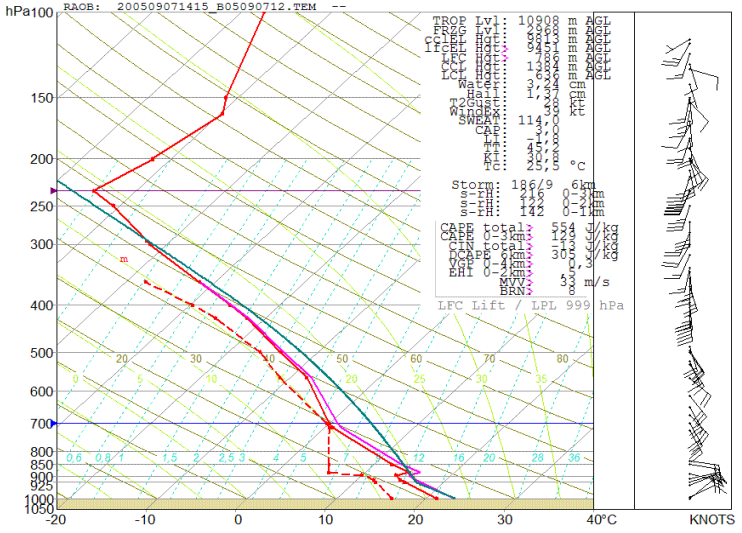
■ Despite extensive damage (8.5 M€), intensity generally weak (F0 – F1) but one F2 (affected 2 commercial airplanes, hangar, VOR, etc.). Fortunately no fatal victims.

Cloud structures with rotational aspect (1820 UTC). Photograph courtesy of M. Messegué.

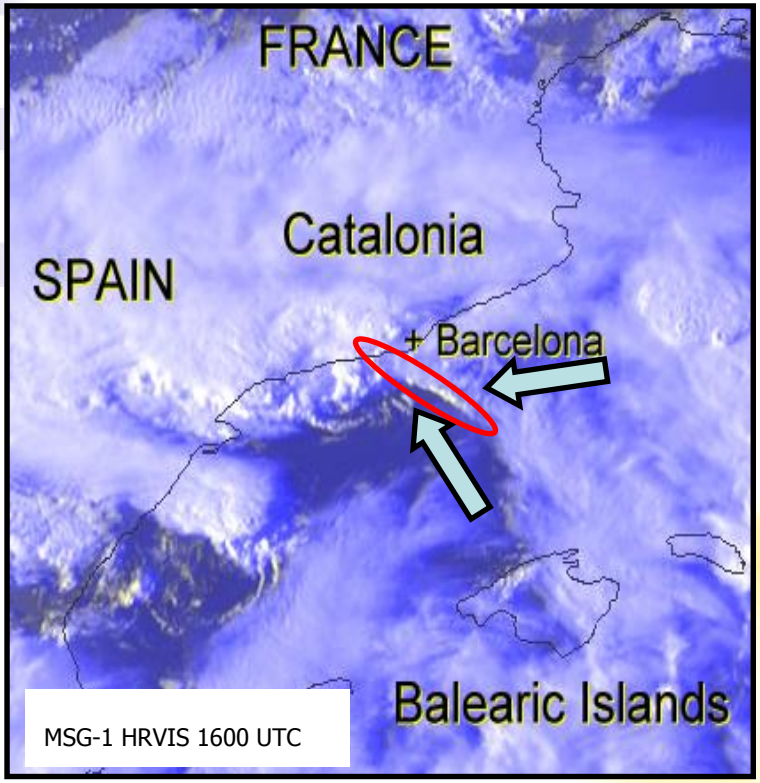


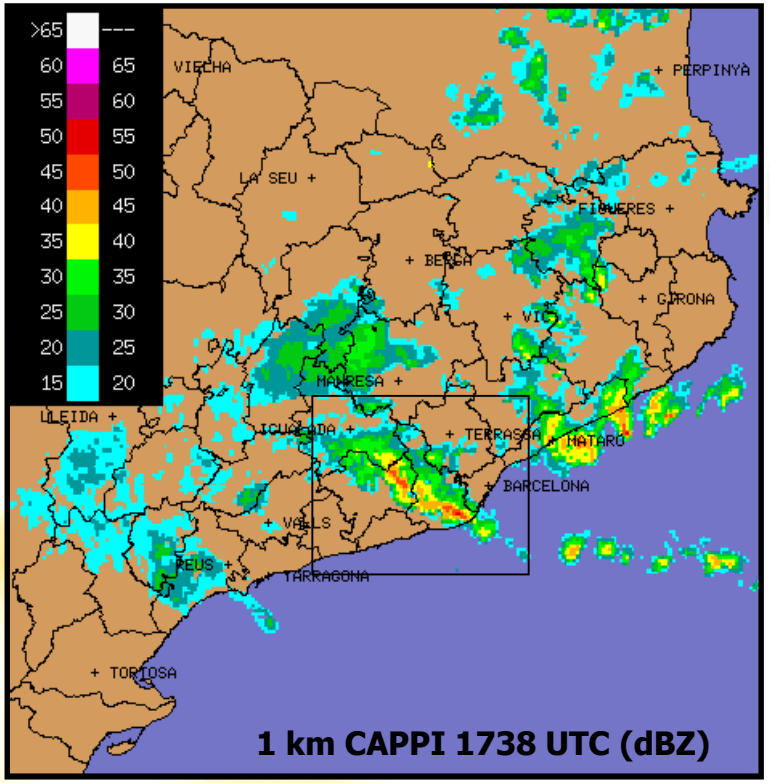


- Deep cold (upper level) low over Iberian Peninsula (-18ºC 500 hPa).
- Jet streak (SE-NW oriented) over Catalonia.
- Weak warm advection < 850 hPa over Catalonia.
- Low-level E/NE flow over Catalonia.

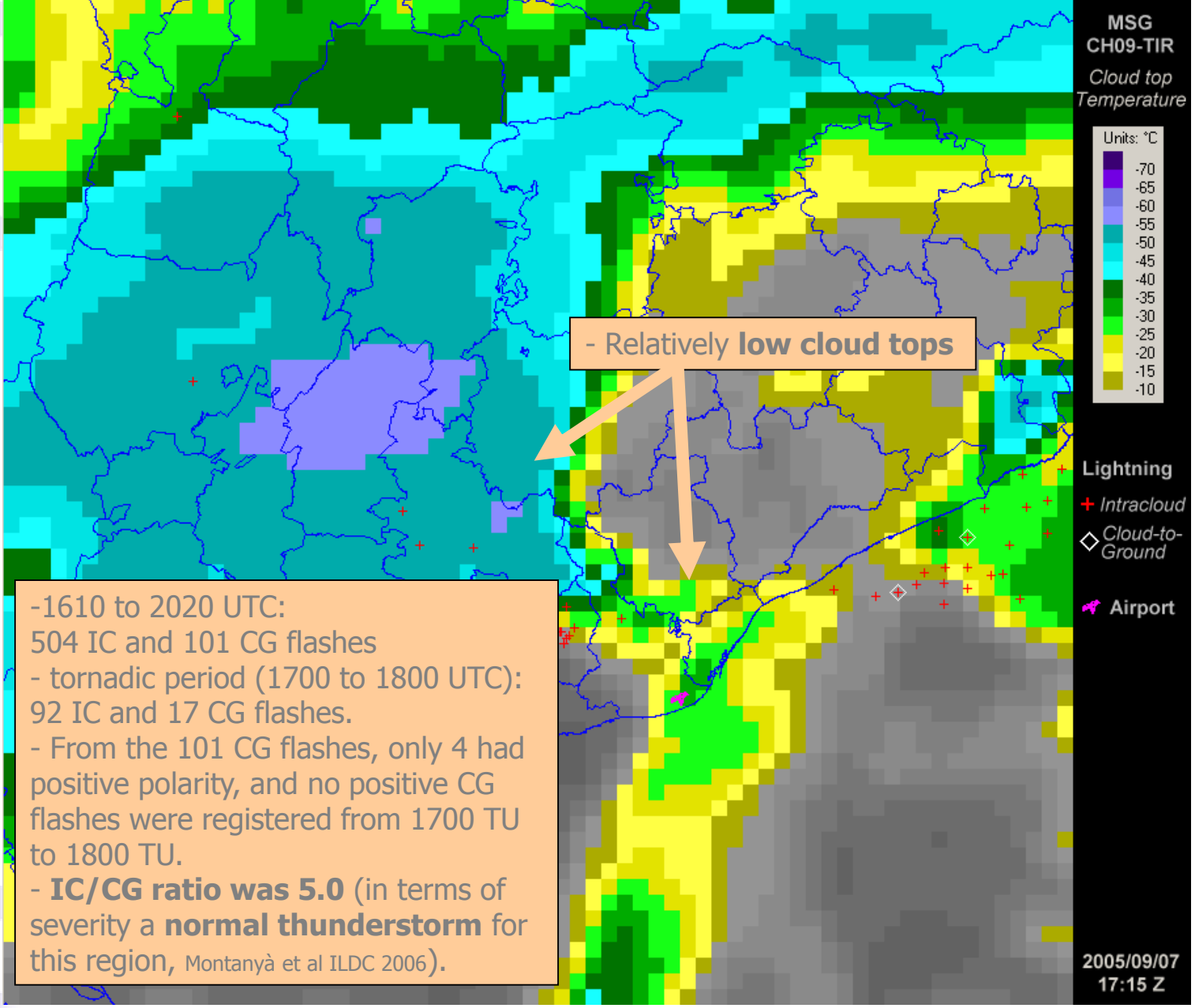


- Easterly LLJ (40 kt) at 850 hPa. Max. vel. 110 km/h < 1500 m. At 500 m ASL, 100 km/h (Fabra obs.).
- Moderate instability (554 J/kg) but high vertical wind shear and helicity (217 m^2/s^2) (Conditions associated to severe storms according to local studies, cg Tudurí & Ramis 1997, WF)

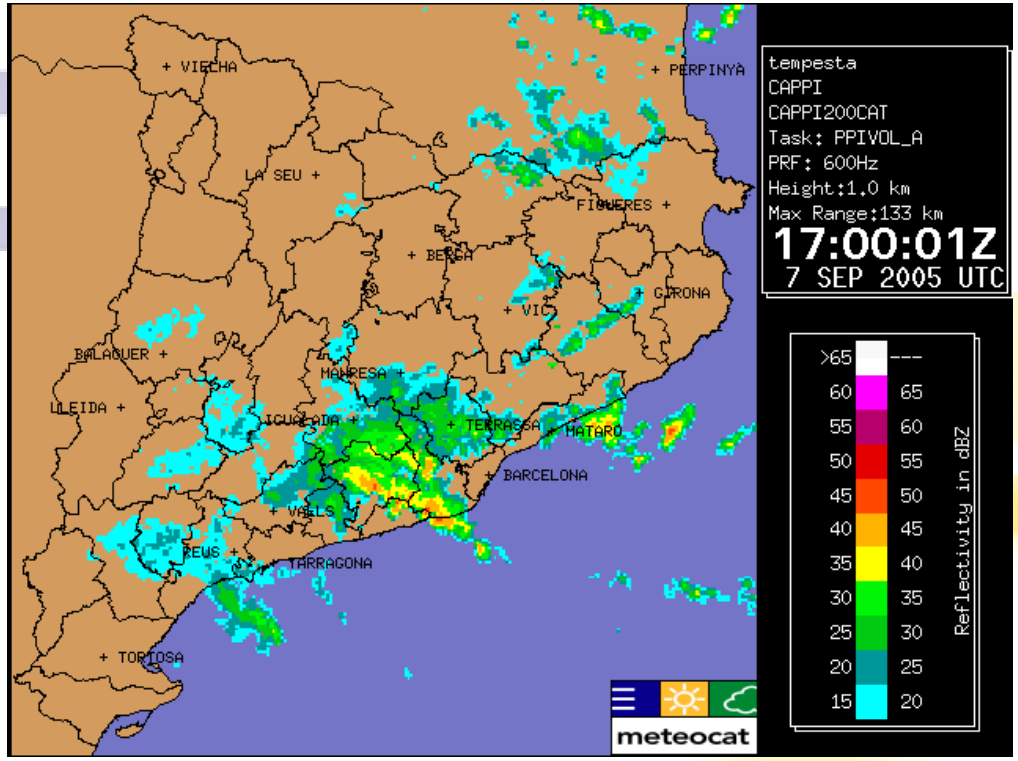


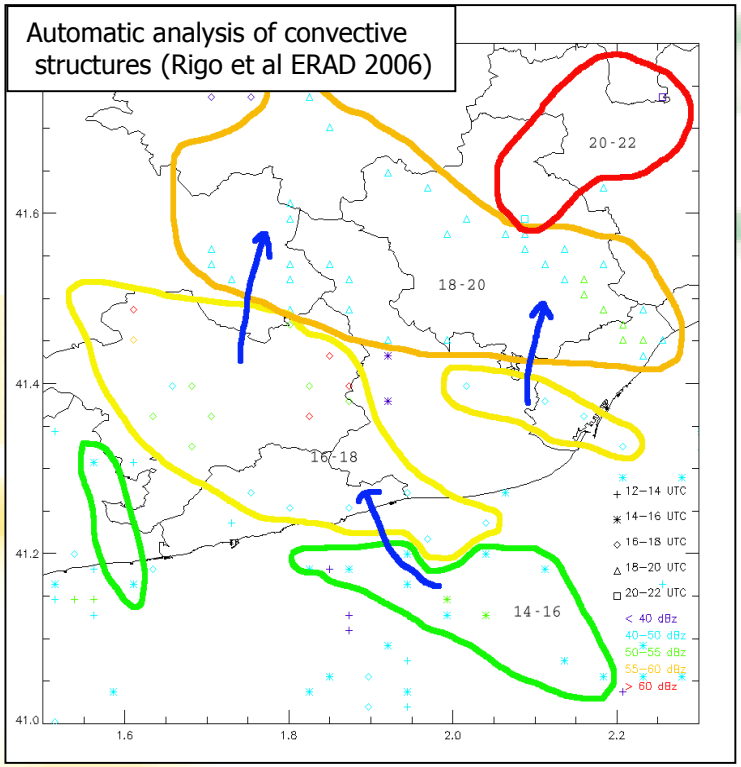


- N of the CL, the flow E/NE while & S side ranged from SE to SW, i.e. there was *horizontal directional shear (HDS)* across the CL.
- No evident mesoscale temperature gradient was present.
- Convective line developed along the CL



-1610 to 2020 UTC:
504 IC and 101 CG flashes
- tornadic period (1700 to 1800 UTC):
92 IC and 17 CG flashes.
- From the 101 CG flashes, only 4 had positive polarity, and no positive CG flashes were registered from 1700 TU to 1800 TU.
- **IC/CG ratio was 5.0** (in terms of severity a **normal thunderstorm** for this region, Montanyà et al ILDC 2006).

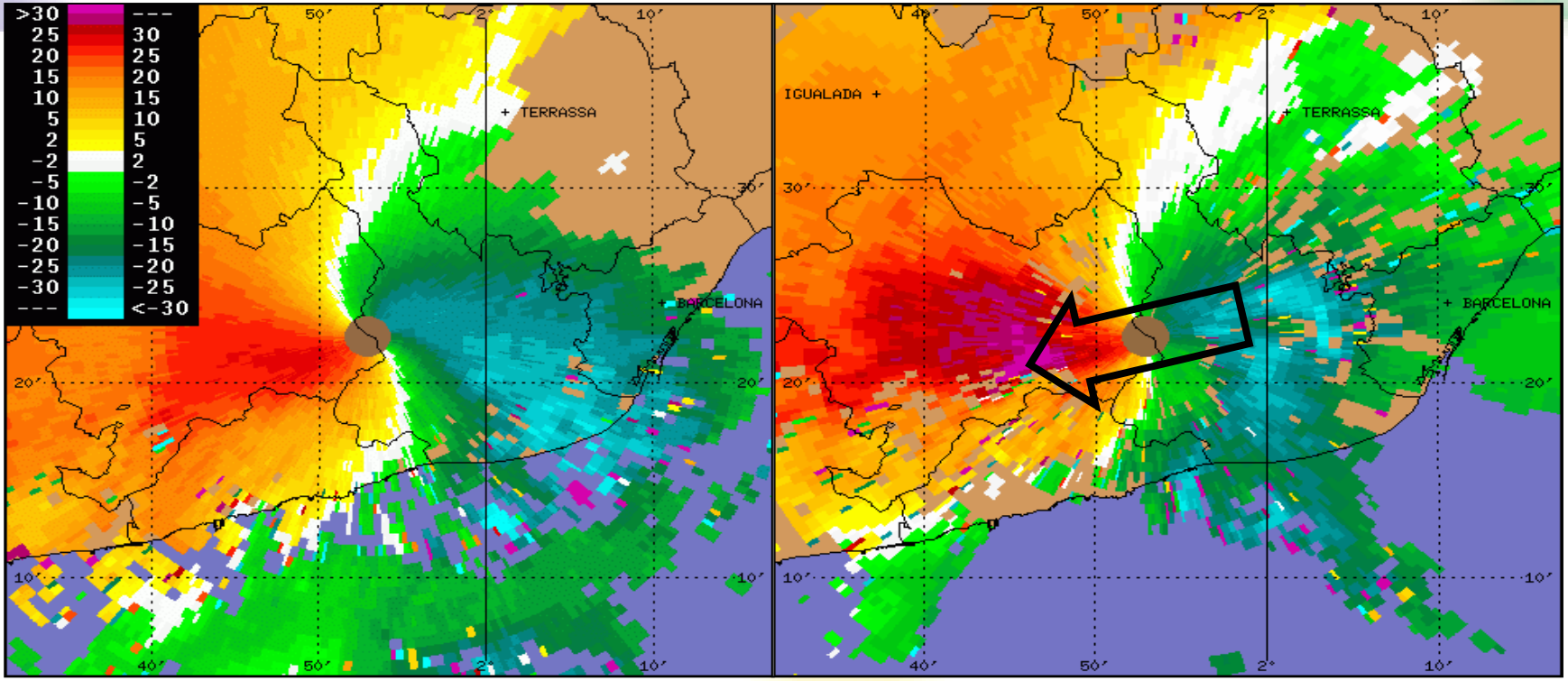




- Convective cells (CC) associated to tornados developed/moved along CL (Train effect Doswell et al., 1996 WF)
- CL persisted for 4 hours. Maximum length: 200 km.
- Small MCS: Back building squall line. Bluestein and Jain, 1985 JAS
- Possible mini-bow echoes along CL.
- Small intense (40-50 dBZ) CC over the sea. Low echotops (< 6 km).
- No clear classical supercell features (No mesocyclone identified,..).

PBE Radar observations: RV

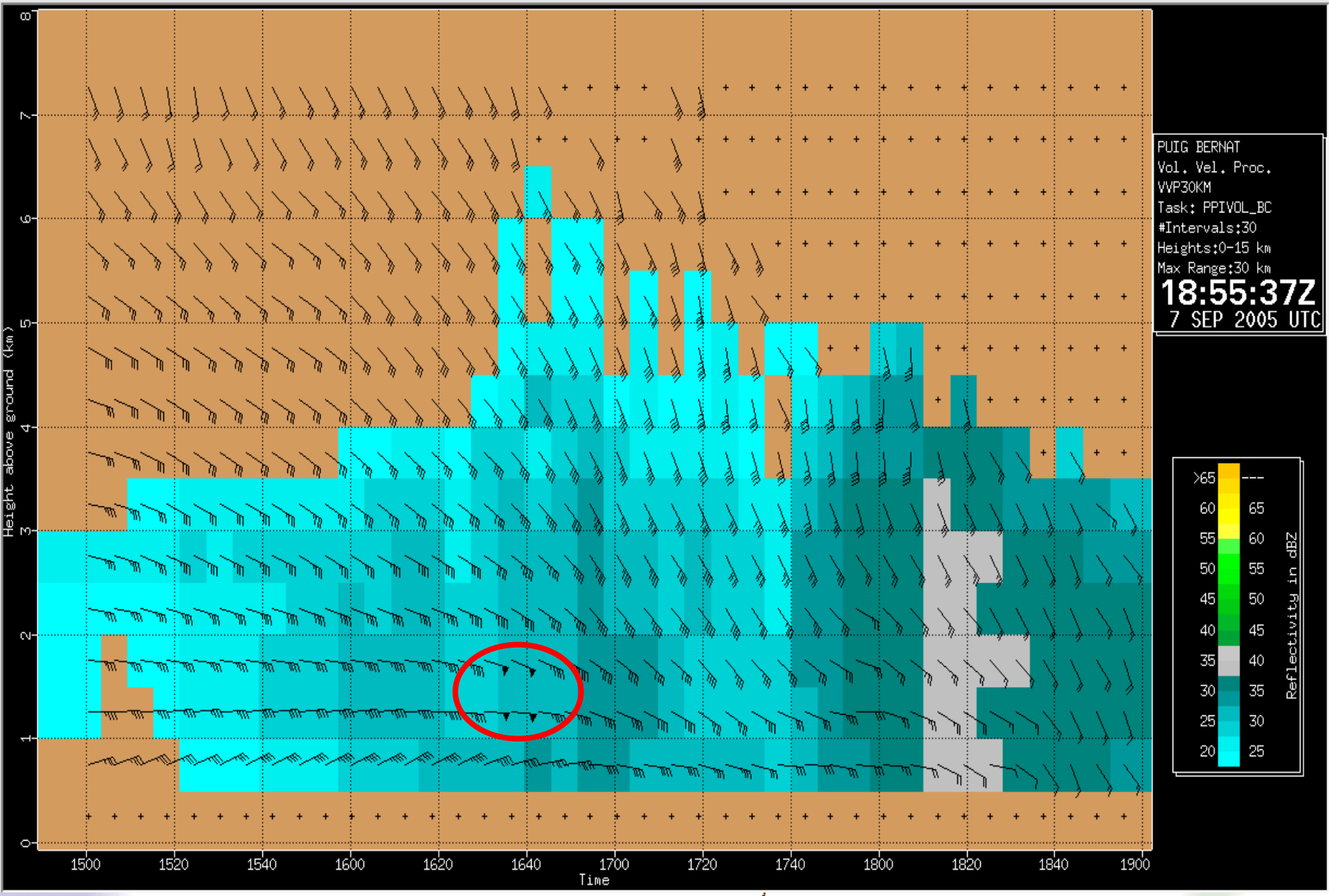
1608 UTC — 32 km — 1644 UTC



4.0º PPI radial velocity field (m/s) observed by the PBE radar.

- Warm advection & vertical wind shear ("S" shaped W field)

- Wind maximum (LLJ) just before the waterspouts & tornadoes


PUIG BERNAT
Vol. Vel. Proc.
VVP30KM
Task: PPIVOL_BC
#Intervals:30
Heights:0-15 km
Max Range:30 km
18:55:37Z
7 SEP 2005 UTC
Height above ground (km)
Time
1500
1520
1540
1600
1620
1640
1700
1720
1740
1800
1820
1840
1900
0
1
2
3
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5
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>65
60
55
50
45
40
35
30
25
20
65
60
55
50
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30
25
Reflectivity in dBZ

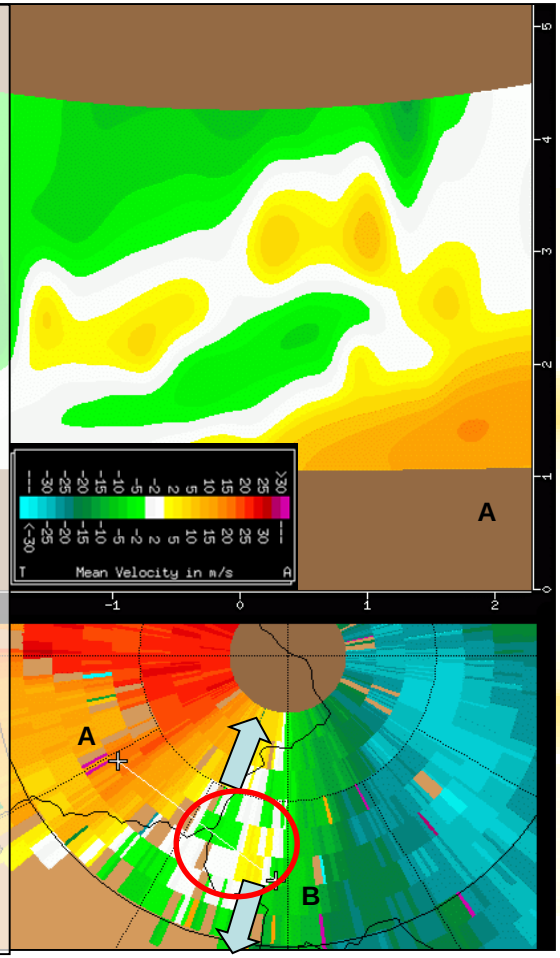
PBE Radar observations: RV & Z

… Moreover, though there are important blockages to the N (Bech *et al.* 2003 JAOT), coverage is good to the S.

A velocity couplet was identified in 4 different PPIs of the 1700 UTC PBE volume scan.

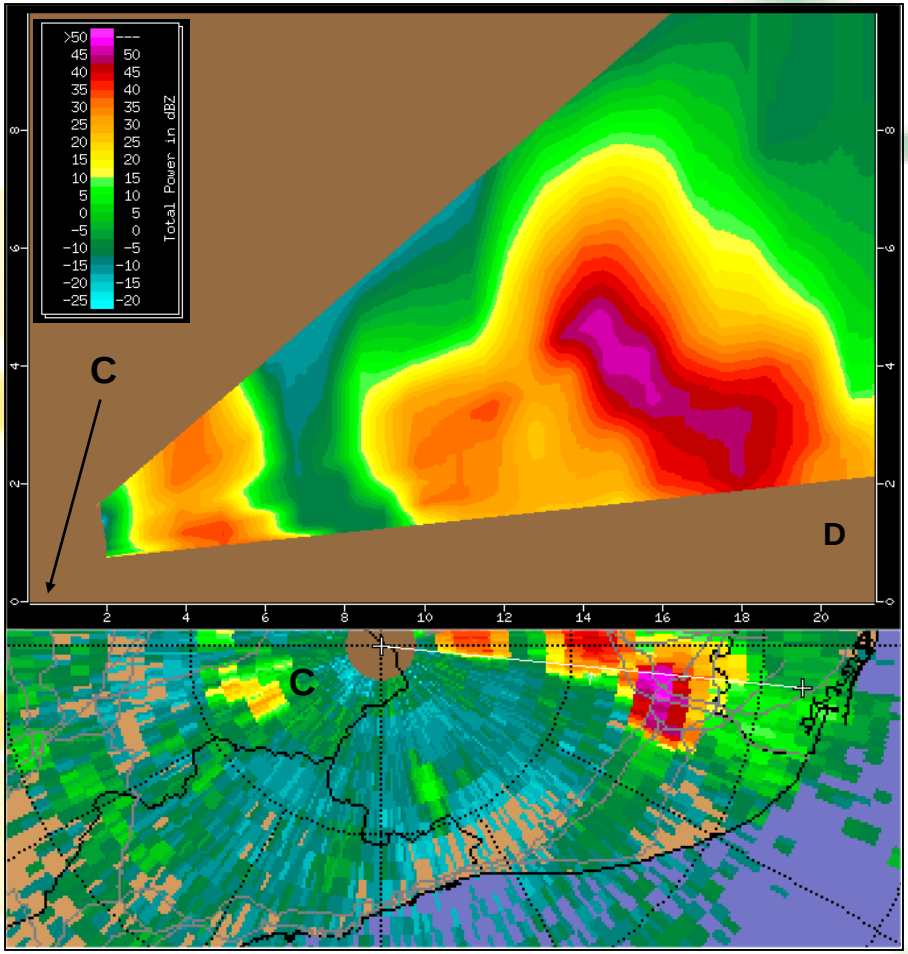
The couplet was embedded in a high vertical shear environment and was located very near the radar (8 km). It extended from 1.5 to 3.0 km and was approximately 2.5 km wide. If associated to a rotating structure, it would be a misoanticyclone.

It was observed in the limit of a precipitating structure coming from the SE, the same direction…



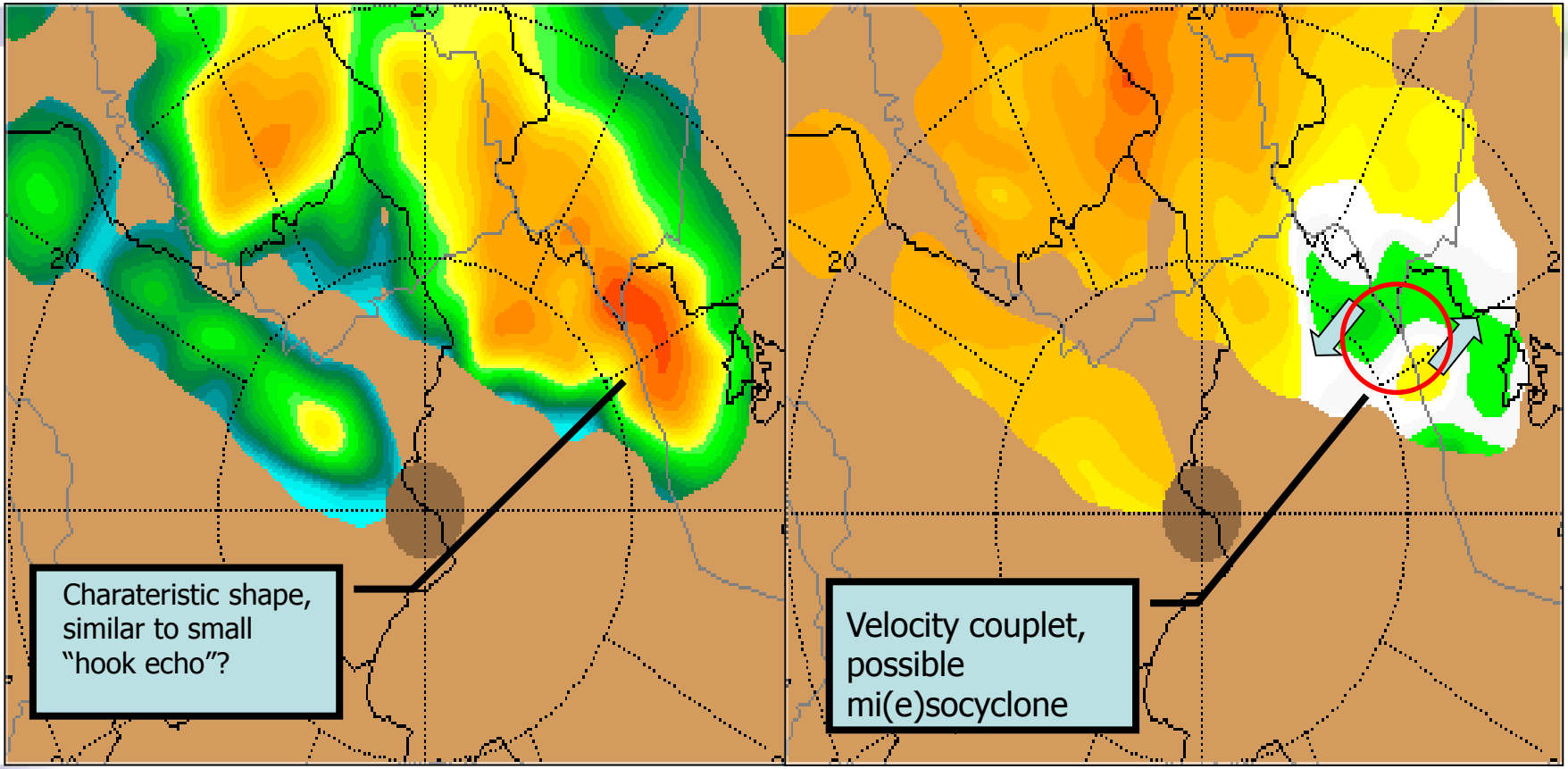
PBE radar 6º PPI (17:03 UTC) velocity couplet in the radial wind field (bottom) and the corresponding cross section (top) between the segment AB. Rings are at 5 km intervals and maximum height is 5 km.

- Possible MISOANTICYCLONE.



PBE radar 16º PPI (18:11 UTC) reflectivity factor (bottom) and the corresponding cross section (top) between the segment CD. Rings are at 10 km intervals and maximum height is 8 km.

PBE Radar observations: RV & Z



PBE radar 8º PPI (18:34 UTC) reflectivity factor (left) and radial wind (right). Rings are at 10 km intervals. Colour scales as in previous images.

Concluding remarks (1/2)

*Some characteristics identified about the **environment**:*

- **Mesoscale convergence line** over the sea resulting possibly from flow interaction with Balearic Islands. Recurrent convergence lines with similar synoptic situations (Balearic Island outbreak, Homar et al 2001 At.Res.).

- **LLJ** north side of convergence line, prior to waterspouts & tornados.

- Formation of a **Convective Line** formed along the convergence line (small squall lines with slow northward movement).

- **Horizontal Directional Shear** across the CL and strong updrafts could have favoured waterspouts and tornadoes development and movement along convective line.

Concluding remarks (2/2)

*Regarding the **convective structures** associated to the waterspouts & tornadoes:*

- **No classical supercell tornadoes** (No mesocyclone, Z, sat) but possible miso(anti)cyclones identified (mini SC?).

- Identification of developing **CL over the sea** (HRVIS MSG and Z field) could alert forecasters. Also, **LLJ** and **shear** near **CL**.

- **Subjective** identification of small couplets (associated with misoscale circulations) is difficult in operational surveillance tasks. Possible use of **automatic** procedures, Conejo & Elizaga, 2004 INM TN43.

- Despite their potential destructive effects the **tornadic cells presented a modest appearance** in remote sensing operational products (input from spotters could help!).