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Recent Severe Weather Events over Apulia Region Observed by Newly Installed C-Band Polarimetric Doppler Radar

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Outline

- Introduction
- The RIVONA project
- Torchiarolo C-Band Dual Polarity Radar
- Case studies:
  - ✓ Flash-Flood, 30 November – 3 December 2013
  - ✓ Heavy Hailstorm in the Itria Valley, 7 October 2014

Introduction

- The Mediterranean Sea is frequently struck by high impact severe weather events causing disasters and serious threats for human safety.
- The development of a suitable weather radar network has been playing an increasingly importance for implementing pervasive and efficient nowcasting systems.
- In this paper, we will focus on Apulia region, located in the Central Mediterranean Sea, in South-eastern Italy.

- Although several heavy rain episodes have affected the region in the last years, Apulia is still lacking of an adequate weather radar coverage!

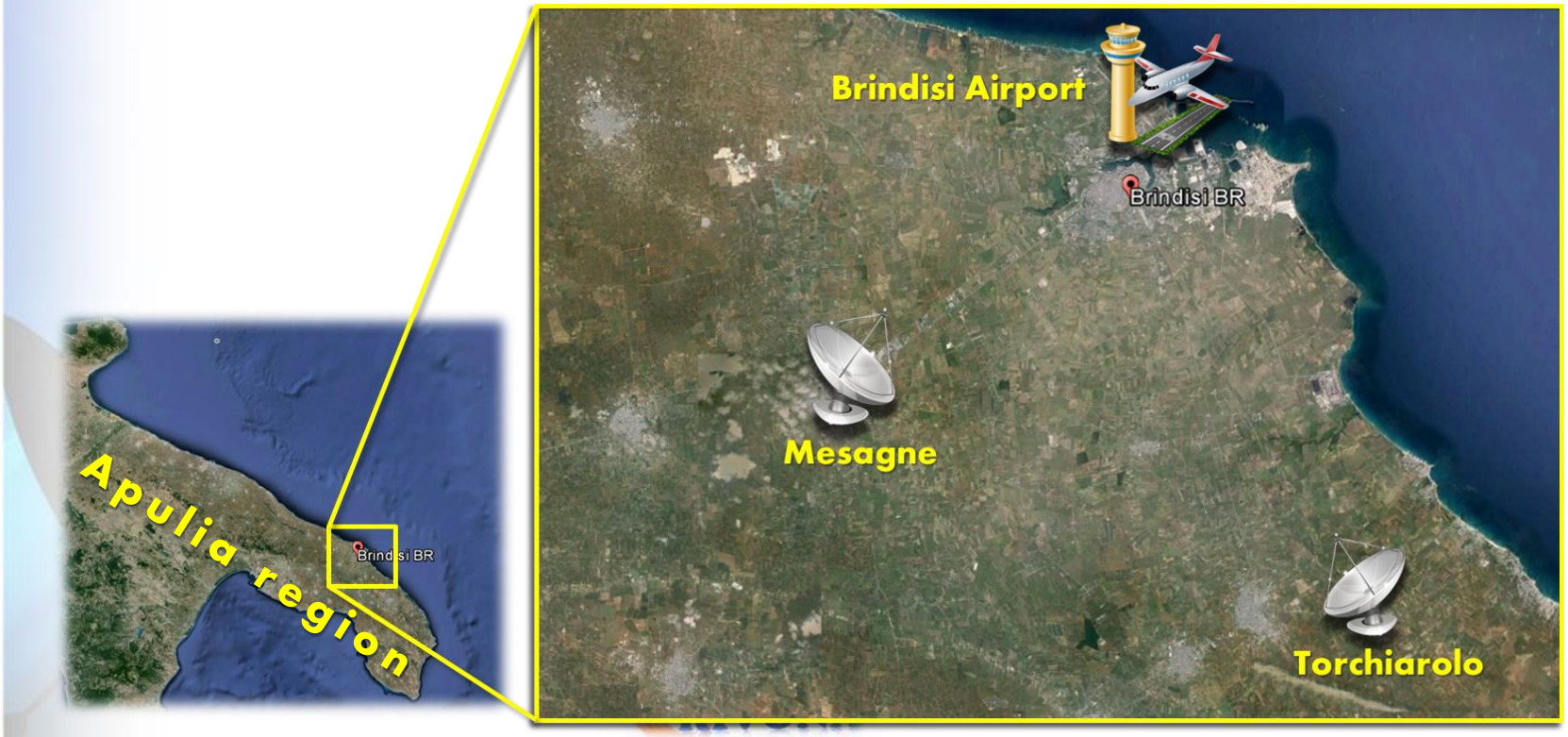
RIVONA

The breakthrough: the RIVONA project

- The **RIVONA project** represents an important breakthrough in weather radar coverage over Apulia region**.**
- RIVONA ("Flight risks mitigation and nowcasting at airports") is a research project funded by Apulia region within FP7.
- RIVONA resumes the "Joint Airport Weather Studies" (JAWS), the first innovative study on microburst-type wind-shear events conducted in the early 80's near to Denver's airport.
- RIVONA aims at
  - developing an advanced wind-shear alert system
  - reducing other risks to flights connected with the storm:
    - destructive precipitation
    - lightning
    - icing of aircraft
    - aquaplaning on runway
    - severe turbulence
  - improving airport nowcasting systems

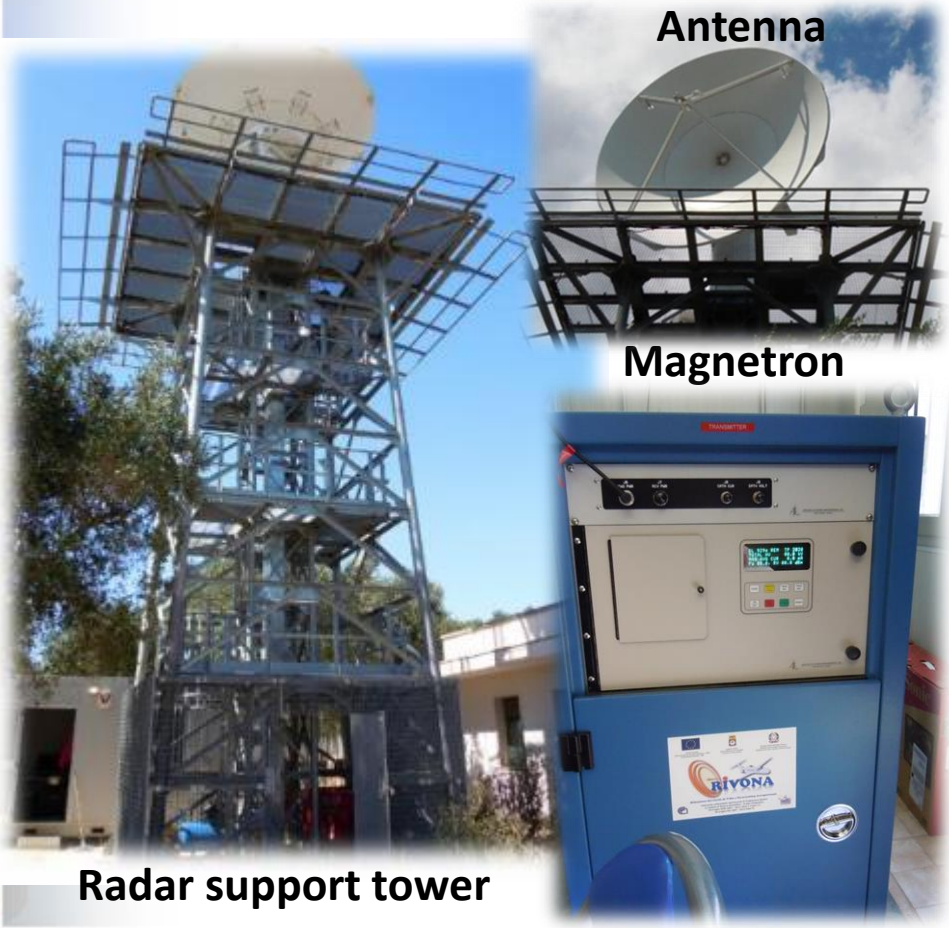
The RIVONA project

- The RIVONA framework is made up of two C-band doppler radars, both around the airport environment.
  - A radar, with full dual-polarization capability, is located in Torchiarolo where another one, in Mesagne, is now close to completion.
- A network of six microbarographs, three microwave disdrometers (PLUDIX) and a Ka-band mobile doppler radar will soon be deployed along the airport landing strip complementing the C-band radar observations of the wind-shear events.



Torchiarolo C-Band Dual Polarity Radar

- Despite the principal aim of RIVONA project, the newly installed Torchiarolo radar is on its own a powerful tool able to detect and follow the evolution over the entire region of intense convective precipitations.
- Equipped with the latest version of the UCAR-TITAN (Thunderstorm Identification Tracking Analysis and Nowcasting) software.



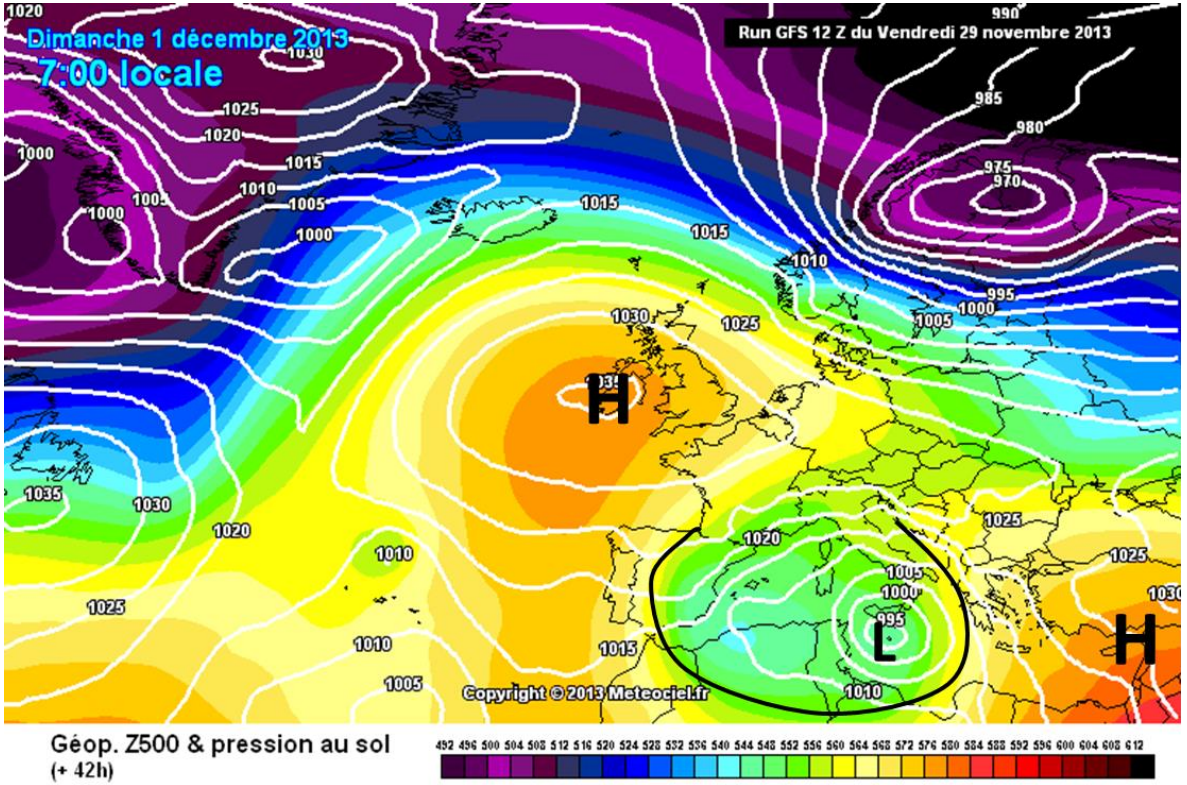
RADAR FEATURES

Feature	Value
Frequency	5.625 GHz
Beamwidth	1°
Antenna gain	dB
Dish diameter	4.2 m
Pick power	250 kW
Duty cycle	0.001
Pulse width	0.4 - 2 μs
PRF	200 – 625 Hz
Range	10 – 297 Km

Flash-Flood, 30 Nov. – 3 Dec. 2013

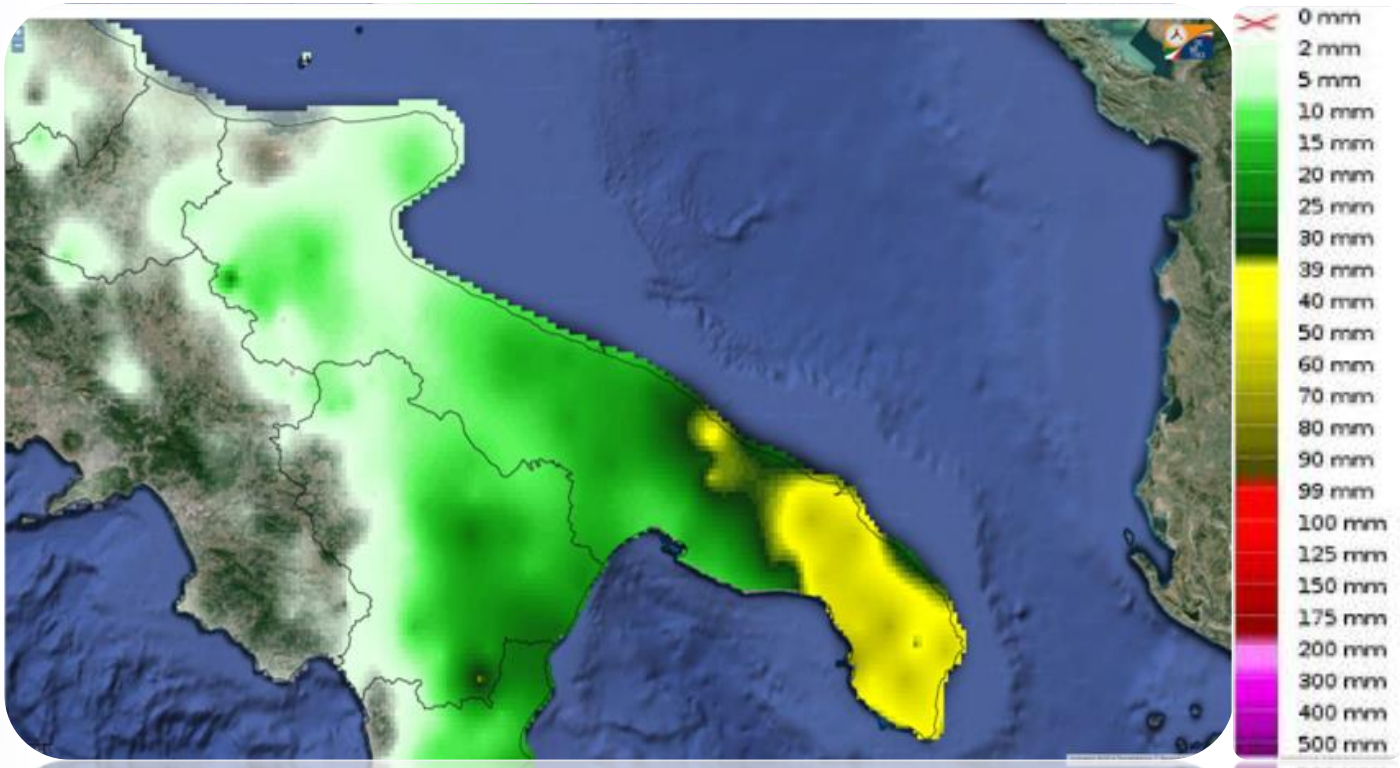
Synoptic analysis

- The cyclonic circulation in the Mediterranean basin stemmed on 30 November from a deep large-scale 500 hPa trough extended from North Europe to Libyan midland.
- A cyclonic circulation conveying warm humid air from Sicily to Greece quickly took place over the northern Libyan coast.
- On the 1st of December, due to the eastward movement of the Azores High's major axis, the entire structure rapidly cut off over the Central-Western Mediterranean Sea.



Flash-Flood, 30 Nov. – 3 Dec. 2013

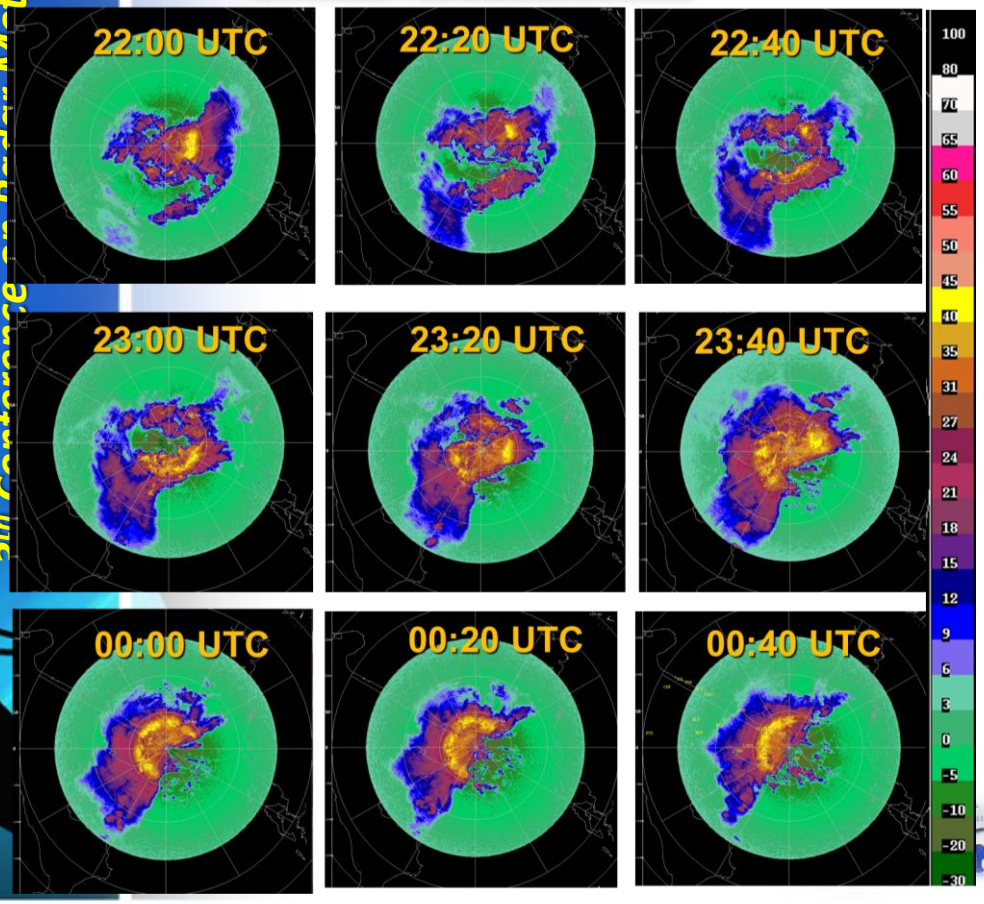
- The rainfall event firstly hit south Apulia, in particular Salento Peninsula, almost without interruption from Saturday afternoon until early morning of the following day.



Total cumulated precipitation from 12:00 UTC on 30 November to 00:00 UTC on 1 December 2013

Flash-Flood, 30 Nov. – 3 Dec. 2013

Radar analysis



- The sequence of reflectivity maps clearly illustrates the mesoscale structure of the system embedding convective cells in a general stratified structure.
- Salento Peninsula dealt with persistent but mainly moderate rain without significant thunderstorm episodes reported.
- Widespread reflectivity peaks up to 45 dBz, corresponding to a rain rate of about 25 mm/h.
- In the following days, the system moved northward giving rise to severe large-scale hydrogeological phenomena in the north part of Apulia.

Hailstorm in the Itria Valley, 7 Oct. 2014

Thermodynamic analysis

- An intense hailstorm which swept through the Itria Valley during the afternoon of 7 October 2013. In particular, Fasano and Ostuni were severely affected by two different storms which in few minutes made the streets completely whitewashed by a mound of ice up to 40 cm.
- The hail event was characterized by a moderately unstable atmosphere

Index	Value
Lifted Index	-3.05 °C
Total Totals	51.90 °C
K Index	25 °C
SWEAT Index	161.2
CAPE	562 J/Kg
CIN	-31.5 J/Kg
Showalter Index	0.11

INSTABILITY INDICES FOR BRINDISI ON 7 OCTOBER 2014 AT 12:00 UTC

Pictures taken in Fasano after the powerful hailstorm

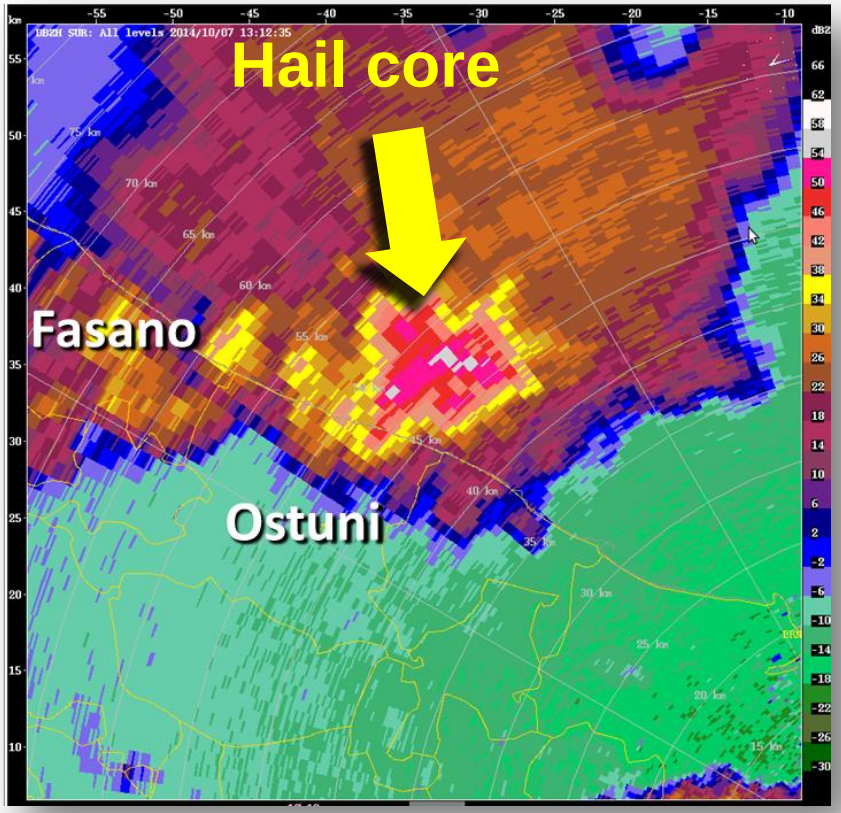
RIVONA

Hailstorm in the Itria Valley, 7 Oct. 2014

Radar analysis

- Plan Position Indicator (PPI) Torchiarolo polarimetric data taken at 0.3° elevation angle refers to the Itria Valley hail core moving eastward to the Adriatic Sea once it had already hit Ostuni.

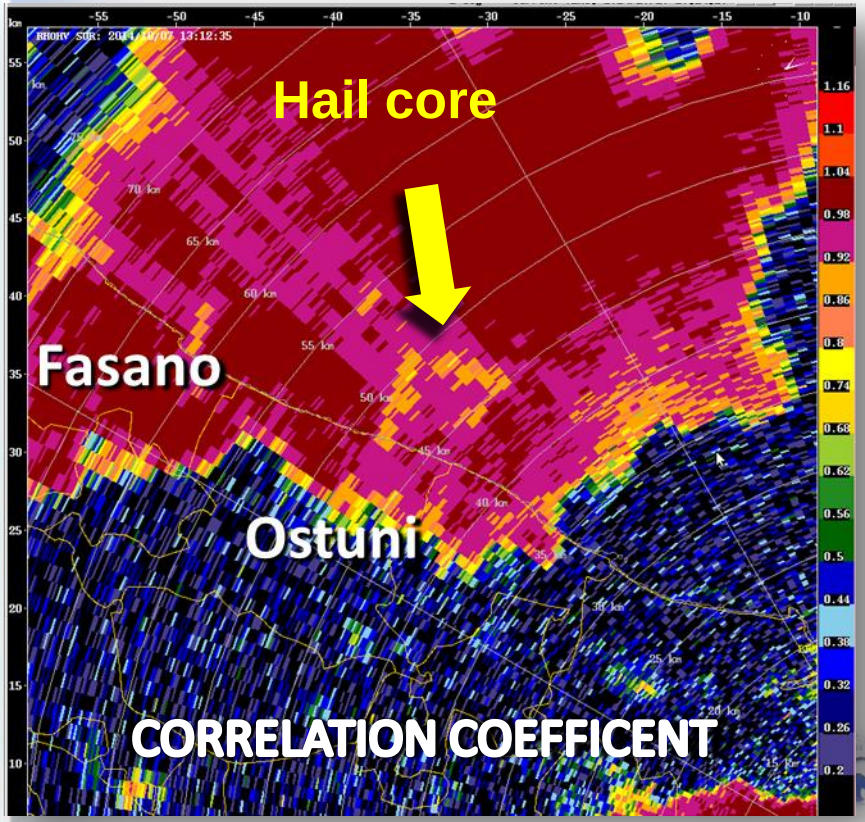
REFLECTIVITY

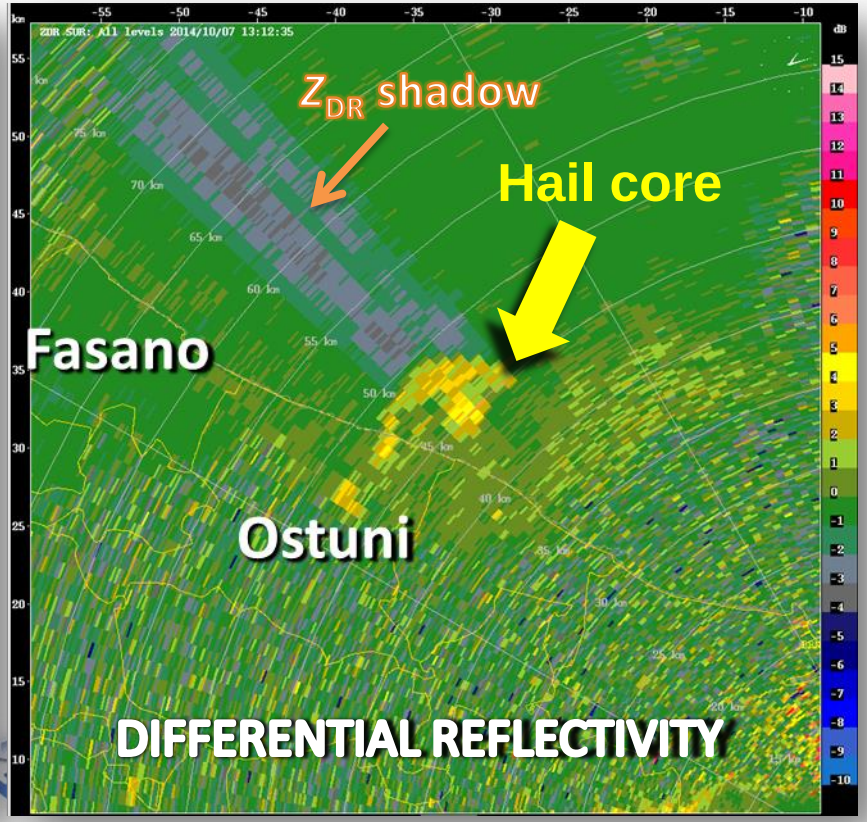


Hailstorm in the Itria Valley, 7 Oct. 2014

Radar analysis

- Reflectivity peaks above 60 dBz combined with correlation coefficient lower than 0.8 are a clear signature of a region with a mixture of irregular shape hydrometeors, specifically big raindrops and melting hailstones.
- Moreover, positive values of Z_{DR} locally as high as 4 dB, owing to melting, smaller resonant-sized hailstones and large raindrops.

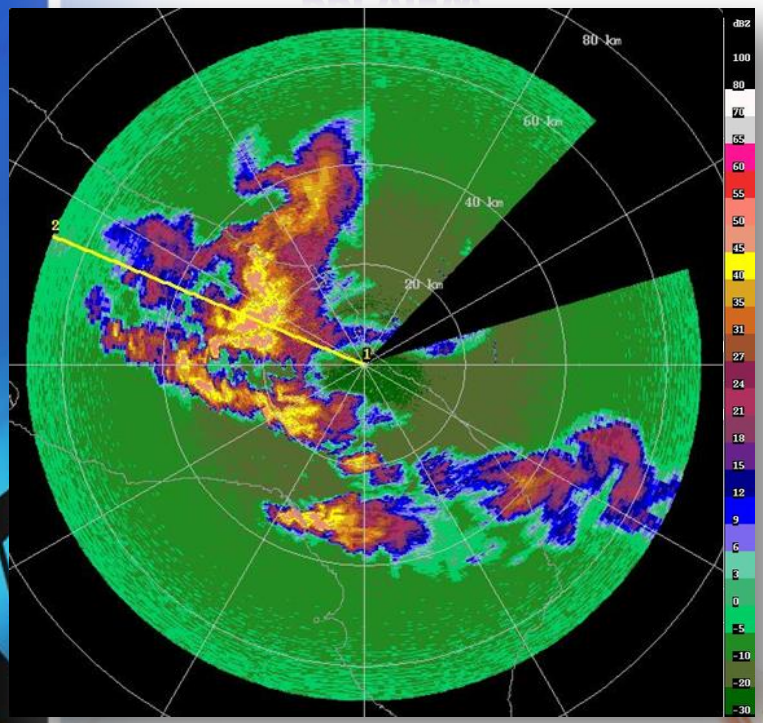




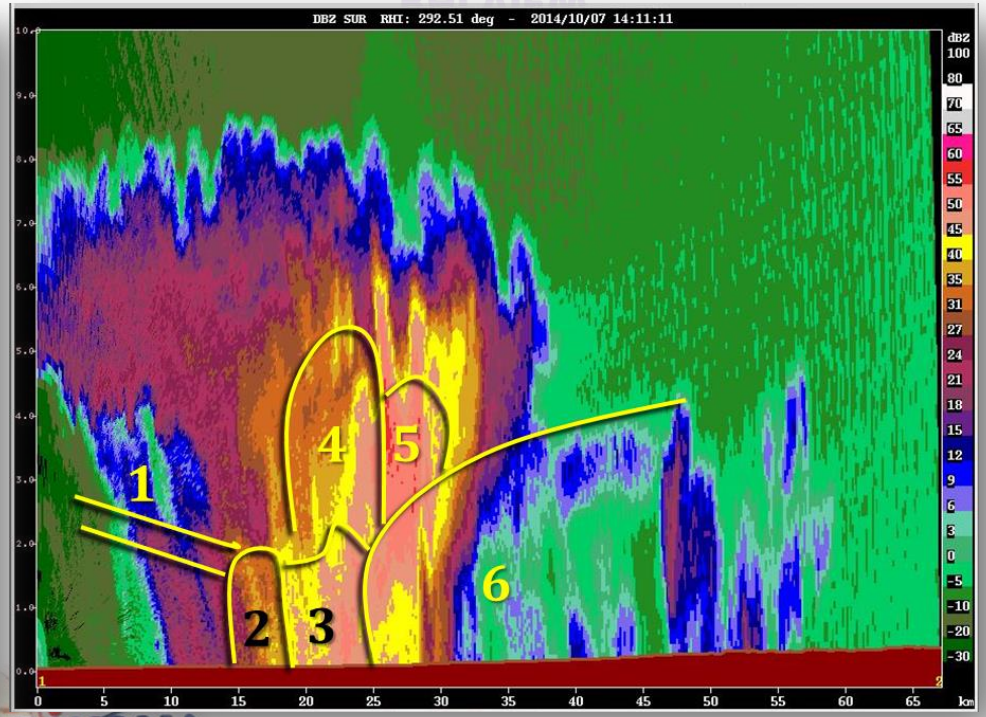
Hailstorm in the Itria Valley, 7 Oct. 2014

- Moderate atmospheric instability conditions continued to support quite widespread convection activity until late afternoon.
- Torchiarolo PPI view at 1° elevation angle taken at 14.11 UTC shows the continued development of locally strong cells capable of heavy rain, hail and gusty winds.
- Range Height Indicator (RHI) view showing reflectivity factor as well as polarimetric data was taken along the yellow line corresponding to 292.52° azimuth angle.

PPI VIEW

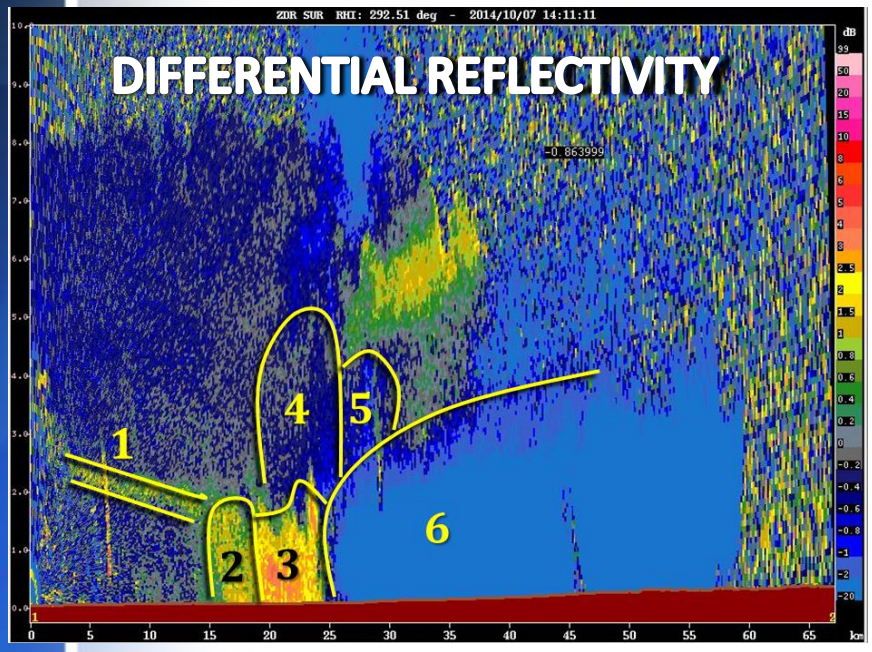


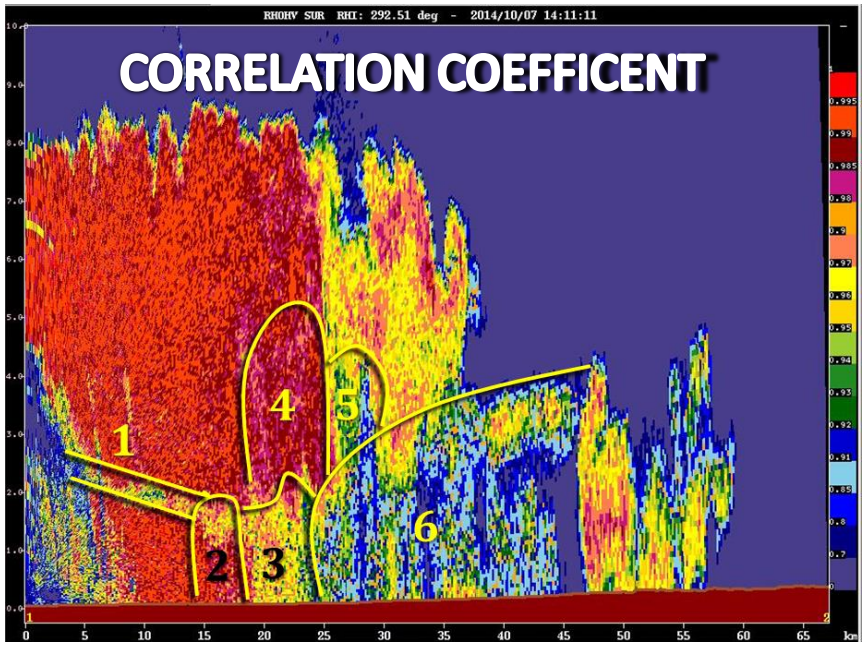
RHI VIEW

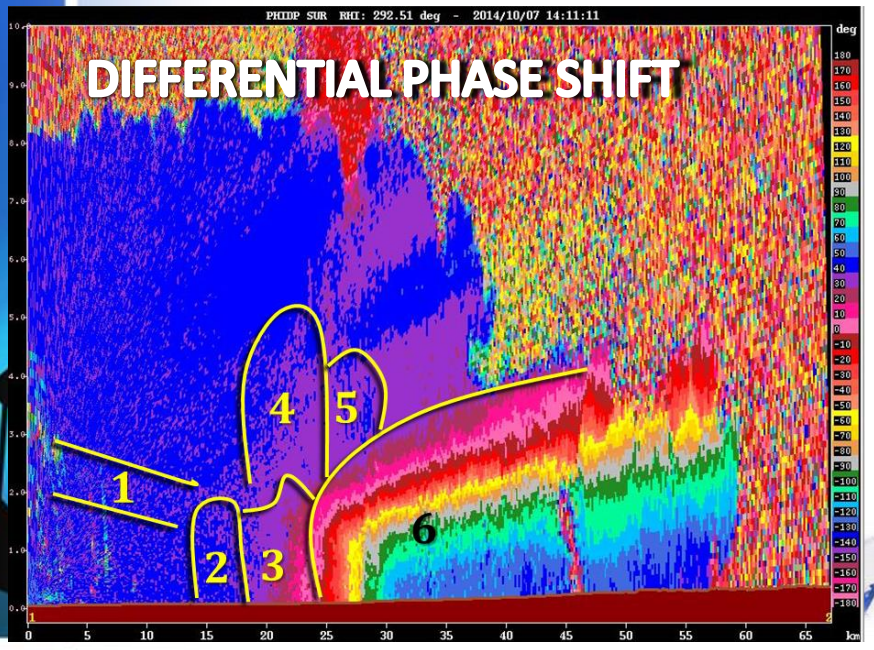


RIVONA

Hailstorm in the Itria Valley, 7 Oct. 2014

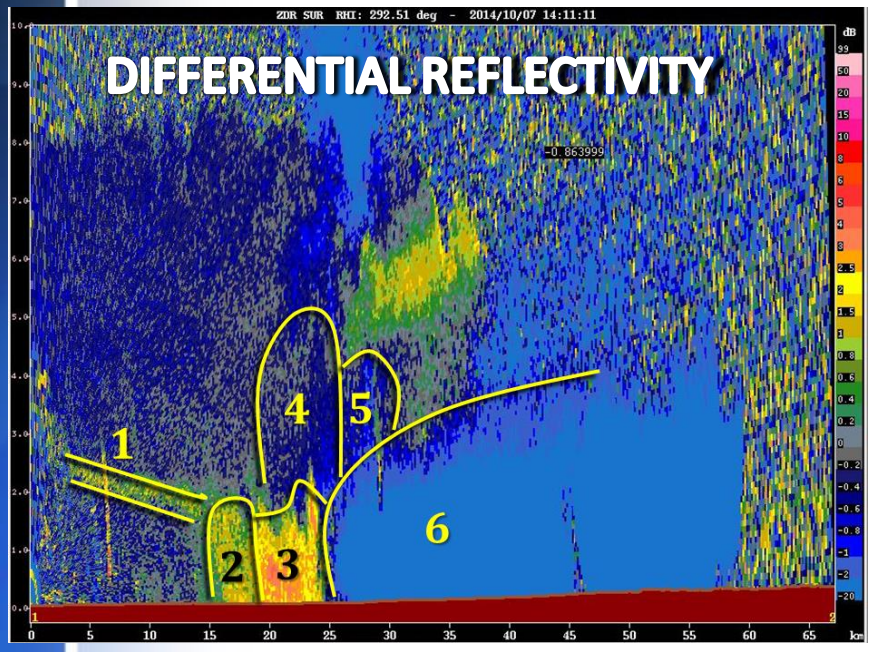


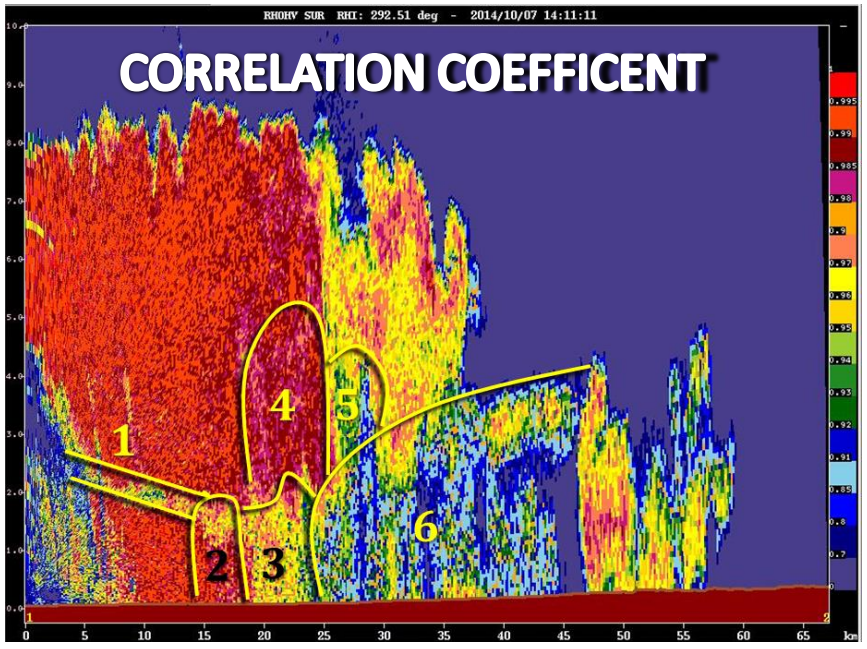


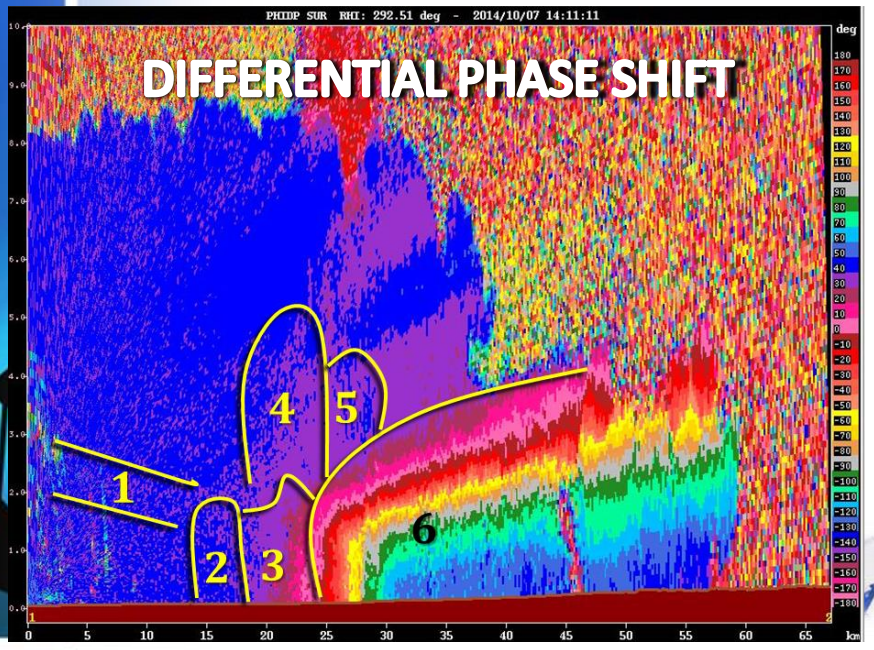


- **Area 1**: melting layer
- **Area 2**: intense downpour mainly composed by medium-size quite spherical drops raindrops
- **Area 3**: heavy rainfall likely mixed with melting resonant-sized hailstones and large raindrops
- **Area 4**: dry tumbling hailstones likely mixed with graupel

Hailstorm in the Itria Valley, 7 Oct. 2014



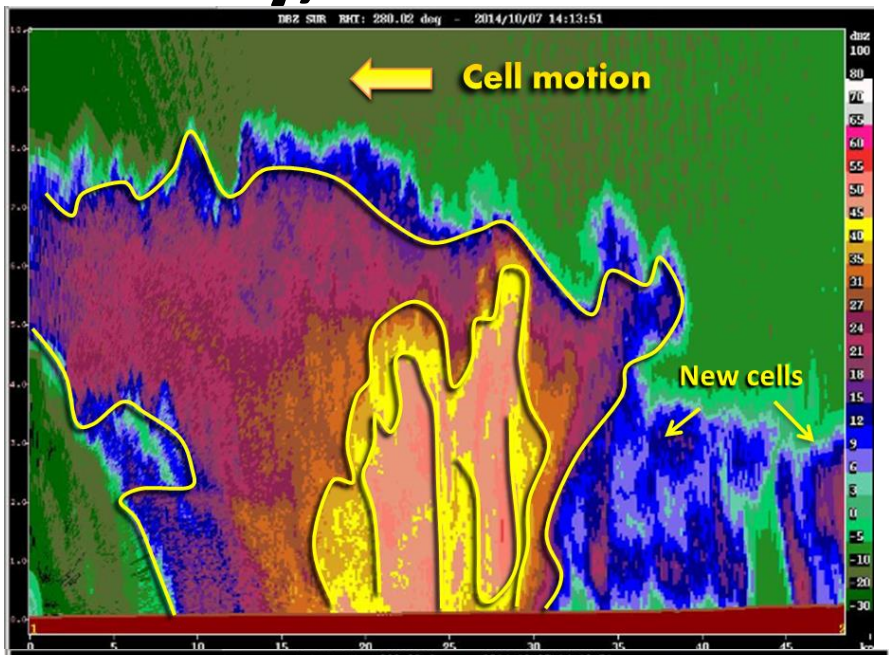


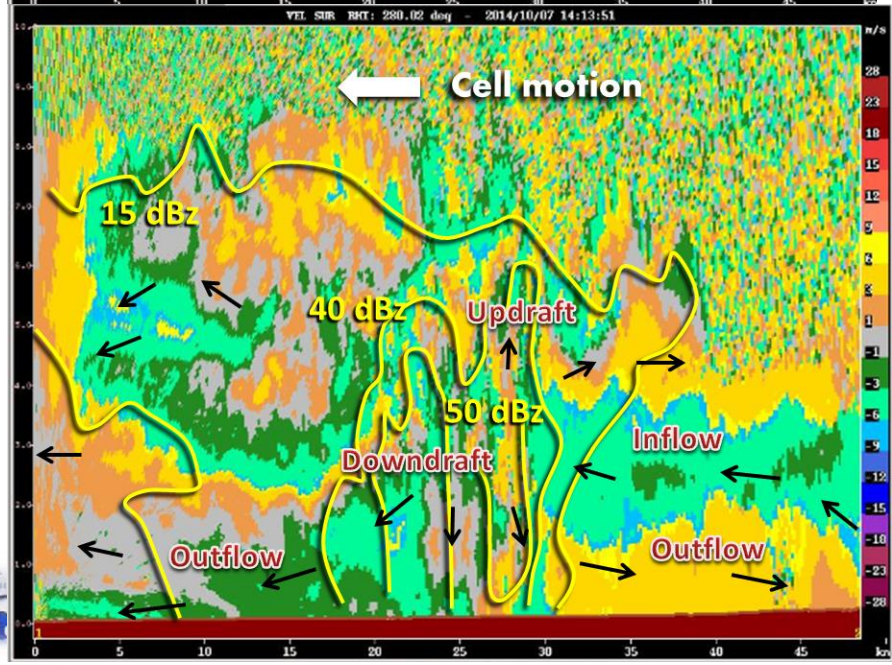


- **Area 5**: larger hail than in area 4
- **Area 6**: the horizontal channel of the radar beam crossing heavy rainfalls and melting hailstones in region 3 suffered from a significant power attenuation downrange of the core.
  - dramatic drop of the differential reflectivity
  - large spread of φ_{DR}
  - substantial reduction of the co-polar correlation coefficient.

Hailstorm in the Itria Valley, 7 Oct. 2014

- RHI views taken on 7 October 2014 at 14:13 UTC along 292.52° azimuth angle.
- Grey and brown zero doppler velocity areas inside the high reflectivity core of the storm reveals the presence of the downdraft and the
- Two outflows can be detected:
  - one, characterized by negative radial doppler velocity (green areas) was blowing toward the radar,
  - the other one was blowing away from the radar (yellow areas with positive doppler velocity) beneath a warmer and moist air current coming into the cell (inflow). Consequently, the outflow boundary forced the less dense warm air of the inflow to lift thus triggering new convection.





Conclusions

- A C-band dual-polarity doppler radar recently installed in Torchiarolo, Southern Apulia, Italy, has been presented and discussed.
- The radar was set up in November 2013 within the RIVONA Project which aims at mitigating flight risks associated with microbursts and wind shear phenomena around the Brindisi Airport area.
- The analysis of polarimetric data together with doppler velocity pattern of two recent severe weather events clearly demonstrates the huge potentiality of Torchiarolo radar for monitoring high-impact weather conditions over large regional areas.

Thank you!

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