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C-Band Hydrometeor Classification Scheme and Its Application on Hail Detection over Central Argentina

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1. Motivation

Central Argentina is one of the most favorable regions for strong mesoscale convective systems in the world, especially during austral warm season. High impact weather events associated with these convective systems are flash flood, strong winds, hail, and tornadoes. DP weather radars may offer the opportunity to detect and identify different classes of hydrometeors present in convective storms. In particular, hydrometeor classification helps to detect hail shafts within storms, thus providing valuable information for nowcasting applications.

2. Objectives

Using C-Band observations from the Argentinian radar network, the aims of the present paper are:

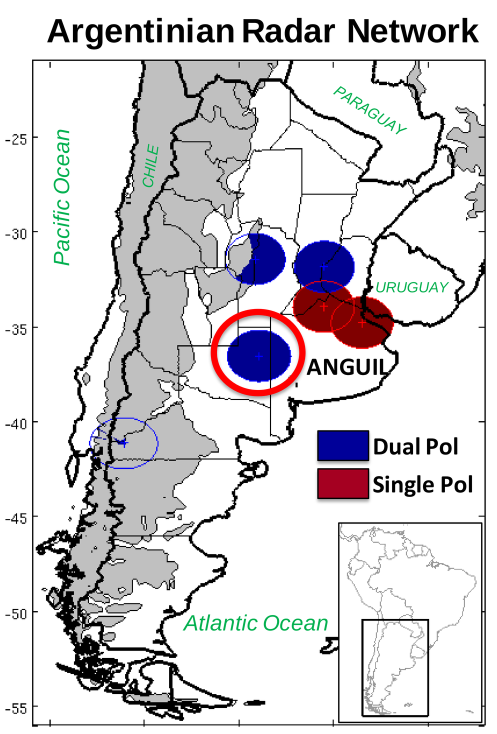
1. To explore different polarimetric signatures from hail and rain, and
2. To evaluate the application of a hydrometeor identification algorithm based on a fuzzy logic approach over two severe hailstorms.

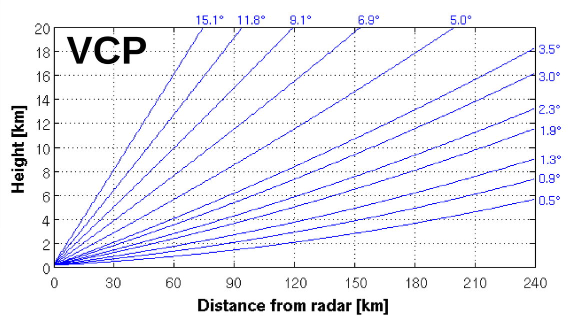
3. Radar data

- *Dual polarization C-band radar data from Anguil are analyzed in the present paper.*
- *Cross-correlation coefficient field was used in order to eliminate non-precipitation echoes (<0.79).*

PARAMETER	SPECIFICATION
Location	*36° 32' 23'' S / 63° 59' 24'' W*
Radar Type	*Gematronik Meteor 600C DP*
Polarisation	*Dual (Horizontal/Vertical)*
Wavelength	*5,635 cm (C-band)*
Power	*250 kW*
Maximum Range	*240 km*
Range Bin Spacing	*0,5 km*
Beam Width	*0,98/0,98 degrees*
PRT	*2000 μs*
Pulse Width	*2 μs*
Radar Height	*170 m*
Beam Elevations	*12 elevations from 0,5 to 15,1 degrees*
Recorded Fields	*Horizontal Reflectivity (Z_{HH}), Radial Velocity (V), Spectral Width (W), Differential Reflectivity (Z_{DR}), Cross-Correlation Coefficient (ρ_{HV}), Differential Phase (Φ_{DP}), Specific Differential Phase (K_{DP}).*
Task Cycle Time	*10 minutes*

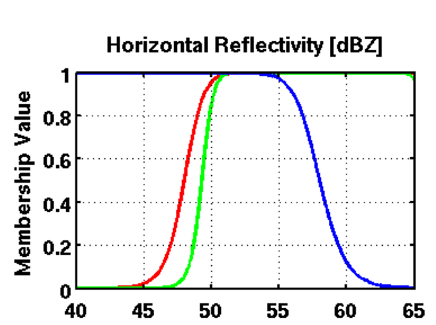
Argentinian Radar Network

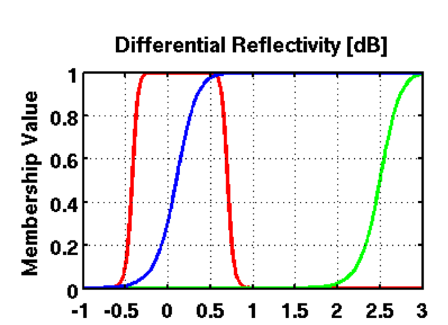




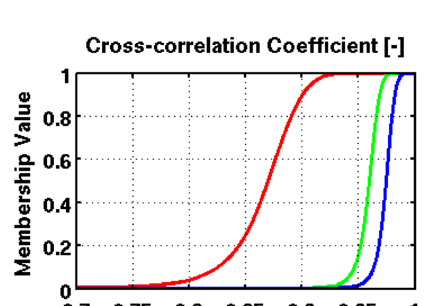
4. HID algorithm

- A fuzzy logic hydrometeor identification algorithm (HID) using Z_{HH}, Z_{DR} and ρ_{HV} was tested in two severe hailstorms events in Central Argentina.
- The algorithm is inspired on CSU-FHC scheme (Dolan and Rutledge, 2009).
- We consider just three hydrometeors categories: rain (RN), big drop (BD), and hail (HL).





Each MBFs parameters for each hydrometeor type and fuzzy set are based on scattering simulations (Dolan and Rutledge, 2009).



MBFs for each hydrometeor type used in this work.

In this case, K_{DP} and temperature profile are not included.

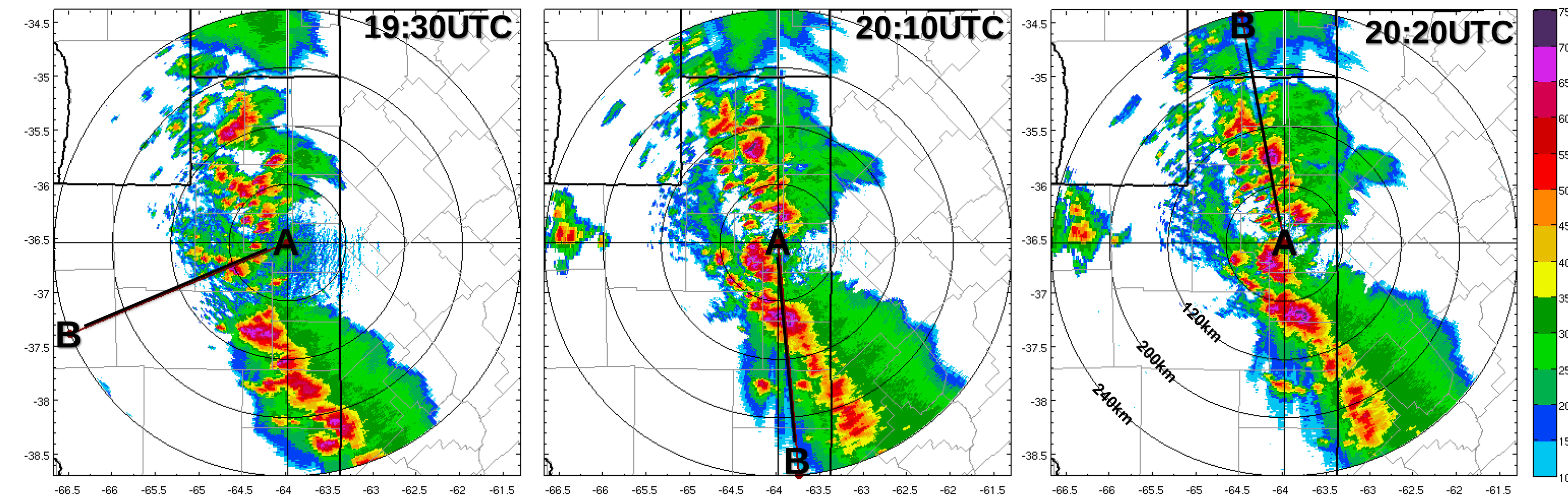
MBF definition

$$\beta = \frac{1}{1 + \left[\left(\frac{x-m}{a}\right)^2\right]^b}$$

5. Hailstorm 13 January 2011

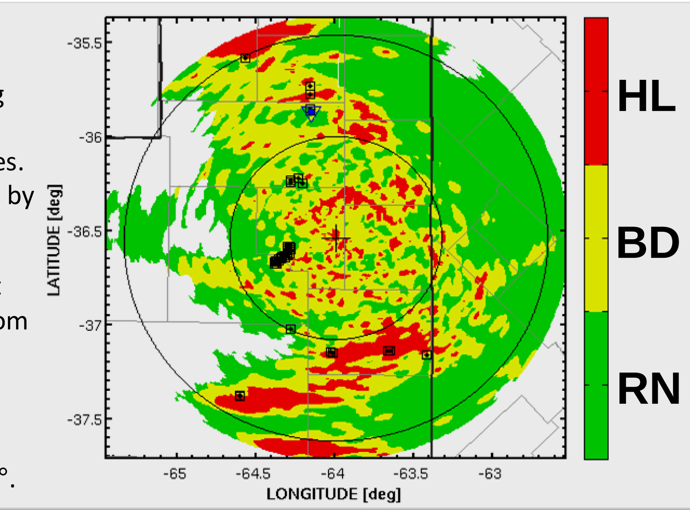
COLMAX maps

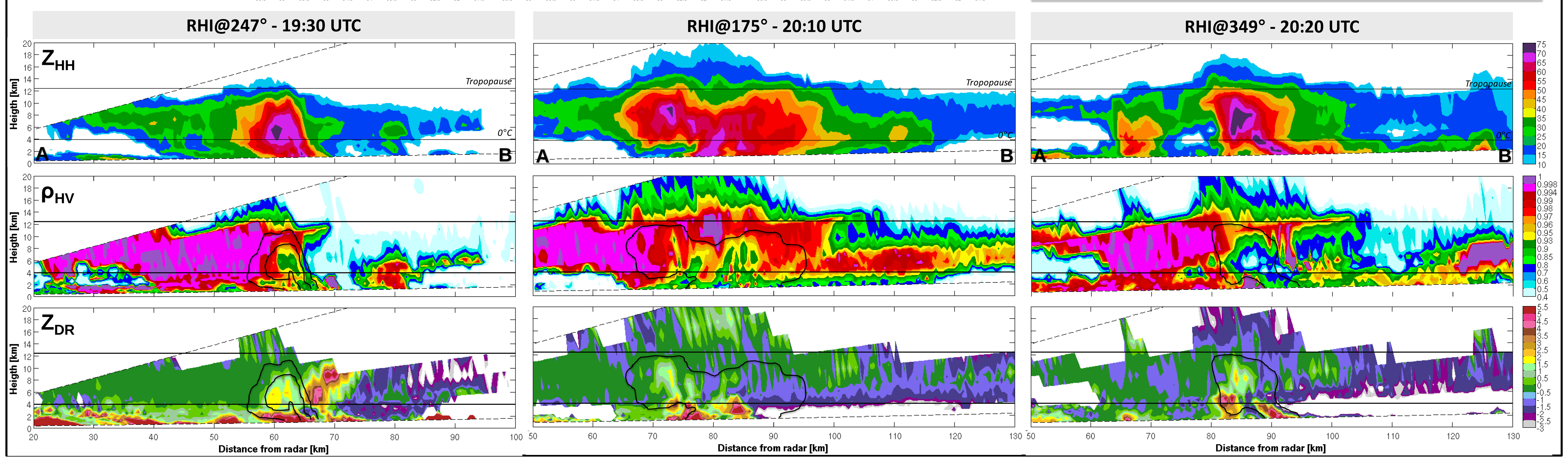
Multicelular system with embeded supercells produced damage due to strong wind gusts, small to moderate hail and even a tornado in Campo Nieves city (blue triangle in HID map).



HID Map

- Hail damage reports during the whole studied day are indicated with black squares. Tornado report is indicated by blue triangle.
- HID categories from lowest PPI (0.5°) are integrated from 17:10UTC to 23:50UTC.
- Surface reports are spread but some coincidences can observed in the cell to 175°.

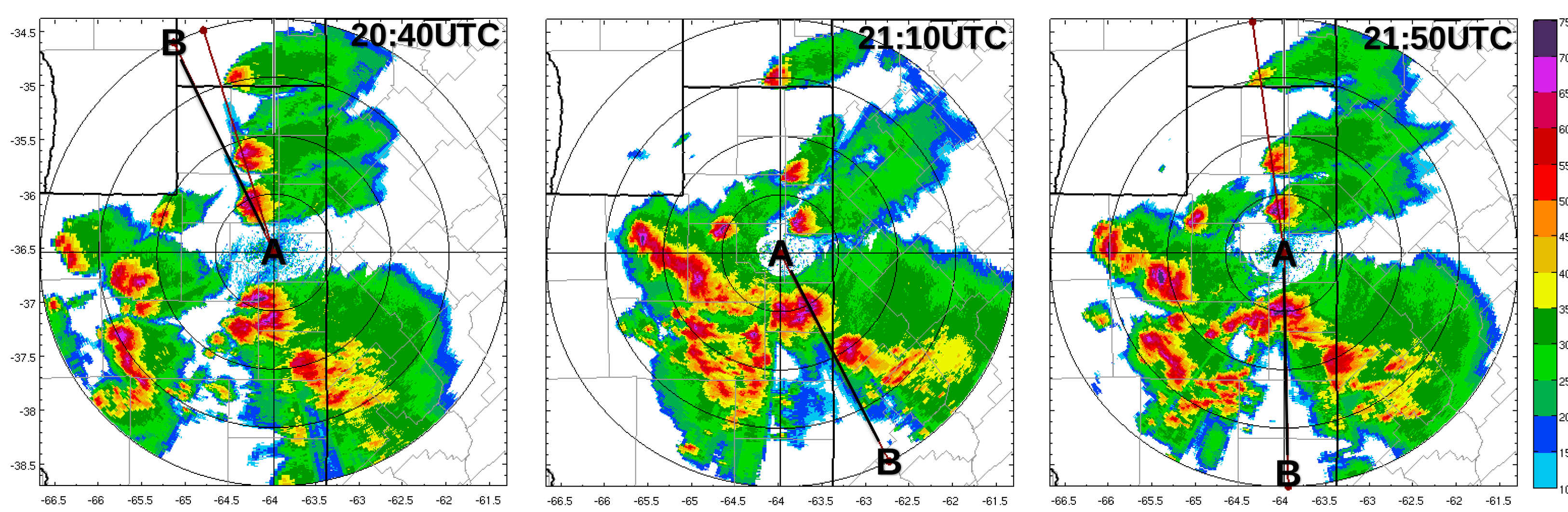




6. Hailstorm 15 January 2011

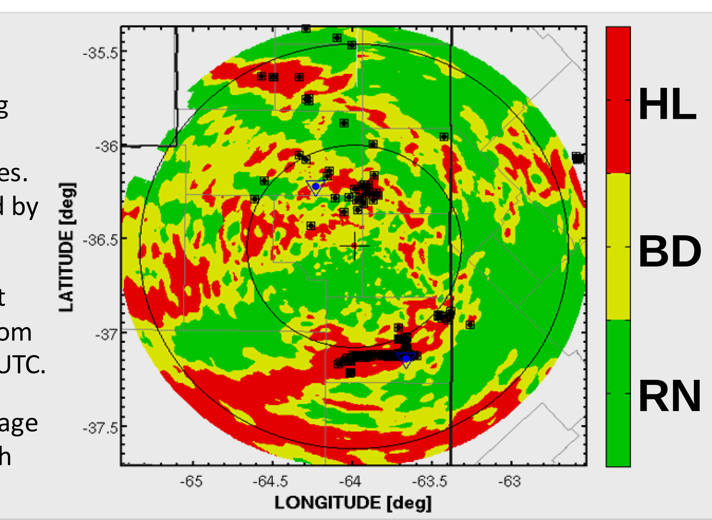
COLMAX maps

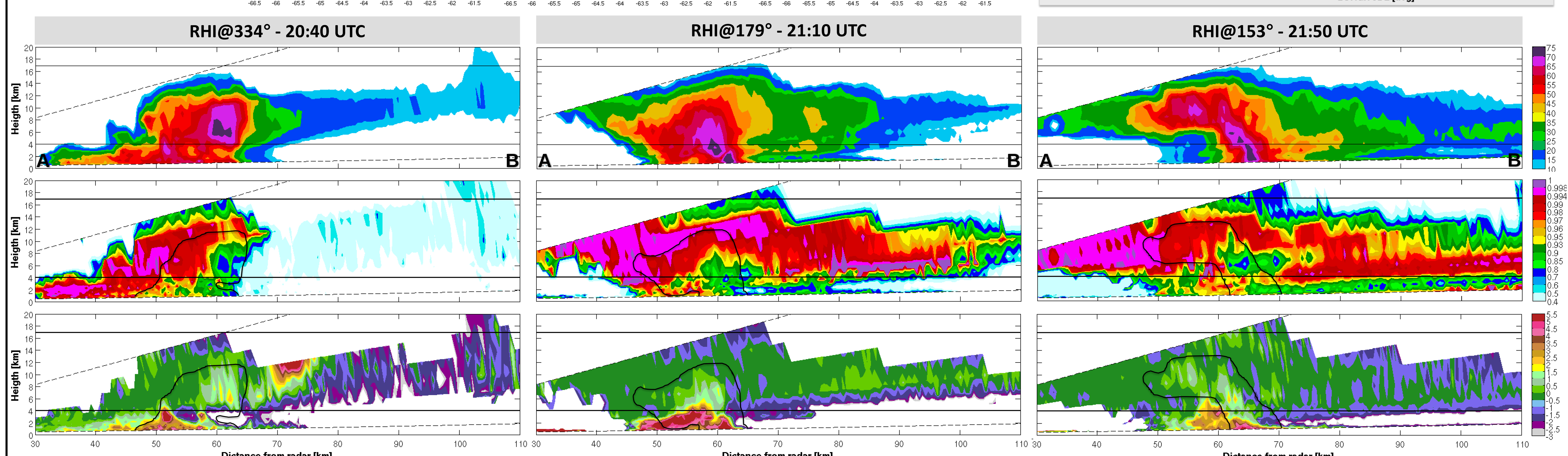
Discrete supercell thunderstorms produced damage due to strong wind gusts, large hail and even two tornadoes in Winifreda and Macachin (blue triangle in HID map).



HID Map

- Hail damage reports during the whole studied day are indicated with black squares. Tornado report is indicated by blue triangle.
- HID categories from lowest PPI (0.5°) are integrated from Jan 15 17UTC to Jan 16 06UTC.
- Southern hail surface damage reports are coincident with HL categories.





7. Conclusions

- C-band dual polarimetric radar signatures over large melting hail near the surface (average egg sized 5 cm) are typically characterized by high Z_{HH} (>55 dBZ), high Z_{DR} (38 dB), and low ρ_{HV} (< 0.8) at low levels.
- High Z_{DR} and low ρ_{HV} values be can explained by melting of resonant sized hailstones and a mixture of hydrometeors near the surface (Kaltenboeck and Ryzhkov, 2012, Anderson et al. 2011)
- Low Z_{DR} (~0 dB) and ρ_{HV} (<0.8) inside a high Z_{HH} core (> 55 dBZ) above melting layer could be associated with tumbling dry hail and graupel.
- Analyzed storms show in both cases a bounded weak echo region, an overhang ZHH maximum and three body scattering signature over these supercell cases.
- Previous mentioned evidence and surface reports corroborate the presence of severe hail in the studied cases.
- HID shows a adequate performance over the studied storms but progress must be made in severe weather reports database in order to have information at higher spatial and temporal resolution.
- Strong attenuation and differential attenuation in the C-band will be explored in future work in order to consider Φ_{DP} and K_{DP} as another fuzzy logic variable.

8. Acknowledgments

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9. References

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