OBSERVATIONS OF A SEVERE HAIL-BEARING STORM BY AN OPERATIONAL X-BAND POLARIMETRIC RADAR IN THE MEDITERRANEAN AREA

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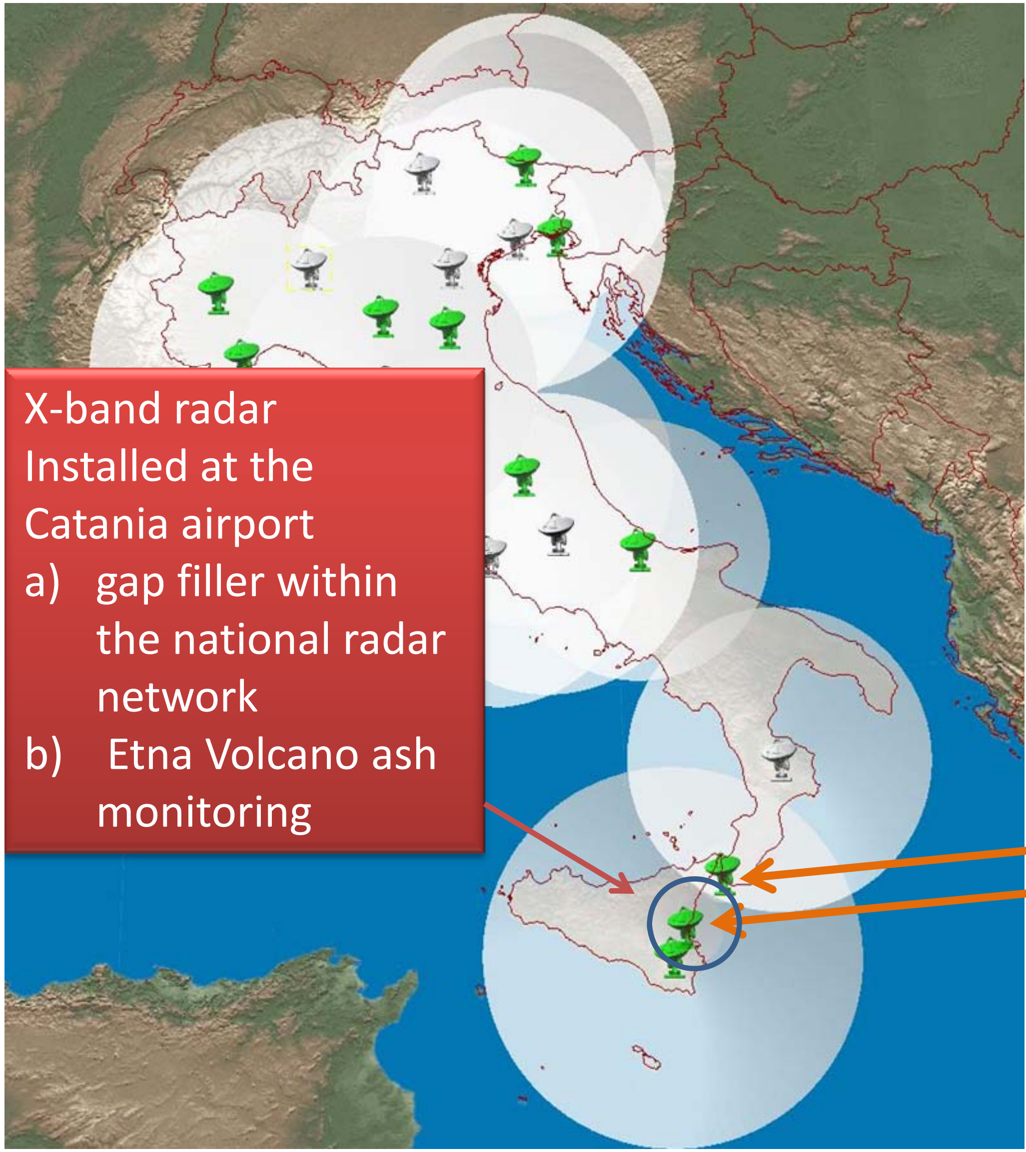
The context

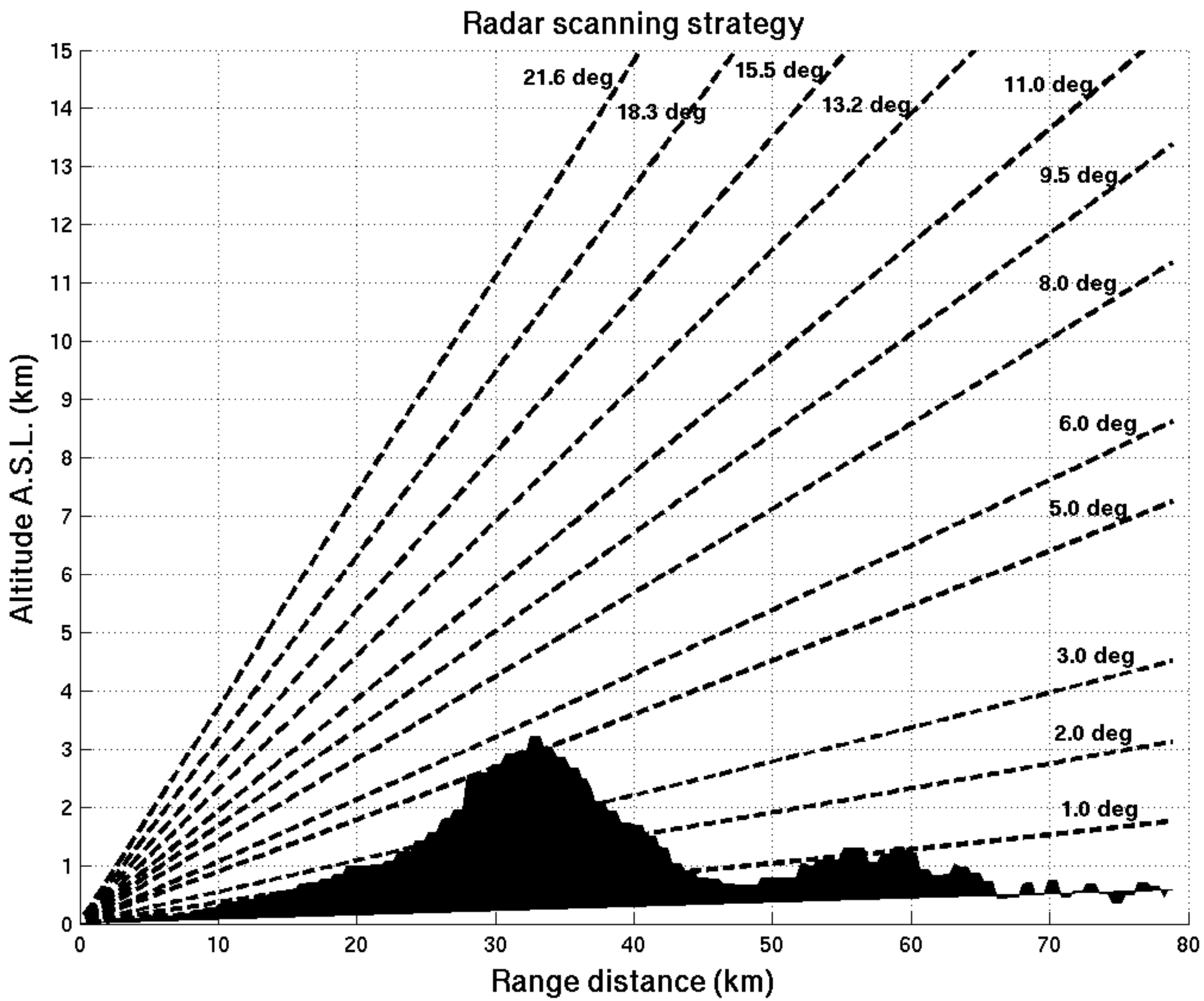
Italian National Weather Radar Network



- **"Federated network"**
- **Radar run from different organization**
- **DPC is responsible of country level products**
- **4 transportable X-band dual-pol radar radar systems**

Catania X-band radar scan strategy

- 12 PPI sweeps and vertical-incidence
- Scan frequency: 10 minutes
- Scan duration: 5 min



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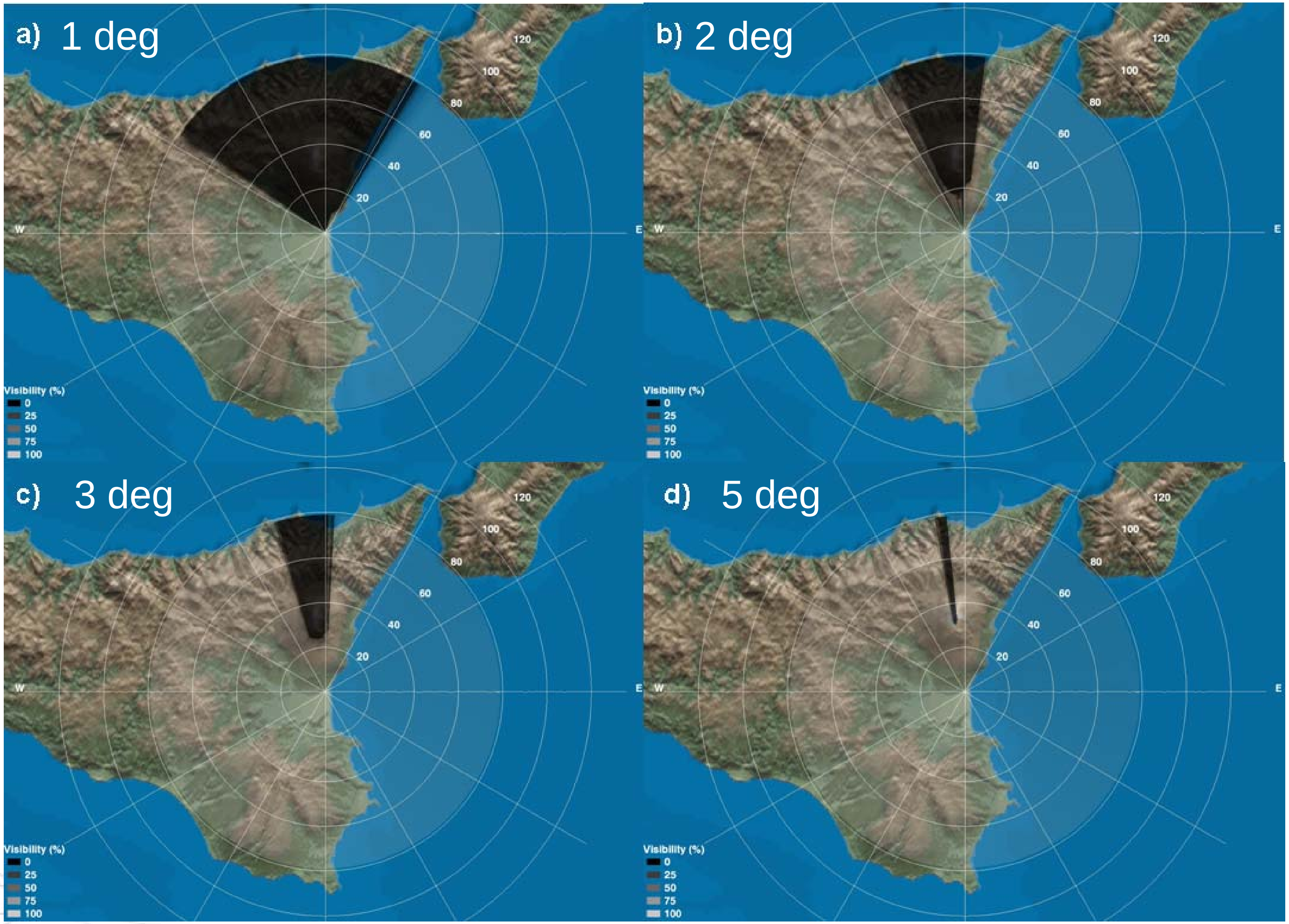
Catania X-band radar visibility map



X-band radar data processing (1/2)

- Z_{DR} calibration using observations at vertical incidence
- Removal of non meteorological echoes
- Differential phase processing through a 2-km moving window applied within a threefold iteration scheme
- A 2-step Bayesian hydrometeor classification approach is applied.
  1) a preliminary attenuation correction is performed assuming a $\gamma_{H,DP}$.
  2) Classification is performed
  3) An optimized coefficient is found
- Rainfall estimation using combination of R(Z) and R(K_{DP})

Vulpiani, G., M. Montopoli, L. Delli Passeri, A. Gioia, P. Giordano and F. S. Marzano, 2012: On the use of dual-polarized C-band radar for operational rainfall retrieval in mountainous areas. J. Appl. Meteor and Clim., vol. 51, N. 2, 405-425.

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X-band radar data processing (2/2)

More on attenuation correction. Two methods are applied for comparison

a) Correction based on fixed linear relations between K_{dp} and specific attenuation and differential attenuation; $\gamma_{H,}$ =0.25 dB/deg γ_{DP} 0.033 dB/deg

b) A procedure optimizing $\gamma_{H,DP}$ with respect to classified hydrometeors
   1. A preliminary attenuation correction is performed assuming a $\gamma_{H,DP}$ constant.
   2. The temperature profile (T), retrieved from the closest available radio sounding, is used to roughly discriminate rain from frozen particles;
   3. The corrected $Z_{H,DR}$ are then used with K_{DP}, ρ_{HV} and T for hydrometeor classification; values of $\gamma_{H,DP}$ are associated to each class as derived from scattering simulations (Vulpiani et al. 2008);
   4. at each range distance *r* an optimal $\gamma^{opt}_{H,DP}(r)$ is computed
   5. Correction to $Z_{H,DR}$ is finally applied

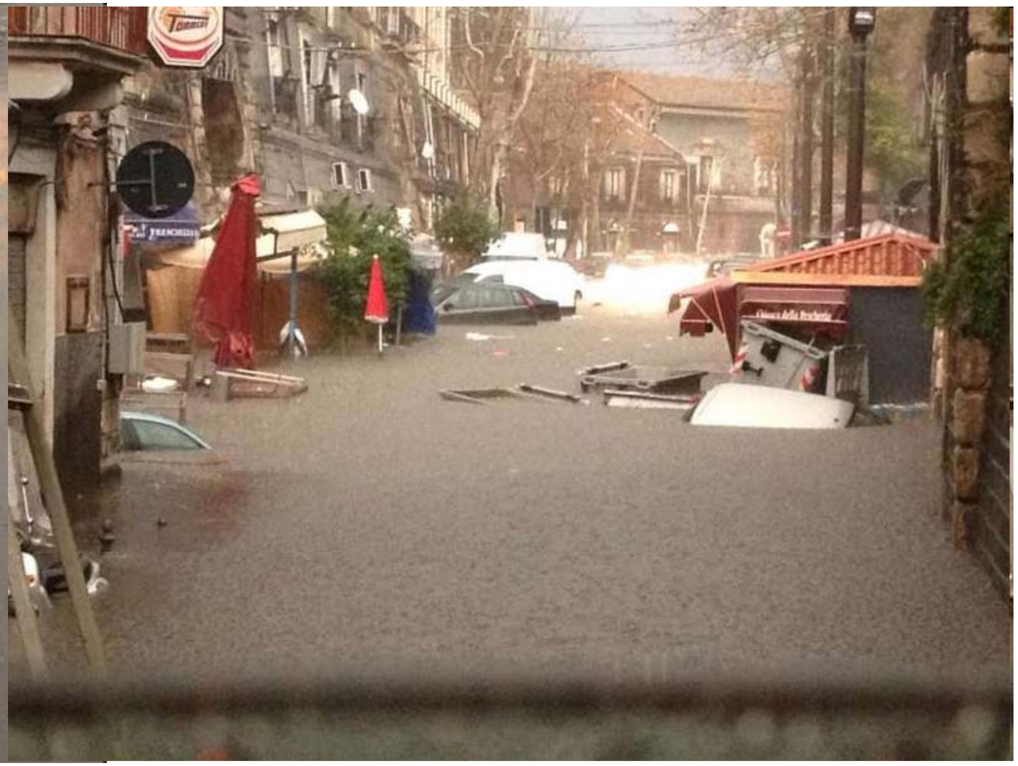
Motivation

Within a context with many experiments on X-band dual pol radars ongoing

- Start evaluating the effectiveness of X-band dual-pol radar systems and processing techniques for severe storm monitoring
  - Radar polarimetric signatures for Hydrometeor Classification
  - X-band dual-pol Quantitative Precipitation Estimation
- Start performing evaluation of the system and review processing with significant case studies

Case study

- On the Feb. 21st 2013 a severe storm hit central-eastern Sicily (Italy) flash-flooding the town of Catania (close to the radar site)
- "Bomba d'acqua su Catania" (Cloudburst over Catania); Hail was also reported



From: http://www.cataniatoday.it/foto/nubifragio-a-catania-21-febbraio-2013/

Case study

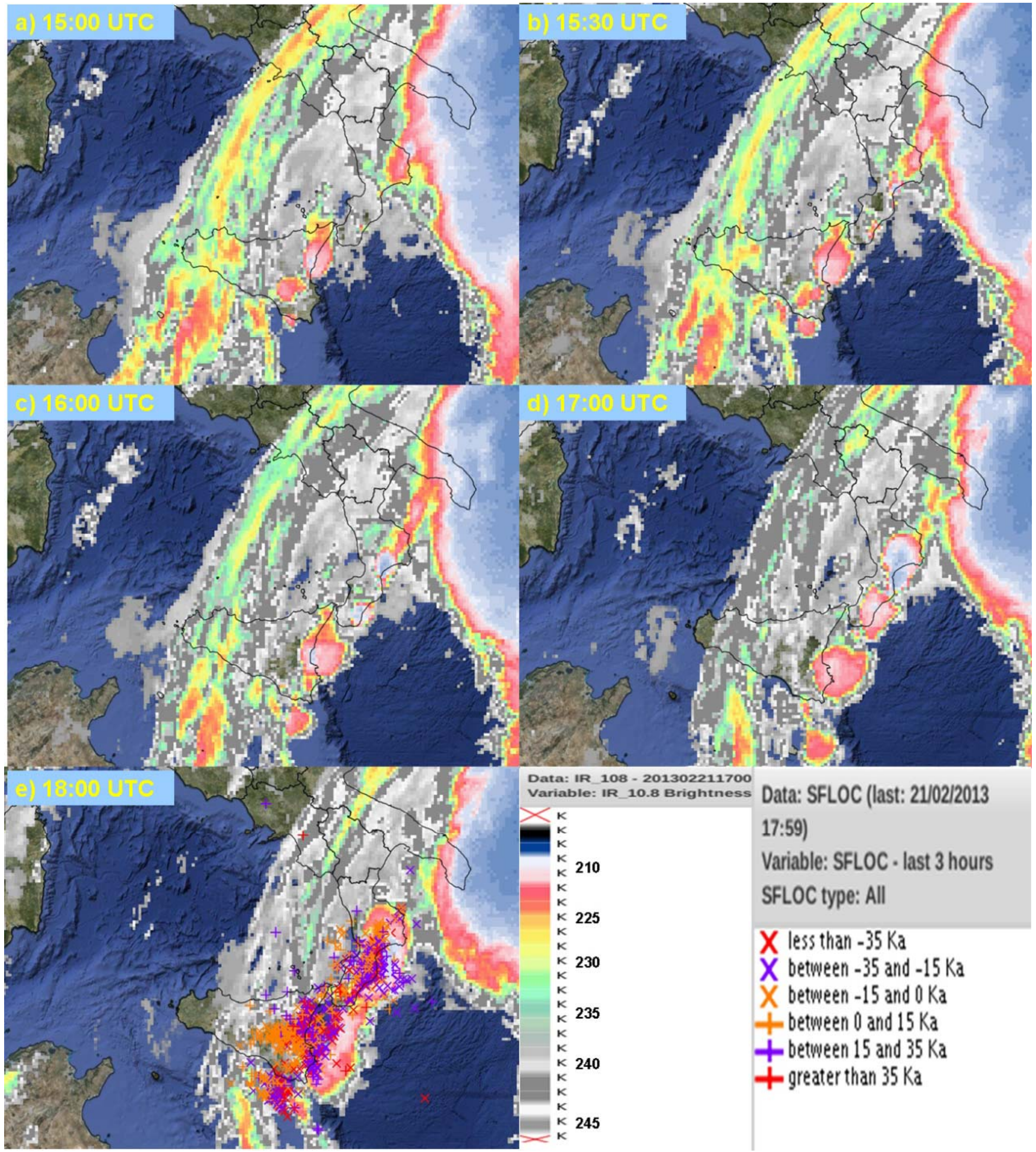
- **MSG (10.8 μm) images (1500-1800 UTC)**

- **SFLOC (Last 3 hours) (panel e)**

- **Rain gauge located in Catania**
  - ✓ 60 mm in between 15:00 and 16:00 UTC
  - ✓ about 70 mm in 1 and half hour.
- **nearby Raingauges** did not record > 20 mm in 3 hours.

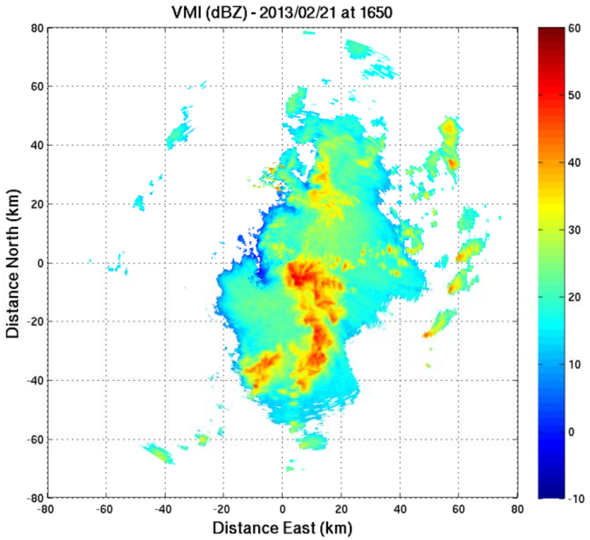
- **2-m temperature between 10.4 (1530 UTC) and 13.5 (till 1500 UTC) in Catania**

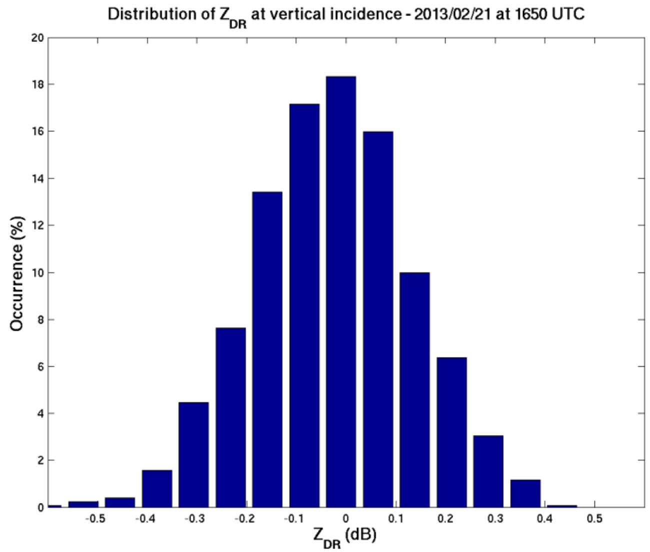
- **FLH ranging between 1.8 and 2.1 km**

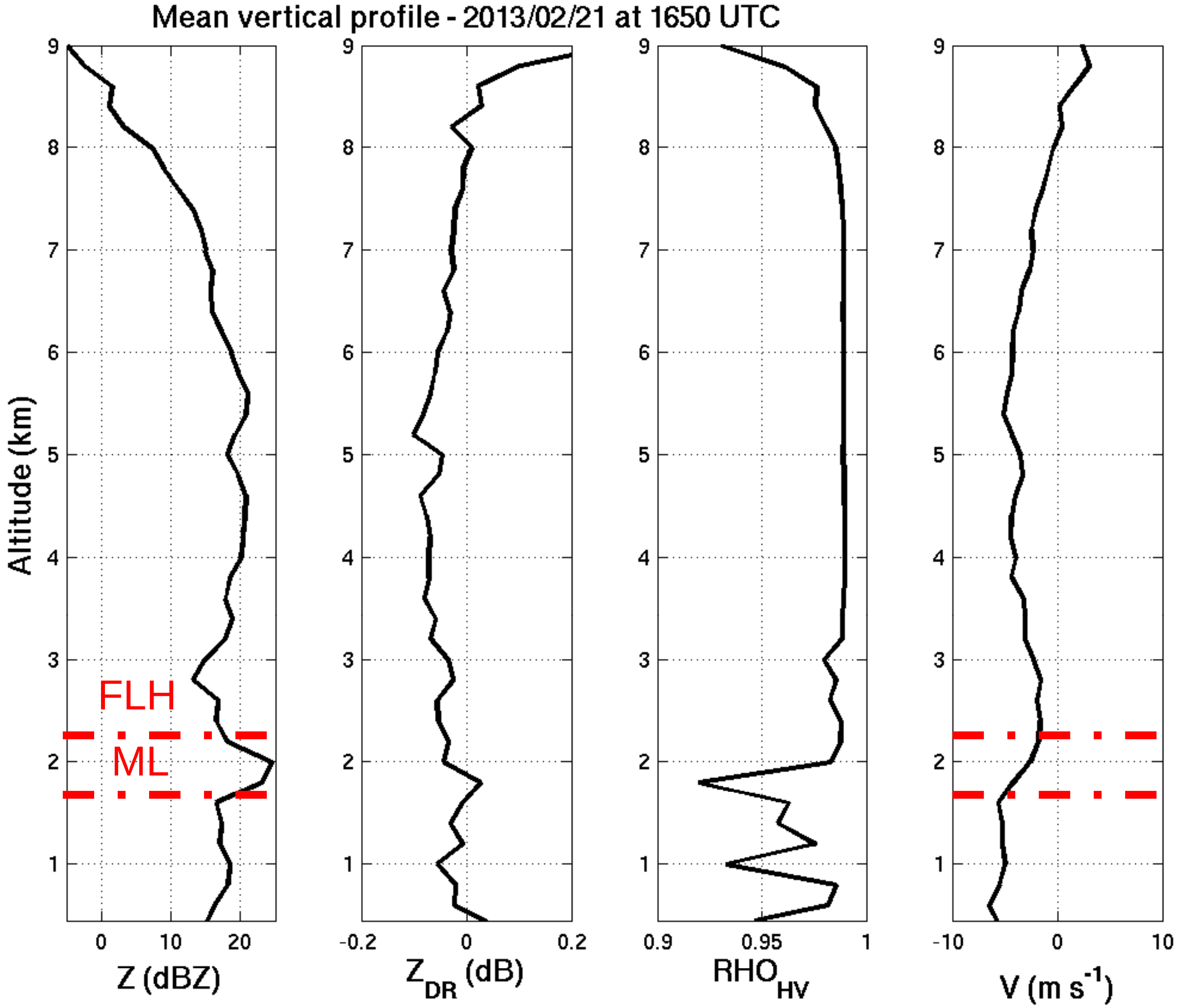


Observations at vertical incidence

16:50 UTC



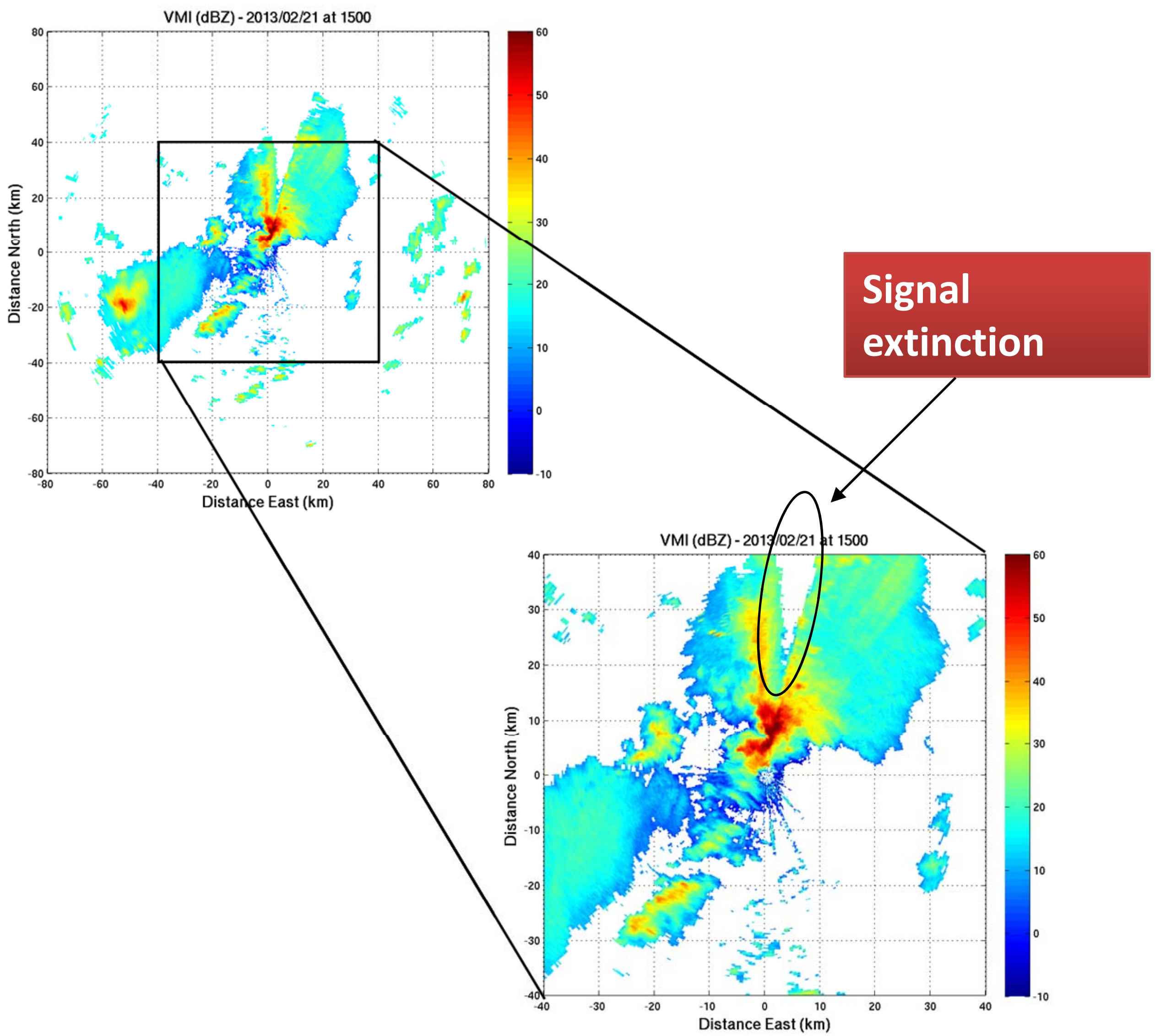




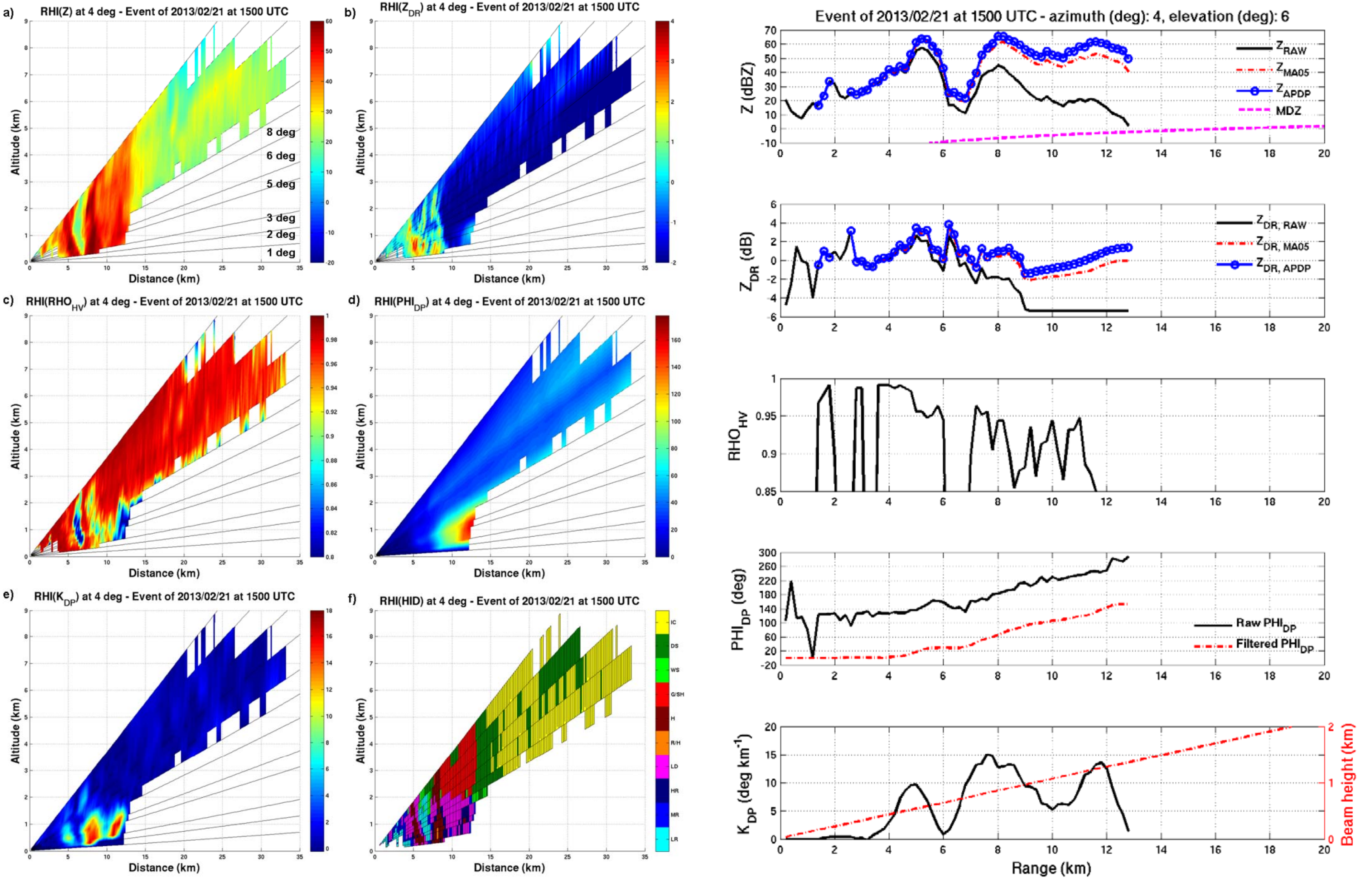
FLH: Freezing Layer Height

ML: Melting Layer

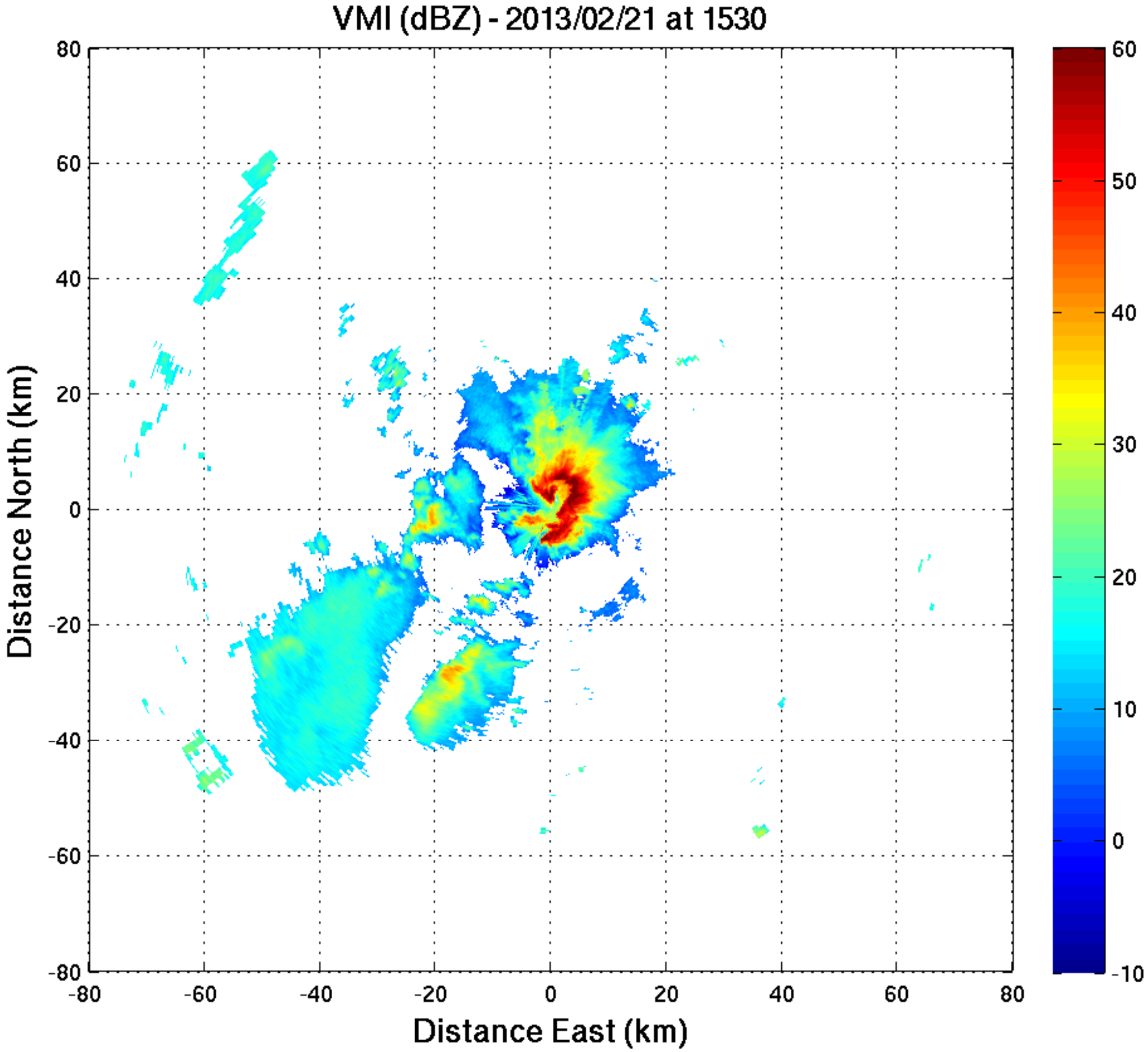
VMI of Z at 15:00 UTC



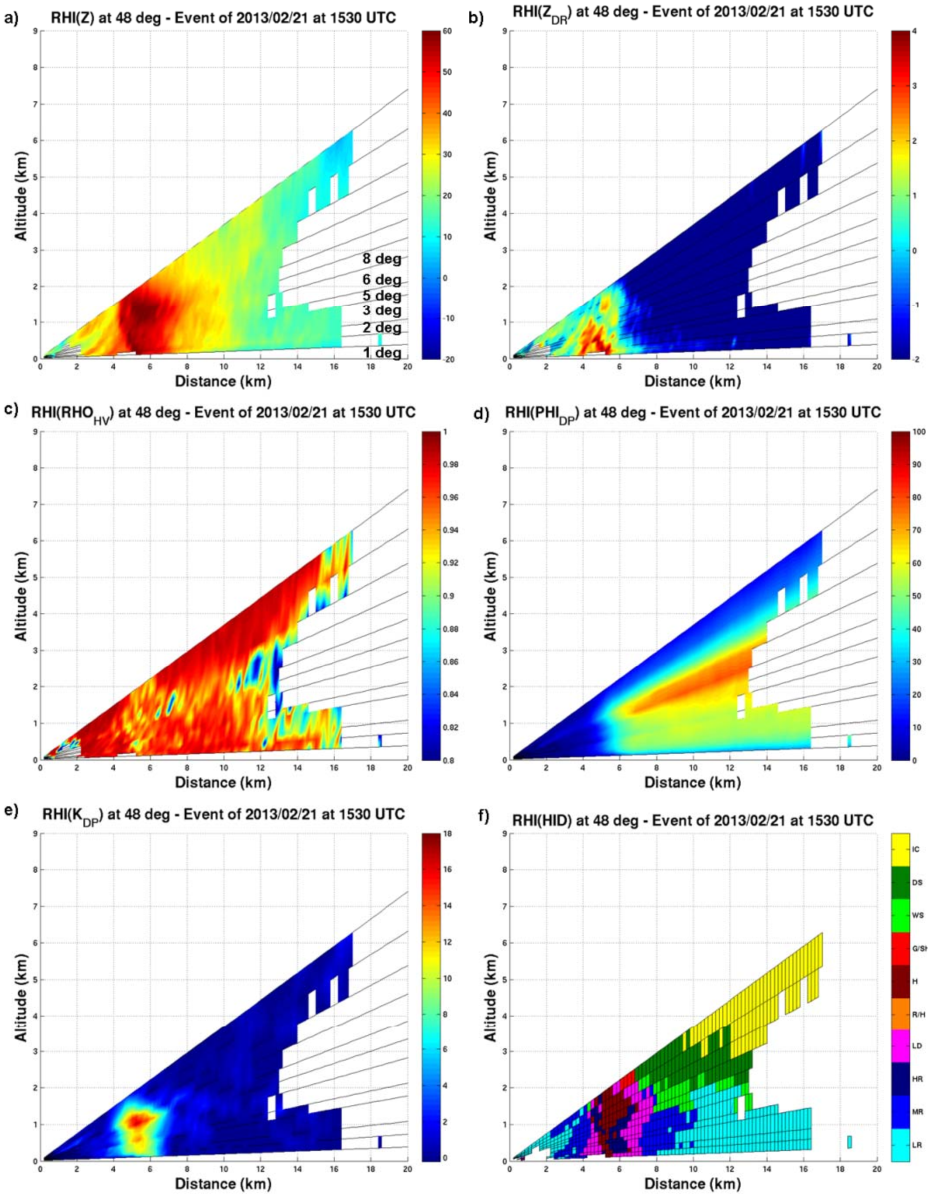
RHIs at 1500 UTC, azim. 4 (deg) + range plots at 6 deg of antenna elevation

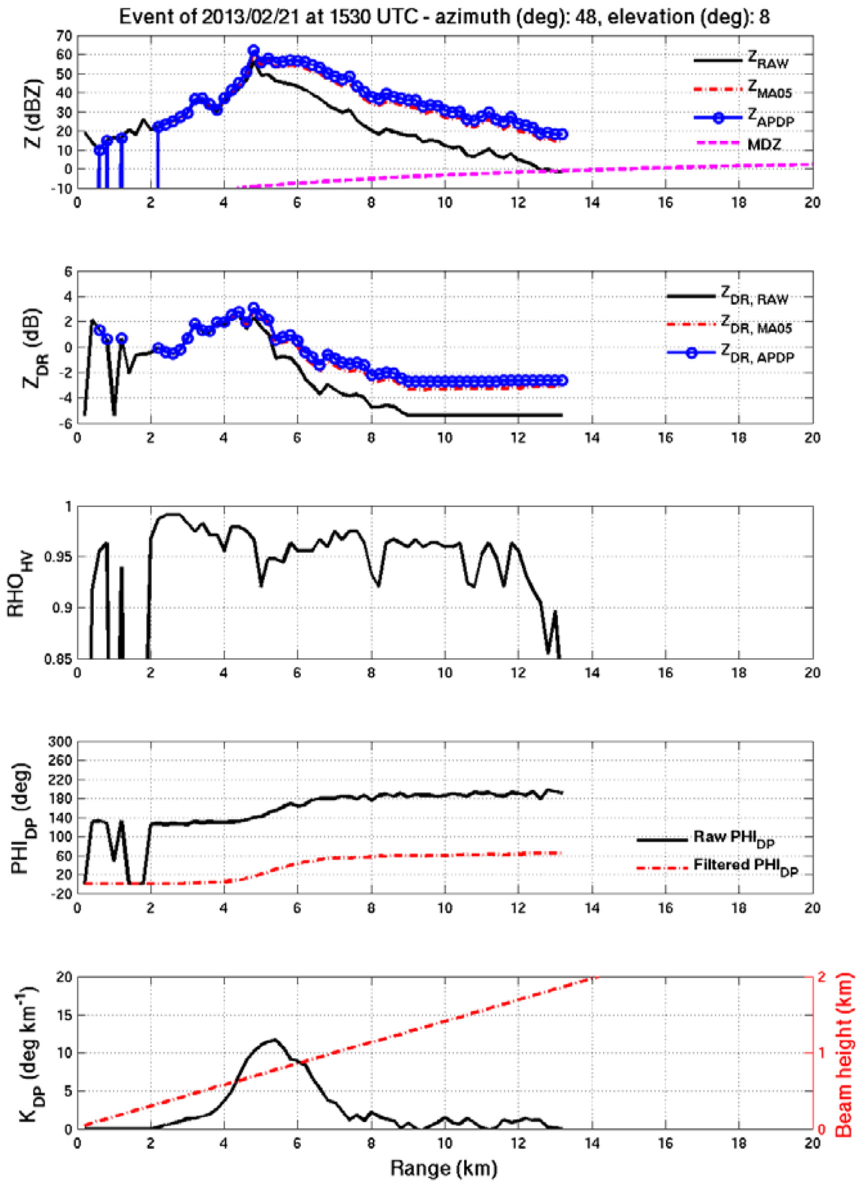


VMI of Z at 15:30 UTC

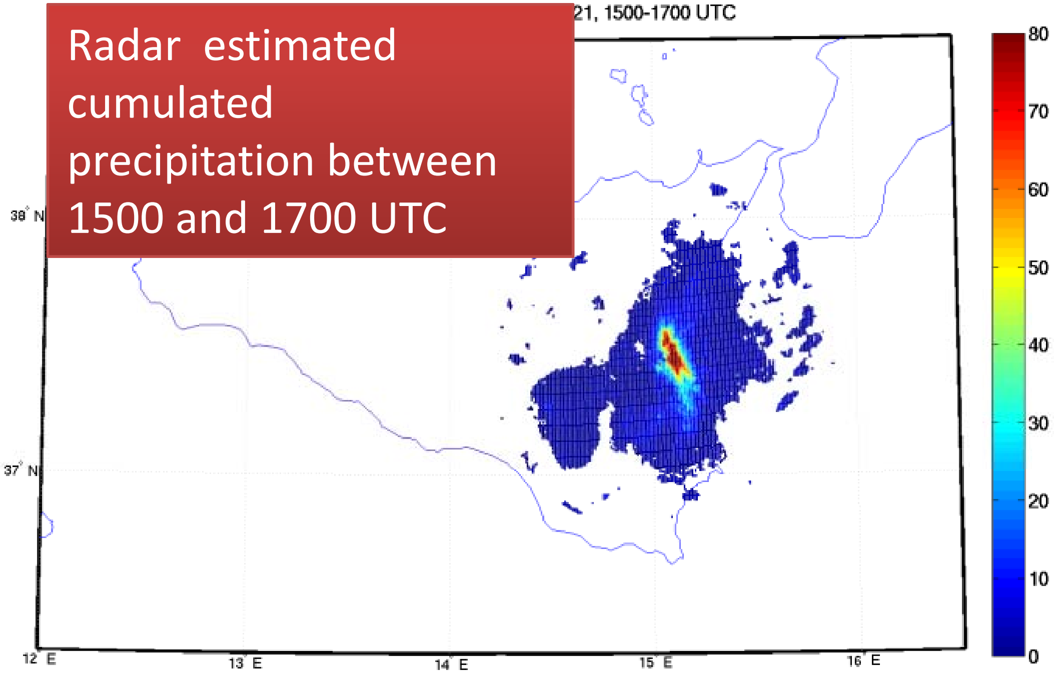


RHIs at 1530 UTC, azim. 48 (deg) + range plots at 8 deg of antenna elevation





Rain estimation



$$R_C = w_K \cdot R_K + (1 - w_K) \cdot R_Z$$

$$w_K = \begin{cases} 0 & K_{DP} \le 0.5 \\ 2 \cdot K_{DP} - 1 & 0.5 < K_{DP} < 1 \\ 1 & K_{DP} \ge 1 \end{cases}$$

Comparison with 26 raingauges within the radar coverage area

	$\langle\varepsilon\rangle$	σ_ε	RMSE	FSE	Bias
R_Z	-1.62	2.12	2.65	0.64	0.61
R_K	-0.36	2.64	2.63	0.64	0.91
R_C	-0.81	2.16	2.28	0.55	0.80

$\langle\varepsilon\rangle = \langle R_R - R_G \rangle$

$\sigma_\varepsilon = (\langle(R_R - R_G)^2\rangle)^{1/2}$

$\text{Bias} = \langle R_R \rangle / \langle R_G \rangle$

$\text{FSE} = \text{RMSE} / \langle R_G \rangle$

Conclusions

- This work has documenteda severe precipitation event causing the flash flood of Catania on the 21st of February 2013 using observations from an operational dual-pol X-band radar
- In addition to the 60 mm of rainfall registered in 1 hour (and about 70 mm in 1 and ½ hour), hail was reported for that event
- HCS is able to confirm the presence of melting hail justifying the huge differential phase shift observed in very short path length
- Attenuation techniques are applied within a HCS. However, correction of differential attenuation is critical especially in conditions determining signal extinction
- Concerning rainfall estimation, a comparison with nearby raingauges shows that the use of K_{dp} or a combination of Z_h and K_{dp} determine resonably accurate precipitation estimates