OPTIMAL EXPLOITATION OF POLARIMETRY FOR PRECIPITATION INDUCED FLOOD FORECAST

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Introduction & Motivation

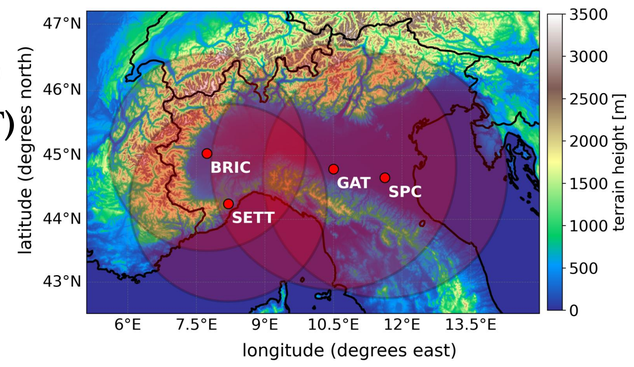
- Heavy rainfall in northern Italy frequently leads to flooding, resulting in socio-economic impacts like infrastructure damage, disruption to agriculture, displacement of residents, and loss of life.
- Numerical Weather Prediction (NWP) models have shown a deficiency in forecasting the intensity and location of such heavy rainfall events in complex terrain.
- Researchers from the University of Bonn and ARPAE-SIMC collaborate to enhance the representation and prediction of moderate to heavy rainfall.

Objectives

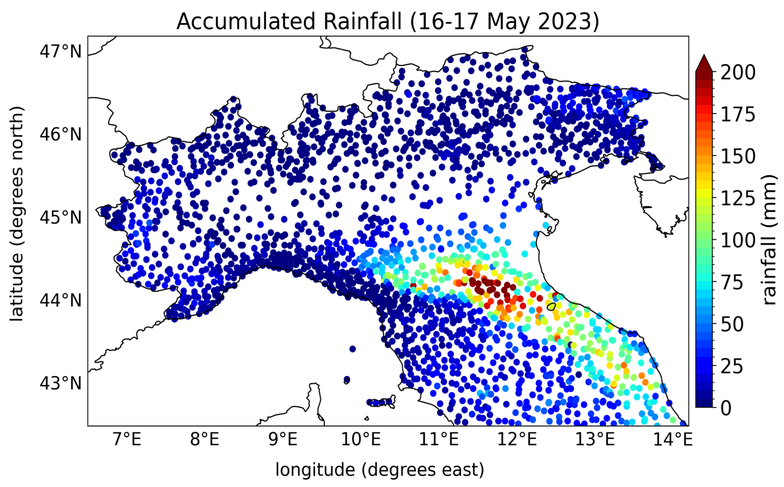
- Enhancing Quantitative Precipitation Estimation (QPE) in Northern Italy with complex orography by exploiting polarimetry, profile corrections, and gap-filler radars
- Exploit enhanced QPE for Latent Heat Nudging (LHN)

Radar network investigated

- Gattatico (GAT)
- Bric della croce (BRIC)
- MonteSettepani (SETT)
- San Pietro Capofiume (SPC)
- Gap-filler radar in Turin (not shown, outlook)



Case study 16-17 May 2023

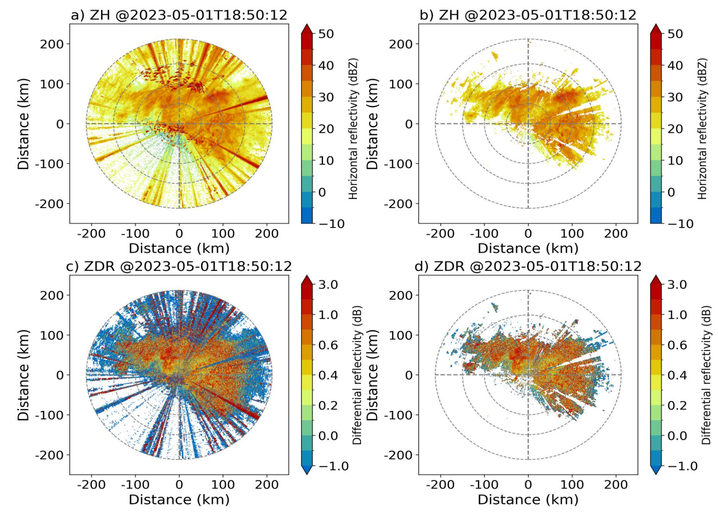


Raingauge derived accumulated rainfall during the event from 16 to 17 May 2023 with the boundaries of country territories.

- Exceeded 200 mm rainfall accumulation in several areas
- Major rivers flooded
- Nearly 1,000 landslides - surpassed historical records in the region
- Roads, buildings, and essential services disrupted

Data quality challenges

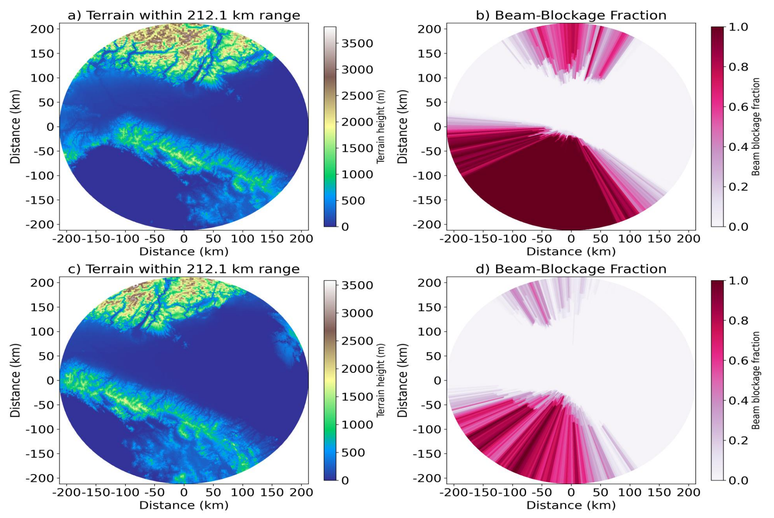
➢ Excessive ground clutter and interference from communication towers operating at similar frequencies :



Horizontal radar reflectivity ZH before (a) and after (b) clutter removal together with differential reflectivity ZDR before (c) and after (d) clutter removal.

- Excessive filtering may lead to loss of precipitation data
- Fuzzy logic methodology used for mitigation of interference signals

➢ Beam blockage :

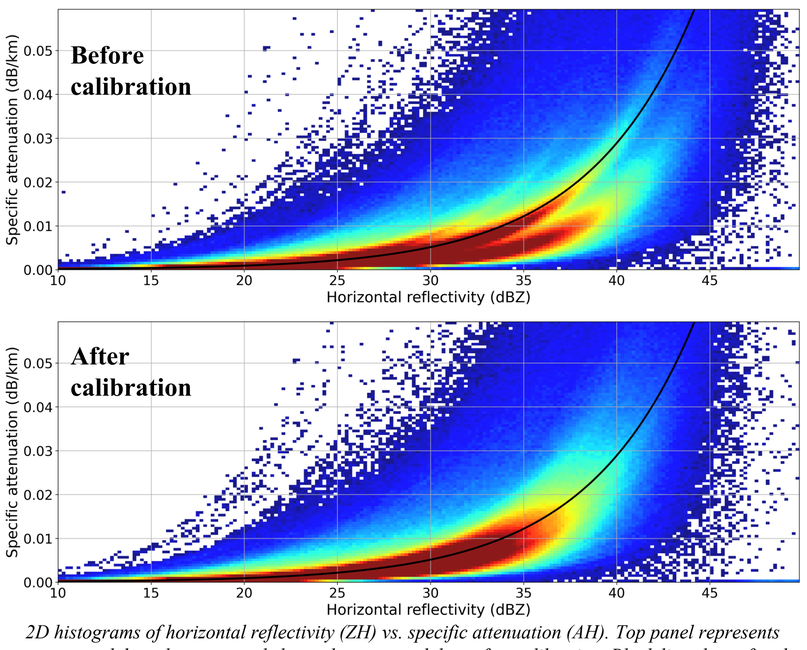


Terrain map (a) and beam blockage fraction (b) for 0.5 deg elevation scan of the Gattatico radar and the San Pietro Capofiume radar (c, d), respectively.

- Low elevation scans, best suited for QPE, suffer from beam blockage
- Radar compositing is used to still achieve full coverage

Data quality control & assurance

Calibration of horizontal reflectivity (ZH) exploiting specific attenuation (AH) :

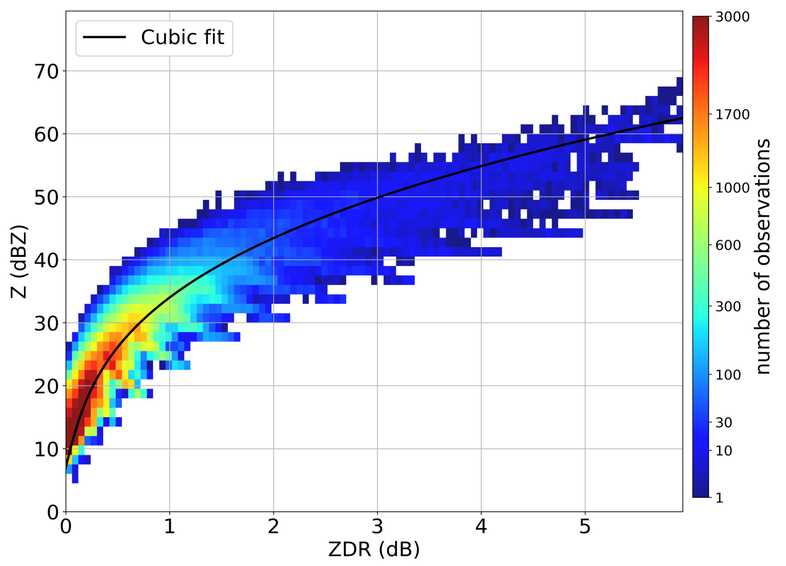


2D histograms of horizontal reflectivity (ZH) vs. specific attenuation (AH). Top panel represents uncorrected data; bottom panel shows the corrected data after calibration. Black line shows fitted power-law curve.

- Expected ZH values are calculated using the AH-ZH relation and compared with measured ZH values:

$$AH = 2.89 \times 10^{-5} (ZH^{0.75})$$

Calibration of differential reflectivity (ZDR) exploiting the ZH - ZDR relation:

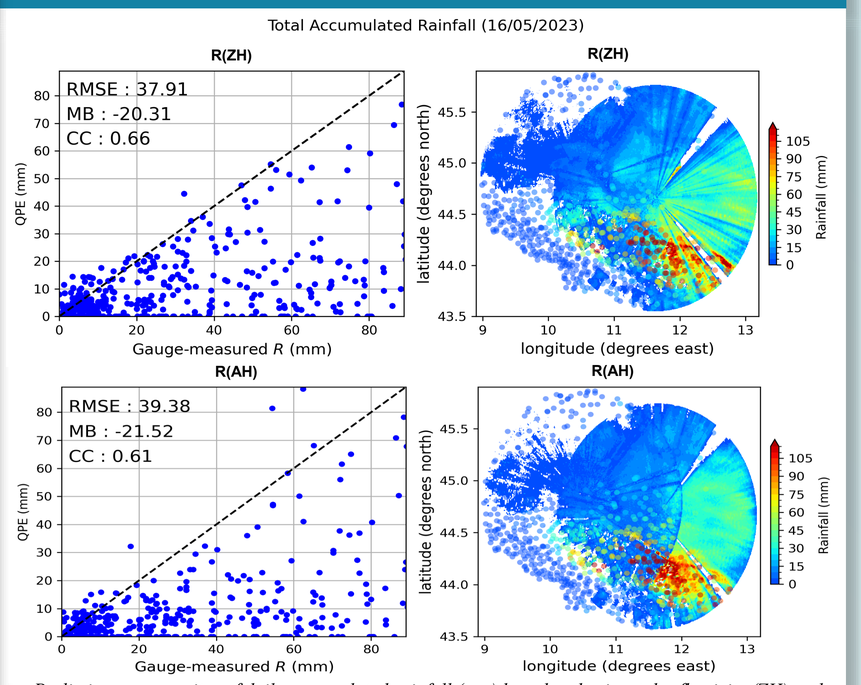


2D histograms of differential reflectivity (ZDR) vs horizontal reflectivity (ZH) derived from T-matrix scattering simulations. The black curve represents a cubic polynomial fit to the simulated ZH - ZDR.

- T-matrix simulations based on disdrometer data to calculate radar variables
- Expected ZDR values based on ZH – ZDR relation are compared with observed ZDR :

$$ZDR = 1.1765(ZH)^3 - 10.4091(ZH)^2 + 30.9880(ZH) + 11.9033$$

Results



Preliminary composites of daily accumulated rainfall (mm) based on horizontal reflectivity (ZH) and specific attenuation (AH) for Gattatico (left circle) and San Pietro Capofiume (right circle) radars. Comparison with 707 rain gauges is illustrated in scatter plots (left column) and as overlaid colored dots in composites (right column)

- Beam blockage in the southwest results in reduced radar-derived rainfall sums.
- Both R(ZH) and R(AH) estimators significantly underestimate daily accumulated rainfall compared to gauge observations.

Conclusions

- Preliminary rainfall composites show high RMSE, negative mean bias, and low correlation with rain gauges.
- Analyses and improvements are ongoing

Next steps

- Debugging of preliminary rainfall algorithms
- Revisiting strategies to handle complex terrain and beam blockage
- Hybrid retrievals, including specific differential phase (KDP), will be explored.
- Once reliable and robust polarimetric rainfall composites are generated, their benefit for latent heat nudging will be explored.

Contact detail

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