

OBJECTIVES

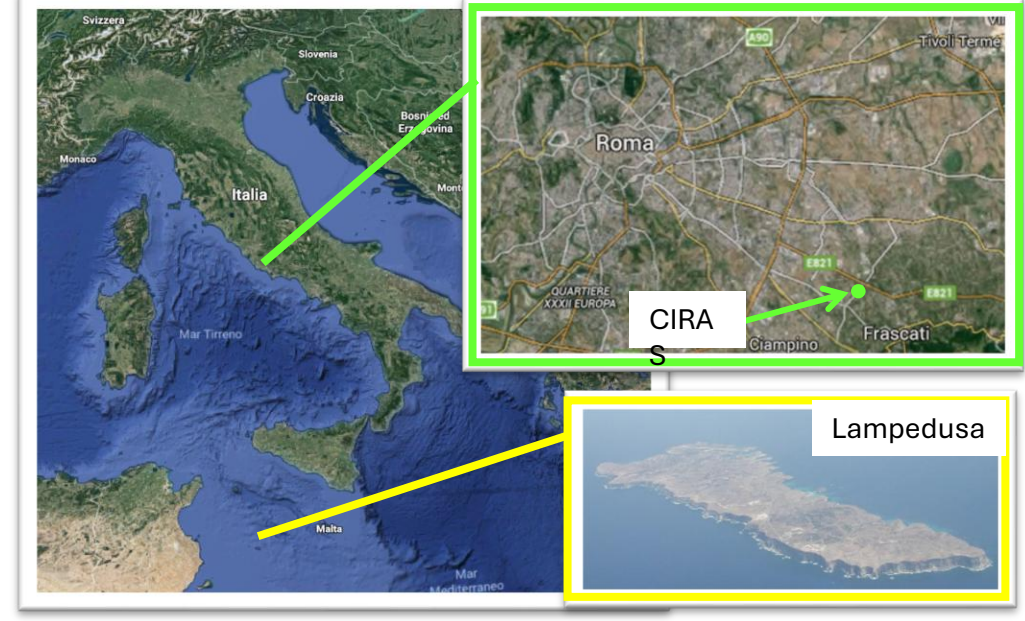


Figure 1: location of the sites

- Within the ESA EarthCARE validation project “An Italian coordinated contribution to the Validation of EarthCARE products from three atmospheric observatories in the Central Mediterranean Sea” (EVID11), and with the support of the Italian Space Agency (ASI) through the EC-ValMed.it project, this study aims to validate EarthCARE (EC) **Level2 cloud and precipitation products** by comparison with ground-based observations collected across Italy.
- An analysis was conducted at two similarly instrumented sites with different climatological settings: the CNR-CIRAS observatory in Rome, Tor Vergata, and the ENEA Climate Observatory in Lampedusa. To account for the lack of coincidence of CPR and ground-based measurements and the high spatio-temporal variability of the precipitation, comparisons were performed using different integration time windows (i.e. 1, 2.5, 4, 10, and 20 seconds for CPR (that correspond to 7.6, 19, 30.4, 76 and 152 km), and 5, 10, 15, 30, 60 and 120 minutes for disdrometer and MRR).
- Then, given the limited number of rainy overpasses, at Rome and Lampedusa, the validation of CPR precipitation products was extended to the entire Italian peninsula using the national radar network to obtain a more statistically robust assessment.

ROME (CIRAS)

Statistical Comparison of CPR and disdrometer data for precipitation events

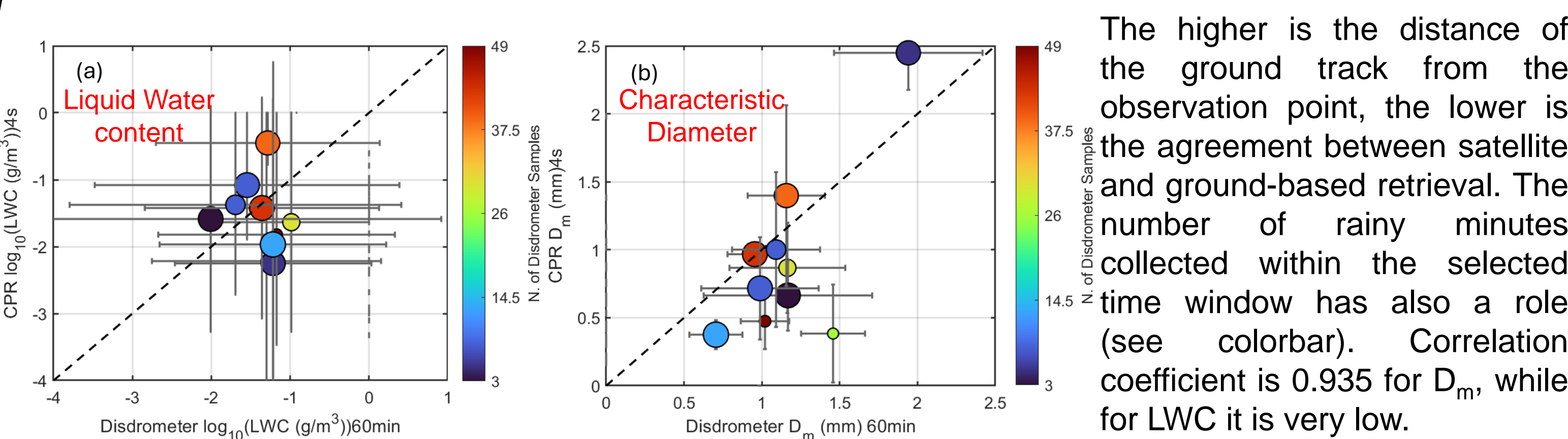


Figure 2: Scatterplot between disdrometer (x-axis) and CPR (y-axis) based LWC (a) and D_m (b). Marker sizes are inversely proportional to the distance of EC ground track with respect to Rome site; the colorbar shows the number of disdrometer rainy minutes collected in the selected time window. The time windows with the higher correlation of D_m are shown.

Statistical Comparison of MSI and sky-camera data for cloud

- Satellite and ground-based reference were compared within coincident areas (i.e. MSI overlaps the field of view of the sky camera)
- A good overall correlation ($R \sim 0.9$) is reached. For cloud cover values above $\sim 40\text{--}50\%$, MSI-CM frequently tends to return lower values than those measured by the sky camera, probably due to the digitalization of the cloudy condition in the MSI products.

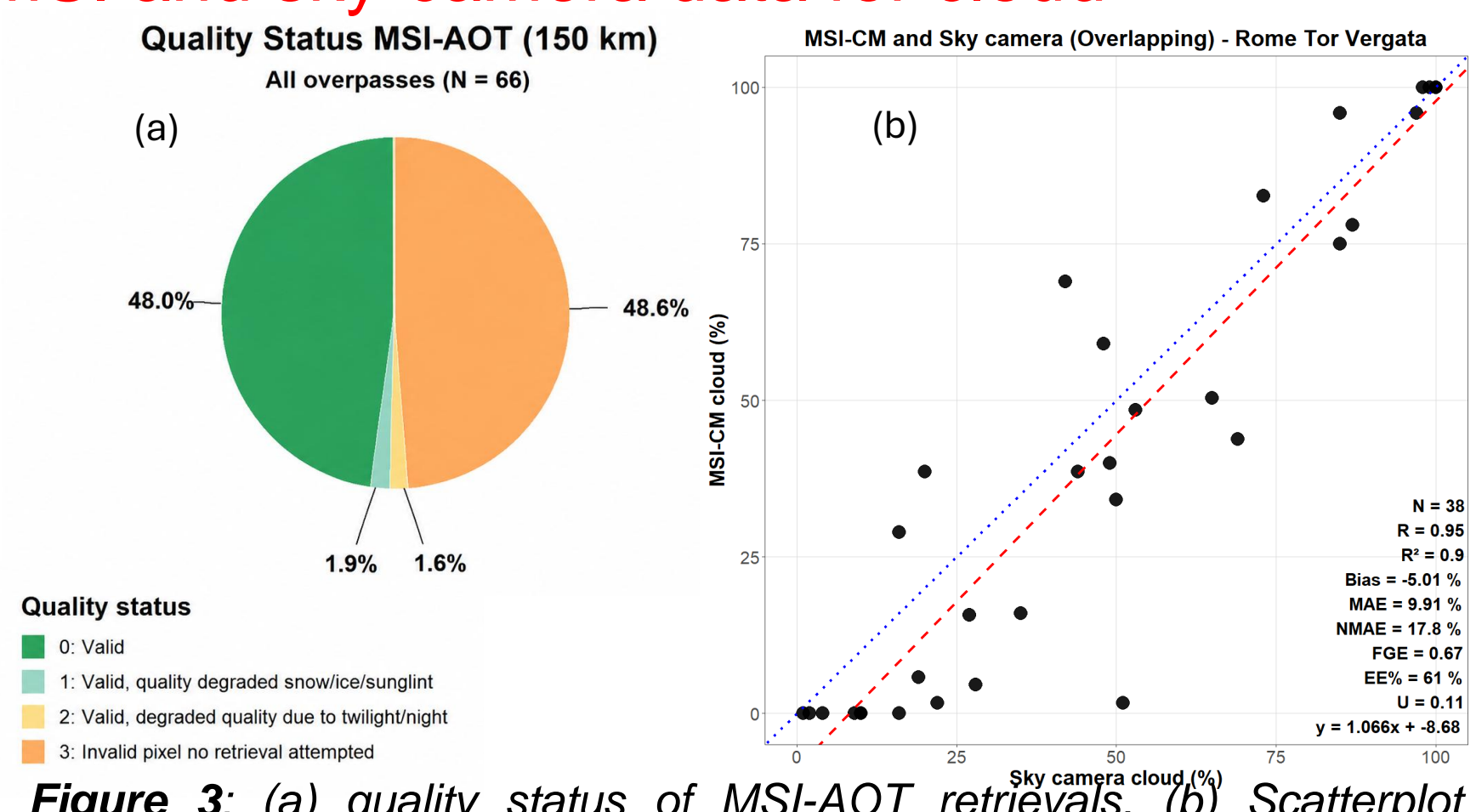


Figure 3: (a) quality status of MSI-AOT retrievals. (b) Scatterplot between sky-camera (x-axis) and MSI (y-axis) based cloud cover.

Examples of CPR and Micro Rain Radar (MRR) vertical profiles comparison

Up to the Melting Layer the agreement between CPR and MRR vertical profiles of microphysical parameters D_m and Liquid Water Content is good. Similarly, the agreement between vertical fall velocities of MRR@24 GHz (and MRR converted to 94GHz) and CPR is very good for the whole profile.

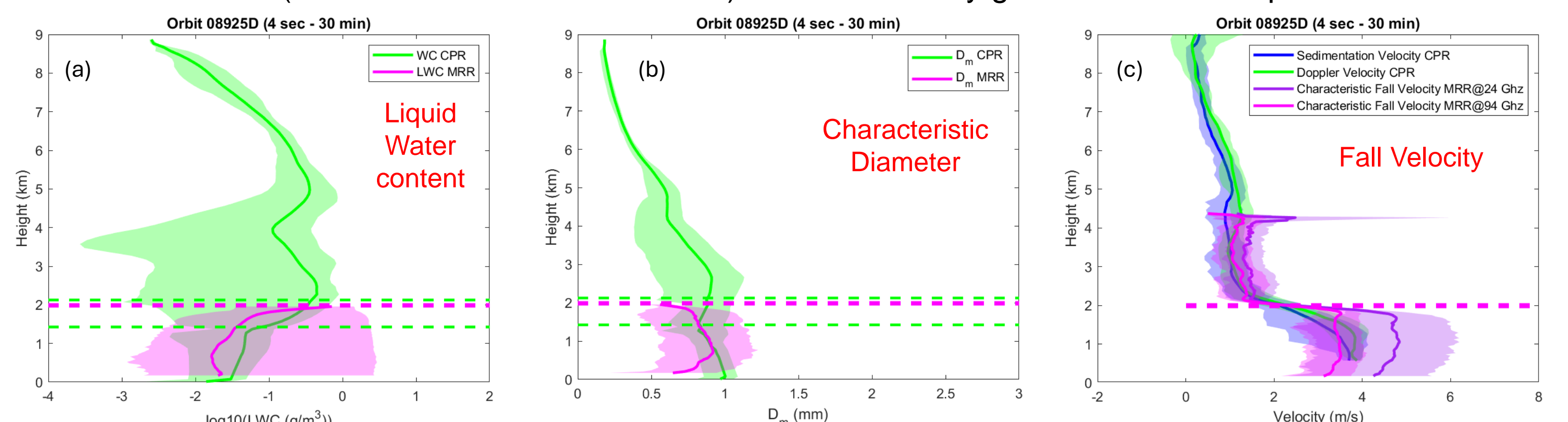


Figure 4: Panels show the vertical profiles of precipitation microphysical retrievals from CPR-CLD and MRR ((a) and (b)), and Doppler and Sedimentation fall velocities from CPR-CD ((c)) and MRR for a stratiform event that occurred on 23 December 2025 around Rome site. Melting layer heights retrieved from both CPR and MRR are also indicated. The EarthCARE ground track was approximately 18 km from Rome site. CPR profiles represent 4 s averages (corresponding to approximately 28 km along track), MRR profiles are averaged over 30 min. Conversion of MRR fall velocity from 24 GHz to 94 GHz has been also applied.

LAMPEDUSA

A statistical comparison between LWC and D_m at Lampedusa site is meaningless because, although we have analysed almost 2 years of data (i.e. from May 2024, the launch of the satellite, up to April 2026), the number of EC overpasses with precipitation are only 3. Furthermore, for all of them, less than 35 minutes of precipitation have been registered by the disdrometer in the 2-hour window around the satellite overpass time.

Statistical Comparison of MSI and sky-camera data for cloud

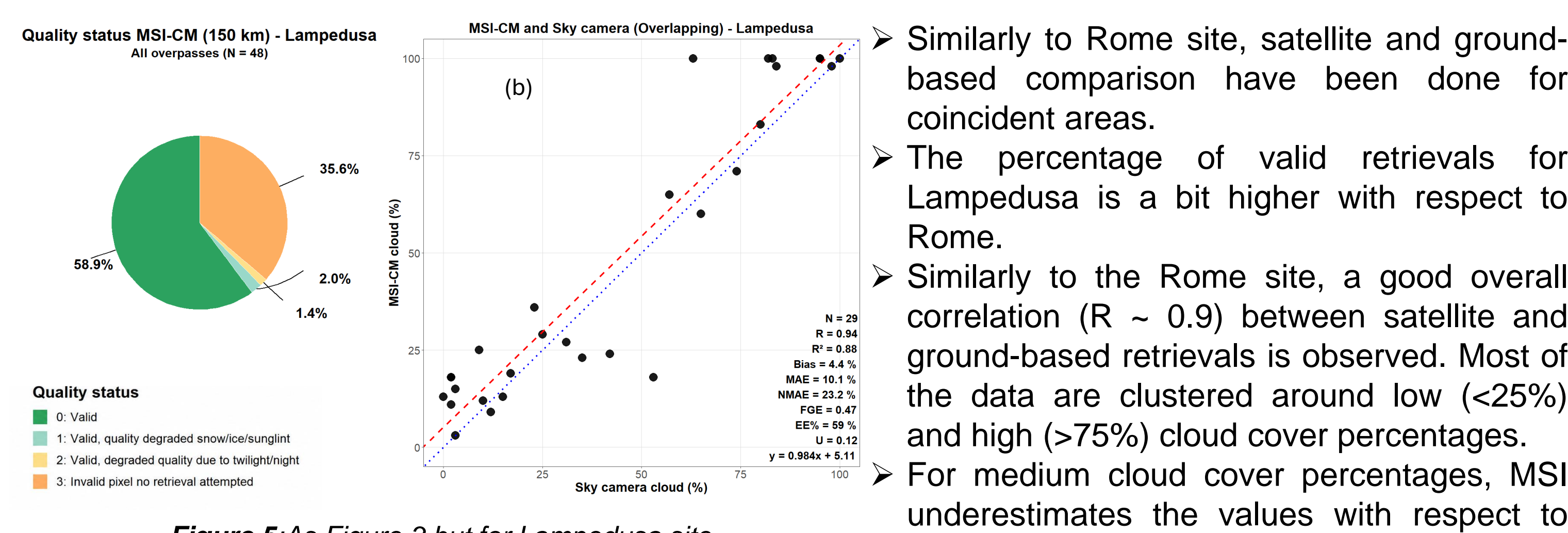


Figure 5: As Figure 3 but for Lampedusa site.

Examples of CPR and Ka-band doppler cloud radar vertical profiles comparison

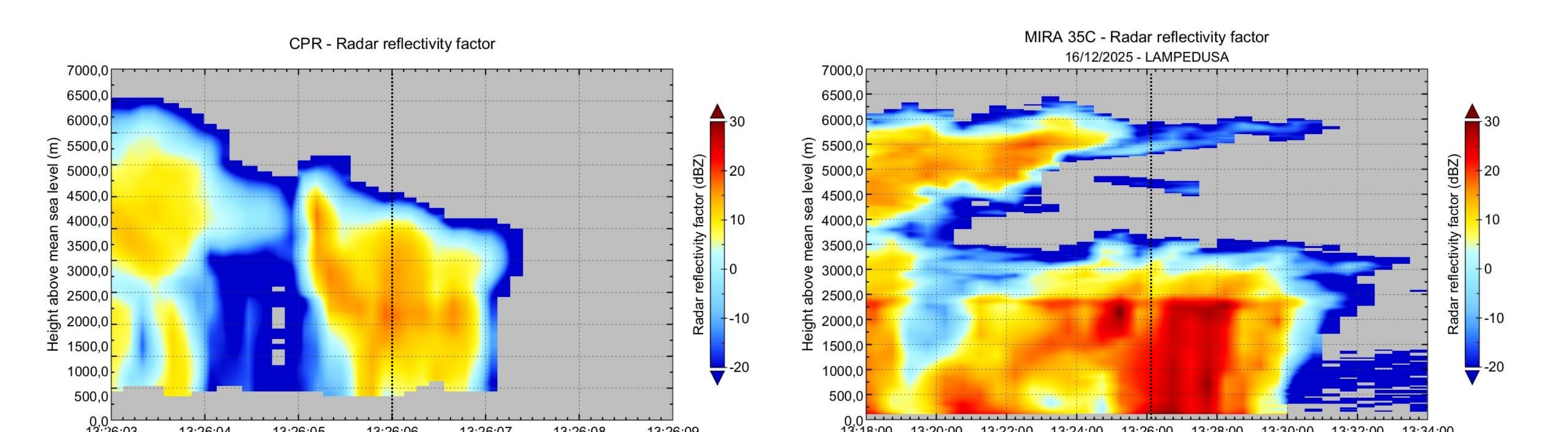


Figure 6: Reflectivity profiles from EarthCARE CPR product (left), and MIRA 35C cloud Doppler Ka-band radar (right) at Lampedusa.

- Between 500 m and 2000 m the differences among ground-based radar averaged over 5 and 15 minutes highlight a large temporal variability of the precipitation event.
- The CPR and MIRA 35C velocity profiles show a generally consistent vertical structure, especially between about 2.5 and 5 km altitude, indicating good agreement between satellite and ground-based observations.
- The CPR profiles exhibit smoother vertical gradients, likely due to the larger satellite footprint and averaging along track.

PRECIPITATION PRODUCTS OVER ITALY

The CAPPI (Constant Altitude Plan Position Indicator) product @2 km ASL, provided by the Italian weather radar network managed by the Department of Civil Protection (DPC) is used to validate EarthCARE CPR Doppler observations in rainy conditions. Almost one year of data (from June 2024 to August 2025) were used for this analysis.

Comparison Methodology

- 1) disdrometer data from 2012-2025 of the Thies Clima disdrometer on the roof of the CNR-ISAC building in Rome has been used to obtain relations linking radar reflectivities @C-band and:
 - ✓ Liquid Water Content (LWC)
 - ✓ Characteristic mean diameter (D_m)
 - ✓ W-band reflectivity weighted sedimentation velocity (V_d)
 The Sequential Intensity Filtering Technique (SIFT) was used to smooth datasets and minimizing noise.

Comparison Results

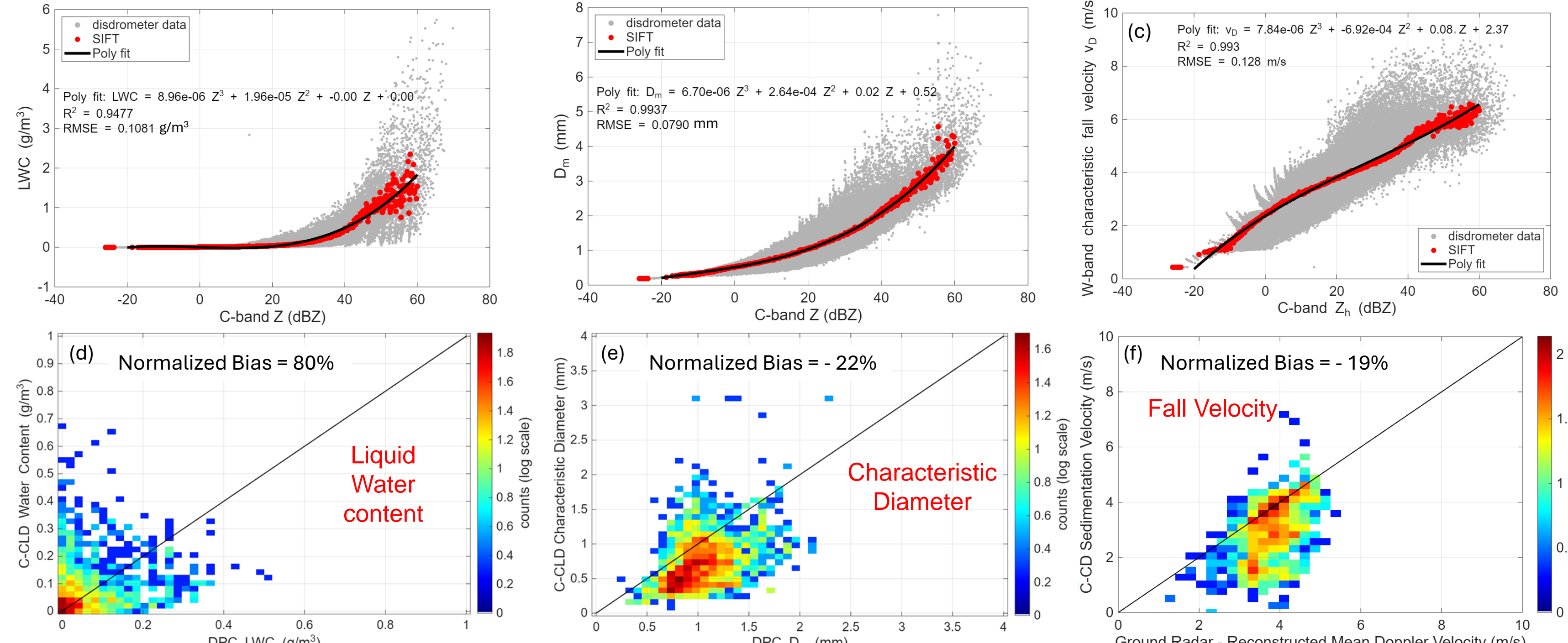


Figure 8: top panels show disdrometer data and corresponding relations used to retrieve LWC (a), D_m (b), and V_d (c) from ground-based radar reflectivity @C-band. Bottom panels shows the 2D scatterplots between ground-based (x-axis) and CPR (y-axis) retrieved LWC (d), D_m (e) and V_d (f).

WARNING

We noticed that, as already reported in the ECVT forum, issues still persist in the header information of the CPR L2 products (CPR-TC, CPR-CD, CPR-FMR, CPR-CLD, baselines BA and BC). In particular, for some orbits, the geographical information reported in the header does not match the corresponding information contained in the product file. As a result, problems arise when automatically downloading CPR products for a given geographical area.

Financial support: This research has been supported by the Italian Space Agency through the EC-VALMED.it project (Agreement n. 2024-1-HB.0). **Acknowledgment:** We acknowledge ACTRIS and Finnish Meteorological Institute for providing the data set which is available for download from <https://cloudnet.fmi.fi>. We acknowledge ECMWF for providing IFS model data.