Preliminary Ground Validation of CPR Radar Reflectivity and Doppler Velocity products at the Mario Zucchelli Antarctic Site using the K2W Methodology with 24 GHz Doppler Radar and Disdrometer

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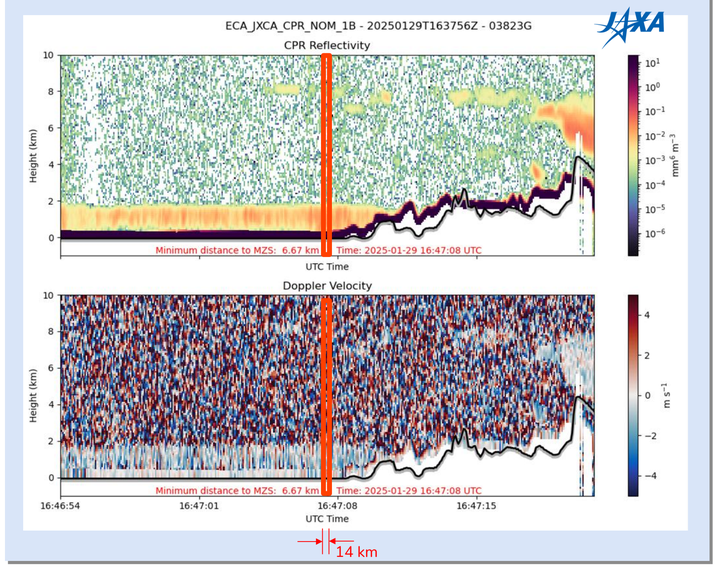
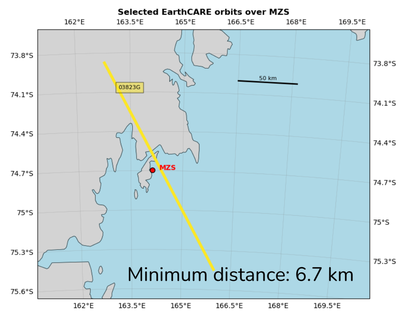
Two approaches for two case studies

Orbit frame: 03823G

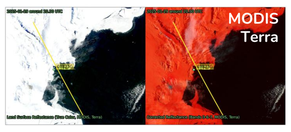
A **coincidence validation approach** at the overpass scale was chosen for the overpass on Jan 29, 2025. This was the closest overpass among the 16 overpasses happening in coincidence with some precipitation signal from the ground, of the 270 total overpasses within a 245 km sided lat-lon square centred on the Italian Antarctic **Mario Zucchelli Station (MZS)** during the six months from August 2024 to January 2025 included. This approach assumes a good representativeness between the ground-measured profiles at the time of closest distance and the space-borne profiles at the closest point. Exact timing and placing are shown in red.

EarthCARE CPR L1 (JXCA)



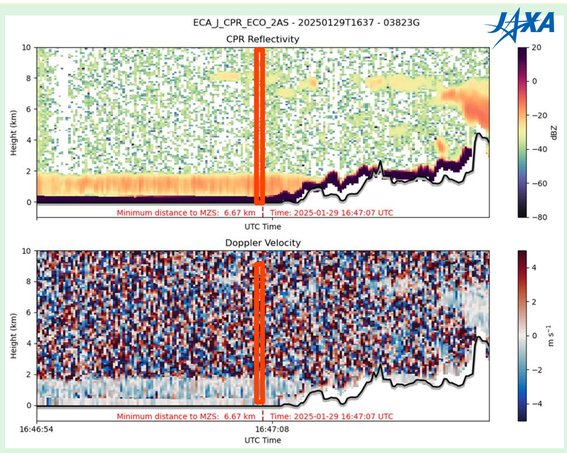


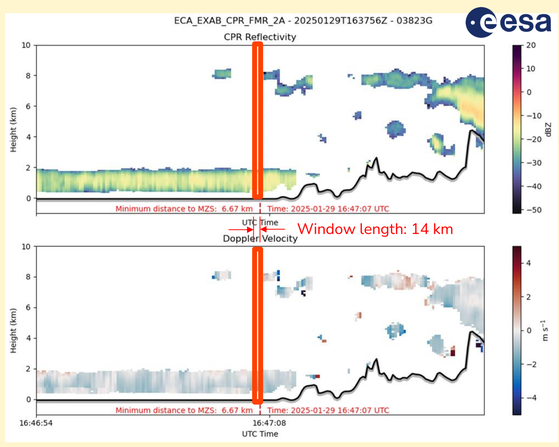
Meteorological scene: A low-level cloud above the sea reaches the coastline but does not climb over the coastal ridge. A thicker cloud over the edge of the Antarctic plateau remains higher. VIS and IR RGB images taken by MODIS a few hours later still show the higher cloud, while the low layers seem to have dissipated.



Note that EC MSI was not available at the time of the analysis.

EarthCARE CPR L2

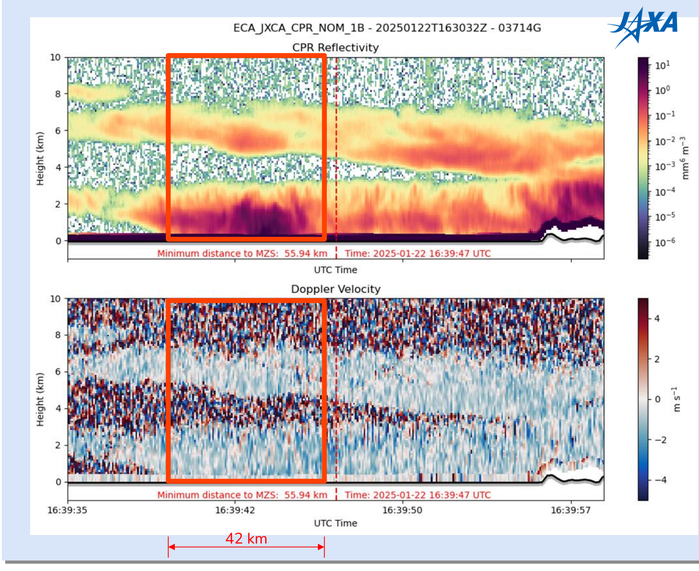


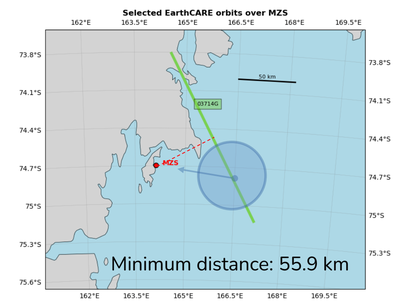


- The selection window spans the two seconds around the time of closest distance, for a total of 14 pixels at the 1km resolution.
- ESA L2 variables: "ScienceData/**reflectivity_corrected**" from CPR_FMR and "ScienceData/**doppler_velocity_best_estimate**" from CPR_CD.
- JAXA L2 variables: "ScienceData/Data/**integrated_radar_reflectivity_1km**" and "ScienceData/Data/**integrated_doppler_velocity_1km**" from CPR_ECO.

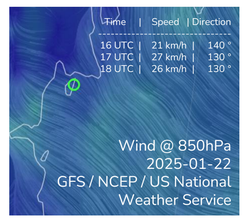
Orbit frame: 03714G

For the overpass on Jan 22, 2025, instead, the analysis is performed **at the event scale**: the distributions of equivalent reflectivity (Ze) and Doppler velocity (vD) profiles of the CPR along the spatial dimension (across the entire cloud extension) are compared with the distributions of the MRR2 profiles along the temporal dimension (throughout the entire event evolution). **Meteorological scene:** a precipitating system in the low levels is detected over the sea around 60 km far from MZS. Ground-based instruments detected an event about three hours later over MZS. A preliminary analysis suggests a phenomenological connection between the two.

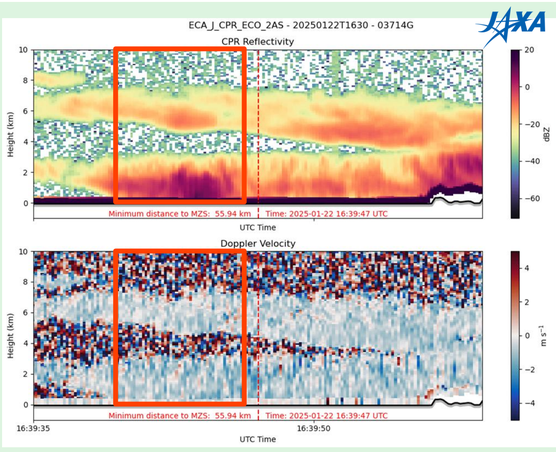


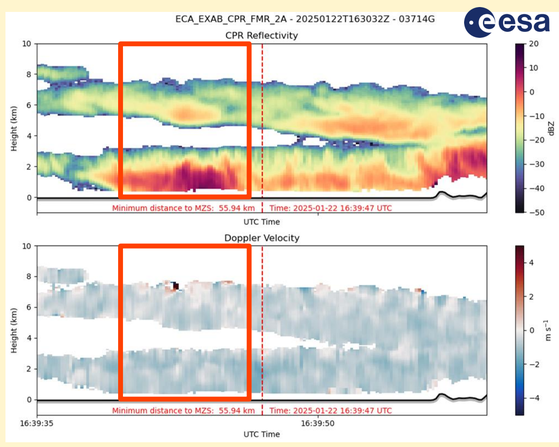


Values of wind speed and direction at 850 hPa from GFS models for the same hours are consistent with the hypothesis that the precipitation detected by EarthCARE advected towards the coast to reach the ground station.



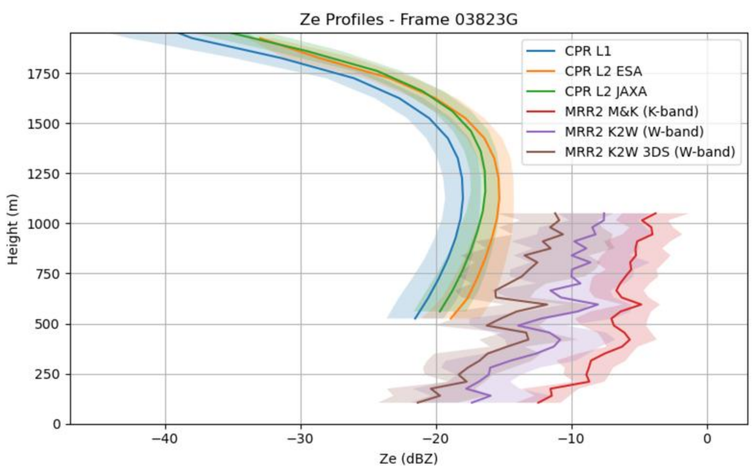
EarthCARE CPR L2

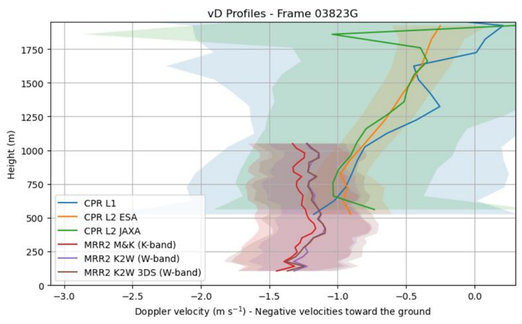




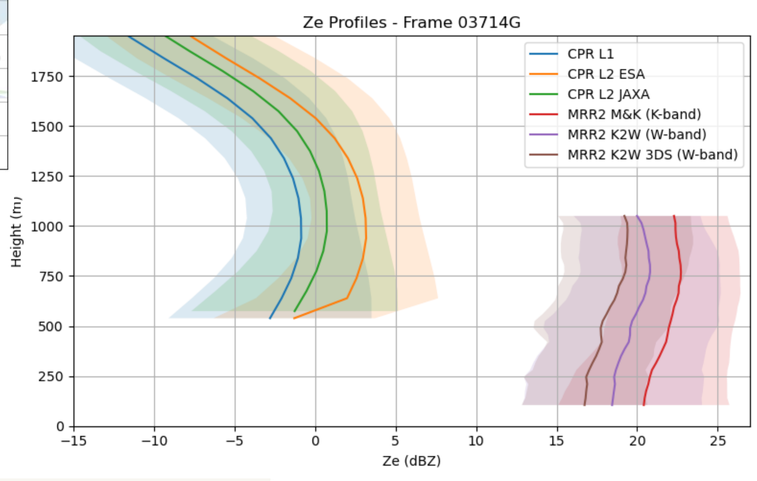
- Here the window spans six seconds and 42 km. The average distance of the precipitating core is 60 km from MZS.
- Both L2 products select the precipitating core of the cloud, with minor differences in the mask edges. ESA L2 product is less noisy.

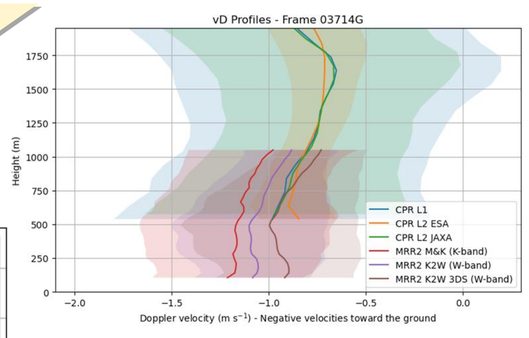
Average +/- standard deviation profiles
The selected samples are indicated by the red boxes.



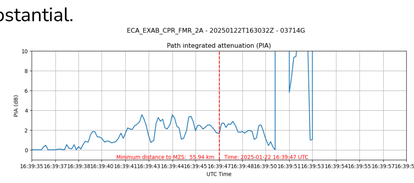


- The decreasing trend towards the ground is similar (indication of **sublimation**).
- The **K2W conversion** helps narrowing the gap in equivalent reflectivity factor Ze.
- Doppler velocities have the same sign but differ slightly in magnitude.
- L1 vD has a great variance, which is still present in JAXA L2, less in ESA L2.





- K2W conversion of the MRR2 is around 2 to 5 dBZ.
- The agreement among the **vD** estimates is strong.
- The discrepancy between **Ze** estimates can not be explained by PIA only
- The variance of Ze from ground-based observations over the full 2-hours event is substantial.

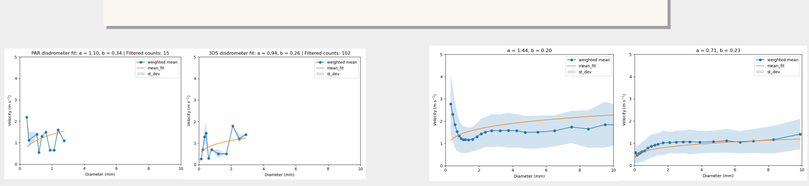


The K2W equation:

$$\eta_{v,W}(v_s) = \eta_{v,K}(v_s)\frac{C_{bk,W}(v = g(D))}{C_{bk,K}(v = g(D))} \Rightarrow \begin{matrix} Z_{e,W} \\ V_{D,w} \end{matrix}$$

K2W is a method of conversion of the Doppler spectral reflectivities measured by a vertical profiling K-band radar to their W-band equivalent, based on the microphysical information provided by a co-located disdrometer.
Specifically, a monotonic increasing, invertible relation v = g(D) between the falling velocity and the diameter of precipitating particles is needed.

K2W



V = g(D) relations derived from the two disdrometers at the MZS site during the two events

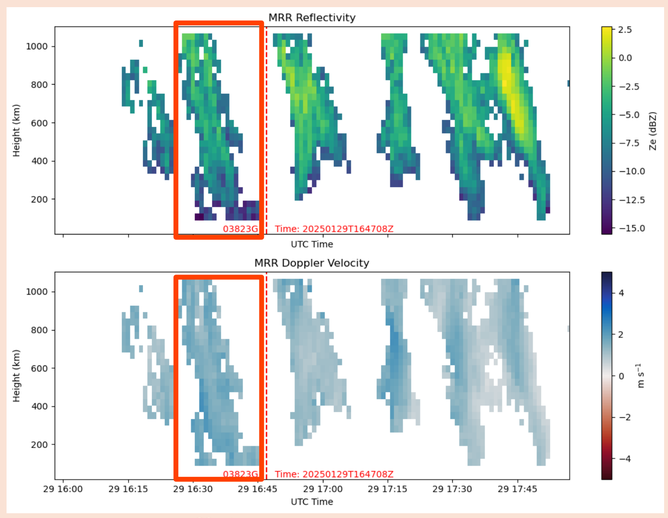
K2W

K2W Reference:

Bracci, A., Sato, K., Baldini, L., Porcù, F., and Okamoto, H., 2023. Development of a methodology for evaluating spaceborne W-band Doppler radar by combined use of Micro Rain Radar and a disdrometer in Antarctica. Remote Sensing of Environment, 294, http://doi.org/10.1016/j.rse.2023.113630

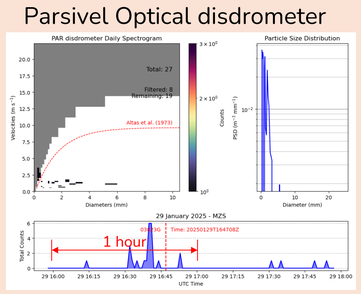
Ground (MZS)

Micro Rain Radar (MRR2) processed with IMProToo

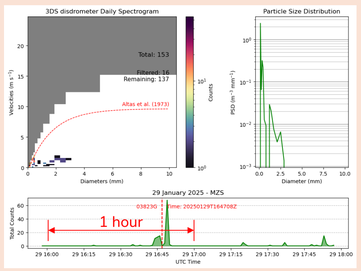


Mario Zucchelli Station site
Lat: -74.694, Lon: 164.115

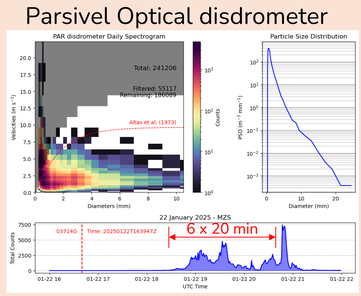
Parsivel Optical disdrometer



Thies Clima Imaging disd.



Parsivel Optical disdrometer



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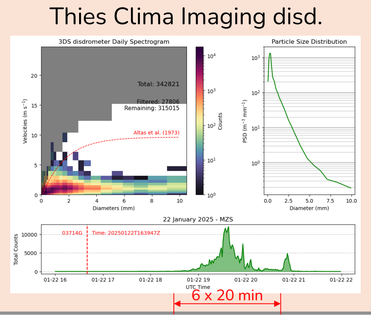

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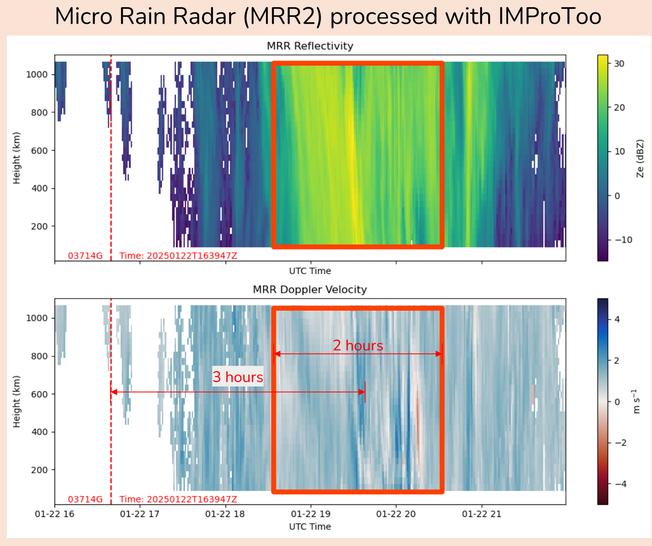

IMProToo reference: Maahn, M. and Kollias, P.: Improved Micro Rain Radar snow measurements using Doppler spectra post-processing, Atmos. Meas. Tech. Discuss., 5, 4771-4808, http://doi.org/10.5194/amtd-5-4771-2012, 2012

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