

Interactive comment on “Calibration of a 35-GHz Airborne Cloud Radar: Lessons Learned and Intercomparisons with 94-GHz Cloud Radars” by Florian Ewald et al.

Anonymous Referee #3

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The manuscript of Ewald et al. documents a nicely done study of the calibration accuracy of a Mira-35 cloud radar system installed on the HALO aircraft. I appreciate that the authors were not satisfied by just evaluating their Mira system against other instruments (RASTA, Cloudsat). The actual high value originates from the detailed characterization of the individual technical components.

The overall quality of the manuscript is good. I did not find any important issues which would require an actual major revision. Nevertheless, the manuscript leaves the reader with some minor issues and unclear statements which I will try to address below. Because a rather high number of unclear passages were identified (which might hamper

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the reproducibility of this AMT study), I recommend to re-distribute the manuscript for a second round after revision was finished. This is the only reason why I chose 'major revision'.

1) Abstract: - The abstract should contain more quantitative information. Currently, the abstract only tells what was done. But it does not tell at all about the findings. It should, e.g., be stated, which technical components were characterized and which issues were found. How did the characterization compare to the ones specified by the manufacturer? Short answers should also be applied for: (1) what the ocean surface backscatter measurements revealed; (2) what the measurements of signal linearity and signal saturation show; (3) what the intercomparison flights with RASTA and Cloudsat revealed.

2) Introduction: - The first paragraph is not really necessary for an AMT article. It could be shortened, e.g.: "In recent years, the deployment of cloud profiling microwave radars on the ground, on aircraft as well as on satellites, like CloudSat (Stephens et al., 2002) or the upcoming EarthCARE satellite mission (Illingworth et al., 2014), greatly advanced our scientific knowledge of cloud microphysics. Nevertheless, large discrepancies in retrieved cloud microphysics (Zhao et al., 2012; Stubenrauch et al., 2013) contribute to uncertainties in the understanding of the role of clouds for the climate system (Boucher et al., 2013). An important aspect for enabling accurate microphysical retrievals based on cloud radar data is the proper calibration of the systems. System parameters of transmitter."

3) Z/Ze: - Please clarify throughout the manuscript, whether Z or Ze are shown. Were all the presented Z-values obtained with Eq. 1? Or was 'eta' considered in some of the occasions of Z and in some not?

Other comments: P1-L4: What is correct? "signal linearity/signal saturation" or "receiver linearity/receiver saturation"?

P1-L22: Only changing temperature and pressure? What about the initial calibration of

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the system?

P2, L1-3: Also many ground-based radars are operated at fixed elevation angles.

P2, L9-12: Is this (calibration spheres, tethered balloons) also true for cloud radars?

P2, L11-12: Is there a reference to “For the airborne perspective on the other hand, the direct fly-over and the subsequent removal of additional background clutter is difficult to reproduce.”

P3, L9: Add “After some considerations about required radar accuracies shown in Sec. 1.1, Section 2 introduces the cloud. . .”

P4,L1-2: Where are standard instruments of ACTRIS defined?

P6,L14-L17: Is there a documentation of the antenna calibration procedure (Is it similar to, e.g., Myagkov et al., 2015)?

P6, L19: Just to cross-check: It is true that 0.31 mm increase in radome thickness increase the attenuation by 1 dB?

P6, L26-28: It would be interesting to see the relationship between temperature, P_t , and I_m .

P6, L27: ‘thermally stabilized’ or ‘thermally controlled’?

P7, Eq. 6: Should be only $P_r = T^{-1}(\text{SNR})$. The relationship $P_r \sim P_n \cdot \text{SNR}$ should be introduced after “dBm.” In Line 25.

P8, Fig. 2: What is the unit [DN] of the signal? Is this signal the same as parameter “ S_r ”?

P8,L16: Is there a reference to the ‘Y factor method’?

P9, L1: A pity, that Figure 2 is cut-off exactly at the 10th range gate.

P9, L 3,5: Is there a difference between the ‘noise factor F_N ’ and the ‘noise figure’

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NF?

P9, L22: What is meant by 'low-noise amplifier is not matched during the noise gate measurement'? Is there a Mira-35-related reference where this is illustrated in a sketch?

P11, L1: "(black horizontal line)" instead of '(orange line)'

P12,L25: What is the impact of F_n being larger by 1.1dB?

P17, Fig. 6: The legend does not cover the range of angles given in the text ($\pm 20^\circ$)

P17, Fig. 7: Introduce a (left),b(right),c(small subfigure in (b)). What does (c) show?

Sec. 4.3 general: Did the authors observe any attenuation effects when probing the ocean surface?

P19,L6: In Fig 8, 'maximum diameter' is given instead of 'melted diameter'?!

P19,L9: size/mass relationship for which particle habit?

P19/20: Figs. 8 and 9 should be switched (Fig. 9 is currently introduced first).

P21,L16: How was it achieved to have a "well-defined" RASTA? Can 'well-defined' be quantified?

Sec5.2/Figs 12&13a: Which parts of the measurement in Figs 12 were used for the regression in Fig. 13a? If all parts were used, how was liquid attenuation by the lower clouds corrected?

Sec.5.3/Figs. 14&13b: Which parts of the measurements shown in Fig. 14 were used for the regression shown in Fig 13(b)?

P22,L16: what was the PRF setting during the calibration flight? 5kHz or 6 kHz?

Fig 12: Z or Ze?

Fig 13: Please add (a) and (b). What kind of instrument is HALO MIRA? :) The label

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in Fig. 13 (b) is hardly readable. The figure mentions “Z” and “Ze”. Please clarify.

Fig 14: Please add (a), (b), (c). What kind of x-axis is shown in Fig. 14(b)? Is this really Cloudsat? Is there a reference available for the instrument that provided the data for Fig 14(a)? What is shown, Z or Ze?

Sec. 6: Also in the conclusions sections some more facts and figures should be provided. Can there any guidelines be given to operators of other cloud radars? Is the actual laboratory setup for doing the calibration measurements (Sec. 3.2-3.4) documented somewhere? This would be a great benefit for this AMT article because it would enable others to actually reproduce the calibration.

Further: No information about data availability is provided. Are the data inside HALO DB?

References: Myagkov, A., P. Seifert, U. Wandinger, M. Bauer-Pfundstein, and S.Y. Matrosov, 2015: Effects of Antenna Patterns on Cloud Radar Polarimetric Measurements. *J. Atmos. Oceanic Technol.*, 32, 1813–1828, <https://doi.org/10.1175/JTECH-D-15-0045.1>

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