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Atmospheric Measurement Techniques Discussions

Interactive comment on "Potential of airborne lidar measurements for cirrus cloud studies" *by* S. Groß et al.

S. Groß et al.

silke.gross@dlr.de

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Review of 'Potential of airborne lidar measurements for cirrus cloud studies', by S. Gross et al., submitted to AMTD for publication in AMT.

We thank this Reviewer for his careful reading of the manuscript and for his suggestions to help us improve the paper.

The answers are given in a direct response.

Summary Using a new airborne platform, HALO, Gross et al. perform DIAL lidar measurements of high-altitude cirrus with a nadir lidar. They observe lidar backscatter and water vapour mixing ratio during a November 2010 case study and use ECMWF

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analysis temperature to derive relative humidity over ice. Furthermore, results from a second aircraft flying in-situ provide temperature and water vapour mixing ratio within the cloud. Such observations of in-cloud water vapour measurements are uncommon yet required to characterise the environment in which cirrus exist. The authors have performed a comprehensive and interesting case study and I recommend that they publish in AMT following their consideration of the following points.

Minor Comments 1) You discuss the optimal distance being 2km above cirrus cloud (tops?) (line 30) yet your case study says HALO's flying only 1km above the clouds (P3 line 11). Perhaps this is why you have overloaded signal in Figure 3a above 12km altitude. Some mention of this should be made in the discussion of Figure 3.

We agree and added "Unfortunately we were not able to reach the maximum cruise altitude during this case study to obtain an optimal distance to the cloud top to avoid signal overload (identified by the white areas in the upper part of the cloud in Figure 3a)." to the text.

2) Section 3.1 Some details of the ECWMF analysis are required. Are you flying in one analysis grid-cell? What space / time resolution is ECWMF? More details on how you constructed the cloud ice water content from the ECMWF gridded data (Figure 3a) should also be provided. You should probably change P7 line 1 to read 'water content indicates that: : :'.

We added some additional information with details about the used model data: "Additionally to the water vapour measurements, the calculation of RHi requires collocated temperature information. As there was no remote measurement of the temperature field beneath HALO, 3-dimensional temperature fields provided by the ECMWF global model were used. Analyses and short-term forecast with at a 1 hourly temporal resolution and a T799L91 spatial resolution, i.e. $\sim$25km horizontal distance between neighboring grid points, are interpolated in space and time to match with the position of the WALES measurement (see Schäfler et al., 2010). Beside temperature, also simulated

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cloud ice water content and water vapor mixing ratios were interpolated to the flight track. The vertical resolution of the terrain following model levels at cirrus altitude (∼10 – 13 km) is about 400 m."

3) Page 7, line 7. Optical depths (OD) using lidar are sometimes calculated differently by different research groups. Some brief detail about how you calculate OD would be useful. Also worth noting the cloud is rather optically thick (for lidar anyway).

The optical depth is calculated with the high spectral resolution method. We added this in the text.

4) From my understanding, Figure 3 shows the cirrus time-series as measured by the multiple 'racetrack' ovals which the aircraft flies in Figure 2b (please note how many of these ovals you are studying in Fig 3 and subsequently). So is it possible that you are at times measuring the same air mass (which looking at Figure 2a moves approx. eastward) at later times as it moves through your aircraft flight? Is this why in Figure 3a the ECMWF IWC shows a semi-repetitive nature every _10min?

For our observations on 4 November 2010 five ovals have been flown at constant flight level. We added this in the text. It is possible that airmasses were observed twice or one could assume a certain horizontal homogeneity in the simulated cirrus clouds.

5) P8 line 13. Comment on your use of the word 'smaller' to discuss temperature fluctuations (implying this is smaller relative to mixing ratio fluctuations). Unless you are comparing their percentage fluctuations, you cannot say/imply that temperature fluctuations are smaller than mixing ratio fluctuations. Please reword, e.g. simply state that 'The temperature fluctuations have a minor: : :'. It might be useful to include the formula which you used to calculate RHi in this section.

We removed the word 'smaller' and followed this reviewers suggestion. However, we do not include the formula in our manuscript, but we refer to the formula used to calculate RHi.

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6) Figure 5. Uncertainties in all observed and derived parameters need to be plotted, and then propagated through to the RHi (bottom figure). You may wish to plot representative uncertainties instead of the uncertainty at each time, but they are certainly needed on Figure 5 to determine whether the RHi are consistent within uncertainties using each different technique.

The main intention of the presented comparison in Figure 5 is to determine the dominating factor regarding the relative variability of RHi within the considered time series. For this, a general comparison of temperature, water vapour and RHi as well as of the uncertainties is crucial. For the measurements the uncertainties can be calculated. In contrast, the uncertainties of the model values are not given. Furthermore temporal and spatial interpolation of the data introduces further uncertainties preventing a more the representative discussion on the uncertainties. Section 3.3 gives a discussion on RHi uncertainties including the propagation of the uncertainties in the single input values.

7) Figure 1 (aircraft photograph) and Table 1 (technical features) can be removed as they do not add anything to your research paper. Table 1 seems especially irrelevant here, although it might be suitable for an overview paper.

Although Figure 1 and Table 1 add nothing to the research presented in this paper we would like to keep them to give the reader an impression of the conditions and limitations with this platform.

8) Figure 10. Overplot the backscatter ratio=4 line to indicate your cloud threshold boundary.

We inserted this line at backscatter ratio = 4 in Figure 10.

Technical Corrections P2, line 14: ‘and therefore of the’

We changed that.

P2 line 26: ‘enables us to’

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We changed that.

P4 line 7 ‘access for commercial’

We changed that.

P4 line 13 “data beneath”

We changed that.

P6 line 21 ‘jetstream’

We changed that.

P9 line 9 ’12 UTS ascents over Munich’

We changed that.

P10 line 25. Do you mean low ‘temporal’ variability?

We changed that to ‘low temporal horizontal variability’

P11 line 21 ‘Figure 10’

We changed that.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 4033, 2014.