Response to RC1 of amt-2024-19

We want to thank the first referee of our paper for the review and comments.

The reviewer posed the following question:

This is very nice but ignores the fact that the clouds are convective, and the vertical growth rate of the clouds can be in the order of half of the horizontal wind speed of 7 m/s in this case. An interesting question is to what extent can the remaining error be caused by the cloud's vertical growth rate?

From a theoretical point of view, one could expect that neglecting the vertical wind speed in our consideration could explain parts of the determined uncertainty. For example, a vertical growing cloud with a growth rate of 3-4 m/s could lead to a height difference of 60 – 80 m within 20 images, which is the maximum number of frames taken into account by the stereographic reconstruction method for a single point. Hence, this could lead to "errors" in the estimation of the cloud top height of 30 – 40 m when compared to the beginning or the end of the tracking time. Here, one can ask the question what the true "cloud top height" actually is. In our model study, we chose to compare to the cloud top heights after half of the simulation time such that this effect should cancel out.

One can further argue that clouds are turbulent. In particular, the cloud edges of shallow cumulus clouds show turbulent eddies and hence, usually up- and downward movements. Thus, one probably does not observe purely growing/shrinking clouds, which will cancel out the described effect.

As described in Sec. 4 l. 154f., a large part of the uncertainty might be explained by small uncertainties in the viewing angles of the camera. This effect dominates over errors made by not considering the vertical wind.

Finally, we performed a simulation without any cloud development, and hence no wind movement (Volkmer et al., 2024, https://doi.org/10.5194/amt-17-1703-2024). We found an uncertainty of about (46 ± 140) m, which thus is in the same order as with the wind movement. We added the following paragraph from l. 155f.:

"One possible error source, the evolution of the observed clouds, has been studied by Volkmer et al. (2023b), using a similar setup as described above but with non-developing and non-moving clouds. Hereby, an absolute mean bias of (46 ± 140) m was found. While the larger mean bias might be explained by a remaining uncertainty in the wind estimation and a cancellation of the error sources, the standard deviation and hence, the error of the single measurement, remains approximately constant."

A missing number is the simulated flight height above the simulated cloud.

We added the missing simulated flight altitude at the beginning of Sec. 4 in line 130: "A flight altitude of 10 km was assumed."

Response to RC2 of amt-2024-19

We want to thank the second referee for reviewing our manuscript. The reviewer posed some minor comments which we have addressed as described below:

Wind correction based on ERA5 reanalysis data

Please, add also *Pcs* in the text.

p. 3, line 90: “of the point on the cloud surface (Pcs)”

to Figure 1: In the printed version the clouds are quite faint.

We applied the suggested change in l. 90/91 and enlarged the opacity of the clouds in Fig. 1.

Validation using measurements from EUREC4A campaign

Figure 2 should be enlarged, it hard to see.

The figure size has been enlarged as suggested.

p.4, line 109: “no significant change” To be more precise, a value should be given here.

We added the median values of the flight legs from the lidar in the suggested sentence: “WALES measurements which are not affected by the cloud movement showed no significant changes in cloud top height during this time with median values of about 745 m on the first leg and 738 m on the second one.”

Figure 3: Could you include the PDF of the WALES measurement, the comparison would be benefit from it.

The WALES PDFs were added to Fig. 3.

Accuracy estimation using realistic simulated measurements from 3-D radiative transfer simulations

p.7, line 133. Can you add an explanation why the used wind speed in the simulations is chosen lower than the real measurement before?

The wind speed of the simulations was taken as obtained from the LES simulations. The simulations were initialized using data from the EUREC^{4}A campaign but afterwards not forced any further. Since we used the second-by-second output from the LES for our radiative transfer simulations, the wind is prescribed by the output, and thus, was not chosen. We changed l. 130f. as following to emphasize that the wind field was obtained from the simulations and was not chosen: “Figure 4 shows the underlying model wind field as obtained

from the LES simulations, indicating wind directions between approximately 140° at low altitudes and 340° at higher altitudes."

Conclusion

To the conclusion: It should be mentioned that further studies with more inhomogeneous cloud state should be added. Since the correction will be even more necessary.

To address this comment, we added the following paragraph at the end of the paper:

"While this study is based on observed and simulated shallow cumulus clouds, the performance of the stereographic retrieval including the wind correction should in future also be tested for other cloud types. In particular, the retrieval should also work in more inhomogeneous cloud fields, with cloud tops spanning larger altitude ranges. This will be investigated in the future, using observations of from past and upcoming field campaigns addressing different cloud types as well as corresponding simulated observations."