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Atmospheric Measurement Techniques Discussions

Interactive comment on "Monitoring Aerosol–Cloud Interactions at CESAR Observatory in the Netherlands" *by* K. Sarna and H. W. J. Russchenberg

Anonymous Referee #1

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Review:

Only few studies have been conducted focusing on Aerosol-Cloud Interactions (ACI) of continental liquid clouds and utilizing ground-based remote sensing. While the physical principles of ACI are generally well understood, their quantification is still highly uncertain, and therefore more studies are required to help improving climate models with observational constraints. The reviewed manuscript adds to this goal, and should be considered for publication after addressing the issues mentioned in the following.

The manuscript refers to a method that was described in a published manuscript by the same authors, while the actual manuscript is an extension of the application on a different dataset. In addition, it discusses the influence of the updraft velocity in clouds

on the ACI metric.

While the results are generally relevant to the scientific community, the paper could be strengthened by considering more Cloudnet stations to gain more robust statistical results from a larger dataset. The discussion could be also a bit more detailed at certain points, which will be outlined below.

1 Major comments

- The reviewed study uses two months of observations from one ground-based observation site within the Cloudnet network. With the required sampling to account for suitable conditions this results in a rather small sample size. To strengthen the conclusions of the paper, it would be worthwhile to consider taking into account more data from other Cloudnet stations. The authors state that the method can be easily adapted to other stations. In my opinion, taking into account more data would help to strengthen the statistical significance of the results.
- While the authors state that similar meteorological conditions should be accounted for, including larger datasets would give the opportunity to also discuss the sensitivity of the results accounting for comparable meteorological conditions versus not doing so. Since the disentanglement of the covariances of aerosol effects and meteorological effects on cloud properties is an important topic (Feingold et al., 2016), I expected to see a more detailed discussion of this issue.
- The discussion should be more comprehensive at certain points: how important is the influence of the sampling method on the resulting ACI metrics? The latter is especially important if small samples are considered as in the case of updraft regimes. The authors mention this problem shortly, but it would be interesting to assess e.g. the uncertainty of the slope, especially for sample sizes n<50.

Another important question is, how sensitive the ACI values are to the choice of the integration height of the ATB? How do results change if the attenuated backscatter is integrated closer to the cloud base?

- Some information is repeatedly given throughout the paper. While it is useful to remind the reader to some information at certain points, some parts should be cleaned up to give the manuscript an better overall flow.
  - Information about LWP binning is discussed at several points (p5,l8; p7,l5; p9,l1). I was expecting a short discussion about LWP bin choices in other studies (e.g. (Kim et al., 2008): 50 gm^{-2}), which would fit perfectly in Sect. 5.3. How would your results change if larger LWP bins were choosen? Could the larger sample size in the bins outweigh the advantage of the smaller bin sizes (i.e. condition of constant LWP better fulfilled)? It would be helpful if you can come up with a statement / suggestion based on your investigations.
  - Sect. 5.4 seems generally a bit mixed up, repeating similar aspects already discussed before (or aspects that should rather go into earlier discussion sections), while the discussion about the relation between the correlation coefficient and ACI_r comes a bit short.

2 Minor comments

- p2,l7: Another big source of uncertainty related to ACI is the problem to disentangle covariances of aerosol effects on cloud properties and the effect of meteorology/thermodynamics/entrainment (Feingold et al., 2016). This should be shortly mentioned in the introduction.
- p3,l11: is now represented by aerosol background →what do you mean by this?

- p4,l24: Why should the cloud base be located below 2000 m AGL? Is there a physical reason behind this choice or is it somewhat arbitrary?
- p7,l8: given the error / typical uncertainty of MWR measurements of 15 gm^{-2}, does it really make sense to use smaller LWP bins than 15 gm^{-2} (10 gm^{-2} in your case)?
- p7,l8: Can you give a justification/reference for the LWP value you have choosen as the precipitation threshold?
- p7,l21: Can you give the amount in % by which the dataset is limited considering only the updraft area?
- p7,l22: Given the significant reduction in sample points, the considerable increase in ACI_r might be possibly due to the smaller sample size. Can you address this issue in more detail? Maybe by accounting for the uncertainty of the regression slope.
- p7,l24: What is meant by significant in terms of ACI_r? Do you mean that the highest values of ACI_r are found in these LWP bins?
- p8,l5: Regarding the algorithm errors, especially the required assumptions lead to large uncertainties. The assumed width of the DSD is likely one of the main sources of uncertainty. Maybe you can discuss this a bit more detailed at this point.
- p8, sect. 5.2: You might consider also discussing other studies mentioning that there is a tendency of larger ACI values in updraft regimes. Look for example at the study of Schmidt et al., 2015.
- p9,l4: you should shortly discuss the possible reasons for the values out of bounds. Is the reason the small sample size or an r_e retrieval error or both?

- p10,l11: The error might be even higher, considering e.g. the assumption about the width of the DSD. Compare Table 1 in Brandau et al., 2010.
- p10,l15: You could mention shortly that using ACI_r results in smaller sample sizes due to the required LWP binning compared to using ACI_N.
- p10,l27: what do you mean by "higher dependency of the paramaters"?
- p10, l32: How could it be adapated to satellite remote sensing? This does not really get clear.
- p19, Figure 4: It would be helpful to provide the regression slopes and also their uncertainty range in the Figure. Same for Figures 5, 6 and 7.
- p23, Figure 8 and 9: I would actually combine both figures, so it would be easier to directly compare the values applying the updraft sampling. The LWP colorbars are not really required since the x-axis already is the LWP. My suggestion is to use two different colors instead; one for ACI_r values of the complete dataset and one for ACI_r values of the updraft dataset.

3 Phrasing / spelling

- p1,l1: the climate models →climate models
- p1,l3: I would use "mitigated" instead of "changed"
- p1,l4: we presented →is presented
- p1,l9: were ranging →range
- p1,l10: impact →the impact

- p1,l10: updraft →I would speak more generally in terms of *vertical Doppler velocity*, since you considered both up- and downdraft regimes of the clouds
- p1,l11: for the LWP between →for LWP values between
- p1,l11: the higher LWP →for higher LWP values
- p1,l14: aerosol-cloud interactions →check the consistency of upper and lower case within the paper and use the acronym after the first introduction
- p2,l2: effect climate →affect climate
- p2,l2: Aerosol →Aerosols (use plural)
- p2,l5: will lead →leads
- p2,l5: cloud droplets concentration →I would use the terminology cloud droplet concentration, same for cloud droplet effective radius (it is mixed up in the paper, see Table 1)
- p2,l17: aerosol concentration on cloud →a change in aerosol concentration on cloud properties
- p2,l23: climate change →I would rather use the term *radiative forcing* here
- p2,l24: the standarize format →a standardized format
- p2,l29: Following →combine with previous sentence: ... calculations, followed by
- p2,l30: over CESAR Observatory →over the CESAR Observatory
- p3,l16: 1 and 0 →I would switch numbers to 0 and 1

- p3,l18: add space after Eq.
- p3,l24: it's →it is
- p4,6: use ACI monitoring scheme →use an ACI monitoring scheme
- p4,l8: of ACI monitoring scheme →of an ACI monitoring scheme
- p4,l14: to facilitate retrieval of →to facilitate the retrieval of
- p4,l23: in specific conditions →under specific conditions
- p4,l27: Other criteria include presence of prec. or drizzle →This phrasing is misleading. I guess you mean that you are using further criteria to filter profiles with precicipation?
- p5,l5: Additional meteorological parameter that we use ... →As an additional meteorological parameter we use ...
- p5,l7: Is controls really the correct word here? LWP is defined as the total amount of liquid water. Maybe phrase the sentence differently.
- p5,l16: Although ACCEPT campaign →Although the ACCEPT campaign
- p5,l27: Cloud radar →cloud radar
- p6,l2: Data from HATPRO MWR →Data from the HATPRO MWR
- p6,l6: ATB →add reference to Sarna et al., 2016.
- p6,l7: all used →all relevant
- p6,l9: was focused →were focused

- p6,l11: I would sort publications by publication year, starting with the oldest
- p6,l18: in similar conditions →under similar conditions
- p6,l18: processes is not obscured →processes are not obscured
- p6,l25: in 1 →in Table 1
- p6,l29: to measure updraft and downdraft →to measure up- and downdrafts.
- p6,l31: measure of the updraft →This statement should be also true for downdrafts, so maybe use the more general term *Doppler velocity* or *vertical wind speeds*
- p7,l8: error →I would rather use the term *typical uncertainty*
- p7,13: This values →These values
- p7,l16: from CESAR ... →from the CESAR ...
- p7,l17: in certain LWPs →for certain LWP values
- p7,l19: updraft area →updraft regime
- p8,l5: By comparison →In comparison
- p8,l5: of the r_e ranges →of the r_e values range
- p8,l15: harder to measure →harder to obtain/derive
- p9,l3: If we makes →If we make
- p9,l13: As we explained in →As shown in

- p9,l30: remove brackets of Sarna 2016 citation
- p9,l31: used Cloudnet dataset →used the/a Cloudnet dataset
- p9,l32: measuring campaign →measurement campaign
- p10,l14: Considering high uncertainty →Considering the high uncertainty
- p10,l16: evaluated impact →evaluated the impact
- p10,l16: updraft →vertical wind speed at cloud base
- p10,l18: I would remove *We also saw that the*
- p10,l21: in the updraft →within updraft regimes
- p10,l22: data sample →data sample size
- p10,l23: ACI metrics is →ACI metrics are
- p10,l24. ... cloud properties. Therefore, a lower value of the correlation coefficient
- p11,l3: dr. →Dr.
- p14, Table 1: Correct upper/lower case
- p17, Figure 2: check units of LWP, I guess it should be gm^{-2}
- p21. Figure 6: add closing bracket at sr^{-1} in the figure
- p23, Figure 8: add space after LWP

References

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