Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2016-262-AC1, 2016

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

K. Sarna and H. W. J. Russchenberg

k.sarna@tudelft.nl

Received and published: 22 December 2016

We thank the reviewer for his thorough review. Our specific responses are detailed below.

Response to main review points

- *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.

  - We appreciate the reviewer comment and fully agree that increasing the sample size would allow to stregthen the statistical significance of this work. However, due to the limits of the project, specifically time and budget constraints, that was not possible. Including information from separate Cloudnet station would be very valuable. However, one should keep in mind that the specific conditions between the stations may vary and combining data points from various stations should be made only after assesing each one of them separately. As stated, using the method describe in this paper could be implement at each station separetely and then combining the results. Such a comparison would be very valuable for a better understanding of the aerosol - cloud interactions, but was beyond the scope of this research project.

- *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 of similar meteorological conditions was broadened in the revised version of tha manuscript. As we mentioned in the previous comment, inclusion of a larger dataset was not possible in this study.

- *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?

  - The revised version of the manuscript includes discussion of the sample size and its influence on the results.

- *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 chosen? 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 ACIr comes a bit short.*

  - The above mentioned sections of were rewritten in the revised version of the manuscript.

Response to detailed minor review 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.*

  - A short discussion of the effects of meteorological conditions was added in the introduction.

- *is now represented by aerosol background →what do you mean by this?*

  - In his early work Twomey referred to aerosol background as “pollution”.

- *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?*

  - The focus of this study is on the Stratocumulus clouds. The cloud base of the Stratocumulus is usually situated below 2000 m AGL (), therefore we chose this height to be a constraint.

- *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)?*

  - Our aim was to make the bins of LWP as small as possible to ensure the constraint of constant amount of water available. As the method is easily adapted, the size of the bins can be changed.

- *p7,l8: Can you give a justification/reference for the LWP value you have chosen as the precipitation threshold?*

  - The threshold was chosen based on the values taken by Feingold in the first work about the ACI (). A citation was added in the revised version of the manuscript.

- *p7,l21: Can you give the amount in % by which the dataset is limited considering only the updraft area?*
  - The percentage was added in the revised version of the manuscript.
- *p7,l22: Given the significant reduction in sample points, the considerable increase in ACIr 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.*
  - The additional discussion about the sample size was added in the revised version of the manuscript
- *p7,l24: What is meant by significant in terms of ACIr? Do you mean that the highest values of ACIr are found in these LWP bins?*
  - Yes. Higher values of the ACIr are present in bins between 50 and 100 gm-2. The sentence was rephrased in the revised version of the manuscript.
- *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.*
  - The discussion about the uncertainties of the retrieval algorithm used in this study was broadly covered in (). We added the reference to this work in this place in the revised version of the manuscript.
- *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.*

  - A short discussion about this effect was added in the revised version of the manuscript.
- *p9,l4: you should shortly discuss the possible reasons for the values out of bounds. Is the reason the small sample size or an re retrieval error or both?*
  - The reason for the values going out of bounds is dictated by both the retrieval error and the sample size. We included a longer discussion of the issue in the revised version of the manuscript.
- *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.*
  - The error value was calculated based on the assumptions of the retrieval algorithm as described in ().
- *p10,l15: You could mention shortly that using ACIr results in smaller sample sizes due to the required LWP binning compared to using ACIN .*
  - A comment was added in the revised version of the manuscript.
- *p10,l27: what do you mean by "higher dependency of the parameters"?*
  - The correlation coefficient between aerosol and cloud properties has negative values, as it represents a reverse relation between aerosol background and cloud droplet effective radius. As this sentance was confusing, we rephrased it in the revised version of the manuscript.
- *p10, l32: How could it be adapted to satellite remote sensing? This does not really get clear.*
  - Adaptation to satellite remote sensing was further explained in the revised version of the manuscript.

- *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.*
  - The figures were redesigned in the revised version of the manuscript based on the input from both reviewers.
- *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 color bars are not really required since the x-axis already is the LWP. My suggestion is to use two different colors instead; one for ACIr values of the complete dataset and one for ACIr values of the updraft dataset.*
  - The figures were redesigned in the revised version of the manuscript based on the input from both reviewers.

Response to phrasing / spelling suggestions

- All remarks and suggestions were adopted in the revised version of the manuscript.

References

WMO, 1965. *International Cloud Atlas.*

Knist, C.L., 2014. *Retrieval of liquid water cloud properties from ground-based remote sensing observations.* TU Delft: Civil Engineering and Geosciences: Geoscience and Remote Sensing.

Feingold, G., 2003. First measurements of the Twomey indirect effect using ground-based remote sensors. Geophysical Research Letters, 30(6), 19–22. http://doi.org/10.1029/2002GL016633