Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2019-565-RC1, 2019

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Variability of cirrus cloud properties using a Polly^{XT} Raman Lidar over high and tropical latitudes" *by* Kalliopi Artemis Voudouri et al.

Anonymous Referee #1

Received and published: 6 September 2019

General comments to acp-2019-565:

The paper presents the results of the cirrus cloud observations performed with a ground-based multi-wavelength PollyXT Raman Lidar during sequential periods between 2008 and 2016, in two subtropical stations (i.e. Gual Pahari in India and Elandsfontein in South Africa) and one subartic station (i.e. Kuopio in Finland). An automatic cirrus cloud detection algorithm was developed to derive the cirrus cloud lidar geometrical characteristics (cloud boundaries, geometrical thickness) and optical properties (cloud optical depth, lidar ratio, ice crystal depolarization ratio). Then, a statistical analysis and the seasonal variability of these parameters are presented comparing

the results of the three sites at different latitudes. The main results of the study are of interest. However, the authors should better characterize these results explaining the scientific context and their novelty and relevancy, re-organizing the structure of the paper that is not well structured. Some sections and figures lack of an accurate description and need to be completed. A more accurate characterization of the developed algorithm used to derive cirrus geometrical and optical properties is required, adding examples and/or references. The discussion of the results, which, in some parts, does not follow a linear path, should be modified giving more emphasis to the comparison among the different stations. The relationships between aerosol load and cirrus optical properties for the three different sites should be considered and discussed in the paper. Furthermore, an added value of this work could be providing an example on how and which the estimated cirrus parameters could be used in the parameterization schemes of the satellite optical retrievals. These issues need to be addressed to better present and to significantly strengthen the results. Thus, I recommend the publication of the manuscript after major revisions, according with the following observations.

Major comments:

Introduction

- The introduction lacks of a discussion about cirrus retrievals through CALIOP. Please add some discussions and references.

- Lines 61-67, the novelty of the work needs to be discussed and detailed.

Section 2

- Line 89, please add some details about the nature of the aerosols and their seasonality over the three different sites with appropriate references.

Section 3 and Section 4

As the retrieval of optical properties is part of the retrieval algorithm, I would suggest merging Section 3 and Section 4 in three different subsections (3.1, 3.2 and 3.3). The

contribution of the background aerosol load to the computation of cirrus cloud products is not negligible. This aspect should be discussed with the appropriate references not only in the last part of the Conclusions but also in this section. Please discuss this point.

- Lines 100-102, please discuss the normalization of signal (step b). How this normalization enhances the method applicability in different atmospheric conditions?

- Lines 113-115, it is not clear to me if the estimated cirrus geometrical and optical parameters are referred to 60-min averages. If yes, it means that, for example, for the cirrus of Fig.2 the detection algorithm will retrieve one cirrus parameter per hour. Is it correct? Please clarify this aspect.

- Lines 116- 119, please add more details and references about the criteria a) and c).

- Lines 143-144, the depolarization condition (particle linear depolarization > 0.25) is used only for Kuopio or also for the other sites? Which is the magnitude of the error/bias introduced by the Rayleigh calibration method? Despite the different calibration method, it could be of interest to show the depolarization ratio values of the other two sites.

- Line 156, it might be helpful to clarify the use of the Eloranta model writing the equation of the term P1(z) of the equation (4) and discussing the assumptions.

Section 5

The authors decided to present the results for the estimated geometrical and optical cirrus parameters for each site (sub-sections 5.0.2, 5.0.3 and 5.0.4, respectively). In my opinion, this choice makes the discussion of the results confusing. Another choice, which could help the comparison between subtropical and sub-artic sites, could be to divide the results according to geometrical and optical parameters (two sub-sections). This latter option allows both to improve the description and analysis of Fig. 4, Fig.6 and Fig. 7, where the parameters are depicted for all the stations, and to better com-

pare each site. Table 2 should be completed adding also the value of all the other relevant cirrus parameters (e.g. mean/base/top heights, COD, temperature).

- Line 172, from Fig. 3 the diurnally variations cannot be observed. Please remove 'diurnally' or clarify.

- Lines 172-176, to analyze if the observed cirrus cover annual pattern is significant, it could be useful to show the number of total measurements per months. Considering your dataset, can you exclude that the observed cirrus cover annual pattern is only an indication of the annual pattern of low clouds/rain? Have you tried to compare this pattern with CALIOP observation over Kuopio region?

- Lines 176-177, could you explain the agreement between cirrus cover and temperature annual pattern? Are there similar results in literature?

- Lines 177-179, please add some numbers about the daytime/nighttime cirrus frequency and the number of total measurements. Could you explain these results?

- Lines 199-201, is this information relevant?

- Line 204, the AOD is referred to the column below the cirrus? Please explain. It could be of interest to relate AOD to cirrus parameters. Could you deepen this aspect?

- Lines 204-206 and 229-231, the discussion about Fig.5 is limited to these lines and does not give any relevant element of interest. Furthermore, concerning COD distribution, Sassen and Cho classification provides similar information. Please add some more elements of discussion or remove Fig. 5.

- Lines 216-229, the plot (e) of Fig. 6 is not discussed in the text. Please add some comments. The particle depolarization ratio together with LR and T could help to understand the cirrus crystal composition, size and shape. Did you find some relationship between delta and LR? Please add some comments and, if relevant, some results.

- Line 245, see comment of line 204.

- Line 262, see comment of line 204.

- Lines 265-269, please add in the discussion the results of the paper of Hoareau et al, 2013, about cirrus measurements at La Reunion sub-tropic site.

- Lines 300-323, this sub-section is of interest and it should be extended. In particular, on the basis of your analyses, is it possible to identify the parameters and the threshold values that could be used in satellite parameterization schemes? How the latitude dependence affect the variability of these parameters?

- Line 307, as already mentioned, the relationships between aerosol load and cirrus optical properties should be discussed more in details with a dedicated sub-section. In particular, the aerosol extinction below the cirrus and the type of aerosol could be of interest to understand the role of aerosol in cirrus formation. Do you have any analysis related to this?

- Line 310, could you explain the choice of using the cirrus base temperature instead of the mean/top temperature as independent parameter?

- Lines 315 and 319, please replace 'Fig.10' with 'Fig. 8'.

- Line 321, from Fig.8d the particle depolarization increases is not clear. Is it significant?

Conclusions

To summarize the results of this work, it would be useful to add a resuming table that, according to the different latitudes, compares the retrieved cirrus parameters to the main results of the literature reported in the paper.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-565, 2019.