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Atmospheric Measurement Techniques Discussions

Interactive comment on "Validation of SCIAMACHY O_2 A band cloud heights using Cloudnet radar/lidar measurements" *by* P. Wang and P. Stammes

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Reply to referee 2

We would like to thank referee 2 for the helpful comments and suggestions. We have included more physical explanations. Simulations using different optical thicknesses of clouds are added in a new section Sect. 2.4. The outcome of the simulations is included in the discussions of the results. More discussions are added in the comparison between SCIAMACHY SACURA and FRESCO products. A new figure about the simulations, Fig. 2, is added. We explained how the readers/users can use the tables.

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Interactive Discussion

Discussion Paper

The quality of the figures is improved. All the questions are answered and the texts are revised according to the comments and suggestions. In the paper, the revised texts are in blue color. The answers of the questions are started with 'A:'.

Referee2 comment on the manuscript "Validation of SCIAMACHY O2 A band cloud heights using Cloudnet radar/lidar measurements" by P. Wang and P. Stammes

General comments : This study intercompares the new version of two SCIAMACHY O2 A band cloud height products with ground based measurements. There is a distinction in the comparison between single-layer and multiple-layer cases. This distinction and the choice to present results as on Figures 6, 7 and Figure 11 are interesting. This intercomparison is valuable, the scientific interest and quality behind the manuscript are not questionable. The author draw certainly conclusions from this study. However, they leave too much to the readers the question of the physical explanations behind their results. As it is, the document resembles more like a internal report than an scientific article. Thus physical explanations should be added, as well as a deeper and finer analysis of the results. For example, the authors write in the abstract on lines 18-20 that "the difference between ... depend on the optical thickness of the clouds", but nowhere in the manuscript is it discussed and analyzed. I think it could have been done and it would be valuable information to the reader. A synthesis is missing between the results issued from Section 4.1 ("Global intercomparison") and from Section 4.2 ("Validation").

Specific comments : - Title : I am wondering if the title should start more with "Evaluation of " than "Validation of". - Abstract : it has to be synthesized.

A: The abstract is revised.

- Page4, line 10 to 12 : add, as an reference's example , Desmons et al, AMT, 6, 2221-2238, 2013. doi:10.5194/amt-6-2221-2013

A: The reference is added.

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- Section 2.2 : there is no discussion about the assumption about the cloud phase in the ESA algorithm. Is it accounted for in the algorithm ? It seems to me that it should, as a forward model is used. Could it be interesting to globally compare FRESCO and ESA products per cloud phase (Section 4.1) ?

A: The cloud phase in the SACURA cloud height retrieval is not discussed in the ATBD of the ESA level 2 product. In the calculation of the reflection function, SACURA uses many parameters. These parameters are more suitable for water clouds. According to Rozanov and Kokhanovsky (2004), the Mie cloud phase function is used; the asymmetry parameter is 0.86. There is a flag in the ESA L2 cloud product about cloud type for ice/water, thick/thin clouds. This cloud phase detection in the ESA L2 product has not been evaluated and it is not the aim of this paper. However, we agree that it would be interesting to compare FRESCO and ESA products per cloud phase. The SACURA phase function is described in sect. 2.2.

- Page 11, lines 15 to 17 : the presence of drizzle and rain don't affect the cloud top estimate from the ground ?

A: There is no effect. The radar can penetrate the drizzle/rain water droplets. Only very heavy precipitation can affect the radar signal.

- Page 11 line 20 : about Figure 2 : be clearer about what "occurrence" means

A: The occurrence means the number of back scatter pixels.

- Section 4.1 : The global comparison of FRESCO and ESA L2 cloud height products could have been more detailed and exploited. For example, the authors write in the abstract on lines 18-20 that "the difference between ... depend on the optical thickness of the clouds", but nowhere in the manuscript is it discussed and analyzed. I think it could have been done and it would be valuable information to the reader. There are $6x10^5$ *collocated points and from it, only the mean and the width of the distributions are compared. It is quite poor. Also, I don't see any sentence in the conclusion about Sec-*

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tion 4.1, nor any cross comment or lessons learned from the results given in Sections 4.1 and 4.2;

A: Thanks for the suggestions. We have added retrieval simulations in a new section, Sect. 2.4 where the optical thickness dependence is studied. More discussions about the FRESCO and ESA L2 cloud height comparison is included in Sect. 4.1 and in the conclusions. Sect. 4.1 is referred to in the validation section, sect. 4.2.

Also, why 4 full days of global data are added to the data coming from one orbit per month ?

A: It is used to increase the number of data and have a good global coverage which is representative for the global distribution of clouds.

In addition, following the short comment given by L. Lelli, 13 nov 2013, the authors should clarify whether or not the quality flags coming with SACURA products, are accounted for, and the implication for it.

A: The L2 flag is used to remove the non-convergence in the data. Some cloud height data are flagged as converged with certain constraints. These data are kept in the analysis. The ESA L2 cloud flag is discussed in sect. 3.

- Section 4.2.1 : The readability of Figure 4 must be improved.

A: Fig. 4 is improved. The symbol is changed from 'star' to 'dot'. The figures are arranged in a column. In the revised paper, Fig.4 is called Fig. 5.

Page 14, line 14 : where does come from the effective cloud fraction (how is it calculated ?)

A: It is now explained in sect. 2.1.

The readability of Figure 5 must be improved.

A: Fig. 5 is improved. The symbol is changed from 'star' to 'dot'. The figures are

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arranged in a column. In the revised paper, Fig.5 is called Fig. 6.

- Lack of quantification and physical explanations : Page15, line 3 : "seems to be better" is not clear; is it better or not ? Can you quantify the distance between ESA and Cloudnet data, and do the same with FRESCO data ?

A: It is quantified and the values are given in the texts.

Page15, lines 6 to 8 : what is the physical explanation for this result ?

A: An explanation is added for this result from Fig. 5 (Fig. 6 in the revised paper). This figure shows that the ESA L2 cloud top height may be related with the ESA L2 cloud fraction. In fact, the reason is that the ESA L2 cloud height is related with the cloud optical thickness. The ESA L2 cloud fraction (effective cloud fraction) is proportional to the cloud optical thickness for fully cloudy scenes (geometric cloud fraction = 1). And in the validation data set, most cases are fully cloudy.

Page15, line 20 : "sometimes ..."; add " in particular when clouds are low and thin".

A: Added.

Figure 6 shows that ESA data are more noisy. Discuss why. A comparison in term of cloud optical thickness could be valuable.

A: Discussions are added to sect. 4.2.1 for the single-layer low clouds of Fig. 7. We performed simulations using different cloud optical thickness and cloud top-base height values. Then we retrieved cloud height using the FRESCO algorithm. It turns out that FRESCO retrieved cloud heights are more scattered (noisy) for the optically thin (COT = 5) cases. According to the SACURA references, SACURA algorithm has larger error bars for optically thin clouds.

- Figure 7 plus the values in the tables are interesting. However, there is a lack of comment of the results (page17, line9) : it would be interesting to add a discussion about the qualities and differences of the two algorithms behind the two compared products, a

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link with the lessons learned from the global intercomparison of these products (section 4.1).

A: Thanks for the suggestions. Discussions are added in sect. 4.2.1. We have explained how the users can use these tables.

- Page16, line 22 and Page17, line 1 and 2 : is it the reason why there is an apparent inconsistency between the bars in Figs 7a and 7b in bin ">10" (the blue bar is very small in Fig 7b and lower that the red bar). Please clarify this result.

A: We have given this example, 'bars in Figs 7a and 7b in bin >10 ' to explain the difference between cloud top height and cloud middle height. It is clarified in the text.

Technical corrections

- Page1, line 9 : "compared" instead of "validated" ?

A: Corrected.

- Page2, line 3 : "Note a good case .. " . To be rephrased.

A: Rephrased.

- Page4, line 2 : redundancy

A: Revised.

- Page5, line 17: rephrase "for one year of data"

A: Revised.

- Page6, line 2 : rephrase "for 51 cases"

A: Revised.

- Page9 line 16 : no space before "1]"

A: Corrected.

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- Page2, line 2 : two “local ” peaks

A: Corrected.

- Page12, line 18 : “not” is missing between “are” and “used”.

A: Corrected.

- Page16, line 12 : typing error

A: Corrected.

- Page34 : define a correct column width

A: The tables are improved.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 8603, 2013.