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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Absorption of aerosols above clouds from POLDER/PARASOL measurements and estimation of their Direct Radiative Effect" *by* F. Peers et al.

Anonymous Referee #3

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The manuscript describes the use of polarization measurements for the separation of aerosol and cloud signals in a aerosol/cloud laden scene, building on previous work. Since aerosols and clouds polarize light in different ways, the polarized signals carry information of both, which can be separated. This works for small polarizing particles like smoke above clouds, and for large unpolarizing particles like dust, albeit in different ways, which has been shown in previous work by the same (co)-authors. This manuscript describes the use of this for the computation of the DRE of different aerosols above clouds, which is a logical continuation of the work.

The manuscript presents interesting new work which will help to promote the field

of estimating and understanding aerosol absorption in cloud scenes. In general, the manuscript is well structured, but many textual corrections will improve the readability. The main concern is a lack of error and uncertainty estimates of the intermediate (AOT and COT) and final (DRE) results. The authors have moved from algorithm development to producing (case study) results of aerosol absorption and climate impacts, and it will be extremely important here, to give a very accurate description of the expected error ranges. This study can be very important for the evaluation of aerosol DRE above clouds, both from model simulations and other observations, and it must be clear from the current study how accurate these results are. The authors show clearly that the DRE results are highly dependent on the correct estimation of especially the COT, confirming other studies, but the accuracy estimates presented here are not sufficiently convincing. For example, it is not clear how the uncertainties change when different methods are applied to small particles or large particles. I think the authors know this, and it might be clear from their previous work, but the results and consequences for the error (change) in the DRE should be clear from this manuscript. Another important point is the lack of exact numbers used in the study to generate the results, which would be important for the reproduction of the results by others. This should be easy to incorporate, but is essential before the study could be published.

In general, this manuscript describes an important technique to derive aerosol DRE above clouds and adds important independent results to the field. It should be publishable when the above changes are applied. Several changes are necessary to make the results unambiguously clear and verifiable. Finally, a number of textual changes will greatly improve the readability.

Main comments:

(1) It should be mentioned clearly in the abstract and the conclusions that the results presented here are only valid for COT > 3. Since DRE is highly dependent on COT, cloud albedo and cloud fraction, this selection criterion automatically generates DRE that are biased high, since many negative and low values are not considered.

(2)

2.4 Sentivity analysis (25542-25544) This is the weakest part of the paper. Some hints are given as to how the algorithm behaves in a few cases, but no clear picture is given of how sensitive the algorithm actually is under different circumstances. A few results are given in tables, but pictures showing the various limitations and sensitivities would be much more helpful. This should be incorporated in this paper, as this paper presents the applicability of the polarization measurements for the computation of the DRE. To assess the uncertainty of the DRE results it is necessary to understand the sensitivity of the retrievals of the aerosol and cloud parameters. The lack of this sensitivity study is most clearly indicated by the following sentences: Lines 21-23: " Of course, we expect larger biases for larger AOT. However, the quantity of aerosols chosen to process the synthetic radiances is representative of the ACA events that have been already observed in Waquet et al. (2013b)." The range of 'quantity' given in table 3 is AOT=0.12 to AOT=0.2. Even in the present manuscript the range in AOT is much larger than that. It should be clear what happens to the accuracy of the retrievals in those cases.

Similarly, the last paragraph (lines 25544, 7-17) signal a very important uncertainty, which will impact the DRE results dramatically. Showing only two points is not very adequate. Do the results respond linearly to the bias? And 70% falls within 8-16 microns, but the remaing 30% will provide the extreme values that are presented in the manuscript. Are they reliable?

These issues should be addressed in a sensitivity analysis that shows the most important relationships between the agorithm assumptions, the retrieved parameters and the resulting DRE.

(3)

Figures 6,7, and 8 -In all these figures the scales of the plotted quantities do not match the description in the text! Apparently the ranges have been cut at a certain maximum, but this is not clear in the picture. This should be corrected. If the authors prever to

show only a part of the whole range, than the color bars should be annotated indicating that the range was cut. E.g. 6a: 0.0, 0.1, 0.2, >=0.3. The figures should be clear by themselves, and not only after a thorough (and confusing) read of the text. Since all three figures were created like this, as I understand after reading the text, I urge the authors to reconsider all figures to make sure this is corrected in all of them. -The captions are too short and too general. All 6 panels should be described in the caption, so that the figures make sense without a thorough read through the text. -The colorbar annotations are illegible.

(4) In all experiments the used parameters should be mentioned and presented, e.g. in tables.

Textual comments:

Abstract

lines 2-7: "While most of the retrievals of above clouds aerosol characteristics rely on assumptions on the aerosol properties,this study offers a new method to evaluate aerosol and cloud optical properties simultaneously (i.e. aerosol and cloud optical thickness, aerosol single scattering albedo and angström exponent)". The word 'while' implies that this is not true for his method. However, the method presented here still relies on the correct selection of aerosol models through use of a inversion method, and is essentially not different from most other methods. However, since more independent information is used, the selection of the aerosol properties can be better contrained. Please, rephrase.

line 15: '..based on exact modeling.' The authors mean 'exact' here as opposed to the approximate method of eq. 1. However, this is not clear here in the abstract without the context. Obviously, one would use an exact (as possible) method to compute something. This should be rephrased to indicate which exact and approximate methods are meant. Or just removed.

line 15-16: Similarly: " beside THE three case studies..". These three case studies have not been introduced at this stage, so describe more generally in the abstract what the paper is about.

lines 19-24: In my opinion, the result that cloud heterogeneity of clouds "leads to a slight underestimation" of the DRE is a very important result. It has become clear that highly models underestimate the DRE of ACA, and most analyses indicate that cloud brightness/fraction is probably the culprit, since it has such a s strong influence on the resulting DRE. Heterogeneity also has an important effect, as shown here: 10% underestimation for an inhomogeneity parameter of 0.6. To me, 10% is a serious effect, the authors claim that an inhomogeneity parameter of 0.6 represents a normal value for stratocumulus clouds. This effect should be investigated further, and the authors should present a sensitivity analysis of the inhomogeity of clouds on the DRE of ACA. That would present a real new addition to this scientific field.

25535 line 2: The last ones -> The latter

line 13: thanks to -> using

line 26: "Over a bright surface such as clouds": Clouds are not surfaces, please rephrase.

line 28: darkening effect -> darkening

25537 line 4: couple -> number

line 9: Since -> When I think the consistency shown in Jethva et al (2014) does not yet warrant the claim that this can be done in general.

lines 11-13: "Though, ACAOT retrieval techniques presented above generally require an assumption on the absorption character of the overlying particles or do not enable to estimate it." This sentence is unclear, please rephrase.

line 18: latest -> latter

line 21: "it becomes hazardous for coarse mode particles" -> "it cannot be applied to coarse mode particles."

line 23: scenes -> in the scene

25538 lines 3-4: remove "based on exact modeling"

lines 4-6: "Beyond their types, aerosol absorption properties are expected to vary a lot depending on space, time and formation processes (Dubovik et al., 2002) and thus, resulting on different radiative responses." This sentence is unclear, especially 'beyond their types', please rephrase.

Similarly, the words "Consequently" (line 6) and "Similarly" (line 7) indicate a reasoning in the text that's not there. Please, rephrase using a clear reasoning or simply sum up the paper's contents.

lines 20-21: all along this paper -> in this paper

lines 21: would refer -> refers

line 17: thanks to -> owing to

25539 line 3: angle -> angles

line 5: are -> is

line 10: Figure 2 is valid for fine mode particles (0.1 micron), but coarse mode particles are not mentioned here. How do coarse mode particles effect the (polarized) signal? More importantly: What is the uncertainty in the retrieved aerosol parameters? Is it the same for the fine and the coarse mode? And how does this uncertainty effect the uncertainty in the final DRE?

line 11-12: "In case of clean sky condition (i.e. without aerosols), the total radiances scattered by cloud water droplets are expected to be relatively spectrally independent from the UV to the Short Wave InfraRed (SWIR) part of the spectrum." I think this is not

"expected", but shown in other studies, e.g. De Graaf et al (2012), using SCIAMACHY measurements.

line 22: .. for a given aerosol size distribution." In fact, this size distribution is not given at all. Please, indicate which experiments were performed. If necessary, add tables with all relevant cloud and aerosol parameters listed, so results can be checked and understood.

25540

line 11-12: "Meanwhile, the data used in this paper corresponds to the previous version." Please, give version numbers and description, which will be important for readers who know this. Be exact.

lines 20-22: Again, please proviode a table with all relevant information.

line 2: a SD -> a standard deviation (SD)

line 3: thanks to -> using

line 5: one -> AOT

line 7: "We consider that the aerosol size corresponds to the one of the nearest model". How is the data fitted and what is the critical selection criterion fro aerosol model/type? Does this mean only aerosol optical properties interpolated and not the size distribution?

lines 14-15: "For the fine mode, k varies from 0.00 to 0.05" Which values have been used? Be specific.

lines 15-16: "..it is assumed to be the same at both wavelengths since a weak variation of this parameter is expected between the used bands.." Why since? Do you mean ONLY a weak variation is expected? Then rephrase it like that.

line 19: radiations -> radiation

25542

lines 3-4: "The retained solution is the one that minimizes the least square error term." This is the usual approach. But please provide the equation that is actually minimized.

line 6: thanks to -> using

line 13: level -> levels

25543

line 19: of -> off

25544

lines 3-6: "To finish with the assumptions about aerosols, we have taken an interest in the altitude of the aerosol layer. We have processed the signal for an aerosol top altitude of 4 and 6km while the aerosol layer reaches 3km in the LUT. However, the results are not displayed since they do not have shown any impact." The purpose of the first senstence is unclear. This is an clear result, and should be mentioned as part of the complete sensitivity study.

line 15: At last -> Lastly

25545

line 6: thanks to -> based on

line 23: is weakly -> is only weakly

25546

Line 1: "The ACA scenes have been selected since they are very usual at global scale." I'm not sure what is intended here. ACA scenes are not very common globally. Change to "Common/representative ACA scenes were selected?"

lines 11-12: "biomass burning particles are frequently observed around the Southern

Africa due to man made vegetation fires" -> biomass burning particles, due to man made vegetation fires, are frequently observed around the Southern Africa.

line 12 : in the same time -> at the same time

lines 13-14: the deck stratocumulus deck does not favor long-range transport, the wind does, or meteorological conditions. Please, rephrase.

line 15: an important amount -> a large amount (or better just biomass burning aerosols were detected/observed).

line 16: The aerosol layer over the Atlantic Ocean is very often a few kilometers thick. If this is the case, please givemore information on the height than just one position of 3 km. Was this the average weighted height, does it extend from the cloud top to 3 km? Or further. And how do you treat that in the LUT?

line 19: The ACAOT value of 0.74 is not shown in the plot! The ACAOT in Fig 6a ranges up to 0.3. After further reading I noticed that the range scales were cut in the plot (or so I assume). This should be corrected in Figs. 6,7, and 8, see the comments on those Figures elsewhere.

25547

line 1: "is respectively of 0.875 and 0.840 at 550 and 865 nm" -> "is 0.875 and 0.840 at 550 and 865 nm, respectively"

line 10: "that takes into the" -> that takes into account the

lines 14-15: "due to the logarithmic relation curve between radiances and with COT". This is bad English, please rephrase.

line 16: "the bias is around 15". The highest values shown is 8. Please, correct.

line 18: "As expected for very" -> As expected for highly

line 19: "DRE up to 195.0". The maximum value shown in 100.

25548

line 2: "due to" -> and / following

lines 5 and 6: "important". Why important? To you? Rather say 'Large'. Or better yet, stay objective.

line 8: The -> On

line 17: peak at 3.0. Not in range of figure

line 19: "the retrieved models" -> the retrieved radii

line 27 "ones" -> ones,

25549

lines 1-3: Can you explain this? Do they have a different origin? Or different path-way/history?

line 8: "bias up to +12". Max in Figure is 4.

line 9: "bias up to -10.7" Min in Figure is -4

lines 12 and 14: Max and minimum DRE values are not in the Figure.

lines 13-14: "Again, the approximate expression (Eq. 1) can clarify both situations." I think clarification should be a physical explanation, e.g. the one that Eq 1. is based on. Please, rephrase.

lines 15-20: the values are not in the figure

25550

line 8: "southern area" -> "western part", to be consistent in the text.

lines 11-12: "closely look alike" -> are close

line 12: a lot -> strongly

lines 12-14: Add a reference to Haywood et al (2004), who first evaluated this.

line 14: overestimate -> overestimates

line 22: noticed -> notice

25551

lines 17-20: the values given ar enot in the figure.

25552

line 2: "between the 9 and the 17 August." -> between 9 and 17 August.

lines 7-8: the values are not in the plot.

line 12: observed -> observe.

line 13-15: This point should be stressed more. The data selected for this manuscript are cloud with COT > 3 and CF=1, which will give a high bias of DRE values. Therefore, the results cannot readily be compared to the results of e.g. De Graaf et al. (2012) who used CF<1 and COT < 3.

25553

line 5 thanks to -> using

line 10 choose -> choosen

line 15: RT -> Radiative Transfer (RT)

line 16: has -> have

line 27: "11%". Do you mean at 490 nm, and about 14% at 865 nm? Please, be clear and concise.

25555

line 3: "impact of aerosols." -> impact of aerosols, in case of cloud heterogeneity.

lines 3-4: "The values presented in this paper can be seen as a lower bound for ACA DRE." This is only true for the cloud heterogeneity argument. E.g. the selection criterion of COT>3 will select high values of ACA DRE. Please, rephrase.

Conclusion.

line 20: "The algorithm has shown its ability to accurately retrieved aerosol and cloud properties". This statement is unfortunately untrue, although this would be the desirable conclusion for this manuscript. But the accuracy assessment is missing, so this cannot be concluded.

line 23: very -> strongly

25556

line 6: has -> have

line 13: very -> highly

line 19: on -> to

line 23-24: PLease, repeat here in the conclusion section that there is a difference between the results of this manuscript and those in the literature, and that those are mainly caused by selection criteria of the clouds.

line 24-25: "This analysis shows how important the studies of ACA are for the climate understanding." I don't agree. I think this study shows in three case studies how ACA radiative impacts on clouds can be studied. This will help, climate studies.

25557

line 10-12:"On the other hand, 3-D effects cause bias on our estimation of the COT. Finally, the homogeneous cloud assumption leads to a slight underestimation of the DRE of aerosols." I think this is an important new conclusion. The effect of homogeneous cloud assumption on the estimation of the DRE should be quantified.

Figure 2: The inset is not explained.

Figure 3:

-This figure is very similar to Fig. 3 in Jethva et al (2013). This reference should be added, and in the text the similarity should be noted.

-It is not clear from the text or the figure caption and/or the text in the figure which parameters have been used to generate this plot. In order to understand, compare (e.g. with Jethva etal, 2013) and reproduce the results, it is imperative that all necessary information is available in the paper. Missing are e.g. size distribution, viewing angles, atmospheric parameters, etc.

Figure 4: The annotations are illegible.

REFERENCES

Hiren Jethva, Omar Torres, Lorraine A. Remer, and Pawan K. Bhartia, (2013) "A Color Ratio Method for Simultaneous RetrievalAerosol and Cloud Optical Thickness of Above-Cloud Absorbing Aerosols From Passive Sensors: Application to MODIS Measurements", IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 51, NO. 7, JULY 2013

Jim M. Haywood, Simon R. Osborne, Steven J. Abel, (2004), The effect of overlying absorbing aerosol layers on remote sensing retrievals of cloud effective radius and cloud optical depth,Quarterly Journal of the Royal Meteorological Society, 130(598), doi:10.1256/qj.03.100

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