Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2019-1176-RC2, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observation of absorbing aerosols above clouds over the South-East Atlantic Ocean from the geostationary satellite SEVIRI – Part 2: Comparison with MODIS and aircraft measurements from the CLARIFY-2017 field campaign" *by* Fanny Peers et al.

Zhibo Zhang (Referee)

zhibo.zhang@umbc.edu

Received and published: 3 April 2020

This is the second part of a remote sensing study of the above cloud smoke aerosols in the South East Atlantic Ocean (SEAO) region based on the observation from the SEVIRI satellite sensor. The first part documents the theoretical basis of the retrieval algo-

rithm and relevant technical details. In this part, the SEVIRI retrievals results are evaluated first through comparisons with an independent satellite retrieval product based on MODIS observations. Then the retrievals are further compared with collocated in situ measurements from the recent CLARIFY-2017 field campaign. Overall, the SEVIRI based above-cloud aerosol (ACA) retrievals are in reasonable agreement with MODIS ACA retrievals and direct in situ measurements. The differences among each retrieval products are studied, and the potential reasons causing the differences are provided.

This paper is a useful addition to the studies on the ACA in the SEAO region. Because of its location and geostationary nature, the SEVIRI observations are ideal for studying the ACA and the underlying clouds, even though the algorithm used here is not really new and has been developed/applied in several previous studies. The manuscript is well organized and easy to read. Overall it is good shape. However, I have several questions and some major concerns regarding the methodology used in the comparisons, which should be explained and clarified before it can be accepted for publications. In addition, I have some thoughts about the differences between SEVIRI and other measurements/retrievals that are different from the paper. I would like to share them and hopefully, them can be helpful for improving the paper.

Questions/Comments/Suggestions:

1. Overall, the references cited in the Introduction and other parts of the manuscripts are rather old. A number of recent studies on the ACA in the SEAO region should be referenced here. For example, there are several recent studies on the direct radiative effects of ACA in SEAO region e.g., [Wilcox, 2012; Zhang et al., 2016b; Kacenelenbogen et al., 2019] should be cited here at line 26 when discussing the DRE of ACA. They are more relevant than Keil and Haywood (2003) in this context. When discussing the CALIPSO ACA retrievals, the three cited studies are based on the two-way transmittance method by Hu et al. (2007). But the operational CALIPSO Aerosol retrieval product, which is based on the "traditional" lidar ratio method, is much more widely used. It should be mentioned with reference here.

2. I have several major concerns and comments about how the SEVIRI retrievals are compared with the MODIS retrievals in Section 2. They need to be clarified and some comparisons should be repeated if possible.

a. Spatial collocation and data screening: as pointed in the paper, the two instruments have a significantly different spatial resolution, SEVIRI at 3x3km at nadir and MODIS at 1x1km. So roughly there are 9 MODIS pixels within each SEVIRI pixel. In this study, both retrievals are aggregated to 0.1o x0.1o common grid box (∼10km). I understand that pixel-to-pixel collocation between SEVIRI and MODIS may be challenging. BTW, it is not a bad idea to explain to the readers why pixel-to-pixel collocation is difficult. But I believe there must be some quality assurance measures to filter out some "bad" or challenging grid boxes that are not suitable for comparison. For example, some 0.1o x0.1o grid boxes may be partly cloudy and others can have either bad SEVIRI or MODIS ACA retrievals. What are the conditions used here to filter out these "bad" grid boxes? If they are not filtered, what are the considerations to keep them and what are the potential implications of the ACA comparison results?

b. Sanity check on "clean" clouds: in my opinion, it is really difficult to understand the ACA retrieval difference between SEVIRI and MODIS without first understanding their differences for "clean" clouds (i.e., not aerosols above). For example, in Figure 3 there is some significant difference between the SEVIRI, and MODIS retrieved COT and CER. It is hard to tell whether these differences are caused by the ACA correction or something in the cloud retrieval part. To address this question, I'd strongly recommend a comparison of the COT and CER between the two satellite sensors for "clean" clouds, even only for some case studies.

c. The sampling rate of SEVIRI ACA retrieval needs to be analyzed and reported, and the implications explained. The SEVIRI sampling strategy is "The SEVIRI algorithm rejects both the aerosol and cloud products when the COT is lower than 3". Based on Figure 1 and Figure 2, it seems that this strategy would lead to a significant loss of samples. Note that, as pointed out in Zhang et al. (2016) the dramatic difference in

sampling rate is an important reason for the fact that the DREs of ACA in the SEAO region reported in the literature differ so substantially. In fact, based on the combination of CALIOP and MODIS, Zhang et al. (2016) found that a large fraction of the ACA cases has COT smaller than 3 (See Figure 9a) of Zhang et al. (2016). The authors need to estimate the fraction of the ACA cases they sample vs. how many they filtered out. Moreover, it should be explained how this sampling strategy could impact the user of the data, for example, when calculating the DRE of ACA.

d. Uncertainty analysis is needed in the comparison: I didn't find any error bar associated either SEVIRI or MODIS retrievals. The signal to noise ratio for ACA retrieval is not very large. So, the uncertainty associated with either retrieval is considerably large. The comparison is only meaningful when they are put in the context of their error budget. Otherwise, the comparison may very well be comparing statistic noises. In particular, I'd suggest adding an error budget to both products in Figure 3. You may put the AOT into several bins and plot the uncertainty of AOT retrievals from each product as an error bar (x-axis error bar for MODIS and y for SEVIRI). Then, the differences between the two products need to be put in the context of the error budget.

e. The explanation for the differences between SEVIRI and MODIS ACA and cloud retrievals in Figure 3 is not very convincing. There are a number of differences between the SEVIRI and MODIS ACA retrievals in Figure 3. First of all, AOT from the SEVIRI retrieval is significantly smaller than MODIS results by about 20%. The paper attributes this mainly to the difference in the aerosol model assumed in the two schemes, e.g., the aerosol model in the SEVIRI retrieval is more absorptive than that in the MODIS retrieval. But this explanation is not very convincing. The SSA difference between the two is only 0.01 (0.85 in SEVIRI vs. 0.86 in MODIS). This is equivalent of about 6% difference in absorption AOT (i.e., 0.01/0.15), which can only explain half of the ∼11% difference between SEVIRI and MODIS AAOT in table 1. To provide a more convincing explanation, I'd suggest the authors run the SEIVIRI ACA retrievals using the same aerosol model as MODIS and then make comparisons. Secondly, the correlation between SEIVIRI and MODIS retrieval is clearly nonlinear. The authors are aware of this nonlinearity and pointed it out in the paper. However, no explanation is provided. BTW, the correlation between the two AAOT retrievals in Figure 3 b is also nonlinear. I wouldn't say this is "slightly". It is clearly and significantly nonlinear. In my opinion, this nonlinearity is partly, if not mainly, due to the sampling difference between the two retrieval algorithms, i.e., MODIS screens out retrievals based on retrieval uncertainty while SEIVIR keeps low-quality retrievals which are mainly low AOT. This goes back to my earlier comments on the sampling differences. Some quality assurance screening is clearly needed here.

3. At line 25 of page 6, when discussing the plane-parallel bias, there are few much more recent studies that should be noted here, in particular [Zhang et al., 2016a] proposed a 2-D framework to account for the plane-parallel bias in both COT and CER retrievals caused by sub-pixel inhomogeneity.

4. In Figure 6, to what extent the longitudinal variation of delta_AAOT is caused by the variation of AAOT itself? It seems to me that the percentage difference is mainly determined by the denominator, i.e., the mean value of the AAOT. I'd suggest adding the climatological domain averaged AAOT to Figure 6 as a reference.

5. At line 1 of page 13, can the authors explain why the aerosol absorption and its wavelength dependence have anything to do with the Twomey effect?

6. At line 22 of page 22, there are actually several more recent studies that suggest the CER retrievals are overestimated when there is significant sub-pixel cloud inhomogeneity [Zhang and Platnick, 2011; Zhang et al., 2012; 2016a].

References Kacenelenbogen, M. S. et al. (2019), Estimations of global shortwave direct aerosol radiative effects above opaque water clouds using a combination of A-Train satellite sensors, Atmospheric Chemistry and Physics, 19(7), 4933–4962, doi:10.5194/acp-19-4933-2019.

Wilcox, E. M. (2012), Direct and semi-direct radiative forcing of smoke aerosols over clouds, Atmospheric Chemistry and Physics, 12(1), 139–149, doi:10.5194/acp-12-139-2012.

Zhang, Z., A. S. Ackerman, G. Feingold, S. Platnick, R. Pincus, and H. Xue (2012), Effects of cloud horizontal inhomogeneity and drizzle on remote sensing of cloud droplet effective radius: Case studies based on large-eddy simulations, J Geophys Res, 117(D19), D19208–, doi:10.1029/2012JD017655.

Zhang, Z., and S. Platnick (2011), An assessment of differences between cloud effective particle radius retrievals for marine water clouds from three MODIS spectral bands, J Geophys Res, 116(D20), D20215, doi:10.1029/2011JD016216.

Zhang, Z., F. Werner, H. M. Cho, G. Wind, S. Platnick, A. S. Ackerman, L. Di Girolamo, A. Marshak, and K. Meyer (2016a), A framework based on 2-D Taylor expansion for quantifying the impacts of sub-pixel reflectance variance and covariance on cloud optical thickness and effective radius retrievals based on the bi-spectral method, Journal of Geophysical Research-Atmospheres, 2016JD024837, doi:10.1002/2016JD024837.

Zhang, Z., K. Meyer, H. Yu, S. Platnick, P. Colarco, Z. Liu, and L. Oreopoulos (2016b), Shortwave direct radiative effects of above-cloud aerosols over global oceans derived from 8 years of CALIOP and MODIS observations, ACP, 16(5), 2877–2900, doi:10.5194/acpd-15-26357-2015.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-1176, 2020.