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Interactive comment on "Satellite inference of water vapor and aerosol-above-cloud combined effect on radiative budget and cloud top processes in the Southeast Atlantic Ocean" *by* Lucia T. Deaconu et al.

Anonymous Referee #1

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Review on "Satellite inference of water vapor and aerosol-above-cloud combined effect on radiative budget and cloud top processes in the Southeast Atlantic Ocean" By Deaconu et al.

This paper presents an analysis of the variation and covariation of aerosol and cloud properties, as well as meteorological conditions, in the SE Atlantic region based on satellite observations. Compared to many previous studies on this topic, this paper sheds an important light on the co-variation of water vapor and above-cloud aerosols, and the implications for radiative effects on cloud. Overall, this paper is well written

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and well-organized. The topic is a good fit to ACP. On the other hand, it can be further improved if the following questions and issues can be addressed and clarified.

Comments/questions/suggestions: A few important papers on the above-cloud aerosols in the SE Atlantic region are missing from the Introduction. They should be cited.

o Page 2 Line 7∼8: Swap et al. (1996) is perhaps the first one documenting the long-range transport of smoke aerosol from African continent to Atlantic.

o Page 2, line 16: Recently, Zhang et al. (2016) provide a nice analysis of how DRE of above-cloud aerosol depends on AOT and COT (see their Figure 9).

o Page 2, line 25: A few recent papers have studied the Twomey effect of above-cloud aerosols in the SE Atlantic region (Costantino and Bréon 2013; Lu et al. 2018). In particular, Lu et al. (2018), showed that the brightening effect due to entrained aerosols is actually stronger than the DRE and semi-direct effect.

o Page 4, line 5∼15: A recent study by Zhou et al. (2017) provides a more comprehensive picture of the radiative interactions between above-cloud aerosols and low clouds in the SE region.

Section 2.1: The Single-scattering albedo (SSA) is used later for deriving the absorption AOT. Is SSA a retrieved parameter or an a-priori assumption in the retrieval?

POLDER retrievals are done at the 6x6 km. At this scale, a significant fraction of pixels would be partly cloudy. How are partly cloudy pixels treated in the analysis? If they are simply screened out, would that lead to sampling bias?

MODIS Reff retrieval is not really biased when above-cloud aerosol is present. But MODIS COT retrieval can be substantially biased (underestimated). See Meyer et al. (2013). It needs to be clarified how the COT retrieval bias is accounted for the LWP estimation.

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Page 7, Line 25: Indeed, CALIOP retrieval of above-cloud smoke AOT can be significantly biased, as pointed out by the authors and many other previous studies. This is because CALIOP cannot "see" the low portion of a thick smoke layer, i.e., it puts the bottom of aerosol layer too high. Therefore, simply using the extinction profile for HR computation seems to be a bad idea. It needs to be clarified here why this is justified.

Page 8 Line 30: Again, is SSA a retrieved parameter or a pre-assumption. Is it a constant or it can vary spatially or temporally, and how?

Page 9 Line 10: It is interesting that the COT bias is pointed out here, but not in Section 2.1.

Page 13, The analysis in this section is somewhat superficial. Overall, it remains unclear after reading if those differences between low and high AOT loading cases in Figure 9 and 10 are significant and meaningful. Are they simply coincidence or there are some underlying physics? Significant revision is needed here. In particular, these differences should be put in the context of previous studies, e.g., Lu et al. 2018; Zhou et al. 2017

Page 14 Line 4$\sim$7: It remains puzzling to me why Figure 10c "seems well illustrating the cloud-radiation-entrainment feedback". It needs to be explained better and, in more detail, here. What is the underlying physics of this feedback? Why does the decrease of LWP with qv "illustrate" this feedback?

Page 15 Line 5: The total HR at cloud top for the unpolluted case is -13.5 K/day and the corresponding value for polluted cases is -12.9 K/day. Considering that the LW cooling rate for both groups is the same (i.e., -17.79 K/day). This difference indicates that the SW heating at the cloud top for the polluted case is actually stronger (i.e., more positive). Isn't this counterinitiative? Shouldn't the extinction of above-cloud aerosol layer reduce the SW heating rate at cloud top in the polluted cases? This SW heating difference should be pointed out here and explained in detail.

The overall values between the polluted and unpolluted cases in Figure 11 seem pretty close. Some statistical test (e.g., T-test) need to be performed to tell if the differences are statistically significant. âĂČ Costantino, L., and F. M. Bréon (2013), Aerosol indirect effect on warm clouds over South-East Atlantic, from co-located MODIS and CALIPSO observations, Atmospheric Chemistry and Physics, 13(1), 69–88, doi:10.5194/acp-13-69-2013.

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Meyer, K., S. Platnick, L. Oreopoulos, and D. Lee (2013), Estimating the direct radiative effect of absorbing aerosols overlying marine boundary layer clouds in the southeast Atlantic using MODIS and CALIOP, Journal of Geophysical Research-Atmospheres, 118(10), 4801–4815, doi:10.1002/jgrd.50449.

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Zhou, X., A. S. Ackerman, A. M. Fridlind, R. Wood, and P. Kollias (2017), Impacts of solar-absorbing aerosol layers on the transition of stratocumulus to trade cumulus clouds, Atmospheric Chemistry and Physics, 17(20), 12725–12742, doi:10.5194/acp-17-12725-2017.

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