

***Interactive comment on “Evaluation of  
satellite-based aerosol datasets and the CAMS  
reanalysis over ocean utilizing shipborne  
reference observations” by Jonas Witthuhn et al.***

**Jonas Witthuhn et al.**

jonas.witthuhn@tropos.de

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Dear Editor and Reviewers,

We thank the editor and the three reviewers for their detailed reviews and thoughtful suggestions. We largely agree with their comments and have tried to address their concerns in the revised paper. In the following text, we give a point-by-point reply to the reviewer's comments. If changes are given in the answers with line, figure or table numbers, those numbers refer to the discussion article. Also the latexdiff file highlights the changes between the discussion article and the revised manuscript.

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In order to separate the reviewer's comments and the author's response, we have printed the comments in black, and our response in blue.

We highly appreciate the detailed comments and suggestions, which have helped to improve the manuscript.

Sincerely, on behalf of all authors

Jonas Witthuhn

e-mail: jonas.witthuhn@tropos.de

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## Overview of changes made to the manuscript:

- Sect. 1:
  - The first three paragraphs have been merged to provide a shorter and more comprehensive introduction about why spectral aerosol observations over ocean are necessary.
- Sect. 2.1:
  - Included short description of MAN Microtops measurement protocol.
  - Included note of calibration procedures for GUVIs and Microtops.
  - Included note of post processing in the GUVIs introduction and restructured segments.
  - Rephrased the COMB dataset description.
- Sect. 2.2:
  - Added the wavelengths of the MODIS aerosol product.
  - Added note about referring to *MxD04* (MODIS) or *SEV\_AER-OC-L2* (SEVIRI) when writing about MODIS or SEVIRI aerosol products.
  - Added a note on the increased side-scatter effect of non-spherical particles.
- Sect. 2.3:
  - Question accuracy of CAMS RA AOD under cloudy sky conditions.
- Sect. 3.1:
  - Change the thresholds of the aerosol classification method as suggested by Stefan Kinne. This effects all figures and tables related to aerosol type by changing number of datapoints but do not change the main conclusions.

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- Emphasize that the presented aerosol classification is an estimate of the dominant aerosol type of the current (mixed) aerosol situation.
- Sect. 4.2:
  - This section receives a major rework to account for changes in aerosol classification and the presentation of the statistics in Table 5., as well as to avoid several repetitions.
  - Added a note about the incompleteness of the analysis of the AOD variation between MODIS overpasses, and the additional value of high temporal resolution observations from SEVIRI, since morning and evening hours with potential aerosol growth are omitted.
- Sect. 4.3:
  - This section receives a rework due to Tables 6 and 7 are omitted or merged to Table 5 in the revised paper.
- Sect. 5:
  - Added a sentence that it has been shown, that the bias of SEVIRI AOD is depend on AOD.
  - Reworded the paragraph about benefits of SEVIRI temporal resolution to emphasize more the targeted applications such as studies about aerosol plumes or frontal zones.
- Table 2 is updated due to the changes made to the aerosol classification.
- Table 4 is updated since outliers are no longer omitted from the calculation of GUViE.
- Table 5 receives a major update as suggested by Stefan Kinne.

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- Results are presented for the comparison to MIC only.
- The table focuses on 550 nm only.
- The table includes the information about aerosol type and in case of CAMS RA additional information with and without AATSR.
- Figure 1 shows all aerosol types.
- Figure 3 shows all aerosol types.
- Figure 4 and similar Figures: added solid lines to connect the median values of each bin for clearer visualisation of the change in bias with increasing wavelength.
- All figures and tables are updated after changing the aerosol classification as suggested by Stefan Kinne.
- Minor changes and corrections to wording, grammar and typos throughout the manuscript as suggested by the reviewers.

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Response to RC2 from Referee #3:

*This paper aims to evaluate the satellite (MODIS, SEVIRI) and reanalysis (CAMS) retrievals of AOD and Angstrom exponent over ocean by comparing them with moving ship-borne observations using Microtops sunphotometers and multi-spectral shadow-band radiometer GUVIS-3511 during several cruises in the Atlantic Ocean. The results are re-evaluated for defined aerosol types, mostly maritime and desert dust.*

*Overall, the manuscript is well written and organized, although some improvements may be attained in the discussion of the results.*

*However, the manuscript is rather long enough and some parts may be significantly shortened without any effect in the general discussion and importance of the results, since there are several repetitions throughout the manuscript.*

- *There is a rather long discussion of aerosol direct and indirect effects in the beginning of the Introduction that is beyond the scope of the current research. I understand that authors initially discuss the role of aerosols on global climate and the necessity of accurate measurements of them, in a way to reduce the uncertainty in their climate response, but this part may be shortened in one paragraph (for example the first three paragraphs could be shortened and merged into one).*
- *You are right. We have now merged the three paragraphs as suggested. The text is reduced to:*  
*"Aerosol particles directly influence the earth's radiation budget through their interaction with solar and terrestrial radiation, and indirectly by modifying the optical properties of clouds (Boucher2013). Studies of aerosol effects on the climate system are based on radiative transfer models. Therefore, knowledge about the spectrally resolved optical properties of different aerosol types is essential. Over ocean, sea spray (Bellouin2005, Loeb2005, Yu2006, Myhre2007) and desert dust*

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(e.g., Tegen2003, Christopher2007, Nabat2015) are the major contributors to the direct radiative effect of aerosol. Observations of aerosol load and optical properties with global coverage are required to improve our understanding of climate-relevant aerosol processes."

- Although a very analytic description is provided for satellite products, GUVIs measurements, collocation procedures and so on, there is lack of information about uncertainties in the Microtops-II AOD retrievals, which may be high if the instrument is not exactly oriented to the sun's disk. Usually, 3-5 sets of measurements are taken from Microtops in order to select the best one via techniques described in previous papers (e.g. Sharma2014, Tiwari et al. 2018, Environ. Science Pollution Res.).
- The Microtops data is processed within the Maritime Aerosol Network (MAN) framework within AERONET. There is a detailed description of the procedure available in (Smirnov2009), indeed the series data consists of the average of >5 consecutive scans. In the paper we simply state the uncertainty estimate of  $\pm 0.02$  and cite the general article (Smirnov2009). For clarification, we added a short description in section 2.1.:  
*"The Microtops is a hand-held sunphotometer, which has to be pointed manually at the sun. To minimize uncertainties arise from manual pointing, more than five consecutive scans are averaged to form one measurement (Smirnov2009). The Microtops instrument measures the incident direct normal solar irradiance with a field of view of 2.5° (Porter2001). The MAN Microtops sunphotometers are calibrated against an AERONET master Cimel sunphotometer, which in turn is calibrated using the Langley-technique. [...] The uncertainty of Microtops AOD is estimated to be within  $\pm 0.02$  (Smirnov2009)."*
- In addition, during the W-ICARB cruise campaign over the Bay of Bengal, there was a comparison between Microtops-II and MODIS AODs revealing a very good

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agreement between them, which may be mentioned in the paper and discussed against the current findings (Kharol2011)

- Thank you for pointing out this relevant study, we now mention this reference in Sect.4.2:  
*"Nevertheless, the correlations found here agree well with the findings of Levy2013 considering the MODIS C6.1 aerosol product (0.937) and the 550 nm channel. A smaller dataset of Microtops observations was compared to MODIS aerosol products by Kharol2011, where a general overestimation of AOD, and a high correlation was found similar to our results."*
- Section 4.2 is composed of numerous relatively short paragraphs, whose meanings are not so distinguishable. This creates some difficulties in reading and understanding exactly the major issue (spirit) of each paragraph. Taking also into account the several repetitions, this becomes more problematic. What I recommend is to merge the paragraphs into longer ones discussing a define issue, for example results of the presented figures and tables and/or discussion on these results.
- We have rewritten this section and refined the structure to increase the clarity of the text.
- Special care should be taken throughout the manuscript on avoiding several repetitions. Some of these are emphasized below.
- As we have rewritten this section we have removed several repetitions.

Minor comments/corrections

- Line 51: Levy et al. (2013) estimated...

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- Done.
- *Line 73: Double use of “system” at the end of this sentence does not make good sense and should be revised.*
- Done.
- *Lines 205-206. I recommend to remove this sentence from this part of the manuscript. In case the reader would expect a better accuracy from MODIS, what’s the reason to read the results of this study?*
- Done.
- *Lines 362-364 and lines 380-381. These sentences are just a repetition and one should be removed.*
- We stripped the first sentence to its bare minimum rather than deleting it, since it is used to describe the expectation. The second sentence now provide the explanation for the expectation.
- *Line 447....is presented here.*
- Done.
- Repetitions:
  - *Line 476-480. Since the data...MIC data. Such statements have been repeated several times in the manuscript and may be removed or significantly shortened.*
  - *Line487. This sentence, even rephrased has been stated several times in the manuscript.*
  - *Line493-494. Since the MODIS...accurately. Similarly, this has been stated several times in the manuscript.*

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- As we have reworked section 4.2 we have removed several repetitions.
- *Line 541. This emphasizes...*
- Done.
- *Line 562. A slight increase...*
- Done.
- *Line 589. This is a similar statement as in line 571.*
- We deleted the first sentence (L571).

Please also note the supplement to this comment:

<https://www.atmos-meas-tech-discuss.net/amt-2019-321/amt-2019-321-AC2-supplement.pdf>

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-321, 2019.