

We would like to thank the Reviewers for the thoughtful comments and suggestions. We have modified the manuscript according to these suggestions. Our replies are below (Reviewer's comments in *Italic*, response in normal face).

Other changes than those suggested by the Reviewers were applied to the manuscript during the revision.

The merging approaches have not been modified, but the number of the products used for merging was revised. TOMS, OMI and EPIC products, which were reported at other than 0.55 μm , were removed from merging. However, we keep those products in the inter-comparison and evaluation with AERONET exercises.

Another product, AVHRR NOAA (over ocean) was added.

In the merging approach 1, the reference to estimate the average offsets with individual products was re-considered: ATSR_ens was replaced with Terra DT&DB. With this change, the overlapping period exists between the reference and all individual products, thus the direct inter-comparison is possible (in the version submitted to the ACPD the offsets between ATSR_ens and VIIRS and ERIC were calculated in two steps, with estimating intermediate offsets to MODIS Aqua).

Section on the estimation of uncertainties in the L3 merged AOD product was added; the spatial and temporal uncertainties are shown and discussed.

In Sect. 6 (revised version), when we discuss the results from different methods for merging annual time series, we now show TOMS (over land) and AVHRR NOAA (over ocean), both shifted to the merged time series (shifted to the reference in the version submitted to the ACPD).

We thoroughly revised the paper, which required an input from a new co-author.

Interactive comment on “Merging regional and global AOD records from 15 available satellite products” by Larisa Sogacheva et al.

Anonymous Referee #2

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Review report of the ACP manuscript Merging regional and global AOD records from 15 available satellite products (<https://doi.org/10.5194/acp-2019-446>), by Sogacheva et al.

This manuscript discusses approaches to merge satellite AOD data sets from a large number of datasets derived from various instruments. The analyses start at the monthly AOD L3 products at a low spatial resolution (1x1° lat-lon). An extensive intercomparison of the various datasets is performed and different merging techniques are discussed.

The strongest part of this manuscript is the section 4, where the different datasets are compared. This could be a publication on its own. The weaker parts are the sections 5 and 6, which should be significantly improved in structure and readability.

Main comments

One of the goals of the manuscript is to present a merged dataset. However, different merging methods are described, and no clear recommendation is made for a merged

dataset. Also, a description of the final dataset is lacking. Therefore, the claim made in the abstract that a merged dataset is introduced is not fulfilled. If a dataset is presented its contents should be described, including on the technical level (in an appendix). Also, the dataset should be made available, preferably on one of the large datacentres, and with a doi.

According to the Reviewer's comments, we revised considerably sections 5-7, where methods for merging are described. The scheme for the merging approaches was added to the introduction for merging approaches (Sec. 4 in the revised version).

All merged products are now described and validated (Section 5 in the revised version). Section on the pixel-level uncertainties for the final L3 merged products is added. The recommendations are given on the final merged product. The merged data set will be openly available at Finnish National Satellite Data center, <http://nsdc.fmi.fi/> ; the full link will be provided in the manuscript accepted for publication.

The intended audience for the manuscript is not clear to me. If the intention is to describe a merged dataset, the intended reader is a potential user of that dataset. This user group is probably not an expert in the aerosol field and is probably not (so) interested in the performance of the individual underlying datasets (section 4, which is the largest part of the manuscript), but rather in a description of the performance and caveats of the merged one. This needs to be taken into account in the sections 5 and 6, which should be written at the right level, and more or less separate from section 4.

So far, individual products, which have certain limitations discussed in the manuscript, have been used in the air quality and climate studies. We expect that the potential users, if not experts, have a good knowledge on aerosols. For the merged product offered here, which has the main advantage in better temporal coverage with similar or better quality, we expect the same audience, which use other individual satellite products, but since the merged product allows looking at the longer period, the climate researchers will benefit from having access to the longer data set.

The interest to the AOD merged product was shown by the AeroCom community. Several request from modelers have already been obtained for evaluation of the modelled AOD products.

To make the manuscript useful for experts in different fields, the discussion of the performance of the merged products has been considerably enlarged by including the evaluation results for all tested merged product and inter-comparison of the selected merged product with individual products.

To summarize my main comments:

- *Make the merged datasets available and include a technical description.*
- *Rewrite the sections 5 and 6 with the intended user of the dataset in mind as the audience. More comments on section 5 and 6 are found below.*
- *Make clear what the final advertised merged data set is.*

The technical description has been revised and supported by the results (Section 5 and 6 are combined).

The scheme for the merging approaches was added to the introduction for merging approaches (Sec. 4 in the revised version).

New section, there the merged L3 monthly products are introduced, evaluated, inter-compared is added.

The main merged product is chosen and inter-compared with individual products.

Section on the pixel-level uncertainties for the final L3 merged products is added.

Section 5

This section should be rewritten, to clarify what was done and limited to methods that are used in the further analyses.

Section 5 and 6 are combined. The technical description has been revised and supported by the results

Section 5.1. This section is too brief and starts with a statement why the mean is not a good statistical indicator, whereas the it is one of the parameters that is calculated. What is missing is information on which data it is applied (to the monthly mean L3, or also to the seasonal and/or annual L3?).

The “mean” approach has been removed from the manuscript.

It was clarified in the text, that the merging has been applied to L3 monthly dataset and annual/seasonal/monthly time series.

Section 5.2. This section is too brief and unclear. With the information contained in this section I would not be able to reproduce the results. The ATSR_ensemble is not available for the entire dataset. How do you deal with this? Clarify all the steps of the method.

Section 5.2 was combined with Section 5.1. The offset correction method was supported by the offset correction results.

Section 5.3. This section describes to methods: RM1 and RM2. However, RM1 is -as far as I can tell- not used in the rest of the paper. Therefore, it should be removed from this section, so approach 3 is limited to RM2 (in the remainder of the manuscript reference to RM2 should be changed to Approach 3). Furthermore, I propose to add one or more equations to clarify the procedure. Also, it should be clarified on which datasets it is applied, because if I understand section 6 correctly, there are also some sub-methods here (e.g. regional weights, monthly weights versus time-series weights, aerosol type weights).

In the revised version, results for RM2 are shown and inter-compared with the results from other merging approaches.

The equation for the weighted mean is added.

The datasets, on which the approaches and sub-methods are applied, is discussed in the new Sect. 5, where the merged L3 products are introduced, evaluated, and inter-compared.

Section 5.3 In approach 1 and 2 the mean, median and standard deviations are calculated. Why is this not done for approach 3 (see for example [https://en.wikipedia.org/wiki/Weighted median](https://en.wikipedia.org/wiki/Weighted_median))?

The conclusion on the choice of one final merged product is based on the fact, that there is a very small deviation between L3 products and time series merged with different approached (1 or 2) and sub-methods (aerosol types), except for approach 1 applied to the shifted products. Thus, we do not see the need to calculated average (median) from all tested merged product, which, if done, makes the analysis more complicated with no significant improvement.

Section 6

Section 6 should in my opinion describe the quality and caveats of the merged data using method 1, 2 and 3. It should not describe the performance of individual datasets. I think that part of my confusion seems to come from what is called the “merged product”. As a reader, I think that methods 1,2 and 3 all yield a merged product but using different merging methods.

In Sect.6 (ACPD version), which is combined with Sect.5 in the revised version, it is important, in our opinion, to show the results for individual products because those results contribute to the final ranking of the products. In the revised version, the results are shown for two regions only, Europe and ChinaSE, as an example. The results for all regions are moved to Supplement.

Section 6.1.1 I think this section doesn't belong in section 6. It describes the rationale for merging approach 2 and therefore should be moved to section 5.2.

Section 6.1.1 was moved to Section 4.1 in the revised version

Section 6.1.2: The title of this section is not covering the contents: in the current manuscript it is comparing the Merging Methods 1 and 2. However, I don't understand why Method 3 is left out in this section. Instead, I propose to describe the comparison of all three minutes, using figure 13 and to drop figures 9 and 12.

Approaches 1 and 2, as in the ms submitted to the ACPD, are combined in the revised version. Annual time series, calculated with the approach 1 (uncorrected AOD) and approach 2 (weighted AOD, former approach 3) are now introduced in Sect. 6; differences in the results from different approaches and different steps (time series from merged L3 product and merged time series) are discussed.

Section 6.2.1: This section described the weights; it doesn't assess the merged data quality. I strongly suggest moving this section to section 5.3, which also increases the readability of that section.

Section 6.2.1 was moved to Sect.4.2, where both method and results (weights) are discussed

Section 6.2.2: first paragraph. This describes sub-methods of approach 3 and should be described in section 5.3.

Figure 11, I like this figure, but why include it only for method 3? I think it should also be generated for methods 2 and 3 and the differences discussed.

In the revised version, the evaluation results for all products are shown and discussed (Sect. 5.1). The evaluation results for the chosen product (former Fig.11) are summarized in Sec. 5.2.1. Uncertainties for the final merged product (M) are introduced and discussed in Sect.5.2.2

Section 6.2.3. In the first 2 sentence 2 sub-methods are introduced of approach 3. This is not the right place, this should be done in section 5.3. The remainder of section 6.2.3 should be moved to 6.1.2, and also differences with the other methods should be described.

Section 6.2.3 was partly combined with Sect.4 (revised version) and partly moved to Sect.6 (revised version). The differences in the time series merging results are discussed in Sect 6; results are summarized in Table 3.

Section 7. I don't really see the need for this section. Line 1-22 would fit with the comparison of the time series of the three methods (e.g. 6.1.2). The last paragraph should be moved to the conclusion.

Section 7 (Sect.6 in the revised version) has been considerably revised. The merged time series are introduced, the difference between them is discussed. The last paragraph was moved to the conclusion.

Specific comments

I strongly suggest adding a figure with timelines of the availability of all the products as part of the section 2. This information is also in Table 1, but a graphical overview would be a great help.

The information on the availability of the products use for merging is now summarized in Table 2. The availability of the other products (TOMS, OMI, AVHRR NOAA) is mentioned in the text.

Table 1 presents the datasets, but the doi's and url's in Table 2. For each dataset the reference of doi (or url if doi is not available), should be included in Table 1, and the

reference doi's and urls should be included in the list of references. Table 2 can be removed.

According to the ACP rule, that data availability should be included as a separate section. In the title for Table 1, we added the information that the data availability is summarised in Table 4.

Page 14, lines 1-11. In the discussion of the comparison of AERONET with AOD L3 data, instead on the more common comparison with L2 data, one argument is missed.

We discuss the L3 validation in Lines 3-11. To make it more clear, we now mention L3 specifically.

When L2 data is compared with AERONET with strict temporal and spatial criteria, the L2 data is implicitly cloud-cleared, because the AERONET data is only available under these conditions. This does not hold when comparing the L3 data. If the cloud clearing is not optimal, this would lead to difference in the comparison results of L2-AERONET versus L3-AERONET.

The problems related to the difference in cloud screening are mentioned in abstract, Introduction, Sect.2 and conclusions, briefly or with some details.

Page 15, line 5 “manuscript” -> “work”

Corrected

Page 16, line 16-17. It is not clear what is meant here. What does “different surface treatment” mean (compared to what?).

Different approaches for surface treatment in different products. Clarification is added.

Page 19, section 4.3. Define how the ATSR_ensemble is computed.

The definition for the ATSR_ensmble product is added to Sect. 2.2

Caption Figure 5, In light of my comments on section 5-6, I don't understand which merged product is shown as “M” in this figure.

The caption was revised by including the reference to the merged product

Page 22, section 5.1. I would suggest to not only compute the standard deviation, but also percentiles, for example the 10th, 25th, 75th and 90th, because the standard deviation is very sensitive to outliers.

The standard deviations were low, thus the contribution of the outliers, if existed, was negligible.

Page 22, line 5: “AOD weighted” is not clear. I suggest “Weighted mean, where the weights are derived from the comparisons with AERONET.

The whole paragraph was re-written

Page 23 line 26: “ATRS” should be “ATSR”.

Corrected, as suggested by the Reviewer

Page 29, line 1: “aerosol particles” should be “aerosol types”

Corrected, as suggested by the Reviewer