

Replies to comments by Referee #2 concerning the manuscript: Assessment of diverse algorithms applied on MODIS Aqua and Terra data over land surfaces in Europe"

We thank the reviewer for the constructive criticism, which we have taken into consideration to improve the manuscript. More detailed answers to the major and minor concerns are presented below. If nothing else is written about the changes that have been performed we refer to the original version of the manuscript. Although no major criticisms about the language of the manuscript were presented by the reviewers the revised version of the manuscript has been proofread. We apologise if not all of these changes made in the text are presented in our answers to the referee's comments. We should mention that large changes have been made to Figures 4, 6, 7 and 8 (see our answers to comment 29 by reviewer 1).

General comments

"General comments. This paper is aimed at verifying the performances of the MODIS SAER and Collection 5 algorithms in deriving the aerosol optical depth and Angstrom exponent over land surfaces in Europe. The aerosol products for these two algorithms are compared with AERONET measurements obtained at different locations in Europe. The main results of this paper indicate that the MODIS Collection 5 algorithm better agree with AERONET observations compared to the SAER algorithm. Instead, larger differences are found for the Angstrom exponent comparison for both MODIS products. I found the paper potentially interesting and useful, despite several other studies have been performed on this topic, especially for the analysis of the Collection 5 algorithm, while a lower number of studies have focussed on the SAER algorithm. However, I have a major concern regarding the significance of the comparison mainly because of the very limited time period covered by this study (only few weeks). My main suggestion is to extend the comparison to a larger time period in order to improve the representativity of the results."

Respond to general comments:

Although only three time periods have been included in the present study the numbers of aerosol optical values compared between satellite and AERONET retrievals are not low. The number of collocation of satellite and AERONET data was not present in the original version of the manuscript. In addition, since we now have included more AERONET stations in the comparisons (see specific comment 12 by reviewer #1) the number of matches has increased. The present Figures 4a and 4b show that 507 matches occurs between MODIS c005 and AERONET, which can be compared to 985 matches that were included in the MODIS c005 and AERONET comparison for East Europe and West Europe and two years of data (Remer et al., 2005). However, the present satellite/AERONET matches are of course very low compared to the 85 463 valid MODIS/AERONET global land collocations, for the years 2000 – 2008, that are included in the study by Levy et al., 2010. The present pixel-by-pixel inter-comparisons between SAER and MODIS c005 are on the other hand of course associated with many matches. Thus, although the limited time period investigated here we think that the general findings (Sections 3.4 and 4) about for example identified deviations in AOT when both the SAER and MODIS c005 algorithms have been compared to AERONET measurements but also improved retrievals of AOT obtained with the SAER algorithm are

representative and valid. Considering the latter finding the following sentences have now been included in the beginning of the fourth paragraph of Section 4: “Nevertheless, the overestimation by a factor of 2 in mean AOT, found for low aerosol loadings with the BAER algorithm (Hoyningen-Huene et al., 2006 and and Glantz et al., 2009a), has substantially been reduced here when SAER of AOT at the blue wavelengths were compared to the AERONET measurements and MODIS c005 retrievals. In addition, better agreement in mean AOT at 443 nm, obtained with the SAER and AERONET sun photometer, was also found considering both Aqua and Terra for high aerosol loadings compared to the previous studies.”

Specific comments and corresponding responds

1) *"Page 2364: the abstract is not fully self-consistent and clear, see for example the last two sentences."*

We agree with the referee and have changed the two last sentences: "Based on the inter-comparison of the SAER and MODIS c005 algorithms it was found that the SAER on the whole is able to obtain results within the expected uncertainty range of MODIS for Aqua and Terra observations." The reaming text in the abstract has also somewhat been rewritten.

2) *"Page 2365, lines 12-14: I suggest to rewrite this sentence, because in the present form is not very clear."*

We agree and have changed the sentence to " However satellite retrieval is no straightforward task, since the radiance at the top-of-atmosphere (TOA), detected by the nadir viewing sensors, is not only affected by aerosols and a relationship with AOT has to be valid for all possible illumination and viewing geometries."

3) *"Page 2365, line 15: I suggest to add a comma “for satellite retrievals,”"*

We agree and the sentence has been changed to: "Beside the development of retrieval algorithms, high priority should therefore also be given to the validation of aerosol optical properties from satellite observations against ground-based data

4) *"Page 2365, line 18: I suggest to replace “with” with “from”"*

We suggest to change the sentence to " Furthermore, results of remote sensing observations from different space-borne platforms as well as by different sensors mounted on the same satellite need to be evaluated.

5) *"Page 2365, lines 23-24: I suggest to replace “situated aboard” with “onboard”"*

We agree with the referee and have performed the suggested change.

6) *"Page 2366, line 1: replace “extend” with “extent”?"*

We agree with the referee and have performed the suggested change.

7) *"Pages 2368 and 2369: it seems there are few errors in formulas 2 and 4; please, correct them."*

The referee is right " $1A_{\text{Surf}}$ " should be " $1 - A_{\text{Surf}}$ " instead.
In addition, in eq. 4 "-" has changed to "+" in the denominator.

To make the description of the parameters included in equation 2 more clear two sentences after Equation 2 have been rewritten: " T_{Ray} and T_{Aer} represent the total (direct and diffuse) atmospheric transmission for the illumination and viewing geometry with respect to gases and aerosols, respectively. M is the air mass factor and ρ_{Hem} is the hemispheric reflectance. T_{Ray} and T_{Aer} as well as ρ_{Hem} are determined by parameterizations as derived from radiative transfer calculations (von Hoyningne-Huene et al., 2006)."

8) *"Page 2369: you have to add a minus sign in formula 7."*

The referee is right and a minus sign is included in the revised text.

9) *"Section 2.1: in some points the discussion appears quite confusingly mainly because of the different wavelengths used when comparing Collection 5/AERONET and SAER/AERONET products."*

We agree with the referee and have performed the changes suggested. Therefore, the beginning of Section 3.2 has been changed to "For a comparison between satellite and ground-based retrievals the Ångström power law (eq. 7) has been used to convert AERONET data to AOT represented at the wavelengths 469 and 555 nm (MODIS c005) as well as 443 and 488 nm (SAER)."

Thus, in line with the comments (point 17) by referee 1 we have used the results from the AERONET Ångström exponent to estimate AOT representing the same wavelengths as the satellite retrievals. It seems that we now more clearly obtain a minor overestimation of the MODIS c005 algorithm, particularly for Aqua. This is shown both for the 469 and 555 nm wavelengths. Therefore, we suggest changing the first sentence of Section 3.4 to "The inter-comparison of the findings of MODIS c005 and SAER retrievals and the validation of these algorithms against AERONET measurements suggests that a small part of the deviation found for high aerosol loadings seems to be due to a general overestimation of AOT by the operational MODIS algorithm."

Furthermore, the following sentence "However, the validation of the MODIS c005 algorithm against AERONET measurements suggests that a small part of the deviation found for high aerosol loadings seems to be due to a general overestimation of MODIS AOT." has been included in the middle of the third paragraph in Section 4.

10) *"Page 2371, line 9: I think you should refer to the 469 nm wavelength (instead of 459 nm) for the MODIS Angstrom exponent retrieval."*

We agree and have changed to "469 nm" in the text.

11) *"Page 2372, line 23: please add a reference for the AERONET cloud screening."*

We agree and have included Smirnov et al. (2000) as a reference in Section 2.2 and in the reference list.

12) *"Page 2373, line 8: "long-range transport of particles from the east"*

We suggest to change this sentence to "Such a weather situation favors the accumulation of aerosols from local sources but also enables long-range transport from sources to the east of the investigation area."

13) *"Page 2374, lines 21-23: for AERONET, you consider the mean for 60 minutes measurements (4 consecutive observations); however, in certain cases the aerosol optical depth may rapidly vary over this time interval. Thus I suggest to calculate also the RMSD for the 4 AERONET observations and, in case, to exclude cases with high aerosol optical depth variability, if they are present."*

In the revised version of the manuscript we suggest to present AAD instead of RMSD (see our answers to specific comment 29 by referee #1). Note that the calculated RMSD and AAD are based on both satellite and AERONET retrieved values (AAD defined in Section 2.3 in the revised version of the manuscript). The variability in AERONET AOT is best represented by the one standard deviation shown in the figures and we do not see any reasons to exclude cases with large variability. It should be mentioned here that the AERONET values in the comparison with MODIS c003 have been averaged according 3 hour in the revised versions of the manuscript (see our answers to specific comment 14 by referee #1).

14) *"You missed the plot for the SAER/AERONET comparison of the Angstrom exponent."*

The referee is right that these figures are not presented in the manuscript. Even so, we suggest instead including information in Figure 7 of estimated median Ångström exponent and corresponding one standard deviation of all data values included in the figures. We think that no figures are needed to convince that poor agreement appears between SAER and AERONET α . In addition, calculated MODIS and AERONET median α and corresponding one standard deviation are shown in Figure 4. The conclusion "Both satellite retrieval algorithms are unable to estimate α accurately, although the MODIS c005 algorithm performs better." presented in Section 4 is now better supported. In addition, the following sentence "This probably also explain the larger discrepancy in α that was found with the SAER compared to the results obtained with the MODIS c005 algorithm." has been included at the end of Section 3.2.2.