Atmos. Chem. Phys. Discuss., 11, C9422–C9428, 2011
www.atmos-chem-phys-discuss.net/11/C9422/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Analysis of linear long-term trend of aerosol optical thickness derived from SeaWiFS using BAER over Europe and South China" *by* J. Yoon et al.

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Received and published: 27 September 2011

Dear anonymous referee,

Thanks for your suggestions and comments to improve this discussion paper. The purposes of the discussion paper are not only to investigate trends in aerosol optical thickness (AOT) at 443 nm and 555 nm over Europe and southern China, but also to show the uncertainty caused by cloud disturbance in the trend analysis of cloud-free aerosol.

Major Comments

Q1. The validation of satellite data (BAER SeaWiFS AOT) is made through comparison against surface measurements from AERONET data. Indeed, this is the appropriate way to do it. However, the number of selected AERONET stations is only 4 and becomes 3 finally after applied filter availability criteria to data. Moreover, all of 3-4 stations are located in Europe, the one of the two studied regions, none in Asia (Pearl River Delta). This is a limited number of stations, and more of them are necessary for deriving reliable conclusions on satellite data quality. Especially, when dealing with trends, the increased number of stations becomes even more necessary. If the former case, i.e. overall comparison between BAER and AERONET, a larger number of AERONET stations should be easily found. In the latter case, i.e. comparison of AOT trends, if the number is limited, the temporal interval could be decreased. Even for less than 11 years, successful comparisons between AOT trends from the two datasets will strengthen the validity of the BAER based results and conclusions.

A: As you mention, there are a lot of global AERONET stations (roughly over 850). However, we could not use all AERONET station within the defined regions in this paper.

1. Not all stations distribute sufficiently large temporal records, which are suitable for the validation of AOT and AOT trends. Specifically, it is difficult to make a validation at Hong_Kong_PolyU station in Pearl River Delta because the matchup points between AERONET and BAER AOTs are only two. Furthermore, long-term and continuous data are highly required in order to make a validation of AOT trends. As you see in Q1-Table 1 (attached to these comments), there are not many global AERONET stations, which could be used for the trend validation.

2. BAER has still limitations to retrieve AOT using SeaWiFS over some regions, which are affected by frequent cloud disturbance or/and high surface reflectance. Especially, at higher latitude in Eastern Mediterranean it is difficult to compare BAER with AERONET AOTs.

Therefore, the only four AERONET stations, which have been chosen in the paper, could be used for validation of AOT and AOT trend. Of course, you definitely have a question about the BAER's retrieval accuracy over South China. Related to this, please check Q1-Figure 1 and 2 (attached to these comments), which were shown as validation results of the BAER AOTs against various AERONET stations (Lee et al., 2004; von Hoyningen-Huene et al., 2011).

Q2. According to the results of section 3, BAER AOT changes are altered by about 1-3% when applying the inter-correction method (between BAER and AERONET). Essentially, this is a first-orderv estimate of the uncertainty of BAER AOT trends. In section 4 the BAER AOT trends over European and Pearl River regions are examined, solely based on BAER. Given the findings of section 3, how can the results of section 4 be affected by the specific BAER AOT uncertainty? Is this uncertainty critical for some of them? I believe that this has to be assessed and will be important for strengthening the validity of the derived conclusions on AOT trends over the studied regions.

A: We found that cloud disturbance is one of most significant uncertainties in the trend of alleged cloud-free aerosol. If we could assume that the aerosol retrieval accuracy is good enough to be compared with AERONET (as we have shown in Figure 3 in the paper), we would initially have expected that the AOT trends from satellite- and ground-based observations should be similar. However, this was not the case because some monthly AOT averages during cloudy seasons led to problems (i.e., a poor mean value calculated by too small observations). Therefore, the trends of cloud-free aerosol based on only satellite observation contain the uncertainty caused by cloud disturbance, and the uncertainty has to be assessed through the seasonal analysis of AOT trends. We will discuss and explain it more clearly in the paper.

Q3. The discussion of AOT trends and their attribution to specific causes/factors is not enough complete. When attempting such an attribution, more thorough analyses need to be undertaken before to draw conclusions. In order to be able to safely state what exactly is the responsible process/parameter for an identified trend, other possible

contributing factors should be excluded after analyses either made by the authors or at least based on existing literature. It is well known that aerosol loads are determined by both emission and removal (wet and dry) processes. Therefore, stating that, for example, an increasing/decreasing AOT trend is due to decreasing emissions, the role of removal mechanisms like precipitation has to be proved that is of minimum importance. This has to be done in the present study as well.

A: There have been many explanations about why AOT is increasing or decreasing in previous studies. Basically, we agree with the explanations and will also mention them in detail. However in this paper, we highlighted the cloud disturbance, which was not discussed before. As we have shown in Figure 8 in the paper, we found that some trend during cloudy seasons is induces problems. However, we did not deduce that some trends are caused by clouds, but rather suggested that the cloudy season trend is easily contaminated by cloud disturbance (not only overestimated AOT in AOT retrieval, but also poorly representative due to less observations), so that it might be ignored to receive a more reliable total trend.

Q4. Although the selection of the two studied regions and sub-regions is explained, it has to be further discussed and explained. Why have the authors selected those and not other regions?

A: We will explain in more detail why the regions are selected in this study.

Q5. As explained above, there exist a number of other studies dealing with trends of AOT over Europe and Asia (China). Even if the study period of these studies does not completely overlap with that of present paper in all cases, it can be relatively close to that. Therefore, it would be useful to compare the findings of this paper with those of others that exist in literature. This will maximize the value of the paper's conclusions.

A: As you recommend, we will check for additional references about AOT trend and discuss them in detail.

Specific Comments

As for all your specific comments, we will try to improve and modify the paper.

Q6. Section 2, page 5, line 27: the results of Figure 2 are not discussed. I suggest omitting this figure.

A: The sensor calibration is one of most important factors in AOT trend analysis. Therefore, we would like to keep this figure. In addition, we will explain how it could influence in the AOT retrieval and trend analysis.

Q7. Section 3.1, page 7, lines 12-16, "In this study, : : : research period": this sentence is irrelevant to the content of present paragraph; what do they authors try to say?

A: We have to mention that the aerosol properties used in LUT calculation are observed from LACE-98 because the aerosol properties are essential to determine the retrieval accuracy. It means that assumed aerosol properties could make an error in AOT trend analysis. We will discuss in more detail in the paper.

Q8. Section 3.2, page 8, lines 18-20, "One of the most : : : in the statistics": this conclusive sentence is somewhat arbitrary; it has to be supported whereas the authors have to argue on that. Is the statement made based on the literature or have the authors performed sensitivity tests to derive it?

A: It was based on Figure 4, 5, 6, 7, and 8 (not from other literatures and sensitivity tests). The position of the sentence could have led to confusion. We will check and improve the logical flow.

Q9. Section 3.2, page 9, second paragraph: how exactly was the inter-correction made? Was it applied to both BAER and AERONET AOTs, as it appears from both BAER and AERONET AOTs being changed, and in what way? Also, the authors should perform a test to check whether or not and in what way do the statistics of linear regression fits change if the non representative monthly AOT values are excluded from the time-series of both BAER and AERONET. Probably, they should try to apply a common

threshold, for example 5 days, for the necessary availability of daily AOT values per month. Finally, while the inter-correction is applied to winter AOTs, this is been made based on linear correlation equations (Fig. 3) that have been derived from year-long data. Probably, even better results can be obtained if similar equations are derived from winter AOT data only.

A: Yes, you are right. If some monthly averages are calculated with very small number of observations (fewer than 5 BAER days in a month, or fewer than 10 AERONET) we remove them. Next, the missing values are recovered by the calculation from other dataset using the correlation plot from validation between AERONET and BAER AOTs. Through the approach, we receive a better agreement between BAER and AERONET AOT trends. This means that it is difficult to compare directly between the AOT trends from ground- and satellite-based observations and that the cloud disturbance has to be considered in the trend analysis of cloud-free aerosol. We will try to make it more clear in the paper. By the way, some monthly AOTs during cloudy seasons could be recovered better using the linear correlation during cloudy seasons.

Reference

1. Lee, K. H., Kim, Y. J., and von Hoyningen-Huene, W.: Estimation of aerosol optical thickness over northeast Asia from Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) data during the 2001 ACE-Asia intensive observation period, J. Geophys. Res., 109, D19S16, doi:10.1029/2003JD004126, 2004.

2. Yoon, J., von Hoyningen-Huene, W., Kokhanovsky, A. A., Vountas, M., and Burrows, J. P.: Trend analysis of the Aerosol Optical Thickness and Ångström Exponent derived from the global AERONET spectral observations, Atmospheric Measurement Techniques Discussions, 4, 5325–5388, doi:10.5194/amtd-4-5325-2011, 2011.

3. von Hoyningen-Huene, W., Yoon, J., Vountas, M., Istomina, L. G., Rohen, G., Dinter, T., Kokhanovsky, A. A., and Burrows, J. P.: Retrieval of spectral aerosol optical thickness over land using ocean color sensors MERIS and SeaWiFS, Atmos. Meas.

Tech., 4, 151–171, doi:10.5194/amt-4-151-2011, 2011.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/11/C9422/2011/acpd-11-C9422-2011-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., 11, 20757, 2011.