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Atmospheric Measurement Techniques Discussions

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Interactive Comment

Interactive comment on "Investigation of the accuracy for single scattering albedo retrieval from global UV irradiance measurements" *by* S. Kazadzis et al.

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Response to the reviewer #2. "Investigation of the accuracy for single scattering albedo retrieval from global UV irradiance measurements" by Kazadzis S., Grobner J., Arola A. and Amiridis V.

We would like to thank the reviewer for his/her useful comments.

General comments

We agree with the reviewer that the results presented here are not a new methodology to derive SSA from global UV measurements. This is a method demonstrated by Bais et al., 2005 in one location and validated for two speciffic days. The authors do not imply (and that was corrected in various parts of the new manuscript) that the method using absolute UV measurements is superior to the existing dimensionless atmospheric transmittance methods used for SSA retrieval. However, till now there are a few publications/groups that calculate SSA at UV wavelengths based on UVMFR and CIMEL sun-photometer combination of measurements. The aim here is to show the possibility of using existing series of UV measurements (trying to use the advantage of the long term, quality controlled time series of such measurements existing worldwide) in order to enrich global and temporal SSA information at UV wavelengths. In order to reconsile inconsistencies mentioned in the general comments we decided to:

a. Change the paper title to:

The effect of the global UV irradiance measurement accuracy on the single scattering albedo retrieval

b. add the following text in the results section of the manuscript

"Summarizing, this work focuses on the possibility to use long term series of UV global irradiance measurements, in order to derive information on the SSA at various locations. Using comparison results of well organized campaigns we aimed to show realistic instrument differences, linked with absolute calibration, angular response and other measurement uncertainties. The uncertainty of deriving SSA from such measurements described, are linked not only with the measurement accuracy but also with the availability to use accurate RTM input parameters such as AOD, surface albedo, asymmetry parameter, ozone, NO2). Other studies showed that using speciffic instruments or combination of instruments that can provide accurate knowledge of dimensionless transmittance, is sufficient for deriving SSA with a provided uncertainty. However, the value of this work/investigation is based on the fact that the number of spectroradiometers (or even UV broadband radiometers) providing absolute UV irradiance measurements from the start of the 90's, could be used for the retrieval of aerosol

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SSA time series worldwide, with an uncertainty depending on each individual instrument. In addition, it has to be mentioned that the uncertainty of this retrieval is also influenced by the availability of measurements or accurate assumption of other RTM input parameters, mentioned above. As an example, the Brewer spectroradiometer Network could provide a valuable database of spectral UV measurements together with AOD retrieval (using their standard direct sun ozone measurement) in order to provide SSA information with relatively high spatial and temporal coverage."

c. follow the reviewer's suggestion to the speciffic comments based on the above discussion

General Comments - points

1. Following the reviewer's comments we have added in the introduction the following text as direct information of the importance of SSA at UV wavelengths. "The above discussion applies even more for aerosol absorption measurements at wavelengths in the UV part of the spectrum. Improvement in measurement and understanding of aerosol absorption in the UV (and parameters like SSA), that are currently used in various scientific applications based on theoretical assumptions, will significantly benefit to applications such as: a. Aerosol effects on photochemical smog production: aerosol absorption, contrary to scattering, decreases photolysis rates of ozone production as it alters the amount of UV radiation available for chemical reactions within and below the aerosol layer (Dickerson et al., 1997). b. Aerosol effects on UV trends may affect stratospheric ozone change: as current future scenario simulations of global UV levels are based on ozone recovery scenarios. In addition to this, the tendency for reduced anthropogenic aerosols in the atmosphere observed in the US and Europe during the last decade have to include not only AOD changes for characterizing possible aerosol trends, but also absorbing aerosol properties' changes. c. Solar irradiance satellite retrieval algorithms are directly affected by the presence of absorbing aerosols: The discrepancies between ground-based UV measurements and satellite-derived (OMI, TOMS) are directly related with aerosol absorption not accounted for in the satellite

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retrieval algorithms (e.g. Kazadzis et al., 2009). d. Commonly used atmospheric, radiative transfer applications and codes: as UV related radiative transfer algorithms suffer in precision due to large uncertainties in the input parameters of absorbing aerosol properties (e.g.:van Weele et al., 2000). "

2. As the reviewer indicates, figure 1 demonstrate per cent irradiance difference from the irradiance using SSA =1. Left and right panels were mixed and now they are corrected. A new figure caption has been added in figure 1:

"Per cent irradiance difference from the irradiance using SSA =1 as a function of AOD's for SZA's of 60o (left) and 30o (right)."

3. We tried to improve the English language with some additional editing of minor points in the new text.

4. Figure 4 was changed according to the reviewer's recommendation.

Specific comments

1. 1304: Suggestion included, abbreviation explained.

2. 1305: Corrected

3. 1305-20 corrected

4. The two references were separated. Krotkov reference is described with the following text: "In addition, Krotkov et al., 2005a has introduced a method based on the combination of co-located AERONET extinction measurements with Multi Filter Radiometer diffuse and global transmittances."

5. We agree that it cannot be stated that SSA retrieval in the UV is more or less difficult from the visible. They have both difficulties that come from different sources of errors. So the comparison of the retrievals among the two ranges has been removed from the text.

6. 1306 5-10. We agree with the reviewer that the major distinction of the two methods is the calibrations techniques that used to retrieve absolute or dimensionless quantities for the application of each method. The text was altered as follows:

“The main difference of these two approaches is that the GSI method requires accurate absolute radiation measurements (i.e. global irradiance) and the GDIR method requires dimensionless quantities (AOD, atmospheric transmittance). The two approached require quite different calibration techniques. Most important is that both methods require accurate AOD and surface albedo for their use as input parameters in the RTM.”

7. The text was changed as recommended to :

“However, there are only a few publications including results of the validation of such methods (Krotkov et al., 2009).“ Reference was added.

8. Text added as suggested: “Most important is that both methods require accurate AOD and surface albedo for their use as input parameters in the RTM.”

9. We agree that the GDIR method can be re-formulated to use only global transmittance. The text was altered see comment 6.

10. The text was altered according to reviewer’s comments:

“For example for exploring aerosol absorption trends in the UV, only few instruments around Europe could be used to achieve this goal. However, even most accurate measurements using the GSI method cannot provide accurate SSA retrievals (i.e. within 0.03) without accurate (i.e. within 0.01) AOD measurements.”

11. Sentence was re-formulated.

12. 1306 – 25. The text that has been added (see also comment 6):

“The main difference of these two approaches is that the GSI method requires accurate absolute radiation measurements (i.e. global irradiance) and the GDIR method requires dimensionless quantities (AOD, atmospheric transmittance). The two approached require quite different calibration techniques. Most important is that both methods require accurate AOD and surface albedo for their use as input parameters in the RTM."

13. Removed as suggested.

14. 1308-11: That was clarified. See general comment.

15.1308-18: That was clarified. See general comment.

16. 1308-19: Corrected

17. 1310 –figure 2 Text added in order to define wavelength ranges shown in figure 2:

"Results shown in figure 2 represent mean irradiance differences at 310-325 nm (UVB) and 325-350 nm (UVA)."

As for the FWHM: The comparison of all instruments to the Qasume instrument was performed by making synchronous measurements from 290nm up to 400nm (or up to the upper limit of each instrument) with 0.5 nm steps. Slit function of each instrument has been measured and the SHICRIVM algorithm was used in order a. to correct any possible wavelength shift s and b. to homogenize all spectra to a triangular 1nm FWHM slit output in order to avoid features related with the differences in the instruments slit functions.

18. Figure 4 X axis was changed using AOD values instead of station number as suggested. The phase function that has been used in the analysis was 0.72 and surface albedo of 0.03 at 340nm for all the calculations in this work. The previous sentence was included in the RTM description section.

19. Page 1311 - 19: To the section referring to AOD uncertainties a text was added as recommended by both reviewers:

"Calibrated sun-photometers can provide AOD measurements with an uncertainty of

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0.01 – 0.02 (Eck et al., 1999)."

20. The whole paragraph dealing with asymmetry parameter and ET has been changed to:

"Assymetry parameter, aerosol profile and extraterrestrial spectrum uncertainties: For the comparison of all spectroradiometers with the QASUME and the SSA retrieval we have used the same aerosol optical parameters for both instruments. So, the present methodology does not include information on the uncertainty included from such issues as their availability depend on the additional instrumentation of the individual UV monitoring site, that this methodology could be applied. For each site there is a need for a methodology to select appropriate values of spectral asymmetry factors that are representative of differing aerosol size distributions such as coarse mode desert dust or fine mode pollution or mixtures of the two. For example the presence of a sun-photometer (AERONET or other Network based), together with the UV irradiance spectroradiometer minimizes such uncertainties."

21. The whole section discussing possibilities of using the GSI method has been changed according to both reviewers' suggestions to:

"It has been mentioned that the calculation of the columnar (effective) SSA using the GSI or the GDIR method are at the moment the only existing methods for calculating this parameter in the UV region. It is clear that the method of Krotkov et al., 2005a which is based on direct-diffuse ratio, has a significant advantage over the technique of using total UV irradiance due to the uncertainty in the irradiance measurements resulting from the calibration uncertainty. However, we decided to analyze the possibilities to use the GSI method because of the large number of UV monitoring station that have been performing global UV measurements from the start of the 90's. On the contrary only very few stations (starting also after the year 2000) are equipped with the instruments that the GDIR method can be applied. So, only results from the GSI method can be used in order to investigate possible long term SSA changes in a number of locations worldwide, when UV irradiance measurements are accompanied by accurate AOD measurements. Such changes can enlarge or diminish the effects of AOD changes in UV radiative forcing."

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 1303, 2010.