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Comment

## ***Interactive comment on “Aerosol Single Scattering Albedo retrieval in the UV range: an application to OMI satellite validation” by I. Ialongo et al.***

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The authors would express thanks to the Referee #2 for positive and constructive comments.

REFeree “Comment 1: There is an important issue that has to be clarified and has to do with the spectral measurement accuracy and the sensitivity of the methodology used to derive the SSA. More specific: a. Based on the fact that the overall accuracy of the UV spectral measurements are in the order of 5% an estimation on the uncertainties for SSA calculations can be reported together with ones of AAOD.”

AUTHORS Page 19017 Line 1: The following sentence will be included: “According to the results provided by Bais et al. (2005), the uncertainties on SSA retrievals derived

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by global UV irradiances with overall accuracy (derived from the calibration) in the order of 5%, can vary from  $\pm 0.05$  (for high AOD and SZA values) to  $\pm 0.15$  (for low AOD and SZA values) due to the sensitivity of this methodology.”

R “b. Please clarify if different points in single hourly UV measurements (spectral scans in figure 1) are calculated using the 1% model/measurement accuracy matching or the 5% measurement uncertainty in combination with the model matching.”

A P 19017 L 4: The following sentence “Two examples of the retrieved results are shown in Fig. 1 for two cloud-free days with different aerosol load.” will be replaced with: “The SSA daily evolution obtained by comparing global irradiance measurements with model calculations is shown in figure 1. The different points in single hourly SSA retrieval are calculated using the 1% model/measurement accuracy matching. Two examples of the retrieved results are given for two cloud-free days with different aerosol load.”

R “c. It has to be clarified if the error bars in figures 2a and 2b refer to the standard deviation of the monthly means or to the uncertainty in the calculation of SSA and AAOD values. It would be useful if this uncertainty (based on mean AOD and SZA for each month) can be added as dashed lines in these figures.

A P 19017 L14: The following statement will replace the old one in the revised manuscript “Figure 2 shows the variability within each month and between different months of SSA (upper panel) and AAOD (lower panel), derived from Brewer global UV irradiance measurements for the period January 2005–June 2008. The error bars refer to one standard deviation of the monthly means.”

It will be included in the caption of fig2a and 2b that the error bars refer to one standard deviation of the monthly means as follows: “Monthly mean SSA (top) and AAOD (bottom) at 320.1nm during the period January 2005–May 2008 with one standard deviation bars.” We did not include the uncertainty values in figures to avoid overlapping lines. We discuss in the revised manuscript the uncertainties in the SSA and AAOD

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calculation in Figure 1.

R d. It has be mentioned that the annual pattern of AAOD (figure 3) is within the limits of the 0.02-0.026 uncertainty that is reported.”

A P19017 L21 The following sentence will be included in the manuscript: “The annual pattern of AAOD (figure 2) is included within the limits of the 0.02-0.026 uncertainty that is reported.”

R “My opinion is that it has to be mentioned in the text that the uncertainty of the SSA retrieval using the global UV irradiance measurements is quite large due to the sensitivity of this method. For example the difference of 9% between the two last Qasume visits at Rome (from -6% (2006) to +3% (2008)) can lead to a difference in the order of 0.15 in the calculated SSA, which is more or less outside any required limits for scientific use of this parameter.”

A P19016 L25: The following sentence will be added in the revised text: “Since global UV irradiance is not very sensitive to changes in SSA, the uncertainty of the SSA retrieval from global UV irradiance measurements can be quite large (from 0.05 to 0.15).”

R “In addition, the +3% difference of Rome instrument with Qasume (2008 report) can lead to a systematic overestimation of SSA that will slightly affect also the OMI comparison results.

A P 19020 L 19: As suggested, the following sentence will be included in the text: “The +3% difference of Rome instrument with Qasume spectroradiometer, observed in 2008, can lead to a systematic overestimation of SSA that can slightly affect also the OMI comparison results.”

R: Also, some very brief description of the cosine correction procedure has to be added.”

A P19013 L. 25: The following sentence “The instrument angular response was esti-

mated during Qasume's visit in 2003 showing that UV irradiances are underestimated on average by 9%" will be replaced in the revised manuscript by: "In this study all UV irradiances were corrected for temperature and cosine effects. The methodology for the temperature correction is described in Siani et al. (2003). The cosine correction was carried out following the methodology described by Groebner et al. (1996) and Bais et al. (1998). It was based on the angular response, the correction factor for the diffuse component and the ratio between the direct and global UV irradiance. The angular response was determined during Qasume's visit in 2003, showing that UV irradiances were underestimated on average by 9%. To estimate the cosine correction factor, the direct irradiance was modeled using the STAR model (Ruggaber, et al., 1994; Schwander et al., 1997) with Rome input settings (Meloni et al., 2000), 50 D.U. (Dobson Units) total ozone steps and SZA ranging between 0° and 90° at 1° steps (Ialongo, 2008). The last comparison with Qasume spectroradiometer in 2008 has shown that, after using cosine and temperature corrected irradiances, the mean ratio Brewer to Qasume is around +3% (Hulsen, 2008)."

The following references will be included:

-Bais, A. F., Kazadzis, S., Balis, D., Zerefos, C., and Blumthaler, M.: Correcting global solar ultraviolet spectra recorded by a Brewer spectroradiometer for its angular response error, *Appl. Opt.*, 37, 6339–6344, 1998."

-Gröbner, J., Blumthaler M. and Ambach W.: Experimental investigation of spectral global irradiance measurement error due to a non ideal cosine response, *Geophys. Res. Lett.* 23(18), 2493-2496, 1996.

-Hulsen, G.: Report on "Protocol of the intercomparison at the University of Rome La Sapienza, Italy on June 03 to 06, 2008 with the traveling reference spectroradiometer Qasume from PMOD/WRC, 2008.

-Ialongo, I. Surface UV radiation, total ozone and aerosol monitoring by means of satellite and ground-based instruments at Rome, Phd Thesis, Sapienza University of Rome,

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2008.

-Meloni, D., Casale, G. R., Siani, A. M., Palmieri, S. and Cappellani, F.: Solar UV dose patterns in Italy. Photochem. Photobiol. 71(6): 681–690,2000.

-Ruggaber, A., Dlugi, R. & Nakajima, T. :Modelling radiation quantities and photolysis frequencies in the troposphere., J. Atmos. Chem. 18: 171–210, 1994.

-Schwander, H., Koepke, P. & Ruggaber, A.: Uncertainties in modelled UV irradiances due to limited accuracy and availability of input data. J. Geophys. Res. 102: 9419–9429, 1997.

-Siani, A.M., G. Benevento, G. R. Casale: Temperature dependence of Brewer UV measurements at Rome station, Proc. The International Symposium on Optical Science and Technology, Ultraviolet Ground and Space based measurements, models and effects III, 5156, 355-366, 2003.

R “Comment 2 Some additional comments on the conclusion section regarding EDR remaining OMI/ground based differences after the correction: In addition to what is mentioned there can be deviations related with the total ozone differences as derived from the Brewer and OMI and also the fact that the calculated slopes for SSA at 324nm using AOD at 320nm can be a bit different due to the enhanced absorption and larger AOD at lower UVB wavelengths. Also, due to the fact that EDR calculated from the single Brewer uses an approach (modeling ?) for including UVA irradiance contribution to the calculated EDR.”

A P 19022 L 4: The following sentences will be added to the conclusions: “Further reasons regarding the remaining differences in EDR could result from the differences between OMI and ground-based total ozone amounts and to the fact that the calculated slopes for SSA at 324 nm using AOD at 320 nm could be slightly different due to the enhanced absorption and larger AOD at lower UVB wavelengths. Additional uncertainties can be due to the fact that in EDR the non-measured part of UV-A band

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(wavelength longer 325nm) are estimated applying weighting coefficients to the irradiance at 324 nm (Fioletov et al., 2004). In addition the effect of gas absorption like NO<sub>2</sub>, not included in the correction, can be another possible reason of OMI overestimation mainly in urban locations (Arola et al., 2009)."

-Fioletov, V. E., M. G. Kimlin, N. Krotkov, L. J. B. McArthur, J. B. Kerr, D. I. Wardle, J. R. Herman, R. Meltzer, T. W. Mathews, and J. Kaurola (2004), UV index climatology over the United States and Canada from ground-based and satellite estimates, *J. Geophys. Res.*, 109, D22308, doi:10.1029/2004JD004820.

-Arola, A., Kazadzis S., Lindfors, A., Krotkov, N., Kujanpää, J., Tamminen, J., Bais, A., di Sarra, A., Villaplana, J. M., Brogniez, C., Siani, A. M., Janouch, M., Weihs, P., Webb, A., Koskela, T., Kouremeti, N., Meloni, D., Buchard, V., Auriol, F., Ialongo, I., Staneck, M., Simic, S., Smedley, A. and Kinne, S.: A new approach to correct for absorbing aerosols in OMI UV, *Geophys. Res. Lett.*, 36, doi:10.1029/2009GL041137, 2009.

R "Comment 3 Part of the above can be confirmed from figures 5 and 6. UV irradiance at 324nm OMI/Brewer comparison seems like showing a solar zenith angle dependence and EDR comparison seem to include an additional shift. Is there any explanation about this solar zenith angle dependence? Could it be a wintertime AAOD underestimation?"

A P 19021 L22: The following sentence will be included in the manuscript, also according to the comment of the referee #1: "The lowest average value of the bias was obtained with method 3, which can be recommended as the proper correction approach. On the other hand, method 2 produced better results at higher SZAs where the effect of the absorbing aerosols may lead to higher UV attenuation due to the increased optical path of the solar photon through the aerosol layer."

Interactive comment on *Atmos. Chem. Phys. Discuss.*, 9, 19009, 2009.

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