

Interactive comment on “A case study on biomass burning aerosols: effects on solar UV irradiance, retrieval of aerosol single scattering albedo” by A. Bagheri et al.

A. Bagheri et al.

Received and published: 14 November 2008

We would like to thank referee 1 for the positive remarks and constructive comments and suggestions, which are highly appreciated and will be taken into account upon manuscript revision. Responses to individual comments are given below.

General comments: Validity of the measurements and uncertainties associated with the measurement instruments Response: In section 3.2.1 of our discussion paper we described an error analysis which is based on the model sensitivity and the assumption that DDR would be independent of the instruments error. We have realized that this is not the case for our DDR method when we employed two different instruments for measuring DDR. Therefore, the errors in the measured DDR have to be taken into

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

account.

The discussion on changing AOD conditions during the short periode in April-May is based on relative comparison from day to day, ratios, for two different instrument. A systematic error will be reduced when discussion relative comparisons, and due to the short periode studied temporary errors from day to day would be small for each instrument. According to the theory of error propagation, the results would be independent of the calibration procedure and the errors associated with the measurement systems. Therefore the uncertainty in the observed effect could be assumed very small in the order of less than 0.1%.

Moreover, taking into account the measurement uncertainty and ozone effects, one could associate uncertainty to the absolute values of the retrieved omega's. The calculated uncertainties in omega's are given in figure 3, these values are based on uncertainties in the model parameters. Based on estimated uncertainties in the measuring instrument and calculated AOD, the total highest delta-omega (see response to specific comment 1), would become about 20% at 305 nm on 9th of May 2006, all other omega's would have lower uncertainties.

On the other hand, looking only at the relative changes in omega's, the extracted information would be independent of the measurement errors, the errors would be canceled in the relative changes. Therefore, the information from the relative changes would be reliable and they might be interpreted as statistical significant.

As a result of the above discussion, we would suggest to rewrite the section 3.2.1 as follow;

In order to account for the uncertainties in calculated DDR, a sensitivity study was performed on the critical input parameters. The sensitivity study showed that retrieved ω 's are much more sensitive to changes in Ångström parameter α than changes in the asymmetry factor or ground albedo (data not shown). Assuming an uncertainty of 5% in α , 7% in asymmetry factor, and 30% for ground albedo, we investigated the effect of

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



errors in α , asymmetry factor, and ground albedo on the retrieved ω for each channel. To justify the choice of these uncertainties the following arguments are used, i) even though we know that the uncertainty in α has a wavelength dependence, for simplicity an average value was used, ii) this value is the maximum change which the model is able to produce realistic values for ω .

In addition, global and direct irradiances were measured with two different measurement systems and the uncertainties in each measurement system have to be taken into account. By accounting for the uncertainties in the global and direct irradiance, one could find a total uncertainty for the measured DDR. Based on the estimated uncertainties in the calculated and measured DDR, the total and highest relative uncertainty in ω at 305 nm for 9th of May 2006 would be about $\pm 20\%$. Table x shows the calculated ω s with their relative uncertainties for 24th of April and 9th of May 2006.

Comment: Table x will be prepared for the revised version, and figure 3 would be revised as well.

Specific comment 1 Referee: 17990 What is the uncertainty in the data from each instrument? Include the reduction of GUV data to a single 1 nm FWHM line, as presumably this was used in the retrieval of the SSA (for the DDR).

Response: The first thing to say is that the GUV s/number 9274 and the Bentham spectroradiometer operating in Trondheim are two independent measurement systems, with different traceability to calibrations and different orientation to the sky. The GUV was measuring horizontal irradiance, using calibration factors based on the International intercomparison of multiband filter radiometers in 2005 (ref. Johnsen et al. 2008) and corrections for the relative change in responsivity in the period 2005 to 2006. While, the Bentham spectrometer was measuring direct irradiance with a telescope having a 1.5 degree field of view. The spectrometer was calibrated against a 1000W standard lamp traceable back to NIST. Even though the major error source in spectral measurements are the calibration and one can explicitly find a total uncertainty for the instrument. But,

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

in the UV community, It is common to compare the instrument with other similar instruments which would give a rough estimated of the total uncertainty in the data for the instrument.

Uncertainties in the data of GUV:

The uncertainty in spectral irradiance of GUV radiometer, corresponding to 1 nm bandwidth (FWHM) has three components:

1. Uncertainty in the correction for drift in absolute responsivity from 2005 to 2006, based on annual intercomparisons with a travelling reference GUV. This uncertainty is estimated to $\pm 1\%$ for the UVA detector channels (channel 3 to 5) and $\pm 3\%$ for the UVB channels (channels 1 and 2) (1-sigma).
2. Uncertainty in the reference data of the International intercomparison, on which the GUV calibrations are traceable to. This uncertainty is estimated to $\pm 3\%$ absolute and $\pm 2\%$ random (1-sigma).
3. The uncertainty resulting from the conversion of broad band measurements (10 nm FWHM) to 1.0 nm bandwidths. Results from the International intercomparison showed ratios of GUV and spectroradiometer measurements that were flat within $\pm 1\%$ and $\pm 3\%$ for a wide range of solar zenith angles and weather conditions (see Figure 1 in Johnsen et al. 2008). Applying root mean square, the total uncertainty in GUV measurements is estimated to $\pm 6\%$ (UVB) and $\pm 4\%$ (UVA) at 1-sigma level.

Uncertainties in the Bentham spectrometer:

Based on international intercomparison (see ref. Johnsen et al. 2008, figure 1), where our spectrometer from NTNU is marked as NTN150, the total uncertainty in the measured direct irradiance could be estimated to $\pm 10\%$.

Specific comment 2 Referee: 17991 GUV calibration in 2005, how stable is it? Has it been compared to anything since (eg the Bentham?). The channels can change independently, giving different results in the retrievals for different wavelengths.

Response: The validation of long term stability of GUV 9274 is based on intercomparison with a travelling standard GUV radiometer (GUV s/number 9273), performed for several days each early summer since 1995. The drift in the travelling standard is determined 3-4 times a year with stable quartz tungsten halogen lamps at NRPA and once a year by the manufacturer Biospherical Instruments Inc., San Diego. Results for the annual intercomparison of GUV 9274 and travelling reference for the period 1995-2008 are depicted in a figure (we can attached the figure as supplementary material if needed). The figure shows that the drift is different for the respective detector channels. Although the intercomparison is performed only once a year, and not during the period of biomass burning, the general smoothness of ratios indicates linear changes between two calibration periods for this instrument. The uncertainty in estimation of drift is largest for the two UVB channels of about 3-4% at maximum.

Specific comment 3 Referee: 17991 I assume the GUV data was one-minute averaged and the nearest minute average to the spectral data was selected (see technical corrections) 8211; if not the sentence should be changed further.

Response: Yes, the data from GUV are one minute averaged and we selected spectral data when they were recorded at nearest minute to GUV data.

Specific comment 4 Referee: 17992 Please give (brief) details of AOD retrieval, and the uncertainty in the results.

Response: We will consider this suggestion and provide the reference which the AOD calculation and uncertainties are based on. AOD and delta-AOD are calculated according to the procedure described by (Franco et al. 1997). Assuming $\pm 10\%$, $\pm 2\%$, and $\pm 10\%$ uncertainty to measured direct irradiance, extraterrestrial irradiance, and ozone amount respectively, the total highest uncertainty in AOD at 305 nm for SZA of 50 degree on 9th of May 2006 would be $\pm 14\%$.

Specific comment 5 Referee: 17993 AOD refers to the integrated columnar aerosol load in the same way that we refer to columnar ozone amount. It is not a function

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

of SZA (though the SZA must be known to derive it). What is meant by the closest average SZA for both days? Do you mean matching SZA because the direct scans were taken at regular (clock) time intervals?

Response: Yes, we mean measured direct irradiance at the same SZA (closest SZA) for both days. In order to simulate the direct irradiance for both days (24th of April and 9th of May), we have to choose a specific SZA. In addition, we have to define Ångström parameters for specific day. Ångström parameters are calculated according to the measured AOD for that day. Our measured data for 24th of April start at 11:37 (corresponding to SZA of 50.8 degree), while the direct measurement for 9th of May start at 13:00 (corresponding to SZA of 49.55). This is the reason for that we have also specified our data to be at SZA of 50 ± 0.5 degree, and in the model specification we use SZA=50 degree.

Specific comment 6 Referee: 17994 The DDR method is only independent of calibration if the same instrument is used to measure both parameters. In this case two different instruments (and calibrations) have been employed so the statement is false (see also comment on GUV calibration). What is the agreement between the Bentham and the GUV when both measuring global irradiance at the GUV wavelengths? This will give an indication of the uncertainty involved in using the two systems for the DDR.

Response: Thanks for pointing out incorrect statement, the DDR method employed in this study is not independent of calibration. The uncertainties associated with our method are explained in response to general comments. Therefore, we will remove the line 12-15 on page 17994 ("The DDR is independent of calibration constants and in particular of the extraterrestrial solar spectrum (Halthore et al., 2004). Thus, the DDR is the most appropriate quantity to be compared with radiative transfer simulations.").

Specific comment 7 Referee: 17995, 11 Why are the shorter wavelengths not mentioned?

Response: We will consider this suggestion and correct the sentence, the new sen-

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

tence will become: "one would expecting increase in the surface irradiance for $\lambda < 350$ nm at the same SZA".

Specific comment 8 Referee: 17995, 20 replace 'very good' by 'within x

Response: We will consider this suggestion and correct the sentence, for the value of x%, see response to general comments and specific comment 1.

Specific comment 9 Referee: 17995, 27 Why is a wavelength of 319 nm used for diffuse radiation when 320 nm is used for global? the curves are smooth, I doubt there is a significant difference between 319 and 320 nm. On page 17996 the phrase 'about 319 nm' is then used. For simplicity I suggest using 320 nm for both global and diffuse.

Response: We will consider this suggestion and replace 319 nm with 320 nm for both global and diffuse.

Specific comment 10 Referee: 17996, Point vi) is a general statement and well known. If you mean the aerosol induced effect on the direct and diffuse, then say so. Otherwise delete the point.

Response: The sentence will be removed in the revised version.

Specific comment 11 Referee: 17996, 12 and also (probably) aerosols with different properties.

Response: We are not sure about what exactly the suggestion is, Kylling et al. (1998) is an study about different aerosol types with respect to smoke aerosols and we could remove the refrence, but we assume that the case studied by Kalashnikova et al. (2007) is the same as this study and it is about the biomass burning aerosols.

Specific comment 12 Referee: 17996, 24 / Figure 3 I do not think the SSAs are significantly different, except at 305 and 380 nm, thus the generalized statement is incorrect, and you need to show (earlier comment) that this is not a feature of the measurements used in the retrieval.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

Response: See response to general comments.

Specific comment 13 Referee: 17997 What is the measurement uncertainty? How do the measurement uncertainties influence the retrieved SSA?

Response: In the response to general comments and specific comment 1, we described the measurement uncertainties. Here we will respond to the second part of the question and explain how the measurement uncertainties influence the retrieved SSA.

The relation which retrieving SSA is based on could be described as; $DDR(\text{meas}) - DDR(\text{model}) \leq 0.05$, Where $DDR(\text{model})$ is calculated DDR through the simulation and is a function of SSA and AOD and asymmetry factor (see ref. Kudo et al. 2008, eq. 1 and 2), And $DDR(\text{meas})$ is the measured DDR . Based on this relation the total relative uncertainty in SSA could be described as;

$$(\Delta\omega)^2 = [\Delta DDR(\text{meas})]^2 + [\Delta DDR(\text{model})]^2 + (0.05)^2,$$

Where $\Delta DDR(\text{model})$ could be estimated based on the sensitivity analysis and is directly related to the ΔAOD or $\Delta\alpha$, And $\Delta DDR(\text{meas})$ could be estimated from the uncertainties in the measuring instruments for global and direct irradiances (If the measurement were performed with the same instrument, this term would have been nearly null and negligible). Furthermore, $DDR(\text{meas})$ could be described as;

$$DDR(\text{meas}) = (I(G) - I(D)) / I(D).$$

From the above relation $[\Delta DDR(\text{meas})]^2$ could be calculated in terms of $\Delta I(G)$ and $\Delta I(D)$, it follows as;

$$[\Delta DDR(\text{meas})]^2 = \Delta [I(G) + \Delta I(D)]^2 + \Delta I(D)^2, [\Delta DDR(\text{meas})]^2 = [\Delta I(G)]^2 + 2[\Delta I(D)]^2.$$

Assuming $\pm 6\%$ and $\pm 10\%$ uncertainties for global and direct irradiances (see specific comment 1), the uncertainty in the measured DDR due to using two different measuring systems would be about $\pm 15\%$ at 305 nm.

Including the uncertainty in the calculated DDR based on ΔAOD and the imposed error

[Full Screen / Esc](#)
[Printer-friendly Version](#)
[Interactive Discussion](#)
[Discussion Paper](#)


in the calculation (limit of 0.05) , the total uncertainty for SSA at 305 nm would become about $\pm 20\%$. Based on the above discussion, we would provide a table showing all the calculated SSA's with their uncertainties and the relative changes.

Specific comment 14 Referee: 17997 Query the validity of a comparison with different wavelengths, UV vs. VIS / IR.

Response: We are not sure what the question is?

Technical corrections:

Technical correction 1 Referee: 17998,4 observed as far away as the Arctic.

Response: Based on the comments from Patrick Espy, as far as the Arctic is correct.

Technical correction 2 Referee: 17998,5,7 State what data is simulated. It is then odd to say the simulated data were used to assess the effect on surface UV when you have surface UV measurements.

Response: Yes, we will consider this suggestion and rephrase the statement in the revised version.

Technical correction 3 Referee: 17998, 10 wavelengths

Response: Will be changed to wavelengths

Technical correction 4 Referee: 17998, 15 and how do these values compare? A brief statement would give continuity from the previous sentence for those not familiar with background SSA for Trondheim.

Response: Here, we are not sure, the comments are specified for line 15, but it seems that they are about line 5. We assume that referee means line 5 and respond to that would be as follow. Yes, we will consider this suggestion and rephrase the statement in the revised version. The calculated omega's for both days with total relative erros and relative changes will be given in a table.

Technical correction 5 Referee: 17989, 15 affect (not effect)

Response: Will be changed to affect

References

[Johnsen et al. 2008] Johnsen, B., B. Kjeldstad, T. N. Aalerud, L. T. Nilsen, J. Schreder, M. Blumthaler, G. Bernhard, C. Topaloglou, O. Meinander, A. Bagheri, J. R. Slusser and J. Davis, Intercomparison and harmonization of UV Index measurements from multi-band filter radiometers, *J. Geophys. Res.*, 113, D15206, doi:10.1029/2007JD009731), 2008

[Franco et al. 1997] Franco Marengo, Vincenzo Santacesaria, Alkiviadis F. Bais, Dimitris Balis, Alcide di Sarra, Alexandros Papayannis, and Christos Zerefos, Optical properties of tropospheric aerosols determined by lidar and spectrophotometric measurements (Photochemical Activity and Solar Ultraviolet Radiation campaign) *APPLIED OPTICS* , Vol. 36, No. 27, 1997.

[Kudo et al. 2008] Rei Kudo, Akihiro Uchiyama, Akihiro Yamazaki, Eriko Kobayashi, and Tomoaki Nishizawa Retrieval of aerosol single-scattering properties from diffuse and direct irradiances: Numerical studies *JOURNAL OF GEOPHYSICAL RESEARCH*, VOL. 113, D09204, doi:10.1029/2007JD009239, 2008

Interactive comment on *Atmos. Chem. Phys. Discuss.*, 8, 17987, 2008.

ACPD

8, S9088–S9097, 2008

Interactive
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

