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Aerosol Single Scattering Albedo retrieval in the UV range: an application to OMI satellite validation

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Abstract

The aerosol Single Scattering Albedo (SSA) and Absorbing Aerosol Optical Depth (AAOD) at 320.1 nm are derived at Rome site by the comparison between Brewer and modelled spectra. The UVSPEC radiative transfer model is used to calculate the UV irradiances for different SSA values, taking into account as input data total ozone and Aerosol Optical Depth (AOD) obtained from Brewer spectral measurements. The accuracy in determining SSA depends on the aerosol amount and on Solar Zenith Angle (SZA) value: SSA uncertainty increases when AOD and SZA decrease. The monthly mean values of SSA and AAOD during the period January 2005–June 2008 are analysed, showing a monthly and seasonal variability. It is found that the SSA and AAOD averages are 0.80±0.08 and 0.056±0.028, respectively.

AAOD retrievals are also used to quantify the error in the Ozone Monitoring Instrument (OMI) surface UV products due to absorbing aerosols, not included in the current OMI UV algorithm. OMI and Brewer UV irradiances at 324.1 nm and Erythemal Dose Rates (EDRs) under clear sky conditions, are compared as a function of AAOD. Three methods are considered to investigate on the applicability of an absorbing aerosol correction on OMI UV data at Rome site. Depending on the correction methodology, the bias value decreases from 18% to 2% for spectral irradiance at 324.1 nm and from 25% to 8% for EDR.

1 Introduction

The amount of solar UV radiation reaching the Earth's surface depends on the solar extraterrastrial radiation and transmission properties of the atmosphere. Solar zenith angle, clouds, ozone, aerosols and surface albedo are the predominant factors that interact with UV radiation determining its variability at the surface (Kerr, 2003). While the relationship between total ozone and UV irradiance is well established, based on observations and theory (McKenzie et al., 1999; Zerefos et al., 1995), the role of the above factors are still under study (WMO, 2007). Aerosols play an important role in radiative budget of atmosphere with both direct and indirect effects, by absorbing and scattering the incoming solar radiation (Mallet et al., 2005; Chou et al., 2006) and modifying cloud properties acting as cloud condensation nuclei (Charlson et al., 1992; Schwartz et al., 1996). Atmospheric aerosols can influence UV radiation masking the increase of UV irradiance due to the stratospheric ozone depletion (Meleti and Cappellani, 2000; WMO, 2007).

Aerosol effects on the UV irradiance have been studied by several authors, using both observations and radiative transfer model calculations (Kerr, 1997; Krzyscin and Pulchalski, 1998; Meloni et al., 2003). Nevertheless, the influence of the aerosols has not been fully understood due to their high spatial and temporal variability (Schwartz et al., 1995; Madronich et al., 1998; WMO, 2007). Radiative transfer models can provide the UV irradiance at the Earth's surface under cloud-free conditions with an uncertainty lower than 10% (Forster et al., 1995; Mayer et al., 1997). Thus, radiative transfer model calculations offers an useful alternative to ground-based and satellite data to estimate surface UV irradiance and aerosol optical properties.

The retrieval of the optical parameters is an important issue of the atmospheric research community (Cheymol et al., 2009). Reuder and Schwander (1999) found that the Single Scattering Albedo, SSA (i.e. the ratio of scattering coefficient to total extinction coefficient), is one of the most important parameter in determining the aerosol effect on UV radiation. The co-albedo, defined as (1-SSA), indicates the fraction of energy absorbed by the aerosols. The Absorbing Aerosol Optical Depth (AAOD) can be derived as the product between the co-albedo and the Aerosol Optical Depth (AOD).

Several methodologies to determine SSA were developed using global irradiances, (Kylling et al., 1998; Kazantzidis et al., 2001). Petters et al. (2003) provided estimates of SSA using measurements of global and diffuse irradiance from an UV multifilter rotating shadowband radiometer and model calculations. Bais et al. (2005) determined the SSA combining the model calculations with measurements of spectral UV irradiances and the AOD by means of Brewer spectrophotometer.

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The knowledge of SSA can contribute to the reduction of errors in satellite estimation of surface UV irradiance (Krotkov et al., 1998, 2005; Arola et al., 2005; Kazadzis et al., 2009). Since the network of ground-based UV measurements will inevitably remain sparse, satellite-based UV methods offer a complementary approach to better document the geographical distribution of surface UV irradiance. Surface UV products based on Ozone Monitoring Instrument (OMI) satellite data have been used to monitor the surface UV radiation levels (Levelt et al., 2006; Tanskanen et al., 2006). Nevertheless, the validation of satellite-derived UV products using ground-based measurements is an essential task in order to assess the accuracy of the satellite products. As suggested in several validation studies (Fioletov et al., 2002; Arola et al., 2005; Ialongo et al., 2008; Kazadzis et al., 2009) the overall TOMS or OMI overestimation of surface UV radiation quantities and hence the observed positive bias, could be attributed to the aerosol absorption mainly in urban boundary layer (Tanskanen et al., 2006; Krotkov et al., 2005). Kazadzis et al. (2009) proposed several correction methodologies for OMI UV products in order to account for the role of absorbing aerosols.

In this work, the aerosol UV scattering and absorption properties derived at Rome site during the period 2005–2008 using a methodology described by Bais et al. (2005), are analysed. The Single Scattering Albedo and Absorbing Aerosol Optical Depth values are derived at 320.1 nm by the comparison between Brewer and modelled global irradiances, using ozone amounts and retrieved AOD as input data. The AAOD values are used to determine the aerosol absorption correction to be applied on the OMI UV products (spectral and erythemally weighted irradiances) at Rome site.

2 Dataset

2.1 Ground-based datasets

The Solar Radiometry Observatory of Sapienza University of Rome (41.9^{o} N, 12.5^{o} E, 75 m a.s.l.) is located on the roof of the building of Physics Department within the University Campus, in the city centre which is a very populated area, strongly influenced by anthropogenic activity (Meloni et al., 2000). Brewer #067, operational since 1992, is a Mark IV spectrophotometer with a single-monochromator and it performs scans in the spectral range from 290 to 325 nm with a stepwidth of 0.5 nm and a Full band Width at Half Maximum (FWHM) of 0.63 nm (Casale et al., 2000).

Erythemal Dose Rates (EDR) are obtained by weighting surface spectral UV irradiances with the erythemal action spectrum (CIE, 1987) and by integrating over the wavelength range 290–400 nm. A correction is made to the erythemal action spectrum to include irradiances of 325–400 nm band. The retrieval of Aerosol Optical Depth (AOD) from Brewer spectrophotometer was performed using the Langley plot method as described in Sellitto et al. (2006). AODs at 320.1 nm were retrieved during cloudless days from January 2005 to June 2008. Clear sky days were derived (see Modesti, 2008) from the Cloud Modification Factor, CMF (i.e. the ratio between radiative transfer model calculations under clear sky conditions and actual irradiances provided by the solar radiometer measurements); days with CMF>0.95 were selected as clear sky days.

Periodic checks and tests (monthly, weekly and daily) are carried out in order to guarantee the accuracy and quality of the observations. Brewer #067 is regularly calibrated by comparison with a travelling reference Brewer by the International Ozone Service (IOS) Inc. Furthermore, the spectrophotometer is intercompared every two years with the travelling standard QASUME spectroradiometer (Gröbner et al., 2005) maintained at the PMOD/WRC (Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center, see http://www.pmodwrc.ch/euvc/euvc.html). The instrument angular response was estimated during QASUME's visit in 2003 showing that UV irradiances are underestimated on average by 9%. In this study, all UV spectral irradiances were corrected for cosine and temperature effects.

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2.2 OMI UV products

Ozone Monitoring Instrument (OMI) onboard the NASA EOS Aura space-craft (on flight from 14 July 2004), is a nadir viewing spectrometer that measures solar reflected and backscattered light in the spectral range from 270 nm to 500 nm with an average spectral resolution of 0.5 nm. The Aura satellite describes a sun-synchronous polar orbit, crossing the equator at 13:45 local time. The width of the instrument's viewing swath (consisting of 60 individual pixels) is 2600 km and it is large enough to provide global daily coverage with a spatial resolution at nadir of 13×24 km. OMI products consist in ozone columns, aerosols, clouds, surface UV irradiance and trace gases (NO_2, SO_2, HCHO, BrO, and OClO) (Levelt et al., 2006).

OMI surface UV retrievals are determined by means of an extension of the TOMS UV algorithm developed by NASA Goddard Space Flight Center (GSFC) (Herman et al., 1999; Krotkov et al., 1998, 2002; Tanskanen et al., 2006). Firstly, the algorithm estimates the surface irradiance under clear-sky conditions (E_{clear}) using as input OMI-derived total ozone and climatological surface albedo (Tanskanen, 2004). Afterwards the clear sky irradiance is adjusted by a satellite derived cloud/non absorbing aerosol transmittance factor C_T in order to determine actual surface irradiance (E_{cloud}) as follows:

$$E_{\text{cloud}}=E_{\text{clear}}\cdot C_T. \tag{1}$$

Krotkov et al. (1998) described in details the model and the assumptions used in the determination of clear-sky irradiances. They concluded that in absence of clouds, aerosols, and snow cover, the satellite estimates of the surface UV can have accuracies comparable to the ground-based measurements.

The current OMI surface UV algorithm does not include absorbing aerosols, therefore OMI UV data are expected to show an overestimation for regions affected by absorbing aerosols (for example urban site). Moreover, since these aerosols also attenuate the outgoing shortwave radiation, the UV algorithm further increases the error, causing an overestimation of UV irradiance, especially in the summertime (Arola et al., 2005; Tanskanen et al., 2007).

The OMI UV collection 3 of EDR and spectral irradiances at 324.1 nm at local solar noon and at overpass time were analysed in this work.

2.3 Radiative transfer modelling

The UVSPEC model (Mayer et al., 1997; Mayer and Kylling, 2005) from the LibRadTran package version 1.2 was used to determine the global spectral UV irradiances at different SSA values ranging from 0.60 to 0.99, with a step of 0.01. UVSPEC solves the radiative-transfer equation using the pseudo-spherical discrete ordinates algorithm (Stamnes et al., 1988) running with 16 streams. Irradiance spectra were calculated at 0.1 nm steps and then they were convoluted with the slit function of the Brewer #067 with FWHM=0.63 nm.

The atmospheric composition used in the model is based on Brewer measured parameters (total ozone, AOD at 320.1 nm) and their standard profiles. The AFGL (Air Force Geophysics Laboratory) mid-latitude profiles were used for ozone, temperature and air pressure (Anderson et al., 1986). Ozone profiles were rescaled to match the ozone column measured at Rome. The aerosol vertical distribution provided by the Elterman (1968) profile was scaled to match the measured optical depth at 320.1 nm. An asymmetry parameter of 0.7 at 320 nm was assumed to be constant with altitude for all days selected for this work (Bais et al., 2005). According to Tanskanen (2004), a climatological surface albedo of 0.05 was used and assumed constant in the entire UV spectral region.

The high-resolution ATLAS 3 extraterrestrial solar spectrum was used in the model calculations with a wavelength step of 0.05 nm. Sun-Earth distance correction (Spencer et al., 1971) was applied to the extraterrestrial spectrum.

3 Single Scattering Albedo retrieval

The Single Scattering Albedo (SSA) represents a key parameter in describing the aerosol optical properties. The SSA describes the portion of solar radiation scattered from the main beam passing through the atmosphere. The SSA influences the diffuse radiation, while its effect on direct radiation can be considered negligible. Theoretically, SSA values can vary between 0 (totally absorbing aerosol) and 1 (totally scattering aerosol). Actual SSA values are ranging from 0.5 to 1.0 in the visible and UV wavelengths.

Model calculations can be used for retrieving SSA when global or diffuse spectral irradiance, Solar Zenith Angle (SZA), total ozone and AOD are known. The accuracy of the retrieved SSA depends on the sensitivity of the radiation quantities to the SSA variations, but it is also affected by the measurements' accuracy and the detection limit of the instruments at low-intensity conditions (i.e. large SZAs, small wavelengths, high-AOD). Bais et al. (2005) described a method for deriving SSA values combining model calculations and Brewer spectral irradiance measurements.

In the present work, this methodology was applied to determine the SSA from Brewer irradiances at 320.1 nm during clear sky days from 2005 to 2008 at Rome site. The Brewer global irradiances at 320.1 nm were compared with UVSPEC modeled irradiances taking into account SZA and the AOD at 320.1 nm, derived from Brewer measurements each 30 min during the day. The daily mean total ozone column data provided by Brewer direct sun measurements were included also as input in the model.

The SSA value for which the modeled and measured irradiances agree to better than 1%, can be determined. Depending on the sensitivity of the global irradiance to SSA variations, many SSA values could satisfy such condition. The number of SSA values is an indicator of the accuracy in estimating SSA.

Uncertainties in both the irradiance measurements and the model input parameters contribute to the overall uncertainty of the methodology. The uncertainty of Brewer UV irradiance is estimated to be 5%, while the overall uncertainty of the modeled global irradiance is 4.6% (Bais et al., 2005). Assuming the error in AAOD $\approx \delta$SSA $\cdot$ AOD (Arola et al., 2005), the uncertainty on the estimated AAOD can vary from 0.020 (high aerosol load) to 0.026 (low aerosol load).

Two examples of the retrieved results are shown in Fig. 1 for two cloud-free days with different aerosol load. The first day (28 April 2008) has an AOD daily mean of 0.15 while the second day (7 August 2007) is characterized by an higher aerosol content(AOD=0.29). The low aerosol content during 28 April has reduced significantly the accuracy of the retrieved SSA value (upper panel in Fig. 1). The dispersion on SSA value for the low AOD day can reach the value 0.05; otherwise, a maximum dispersion of 0.02 can be observed during the day with the higher aerosol load (lower panel in Fig. 1). The same results were found by Bais et al. (2005). No such a clear difference in SSA dispersion is observed at different hours during the day, showing that the accuracy on SSA retrieval is slightly affected by SZA variations.

Figure 2 shows the SSA (upper panel) and AAOD (lower panel) monthly mean values, derived from Brewer global UV irradiance measurements for the period January 2005–June 2008. The SSA average over this period is 0.80±0.08 while the AAOD average is 0.056±0.028, where the uncertainties are given as one standard deviation. The SSA and AAOD monthly means show a significant variability within each month; a seasonal variation in SSA can be observed, with lowest values in winter and increasing in summer and in early autumn. Otherwise, a seasonal variability in AAOD monthly means is not evident.

4 OMI UV data validation: the role of absorbing aerosols

The SSA and AAOD at 320.1 nm were retrieved at Rome site using the methodology described in Sect. 3. The relative differences (OMI-Brewer)/Brewer irradiance at 324.1 nm and EDR at overpass time are plotted against AAOD in Fig. 3 (upper and lower panel, respectively). It can be noticed that the bias increases with increasing AAOD, since OMI algorithm does not properly account for the absorbing aerosols in the boundary layer. The regression equations were estimated, showing for AAOD larger slopes (S>1.3) and higher correlation coefficient values (r >0.38) than those obtained for AOD (S<0.3 and r<0.3) (not shown). Thus, AAOD is the most appropriate quantity to evaluate the effect of aerosol on the OMI products.

Based on the above results, OMI UV data can be post-corrected using measurements of SSA and AOD in the UV range and the regression coefficients between (OMI-Brewer)/Brewer and AAOD. According to the methodology described by (Kazadzis et al., 2009), the slope can be used to determine the aerosol absorption correction factor C_A, which can be applied to OMI UV irradiance (E_{cloud} in Eq. 1) as follows:

$$E_{\text{corr}} = E_{\text{cloud}} \cdot C_A = E_{\text{clear}} \cdot C_T \cdot C_A. \tag{2}$$

where E_{corr} represents the post-corrected OMI UV product. C_A is defined to be equal to unity in case of non-absorbing aerosols (sulfate, sea salt) and less than unity in case of absorbing aerosols (i.e. dust, carbonaceous, pollution).

According to Kazadzis et al. (2009), C_A can be obtained using three methods.

$$\text{Method 1}: \; C_A = (1 + S \cdot \text{AAOD})^{-1} \tag{3}$$

In the first method, the slope S was derived from the linear regression between the relative difference (OMI–Brewer)/Brewer and AAOD.

$$\text{Method 2}: C_A = (1 + S \cdot \text{AAODS})^{-1} \tag{4}$$

In the second method, the SZA dependence was taken into account. Indeed, the effect of an aerosol absorbing layer may lead to higher UV attenuation at higher SZAs due to the increased optical path of the solar photons through this layer. The slant absorption optical depth (AAODS) is derived as:

$$\text{AAODS} = \text{AAOD} \cdot \cos(\text{SZA}) \tag{5}$$

The slope S of linear regression was determined using AAODS values.

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Method 3 : Krotkov et al. (2005) proposed a correction factor derived for Washington DC (USA) area with a fixed slope S=3 which was also applied at Rome data, being both locations classified as urban sites.

The corrected OMI UV irradiances at 324.1 nm and EDR at overpass time have been derived using the retrieved by means of the three methods described above.

The results are shown in Table 1. All methods lead to reduce the bias between OMI and ground-based data. The correction of OMI overpass UV irradiance at 324.1 nm is here analysed in detail. If no correction was applied (C_A=1), the mean positive bias, obtained taking into account the clear sky days for which AAOD retrievals are available within 15 min from the OMI overpass, is 17.7% with a standard deviation (SD) of 10.2%.

If Method 1 is applied, the average value of C_A is 0.93 taking into account the AAOD mean values with a slope of 1.32, (upper panel in Fig. 3). The mean positive bias is reduced to 9.9%±9.1%.

If Method 2 is applied, a new slope of 1.64 per unit of AAODS was obtained. Therefore the average correction is C_A=0.90 (assuming the mean AAODS value) which leads to a larger reduction of the bias value to 5.8%±7.4%.

Following the correction methodology proposed by Krotkov et al. (2005), the average correction factor is C_A=0.87, the bias value decreases to 1.6% with a larger standard deviation (9.7%).

For the EDR data at overpass time, the mean positive bias is 25.0%±10.7% when no correction was applied. When Method 1 (AAOD data) was applied with the regression slope value of 1.8 (lower panel in Fig. 3) or when Method 2 (AAODS data) was applied with the slope value equal to 2.05 (not shown), the average value of C_A is 0.91. If the slope value S=3 was used (Method 3) the average C_A is 0.86. Depending on the correction methodology the bias value decreases from 25% to 8%.

These results are similar to those obtained by Kazadzis et al. (2009) for Thessaloniki, confirming that above values can be used for urban areas characterized by similar aerosol properties.

If the AAOD mean of dataset was used for the correction, the bias is not significantly affected (the variation in the bias values is lower than 1 percentage point) with respect to the previous corrections, but the standard deviations get slightly worse.

Thus, if only climatological AAOD values are available, a constant correction factor value can be applied even if the actual variability in AAOD cannot be assessed. Similar correction values were obtained for OMI UV dataset at noon time (see Table 1).

Figure 4 shows the ratio (OMI-Brewer)/Brewer for the different levels of correction as a function of SZA, taking into acount irradiance at 324.1 nm (upper panel) and EDR (lower panel). Methods 2 and 3 provide the best correction approaches. In particular, in the latter the bias decreases significantly while the former reduces the larger relative differences at higher SZAs, descreasing the standard deviation values (Table 1).

The scatterplots OMI versus Brewer irradiance at 324 nm and EDR at overpass are shown in Figs. 5 and 6, respectively. Both Methods 2 and 3 were used to correct OMI UV original data. After applying the corrections, the OMI UV data result closer to the bisectrix. The results of the comparisons confirm that there is still a remaining positive bias not explained by the aerosol effect (Table 1). This can be partly related to the OMI sub-pixel variability of aerosol optical properties and thus of UV irradiances (Weihs et al., 2008). Furthermore, the fact that OMI overpasses and ground based (GB) UV measurements are not exactly synchronous can lead to an increased uncertainty in OMI-ground based comparison results.

5 Conclusions

An indirect method for determining the effective SSA in the UV region by comparing the Brewer global irradiance measurements with model calculations was applied at Rome site. The UVSPEC radiative transfer model, initialised with the measured values of total ozone and AOD at 320.1 nm, was used to calculate the global UV irradiance. The SSA values for which the modeled and measured irradiances agree to better than 1%, were determined at different solar zenith angles during the day. It was found that this methodology provides less uncertain results when high aerosol load cases were selected. The uncertainties of the measurements together with the modelling and the AOD retrieval uncertainties contribute to the overall uncertainty in estimating of the SSA value. The AAODs have been derived from simultaneous SSA and AOD data from January 2005 to June 2008. The monthly means of SSA and AAOD at 320.1 nm were derived. The SSA and AAOD averages over the period study are 0.80±0.08 and 0.056±0.028, respectively.

The SSA and AAOD monthly means showed a significant variability within each month; it can be observed a seasonal variation in SSA, with lowest values in winter and increasing in summer and in early autumn. Otherwise, there is not such a clear seasonal variability in AAOD monthly means.

AAOD retrievals derived at Rome site were also used to quantify the error in OMI surface UV estimates due to aerosol absorption effect. OMI and Brewer UV irradiance (324.1 nm) and EDR measurements under clear sky conditions for the period January 2005–June 2008, were compared as a function of absorbing aerosol optical depth, which are not included in the OMI UV algorithm. Three methods, based on AAOD retrievals at 320.1 nm, were used in order to investigate on the effect of absorbing aerosols on OMI UV data. All methods led to an improvements of OMI-GB comparisons. Results showed that for both irradiance at 324.1 nm and EDR data, the correction factor C_A reduced most of the observed overestimation, with a reduction of the bias by 10–15 percentage points. C_A values obtained at Rome site can vary between 0.86 and 0.91, depending on the correction methodology. Such values are comparable to those obtained by Kazadzis et al. (2009) at Thessaloniki, Greece. Similar results were obtained correcting OMI UV data at noon time; thus, the absorbing aerosol effect explains the larger part of the bias also for OMI data at noon time.

There is still a remaining positive bias not explained by the aerosol effect, especially when EDR data were taken into account, a small positive bias not related to aerosol absorption was found. A possible explanation for this could be the fact that in cloudless cases, absorbing aerosols attenuate also the reflected irradiance from the ground. That could lead to a small underestimation of reflectivity resulting in a small atmosphere transmittance overestimation. An additional reason can depend on the OMI sub-pixel variability of aerosol optical properties. Furthermore, the fact that OMI overpasses and ground-based UV measurements are not exactly synchronous can lead to an increased uncertainty in comparison results.

Finally when the climatological mean values of AAOD were included in the methodologies, correction values comparable to those retrieved from actual AAOD measurements, were obtained. Thus, this correction methodology can be reliably applied also in different urban sites, if either climatological or actually measured AAOD values are available.

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Table 1. Results of the correction for absorbing aerosol of OMI UV data. SD indicates Standard Deviation. The bias is calculated as [(OMI-Brewer)/Brewer] *100%. S indicates the slope estimated from linear regressions.

		overpass			noon		
#	C_A^{-1}	S	bias	SD	S	bias	SD
Irradiance at 324 nm							
–	1	–	17.7	10.2	–	15.0	7.9
1	$1+S{\cdot}$AAOD	1.32	9.9	9.1	1.60	5.4	5.9
2	$1+S{\cdot}$AAODS	1.64	5.8	7.4	1.44	4.3	5.4
3	$1+3{\cdot}$AAOD	3	1.6	9.7	3	-2.0	6.7
EDR							
–	1	–	25.0	10.7	–	25.8	10.1
1	$1+S{\cdot}$AAOD	1.80	14.3	8.1	1.60	14.5	6.7
2	$1+S{\cdot}$AAODS	2.05	9.6	6.5	1.24	14.7	6.3
3	$1+3{\cdot}$AAOD	3	7.8	8.1	3	6.6	8.2

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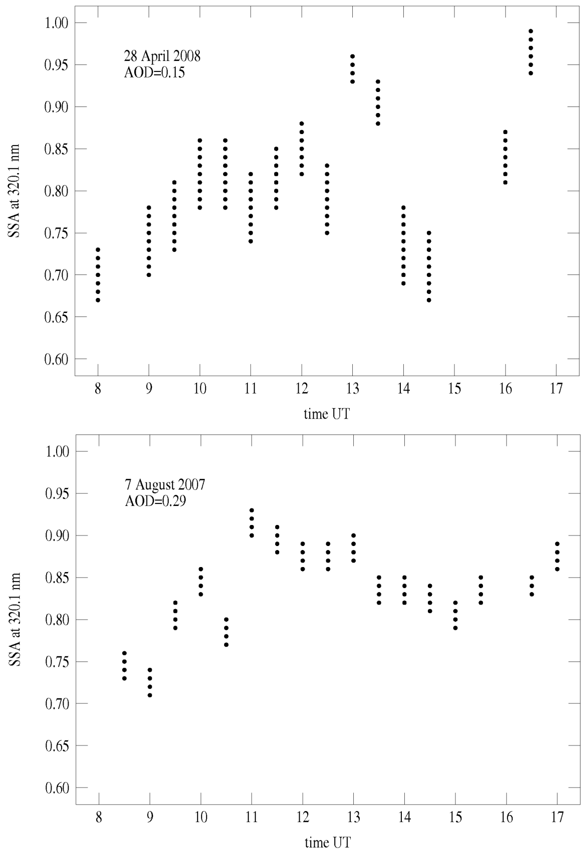

Fig. 1. SSA daily evolution obtained by comparing global irradiance measurements with model calculations, during 2 days with low (28 April 2008) and high (7 August 2007) aerosol content.

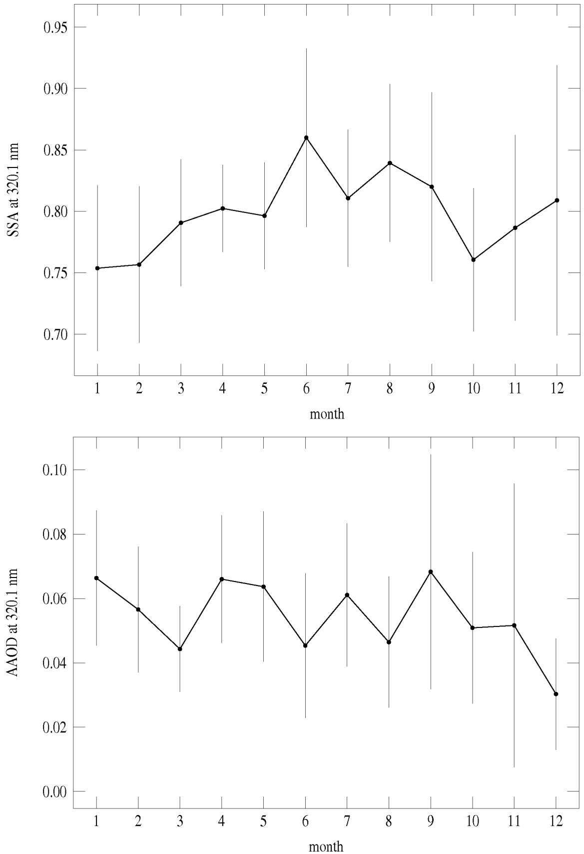

Fig. 2. Monthly mean SSA (top) and AAOD (bottom) at 320.1 nm during the period January 2005–May 2008 with standard deviation bars.

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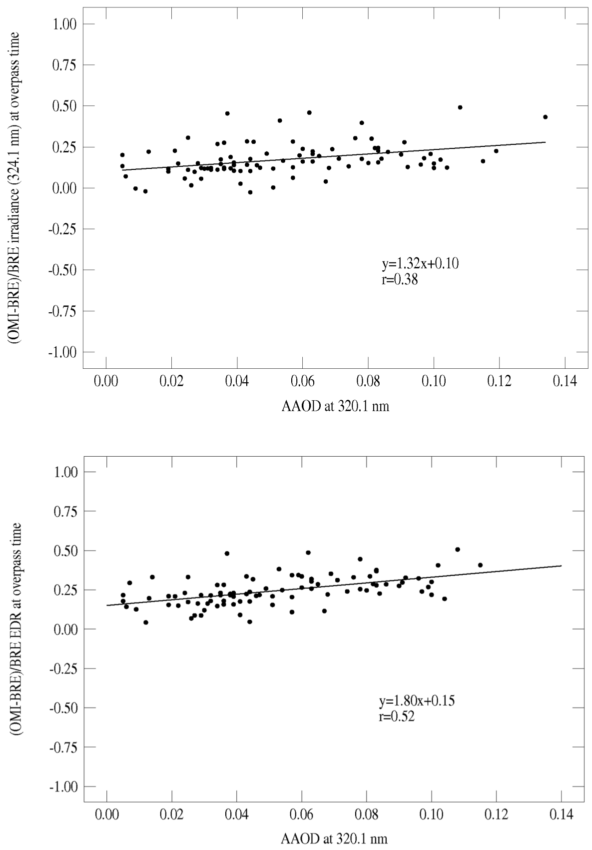

Fig. 3. (OMI-Brewer)/Brewer irradiance at 324 nm (upper panel) and EDR (lower panel) versus AAOD at 320 nm at OMI overpass time. The black line is the regression line.

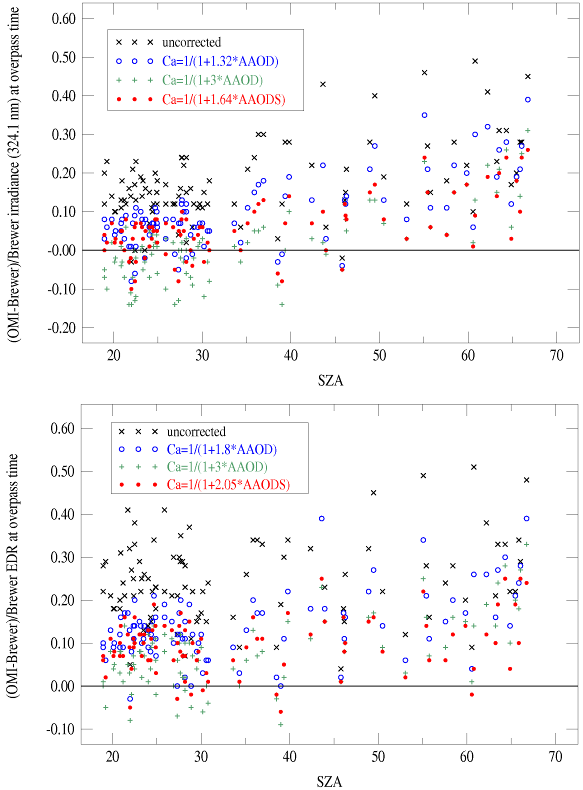

Fig. 4. (OMI-Brewer)/Brewer irradiance at 324.1 nm (top) and EDR (bottom) versus SZA at OMI overpass time. Black symbols indicate the original data; blue circles, red dots and green crosses represent, respectively, the results of the corrections # 1, 2 and 3 described in the text. As reference the line y=0 is plotted.

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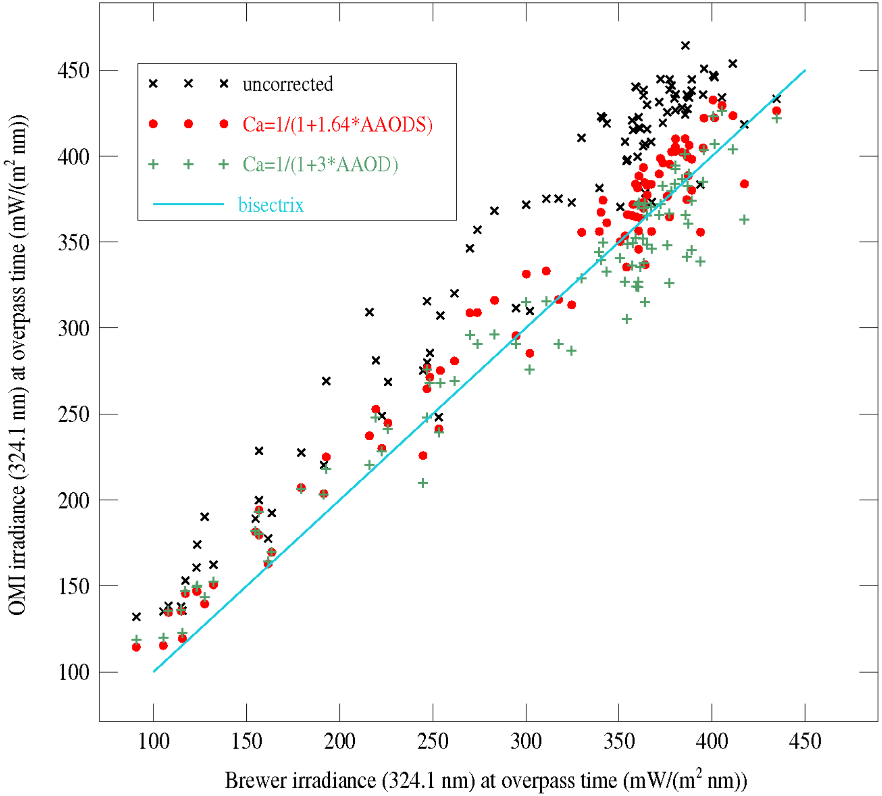

Fig. 5. OMI vs Brewer irradiance at 324.1 nm at overpass time scatterplot. The red dots and green crosses represent the results of the corrections # 2 and 3 described in the text. As reference the line y=x is shown (light blue line).

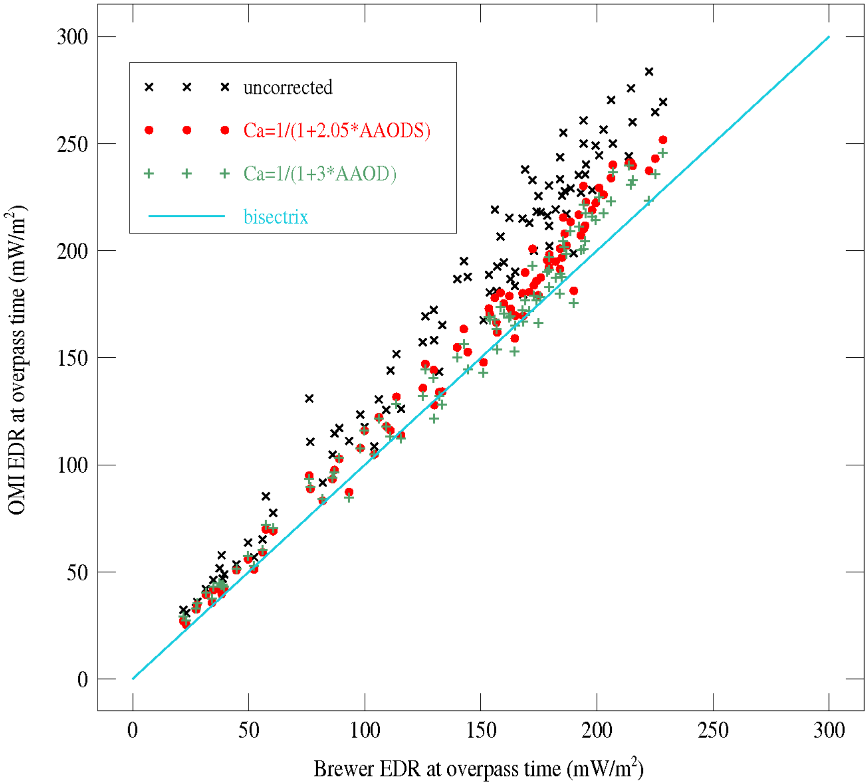

Fig. 6. OMI vs Brewer EDR at overpass time scatterplot. The red dots and green crosses represent the results of the corrections # 2 and 3 described in the text. As reference the line y=x is shown (light blue line).

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Aerosol Single Scattering Albedo retrieval

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