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Atmospheric Measurement Techniques Discussions

Interactive comment on "First national intercomparison of solar ultraviolet radiometers in Italy" *by* H. Diémoz et al.

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Answers to referee #2

Comment #1: General comment: This paper presents the results of an intercomparison of UV measurements performed with ground-based instruments during a campaign in Italy. The aim of such a campaign is to check the consistency and the accuracy of all the measuring instruments before the settling of a network.

The analysis of the measurements is carefully and honestly conducted. The technique proposed to perform the comparison of high frequency broadband

measurements with spectra is interesting and seems efficient. In addition performances of the various radiometers are detailed allowing to make a classification between them. This paper should be useful for people willing to perform accurate UV measurements within a network and willing to carry out comparisons between measurements from different types of instruments.

Answer #1: The authors thank the referee for his positive comments and his constructive criticism.

Comment #2: Section 2.5: - there are not enough details in Table 4. - the authors say that the solar spectrum is taken from Atlas 3 plus Modtran, but in Modtran it is possible to choose among several extraterrestrial spectra. Details must be given.

Answer #2: Only Atlas 3 is used by libRadtran for wavelengths lower than 407.8 nm and the upper limit of the simulations presented in this study is 400 nm. Therefore, only references to Atlas 3 were maintained in the revised manuscript.

Comment #3: the choice of aerosol parameters must be explained. For ex, why the SSA default value has been reduced and what is its new value? The Angstrom parameter "beta" comes from the Brewer, therefore I believe it is not the turbidity (beta is AOD at 1000nm); if beta is really the AOD at 1000 nm, how has it been obtained ? Similarly how is defined alpha? Does it come from Brewer as can be understood when reading table 4? Give details.

Answer #3: The model description in Sect. 2.5 has been expanded as follows:

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A radiative transfer model, the libRadtran package (Mayer and Kylling, 2005), was used in the campaign for comparing different kinds of data as explained in Sect. 4 and as a further quality control. Table 4 summarizes the data set entered as input to the model.

The solar spectrum was set to the recommended value following the model documentation (Atlas-3, shifted to air wavelengths). Default summer atmospheric profiles were used. Pseudo-spherical discrete-ordinate method (DISORT) with double precision was chosen as the solver, since a simple plane-parallel DISORT solver showed relevant deviations from the reference instrument even for low zenith angles. The effective ground albedo was set to 3% (Degünther et al., 1998). Rural aerosol properties, background stratospheric aerosols and the default Shettle aerosol profile were given as inputs to the model. Since independent measurements of the aerosol single scattering albedo (SSA) were not available during the campaign, the SSA value was chosen in order to best reproduce several spectral measurements recorded with Bentham 5541 during clear-sky days in summers 2008 to 2010 at Saint-Christophe (wintertime measurements were not considered because of changes of effective ground albedo due to the snow) as explained by Ialongo et al. (2010). Therefore, the single scattering albedo (SSA) was reduced by 10% relative to the default model value (i.e. 0.90 to 0.95 depending on the wavelength). Similarly, the Molina&Molina ozone cross sections were chosen because of their agreement with the Bentham spectral measurements in the range 295÷330 nm.

The Ångström coefficients were retrieved from the Brewer measurements in the UV and visible range, as explained in Sect. 2.2. Local atmospheric pressure was taken equal to a constant value of 950 hPa, since the measured pressure during the campaign was stable within ±5 hPa (the error introduced by using a constant value is less than 0.4% at 290 nm and even lower at higher wavelengths). The diffuse irradiance was scaled to 95% accounting for the mountain horizon under the hypothesis of isotropic diffuse radiation, as explained by Diémoz and Mayer (2007). This cosine-weighted fraction was calculated from both theodolite measurements and a digital elevation model.

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The simulated spectra were then treated similarly to the instrumental data (id 14 was assigned to the model) and compared to the reference.

It should be stressed that the aim of our work was not to accurately retrieve the previously mentioned parameters, since a relatively large range of values may originate realistic spectra. The purpose was rather to restrain some relevant and free model parameters on the base of the observations and to achieve the best agreement between model and measurements. Of course, other minor factors which are not taken into account (such as aerosol and gas vertical profiles, other aerosol properties, surrounding surfaces orientation, etc.) can still influence the model.

Moreover, Sect. 2.2 was updated as follows:

The algorithm developed by Cheymol and De Backer (2003), together with data from an in-situ Langley Plot calibration, is regularly employed to retrieve the aerosol optical depth (AOD) at 320 and 453 nm from clear-sky UV direct irradiance. The Ångström coefficients can then be estimated from measurements at these two wavelengths, according to Gröbner and Meleti (2004). The AOD and the Ångström coefficients are later included in the radiative transfer calculations.

Integrations to Table 4 are presented in the Supplement.

Comment #4: replace "effective albedo" with "effective ground albedo".

Answer #4: The terms were replaced throughout the manuscript following the suggestion of the referee.

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Comment #5: Explain why the pressure is taken equal to a constant value; was there no meteorological measurements on the site? Does this lead to no error?

Answer #5: see answer #3.

Comment #6: the factor to account for the horizon is equal to 95%, that means it does not depend on the SZA, aerosols, etc. Justify this assumption.

Answer #6: The horizon factor is calculated under the hypothesis of isotropic diffuse radiation and a reference has been included in Sect. 2.5.

Actually, the horizon factor does depend on the solar zenith angle, clouds, aerosols, etc., since diffuse radiation is not perfectly isotropic. However, an accurate estimate of this value with respect to all astronomic and atmospheric factors would have required elaborate radiance simulations and much longer time. The following paragraph has been included at the end of Sect. 5.2:

The daily variability can arise from the hypothesis of isotropy. Actually, since the diffuse radiation is not perfectly isotropic, the factor accounting for the horizon may be different from 95% and may even vary depending on the solar zenith angle, cloud cover, aerosol load, etc. However, the induced error is likely much lower than the uncertainty resulting from the unknown input model parameters.

Comment #7: in the processing of the simulated spectra, is there a convolution with the slit function of the reference instrument ? Please give infos.

Answer #7: Both the model and the (deconvoluted) reference spectra were convoluted

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with a triangular slit function with FWHM of 1 nm. Section 2.1 was modified according the referee suggestion in the following way:

In order to reduce the errors caused by a wavelength misalignment, the spectra were processed with the SHICrivm package (Williams et al., 2003) using the instrumental slit function (measured with a He-Cd laser in 2009), deconvoluted and then reconvoluted using a triangular slit function (FWHM 1 nm).

A similar information about the model was added to Table 4 (see Supplement).

Comment #8: Section 4.1, lines 5-6: specify "or the UV-A unitary function between 315 and 400 nm and zero below 315 nm".

Answer #8: The sentence has been modified according to the referee suggestion.

Comment #9: Section 5.2, line 44: the last sentence "This behaviour should be probably..." is rather amazing. It must be changed.

Answer #9: The sentence was rewritten in the following way:

This behaviour will be investigated in detail by the owner agency.

Comment #10: Caption of Figure 3: the word "broadband" before "UV-A irradiance" is in my opinion redundant.

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Answer #10: The term “broadband” was removed as suggested.

Comment #11: Caption of Figure 3: I wonder if measurements that are not made before sunrise or after sunset must be called “missing data”. Please change the sentence.

Answer #11: The caption was modified as follows:

Data for rainy periods, before sunrise, after sunset, during calibration of the reference and dome cleaning were not included in the graph.

The comparison has not been performed during these periods, since most of the matrices were calculated for clear-sky and visible sun.

Comment #12: Figures 7 and 8: Specify in the captions that it is for clear sky.

Answer #12: The captions were corrected following the referee suggestion.

Comment #13: Technical corrections:

- p. 3, line 23: “irrandiance” → “irradiance”.

- p 4, line 11: remove the word “and” before the word “depending”.

- caption of Figure 3: “occurs” → “occur”.

- caption of Figure 9: “id04” → “id14”

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Answer #13: The above corrections were done in the revised manuscript.

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