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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Intercomparison of erythemal broadband radiometers calibrated by seven UV calibration facilities in Europe and the USA" *by* Hülsen et al.

Hülsen et al.

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This is the response to comments and suggestions of referees 2. We thank the referee for his comprehensive and valuable suggestions and constructive remarks.

With respect to the comments we will give the following responses and will perform changes due to the suggestions.

I. Specific comments:

1.) Bandwidth of the Monochromator at FWHM: The Bandpass of the different monochromators ranges from 0.75nm to 9nm. The smaller the bandpass the more precise the steep slope of the SRF will be captured by the measurement system. Mea-

surements with a larger bandpass will result in a smaller slope of the SRF. Differences between the systems can best be seen in the slope region between around 300nm to 340nm. The ratio between two systems with a small and a wider bandpass will therefore show a distinct dip. This can be seen in the ratio of the SRF measured by PMOD/WRC and UIIMP (Fig. 1b). The later institute uses a monochromator with a twice as wide bandpass as the one of PMOD/WRC. Schreder et al. (2004) discusses the difference seen between these two systems and estimate it to about 5%. Even more pronounced is the dip in Figure 1c (PMOD/WRC to LAP) where the bandpass difference is nearly 5 times larger. A quantitative estimate of the effect of different bandpasses requires a more extended analysis which is beyond the scope of this manuscript. We are planning to provide this kind of quantification in a separate publication. As requested by the two reviewers, we have provided the details of the individual monochromators used by the institutes:

Page 2253, line 13/14: "The width of the monochromator output slit function is a compromise between the output intensity and the wavelength resolution of the system (1.9, 0.75, 4, 9, 2.1, 2 and 1.6 nm for PMOD/WRC, CUCF, UIIMP, LAP, INTA, STUK and NRPA respectively)."

2.) Equation 5 is stated in its most general form as defined by Webb et al., 2006. If Coscor is neglected the absolute calibration factor should be treated as a function C(SZA,others) as suggested by the referee. Therefore a clarification was added to the text following equation 6 (see also point 5 and 6). Page 2256, line 13: "If no cosine correction is available (Coscor=1), the absolute calibration factor becomes a function depending on SZA and possibly also on other factors."

3.) The "average" radiometer signal U_D is a representative value for each solar spectrum scan. During one scan of the spectroradiometer many data points from the test instrument are recorded. To match the different measurements the changing atmospheric conditions during the time of one spectroradiometer scan (SZA and the cloud variability) have to be taken into account. The methodology of PMOD/WRC is de-

ACPD
8, S508–S513, 2008

scribed in detail in the publication Huelsen and Groebner, 2007, and we believe a reference to this work is enough for this publication. Methods from the other institutes will differ slightly, but the consequences to the resulting radiometer signal U_D are small. Below we provide an excerpt of the method of PMOD/WRC (published in Huelsen and Groebner, 2007):

The solar spectrum as measured by the spectroradiometer, E, is weighted with the detector spectral response to produce a spectral detector weighted solar irradiance $E_D(\lambda)$:

$E_D(\lambda) = SRF(\lambda) \cdot E(\lambda)$.

The integral of $E_D(\lambda)$ over the wavelength yields the detector weighted irradiance E_D. The representative time T_D of this value is the integral over all the time stamps of each spectroradiometer recording $\mathrm{t}(\lambda)$ weighted by the detector response function and normalised by E_D :

$T_D = \frac{1}{E_D} \int SRF(\lambda)E(\lambda)t(\lambda)d\lambda$.

This effectively means that the radiation contribution of each wavelength weighted with the detector sensitivity is used as a measure of the 'relative importance' of each recording relative to the total measured irradiance. The radiometer readings $\mathrm{U}[\mathrm{t}(\lambda)]$ during the time of the solar spectrum scan are weighted correspondingly to calculate an average radiometer signal for each solar irradiance scan:

$U_D = \frac{1}{E_D} \int SRF(\lambda)E(\lambda)U[t(\lambda)]d\lambda$.

Text change:

Page 2256, line 7: "...with the representative radiometer signal U_D"

Page 2256, line 9: "U_D is obtained from a judicious combination of the individual radiometer signals during the solar spectrum scan (see Hülsen and Gröbner, (2007) for the PMOD/WRC method; methods from other institutes differ slightly)."

ACPD
8, S508–S513, 2008

4.) Equation 4 is stated in its correct form. f_0 is the normalisation factor of the conversion function as defined on Page 2256, line 1. The following sentence as also been added to the text:

Page 2256, line 9: "where f_0 is the normalisation factor of the conversion function."

5.) The statement that "an average cosine correction is already included in the conversion function" is maybe misleading. Therefore the three items which list deviations from Equation 5 for UIIMP, LAP and INTA has been changed.

Page 2256: line 21 ff: "UIIMP, LAP and INTA: the absolute calibration factor C obtained from the clear sky calibration periods is included in the conversion function f_n as a function C'(SZA)."

6.) STUCK does account for the spectral mismatch between the instrument and CIE weighting function by using an outdoor calibration. The absolute calibration factor is an average over the outdoor measurements during the calibration period and therefore contains implicitly the normalisation factor of the conversion function, f_0, and an average cosine correction representative for the selected measurement points.

The item Page 2257, line 1-2 is extended to the following form:

"STUK: a single absolute calibration factor is used to convert the raw data to erythema weighted irradiance ($Coscor = 1$, $f_n = 1$). The normalization factor of the conversion function, f_0, and the cosine error are implicitly included in C during the outdoor calibration."

7.) Extrapolation method of the SRF: The extrapolation methods used by the different institutes are quite similar and the effect on the resulting conversion function is very small. PMOD/WRC and INTA use a logarithmic and linear extrapolation respectively, from the last measured point to the point at 400nm which is set to 10^{-6}. CUCF measured until 400nm. UIIMP and STUCK set the missing data points to 10^{-7} while LAP and NRPA set them to zero.

ACPD
8, S508–S513, 2008

The following sentence as been added to the text:

Page 2259, line 4: "Either a linear or logarithmic extrapolation from the last measured point to the point $\mathrm{SRF}(400\ \mathrm{nm}) \approx 10^{-6}$ was used to complete the dataset, or the missing data points were set to a fixed value (zero or $\approx 10^{-6}$)."

8.) Page 2251, Line 17: "Nevertheless an excellent agreement of the order of ± 2 could be found". Plus-minus two percent is 'in the order' of the values listed in table 4. However as it is very 'optimistic' we will change to: "Nevertheless a good agreement of the order of $\pm 4\%$ could be found"

II. Technical corrections applied:

1.) Replace "UVCF's" -> "UVCFs" (throughout paper)

2.) Abstract, line 2: "The owners calibrations" -> "Calibrations provided by the instruments owners..."

3.) Abstract, line 9: "determinations ... have"

4.) Page 2251, Line 17: "when all the data was" -> "when all data were"

5.) Page 2251, Line 18: "owners institute" -> "owner's institute"

6.) Page 2252, Line 14: slitfunction -> slit function

7.) Page 2254, Line 18: "... to calculate the simulated solar spectrum ..." -> "... to simulate the solar spectrum ..."

8.) Page 2256, Lines 21-24: The two bullet points could be combined: "LAP and UIIMP:..." -> change of abstract, see also point 5 of 'specific comments'.

9.) Page 2257, Line 7: "the originating UVCF calibration... each UVCF." -> "calibrations established by the UVCFs and PMOD/WRC."

10.) Page 2257, Lines 8-9: "there was ... UVCF," -> "there were no direct comparisons between the UVCFs,"

ACPD
8, S508–S513, 2008

11.) Page 2257, Line 17: responsivities -> spectral response functions

12.) Page 2257, Lines 20-23: "Errors ... introduce therefore significant ... radiometer" -> "Potential errors ... may introduce significant ... radiometers".

13.) Page 2258, Line 1: "the owners institute... figures" -> "the other UVCFs .... The ratio of the two data sets is presented in the corresponding lower figures."

14.) Page 2258, Line 58, Line 5: "with two institutes" -> for two institutes"

15.) Page 2258, Line 26: "the owners institute" -> "the other UVCFs"

16.) Page 2261, Line 20: "....function, f_n, which was set to unity." -> "... function f_n to unity."

17.) Page 2262, Line 19: "are will within" -> "are well within"

18.) Figure 3: different line style.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 2249, 2008.