

Response to Anonymous Referee #2

After each comment by the referee (bold letters) there is the corresponding answer. The page and the line numbers referred correspond to the new version with tracked-changes.

Brewer spectrophotometers have been used extensively in the past for measuring global UV irradiance. The high number of such instruments performing such measurements worldwide for very long periods, makes investigations like the one submitted valuable for the UV community.

Comments

Section 2

Since this paper is introducing a number of different instruments with different characteristics, including hardware, calibration facilities e.t.c. it would be essential for the authors to start this paragraph describing the main problem.

Reply

The problem is now described clearly in the introduction (P3, L16-P4,L7).

Temperature effect on Brewer measurements can be linked with PMT, diffuser difference in temperature compared with the ones during the standard calibration procedure, hysteresis effects, wavelength shift issues, other kind of stresses within the instrument.

The authors have to prioritize these effects and describe the methodology followed in order to eliminate or to investigate the effect of each of these factors.

Reply

In the revised version of the manuscript, information regarding the complexity of this issue has been added in the introduction and the beginning of Sections 2 and 3. In the introduction of Section 3 there was already information regarding what has been done to avoid large temperature gradients inside the instruments and to ensure the good quality of the characterization procedure in each case. More information has been added in the new version regarding what has been done in order to eliminate the effect of wavelength shifts (P10, L6-8). Furthermore, a more detailed description of the remaining uncertainties is now provided in paragraph 3.3.

A table with the instruments used together with some details on the method used for each one could be also useful for the reader.

Reply

Table 1 has been added in Section 3, which contains all the suggested information.

Section 3

“carried inside” ? you mean moved from sun measurements to the calibration room ?

Reply

Yes, the manuscript has been changed so this is clear (P9, L11).

Figure 4 shows that changes are not wavelength independent, at least for some instruments

Reply

Yes, this is clearly stated in both, the old and the new version of the manuscript (P12, L14-18).

The standard deviations of what ? how many measurements have been performed for each temperature, wavelength ?

Reply

The reviewer has a point here. The discussion for the standard deviation might be misleading. Thus, the relative figures and discussion have been removed.

In addition it is worth noted that only one instrument has a positive change with temperature in TR3.

Reply

This information has been added in P12, L8.

Are Ylliantilla results applicable to the Brewer using diffusers? Do some of the instruments use modified (that the Brewer initial) diffusers ?

Reply

Discussion relative to this question has been added in section 3.2 (P14,L16 – 25)

Section 3.2

“This confirms that the different patterns found between the three TRs are due to the change in the transmissivity of the Teflon diffuser.”

Based on this and figure 2: For measuring the instrument response the calibration is performed with the 1000W lamps in an environmental temperature of 25 degrees. Do this results imply that it is possible that, based on the above statement, the total duration of the normal calibration procedure may affect the calibration results ? (by having the diffuser heating up). Or most

importantly that sun and 1000W-lamp measurements are partly incompatible due to the different diffuser temperature inside the calibration room and outside, even if the ambient and calibration room temperatures are 25 degrees ?

Reply

Although the 1000 Watt lamps were not found to heat the diffuser (at least importantly), as was already discussed in section 2, the change of the room temperature during the characterization procedure may affect the results of the calibration. A more analytical discussion has been added in sub-section 3.3.3. As discussed in sub-section 3.3.1 the difference between the temperatures of the diffuser and the PMT is not important when the Brewer is illuminated by the sun. The relative uncertainties are already discussed in the same section.

Figure 4. I wonder how reliable are the results for wavelengths below 300nm given the low counts that the instrument is measuring using the 1000W lamp.

Reply

The level of the signal below 300 nm is of course lower than the signal at longer wavelengths, though for all the studied cases it is adequately high to give results of similar reliability to that of the results for longer wavelengths. For 1000 and Watt lamps the signal below 300 nm is much stronger than for the sun at the same wavelengths. We estimate that even the stray light effect on the measurements of single monochromator Brewers does not affect the results significantly.

Wavelength shifts for higher wavelengths is not out of the discussion even if a wavelength control/correction is performed at 297 (?) nm.

Reply

Relative discussion regarding the effects of wavelength shifts on the determination of the correction factors for the effect of temperature has been added (sub-section 3.3.6). Regarding the wavelength shift during field measurements, it may occur due to many reasons in addition to the effect of temperature. However, a wavelength correction is usually applied when the spectra are processed, which eliminates the greatest part of this later effect.

Conclusions

I understand that this is a mostly technical paper. But it would be interesting for the readers to demonstrate the brewer temperature effect a bit more clear and realistic. Reading this work I come to the conclusion that:

a. since there is a heater in the instrument (and not a cooling system), we are mainly interested by the temperature effects from 10 to 40+ degrees

b. Brewer temperature is different from ambient temperature (most probably the instrument (out on the sun) temperature is higher in the hot days than the temperature (measured in the shadow).

c. Temperature issues will affect mostly diurnal and seasonal global UV irradiance related investigations and not so much year to year trends.

Reply

All the above have been taken into account and relative discussion has been added (P21,L5 – P22,L4). However, (c) is partially true. Over high latitudes the mean temperature already changes, and is projected to change by more than 10 degrees until the end of the century. Such large changes might induce important biases in the study of the UV trends if the effect of temperature has not been removed from the spectra. Also there can be big differences (higher than 10 C degrees in mean temperature) between even subsequent years depending on the local weather conditions. The above are discussed in the paragraph of the Discussion and Conclusions section.

So since the study is including a number of instruments that have different response in the temperature change and also perform measurements in very different environments concerning actual ambient (and Brewer) temperatures, it would be interesting to show the actual global UV % deviations for each site based on the actual brewer temperature. Either on a daily basis using the daily temperature change or during the year using the temperature at the measurement performed at the maximum -all year long existent- solar elevation angle.

Reply

Figure 7 has been added in the manuscript.