Response to Referee #2

We would like to thank anonymous reviewer #2 for his very constructive and useful comments. Our responses follow the reviewer's comments (in bold).

General comments:

This paper provides a very sound study on the impact of dead time from the Brewer instrument photomultiplier detector system on the uncertainties of different products derived from the Brewer instruments such as UV irradiance, total ozone column and aerosol optical depths. The authors well describe the detector system, the theoretical framework of dead time determination and the practical determination of the dead time with different approaches. The results of the study are also useful to correct the dead time effect in order to reduce the overall uncertainties of the products. Both the correction and the calculation of the uncertainties are important to be published in the scientific community to improve the Brewer measurements.

There is one issue which would complete the thorough study: The uncertainty of the raw signal in terms of counts as a function of dead time effect and depending on the different conditions should be summarized. With such a summary the reader can apply the results of the study for other quantities derived from the raw signal.

Answer

The discussion regarding the uncertainties in the raw signal has been expanded. However, the raw signal for different atmospheric conditions is instrument dependent. For exactly the same atmospheric conditions the recorded signal from two Brewers of the same type (e.g. two multi-board MKIII Brewers with the same type PMT) may differ importantly. Even for the same instrument and the same atmospheric conditions, the signal in two different time spots may differ due to changes in the instrument response. Thus it is difficult to summarize the uncertainties in relation to different conditions. The uncertainties are now discussed in relation to the level of the recorded raw signal (and not the corrected signal) for the global UV measurements and for the AOD. For TOC, conclusion regarding the effect of changes in different atmospheric factors (SZA and TOC) and the signal level can be derived from figures 7 and 8.

The submitted paper is well written and organized and the methods and data are fully described.

The paper can be published with minor revision.

Specific comments:

For me it is unclear how the number of counts is related to the specific uncertainty of this number of counts, the dark counts and the uncertainty of the dead time. This issue is addresses several times in the paper, however, an overview of this relationship would be very helpful, maybe in form of an additional table.

Answer

The reviewer is right that the relationship between the number of counts, the dead time, the dark counts and the noise was not described clearly and the dark counts were erroneously referred as noise in several

points of the manuscript. In the revised version the authors tried to be more accurate and to clarify the relationship between the number of counts, the dead time, the dark counts and the noise.

E.g.: On page 12595 line 26 the authors state that a weak signal may lead to large uncertainties. This is obvious, however the author also state in section 3.1 that at very large counts the uncertainty is also large (by the effect of dead time). Therefore there should be an optimal number of counts with a minimum uncertainty. If this is correct, a range of best number of counts can be determined. This very useful finding to optimize the instruments setting could be stated in the text.

Answer

A table with the noise level as a function of the measured signal and the sampling time has been added in section 2.1. Based on the results presented in the table and the estimated uncertainties due to the DT effect (presented in section 3.1) we tried to determine the optimum operational range for different types of measurements.

In order to reproduce the uncertainties derived for the different products, such as UV irradiance, TOC and aerosols, it will be very helpful for other scientists to see numbers of the counts and their corresponding uncertainties for each wavelength depending on dead time and different atmospheric conditions e.g. different solar zenith angles. Such a table of numbers would serve to obtain an overview of the uncertainty source at the raw signal level.

Answer

The uncertainties in the UV measurements due to dead time are now described and discussed relative to the level of the raw signal in section 3.1, as well as the uncertainties in the AOD in section 3.3. The level of the recorded signal at each wavelength is instrument dependent and may vary importantly for different instruments or even for the same instrument for different time periods. Thus, it is not possible to summarize the uncertainties in the raw signal for different atmospheric conditions. Since the relative differences between the signal level at different wavelengths are important for deriving TOC, the results in figures 6 – 8 are presented as a function of the product of the atmospheric parameters that mainly determine the shape of the UV spectra (TOC*sec(SZA)). However, even in this case the results are indicative for the differences between the MKII and MKIII Brewers and for the magnitude of uncertainties in each. For instruments other than those presented they would probably be similar but not the same.

Section 2.3.3: it is an interesting finding that the dark counts are not much affected by the dead time effect below 10’000 counts. However, since the authors also stated that generally the dark counts are much lower (e.g. pp 12594, line 9), this section is not that important and could be reduced. If there are other implications regarding dark counts on the overall uncertainty of products, this should be elaborated more specific and stated clearly.

Answer

The statement at pp 12594 was not accurate and has been revised. Although the dark signal is usually lower than 1000 count/sec, values that are higher than 10000 counts/sec are not impossible.

In the following some small suggestions are listed to improve the clarity of the manuscript, which needs minor revision before publication.

Smaller issues:

Abstract:

The abstract basically describes the intention and results of the study – no changes.

Section 2.3.4: page 12602 line 21: Is there any evidence that the stray light effect, cause the increased uncertainty? Maybe a reference from literature?

Answer

A proper reference was added.

Section 2.4: the advantages of determinations DT from sun measurement are stated several times – the disadvantages of this method should also be highlighted.

Answer

The disadvantages are now also discussed in more detail.

Page 12604, line 12. …at local noon: what was the solar zenith angle? Line 16 what was the range of the solar zenith angles?

Answer

The range for the noon SZAs in the year has been added which is also indicative for the range of SZAs in the day.

Page 12604, line 16: a quantification of the estimated DT would be very helpful.

Answer

A quantification of the dead time has been added in the manuscript.

Page 12604,line 23: why is the calculated DT lower than the nominal?

Answer

Explenation has been added in the manuscript.

Section 3.1: page 12607, line 7: please state the range of UV irradiance. Is the effect mentioned below in this section valid for the entire range?

Answer

The range of the measured irradiances is stated in the beginning of the paragraph. We have also added a more analytical explanation of how the uncertainties in the raw counts are transferred to the finally calculated signal.

Section: 3.3, page 12613, line 14: 0.01 and 0.05 are these absolute values? Please state, line 180:…05 to 0.07 again please state the absolute values.

Answer

They are absolute values as it is now clarified in the manuscript.

Section 5, page 12618, line 8 ff: For better overview a list of bullet points to provide a short summary is helpful.

Answer

Done.

Figure 5: The range of investigated UV range should be stated.

Answer

It is now stated in paragraph 3.1.