Response to Referee #1 – V. Savastiouk

We would like to acknowledge V. Savastiouk for his careful and analytical review. We believe that his comments improved the quality of this work. Our responses follow the reviewer's comments (in bold).

General comments: the paper makes a good review of the existing knowledge state about a particular characteristic of the Brewer spectrophotometer photon counting system, the dead time (DT), and provides some new ways to estimate it and analysis of its effects on the final products like total ozone column (TOC), spectral UV and the aerosol optical depth (AOD). Some parts of the text need more accuracy and precision, while others seem to be not fully relevant and can be removed. In one numerical experiment described in the paper that I was able to replicate the authors did not recognized that the algorithm for the DT calculations has to be changed (the number of iterations has to be increased for the calculation process to converge) when the data collection method changes. This led to a misleading plot in the paper as well as references through out the text assuming there is a limitation to when DT can be successfully calculated. Those parts of the paper will need to be changed.

Here are more detailed, line-by-line comments.

page 12590

line 2: add "scattered" to the list of measured UV irradiances to cover the zenith sky observations;

Answer

Done

line 7: start a new paragraph at "The dead time is..."

Answer

Done

line 8: "characteristic" is not a good choice here. Try "specific" or similar. Use "improper" instead of "non-proper"

Answer

Done

line 9: change "It may change" to "The dead time value may change" or similar.

Answer

Done

line 12: add "to" between "due" and "a"

Answer

Done

line 13: This comment is relevant not only here but everywhere in the text: the use of the word "nominal" is not very appropriate here. I suggest "the value in use" for the value that is in the configuration file and "the value calculated by the DT test" for values that are reported by DT. Please review the entire text for this.

Answer

Done

line 24: "provides" instead of "provide"

Answer

Done

page 12591

line 6: "in" Canada; In the Netherlands the equivalent to "Inc." is "BV" and should be used instead

Answer

Done

line 7: remove "they"; it is proper to use the Netherlands, not Holland (this is just a region of the Netherlands)

Answer

Done

line 10: there are more than two types of Brewer electronics, but rather than counting them it is best to refer to "multiple-board and single-board" electronics. It is common to use MB and SB for these.

Answer

The manuscript has been revised properly.

line 27: from here the discussion of various issues affecting Brewer products is not very relevant and takes the reader away from the main focus of the paper without providing useful context. Consider reducing or removing this part.

Answer

Most of the discussion was removed.

page 12592

line 13: Here discussion about the DT starts without any word about what it is. Add text to introduce the main topic of the paper.

Answer

Information regarding the dead time has been added.

line 14: make RBCC-E non breakable text

Answer

Done.

line 15: please rephrase or expand "the actual DT derived" to make easy to follow

Answer

The relative discussion has been moved to the end of section 2.1. The manuscript has been changed properly.

line 17: the correct spelling of the name is "Grajnar" - please also correct in the bibliography

Answer

Done.

page 12593

In the description of the detection system there is no mentioning of the way the system decides what is signal and what is noise. If this is not working properly the system may have different DT values for different signal levels !!!

Answer

The way that the system decides what is signal and what is noise is now described more analytically.

line 10: add "tube" after "photomultiplier"

Answer

Done.

line 16: please review the description of the DT. You seem to suggest that the dead time is the finite temporal width of photon pulses, which is not correct.

Answer

A more accurate description of the dead time has been added in section 1.

line 18: again the use of the word "characteristic"; I suggest splitting the DT range based on the type of the PMT, otherwise the text makes an impression that the DT can actually vary from 15 to 45.

Answer

The manuscript has been revised according to the suggestion of the reviewer.

line 22: "correction .. is complicated" doesn't sound very scientific. Please either provide more details or remove.

Answer

The sentence has been removed.

line 23: add "and comparing" between "measuring" and "different"

Answer

Done.

page 12594

line 6: "common" - please add a qualifier why this is common (oversight, mistakes, one value better than the other or unknown reason(s)?)

Answer

The specific conclusion is based on the results from the RBCC-E calibration campaigns. The discussion has moved to the end of the section. A brief discussion regarding the possible causes of the difference between the used and the calculated DT has been added.

line 8: usually, "Brewer" is used with the definite article "the" as it comes from "the Brewer spectrophotometer"; Also, the process of the high voltage selection takes into account the slope of intensity vs voltage to minimize the effects of the HV variability. Please review to make this description more precise.

Answer

The manuscript has been revised properly.

line 11: signal to noise ratio is only one consideration for HV adjustment and not the most definitive.

Answer

The description of the HV adjustment has changed properly and now is more accurate.

line 17: Please justify why at high signal it is not easy to correct for non-linearity.

Answer

Done.

line 20: not all measurements are interrupted when the signal is high, spectral UV is not, scans of the lamps are not either.

Answer

The manuscript has been revised properly.

line 24: suggest "set for making ozone observations" or similar. This is never referred to as "zero" position. I suggest using "operational"

Answer

Done

line 25: Please add a comment about the dark count position in the slit mask and either explain that how you use wavelength numbers (0 to 5) vs slit mask positions (0, 2-6) or better still pick one system (wavelengths or slit mask) throughout the paper. Otherwise it is very confusing for readers.

Answer

Done

page 12595

line 5: please revise this paragraph. You mention "low" and "high" intensities before describing what they mean later in the paragraph. Also, there is no explanation why low/high are used and the paper never mentions this again. The DT test is design specifically to do lo+hi. Address this.

Answer

The discussion for the high and the low intensity DT has moved to the end of the paragraph. A more analytical explanation has been added.

line 12: "holes" are not selected, positions on the filterwheels are. Please revise. Not all Brewers use no attenuation ("empty" is not a good word here) for high intensity. Please reword.

Answer

The specific commend is correct. The manuscript has been revised properly.

page 12597

line 3: don't forget to fix the typo in equation 7

Answer

Fixed

line 6: this is a bit of a confused description of the dead time application and calculation. Please make sure you are clear what you are describing and why.

Answer

Authors tried to improve the description of the dead time application and calculation,

line 13: in the standard Brewer algorithm there are 10 iterations of equation 10 together with equation 9 (only for slits 2 and 4). Please review this description to make it clear, accurate and precise.

Answer

The specific part of the manuscript has been revised properly.

page 12598

line 1: It isn't clear if this section adds anything to the paper. You are not providing any new information and only seem to repeat what (Kiedron, 2007) said. Since you cannot improve on what (Kiedron, 2007) published I suggest reducing or removing this section.

Answer

This part of the manuscript provides information that is necessary for the discussion in the following paragraph. The authors believe that it should not be removed.

line 3: this text is a repetition of lines 22-25 in this page. Please review.

Answer

The manuscript has been revised properly.

page 12599

line 1: I don't quite understand the value comparison between the full equation (11) and its simplification (13). From the mathematics point of view it is obviously better to use the full version if possible. Please justify this numerical experiment.

Answer

According to the bibliography, the simplified equation (13) describes more accurately the effect of DT on non-paralyzable systems (Schätzel, 1986; Yu and Fessler, 2000, Kiedron, 2007). Thus, if the counting system of Brewer is non-paralyzable we should at least know what is the error due to the use of equation (11). We tried to make the above clearer in the manuscript.

line 17: "less than"

Answer

Done

line 22: This section 2.3.2 describes a numerical experiment that explores light level distribution among the exit slits that is very different from that assumed by the design of the DT test. While doing so is interesting and useful the authors need to be careful not to use algorithms for data analysis outside of the algorithm scope/limitation. The authors used 9 iterations in the DT calculation algorithm (while the Brewer software has 10, by the way) for light levels that are never present during the DT test. 10 iterations are enough for the signal level distribution from the standard lamp at the ozone operational position (intensity on slit 2 and slit 4 are comparable), but not enough for signal level distribution that is artificially modified (either using the sun instead of the lamp or simply modeling numerically). If authors repeat this numerical experiment with 500 iterations(to be on the safe side) they will find that the correct DT value is derived no mater what ratio of N3/N7 is. This also has an implication to another section of the paper where DT data on the sun is processed: authors need to reprocess those results using significantly larger number of iterations. Please recalculate relevant data, re-plot graphs and review the text where this is used.

Answer

This comment was very helpful. Indeed, increasing the number of iterations in the numerical experiment changed the results as the reviewer suggested. The entire manuscript has been revised properly.

page 12601

line 10: was the usual 20W lamp replaced with 50W or is it a typo?

Answer

It was a typo.

line 17: when using an external lamp through the quartz window at short distances it is unclear what effect has the fact that this is not a point source (light rays are not parallel). Please comment.

Answer

As explained in the manuscript, the origin and the geometry of the light from the lamp do not affect the results of the specific experiment.

line 26: Can you provide any reference that states that the ND transmittance is independent of intensity? How can you claim that all the various manufacturers used as suppliers conform to this? For the non-linearity to be only (mostly) due to the DT the separation between the signal and noise has to work properly. Please be more precise in your assumption description.

Answer

The specific comment is correct. We removed the specific sentence as we could not prove that the transmittance of the ND filters is independent from the intensity. However, if the transmittance of the ND filters was changing as a function of the intensity, then both the experiment that is presented here and the analysis of TOC when ND filters change would probably give DT that is different compared to the DT that is calculated from the dt.rtn.

page 12602

line 7: please clarify if "lower and higher" refers to results from the internal lamp or??

Answer

No, it was not. The specific part has been re-written more clearly.

page 12603

line 18: why did you use different number of cycles? Did you explore low/high signal levels for the DT on the sun (like the normal DT test does on the lamp)?

Answer

The number of cycles was increased to test if (and how much) the uncertainty in the calculated DT would be decreased. As explained more analytically in the manuscript, exploring low/high signal levels like the operational dt test was not considered to be necessary.

page 12604

line 20: add "of" between "inclusion" and "data"

Answer

Done

page 12605

line 19: how "very clear days" were selected?

Answer

Explanation has been added in the manuscript.

line 28: I don't want to repeat what is relevant here about n3/n7

Answer

The manuscript has been revised properly.

page 12606

line 23: please review the usage of the words "uncertainty" and "error"

Answer

The entire manuscript has been revised properly.

page 12607

line 7: This seems to be a more complicated description than it needs to be. The DT correction for a single intensity measurement is essentially a simple exponent and so errors can be easily expressed analytically and estimated then numerically.

Answer

There was an effort to simplify and improve the description of errors in UV irradiance due to DT.

line 19: Only the signal level ("intensity"?) is important for the DT effect calculation, not the Brewer sensitivity (which is also not the same as responsivity). Please be more accurate here.

Answer

The comment was probably for line 22 and not line 19. What the reviewer suggest is correct. The entire section 3.1 has been changed and the DT effect is now studied relative to the measured signal.

page 12608

line 3: Does anybody use UV data with no DT correction? If not, why mention it here?

Answer

The specific part has been removed.

line 25: actually, the filter is a combination filter consisting of NiSO4 crystal together with a UG11 filter.

Answer

It is now clear that the filter is a combination filter consisting of NiSO4 crystal together with a UG11 filter.

line 27: the type of electronics has no effect on the shape the spectral response, please either explain how this is possible or remove this comment.

Answer

The reviewer is wright. The type of electronics does not affect the shape the spectral response. However, spectral response may differ between different PMTs as it is now explained in the manuscript.

page 12609

line 11: "ratio" is not defined/explained here. Please provide context for readers.

Answer

A short description (and the appropriate references) has been added in the introductory part of section 3.2.

page 12610

line 1: This paragraph will be better position in the next section 3.2.2

Answer

Done.

line 15: The same effect happens when ND filters change from higher to lower attenuation.

Answer

The specific comment is correct. The manuscript has been changed properly.

line 20: not only that, but the distribution of light among slits is different at different slant ozone

Answer

The comment is correct. The specific information has been added in the manuscript.

page 12612

line 12: try "in either reference instrument or the instrument being calibrated"

Answer

Done.

page 12613

line 12: "we estimated" is too vague here. natural log of the error in intensity is the error in AOD.

Answer

The manuscript has been changed according to the reviewer's suggestion.

page 12614

line 1: analyzing TOC when NDF changes will tell you whether DT is correct - the best way also.

Answer

The reviewer is right. The above information is now added in the manuscript.

page 12615

line 8: "photon counting system", not just the PMT - remember to review the text for signal vs noise decision of the counting system

Answer

The entire manuscript has been revised and "PMT" has been replaced with "photon counting system" where necessary. A discussion regarding the decision of what is noise and what is signal has been added in section 2.1.

page 12616

line 8: I'm not convinced that reducing the number of iterations will improve timing. Have you done tests for this? How much time is saved?

Answer

This is correct. The change in the number of iteration does not improve timing (at least in a detectable time scale). The manuscript has been changed properly to clear that out.

line 21: please remember revising anything relating to your conclusions about N3/N7 ratio and DT calculations

Answer

The entire manuscript has been changed properly.

page 12617

line 13: The rates of 5 x 10^6 are not uncommon in the UV observations.

Answer

The reviewer is right. The count rates may be as high as 6-7x10^6 counts/sec. The analysis and the conclusions in the study were based on the (erroneous) assumption that the recorded signal does not exceed 3-3.5x10^6 counts/sec. The discussion throughout the entire manuscript has changed accordingly.

line 20: What do you refer to when saying "tolerance of 2ns"? How is tolerance estimated/used?

Answer

As it is now written in the introduction (section 1) the calculated value should not differ from the value used to correct the measurements by more than 2 ns (Grajnar et al (2008)). The appropriate reference has been added.

page 12618

line 4: Same comment as before, can you quantify the time saving?

Answer

As already explained, we were wrong about this. There is practically no timesaving.

line 11: Due to the shape of spectral sensitivity in most MKIIIs lower overall signal level will lead to very dim light at slits 0-2. How do you propose to deal with this?

Answer

Thank you for pointing this out. This is something that we hadn't thought of. Slit 0 is not a problem since it is not used to derive any products. However reducing the lower level for signal at slit 2 would increase the uncertainties. The conclusions have been changed properly since we could not think of any solution for the specific problem.

page 12620

line 20: "Grajnar"

Answer

Done

Figure 2

Remove this plot as it is very misleading. See my comments in the text.

Answer

Figure 2 has been changed and the presented results are now more accurate.

Figure 3(a)

it is not clear how from this result 29ns is any better than 33ns or even 56 ns

Answer

Figure 3, as well as the relative discussion, have changed in order to make the presented results clearer.

Figure 4

Please recalculate the sun data using larger number of iterations and replot

Answer

Figure 4, is changed according to the reviewer suggestion.