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Comment on amt-2021-52

Anonymous Referee #3

Referee comment on "Total ozone column intercomparison of Brewers, Dobsons, and BTS-Solar at Hohenpeißenberg and Davos in 2019/2020" by Ralf Zuber et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-52-RC2>, 2021

This is the first review of the paper submitted to AMTD by R. Zuber et al. The paper is titled "TOC intercomparison of Brewer, Dobson and BTS Solar at Hohenpeißenberg and Davos 2019/2020" and is focused on discussion of the BTS instrumental performance with different optical system setups at two established ground-based stations in Europe. The authors address the benefits and limitations of the new instrument and two algorithms used to process the data. Comparisons against one Dobson and several Brewer coincident observations are discussed in the paper. The authors discuss stray light interference and temperature sensitivity in the BTS-derived total column ozone. Results of comparisons are of interest to the ozone community to understand biases and seasonal dependencies in the established and new ozone observing systems. With the advancement of the geostationary satellite observing systems and the societal focus on understanding air quality impacts on human health and the environment, the high temporal resolution in ozone observations that can provide high accuracy and stability offer support for monitoring ozone changes in the range of minute to seasonal scales and with a hands-off approach. The authors acknowledge the need for future improvements in the data processing and improved modeling of observations instead of look-up tables.

This paper is structured well, addressing various aspects of comparisons. One would wish the authors had a longer period of data at both stations to address seasonal variability. Also, data processing and optical system differences make comparisons and conclusions complicated. Ideally, it would be great to have BTS Solar and Coherent observations done at the same location to compare the performance of both systems and a setup. On the other hand, Hohenpeißenberg and Davos are located at a close distance from each other, and all Brewers have been recently calibrated and therefore should be performing similarly at both locations. Therefore, I would recommend accepting this paper for publication after all comments are answered.

I would recommend that the authors ask for help from an English-speaking colleague to improve the readability of the text.

The authors use the terminology "expanded standard deviation". If it is the same as 2 standard deviations, please add this explanation in the text (or refer to 95 % confidence limits).

Detailed comments:

Lines 14:15. "The array-spectrometer-based BTS systems have been **traceable calibrated** to National Metrology Institutes (NMI) and the used TOC retrieval algorithms" – you should choose either traceable or calibrated. Instead of "used" select "respected" or "both versions of".

Line 16: add "wavelength pair for Dobson" as Dobson does not measure at individual wavelengths (as you discuss later in the text).

Line 18 "deviation of the Solar BTS and Brewer" – did you mean difference from Brewer total column ozone?

Line 19 "deviation" – is it mean bias or standard deviation (one sigma)? You can replace "given" with "caused".

Line 20 – is it continuous drift or seasonal bias?

Consider re-writing the sentences starting from "Resulting", here is one option:

To summarize, the BTS Solar instrument performed at the level of Brewer stability and accuracy during the intercomparison campaign held in Hohenpeissenberg, Germany in 2019/2020."

Line 25 "defined" -> "recognized"

Line 30 "bit no further decline either" -> was either observed?

Line 32 "monitoring of the protocol for the CFC ban" -> monitoring protocol for banned CFCs?

Line 35 "argument why further observations will be necessary" -> "requirement for continuing observations".

Line 37 "when the at that time" -> with the development of the Dobson, built by

Line 38 "A first small" -> "The first small"

Line 50 "Publications about the function of Brewer spectrometers" -> "Publications describing the Brewer spectrophotometer"

Line 57 "newly" -> recently?

Line 65 - (2 and 2x2 wavelengths)? should it be "single or double pair observations"

Line 66 "It is expected that this additional " - Do you have a reference to the paper?

Line 69 "within an intercomparison" -> at the intercomparison campaign and reported by Egli et al., 2016

Line 73 "range of 5 %" - is this error used for the irradiance or total ozone results? If it is for total ozone, then why is 5 % acceptable and not 1 %, which is the goal for direct sun observations at higher SZAs? If the instrument measures poorly at large SZAs, why use it?

Lines 79 and 80. Please make it clear that Dobson was not corrected for artifacts of the stray light. Moreover, only AD-pair direct sun Dobson observations were used in comparisons with Pandora in Boulder, CO that were taken within the acceptable range of air masses that would minimize the impact of stray light observations.

Line 86 "released" -> developed? "quality assessment" -> "assessment of quality"

Line 87-88 "The BTS In terms of solar global spectral irradiance" -> "The accuracy and stability of the BTS's solar global spectral irradiance were compared against the well-established double monochromator-based systems, such as double Brewer and ?"

Line 92 "wavelength" used twice in the sentence

Line 103 "long term" – define how long, i.e. 3 months, one year...

Line 111 "belong as" -> is part of

Line 114 "double Brewer #163"?

Line 137 define "very good calibration-level", please be more specific

Lines 146-150 – if this discussion was to show the advantage of the BTS for faster observations than available in Brewer schedule, it failed after I read the following statement "however usually an averaging of 1 to 5 min is applied" which is similar to 3-min for Brewer integration time. Please modify this section.

Line 160 "in principle a full least square algorithm" – not clear what you are trying to say. The least-square fit to the spectral observations is used to derive TOC? Or "the TOC algorithm is based on the least square fit in the spectral range of 305-350 nm"

Line 162 "validate"? Do you mean test or reduce?

Line 175 "dynamic" -< variability?

Line 176 "maximum 2.5 DU" – but just before that statement, the error is claimed to be <0.8 DU.

Line 196 You are using the climatological profiles embedded in the Libtran software to derive the total ozone column from BTS observations. Since the shape of the profile becomes more important at large SZAs, have you compared standard profiles against the ozonesonde record of Hohenpeissenberg to prove that these profiles are representative

and do not introduce additional errors? In addition, you are using 22 km to derive the airmass factor. How does it compare with the Libtran ozone profile shape?

Line 200 – Does this statement hold for TOC at large SZAs?

Line 213 and again on line 223. How did you select 10 DU as a quality criterion?

Line 219. What is the field of view for the BTS Solar and how does it compare with the Koherent field of view?

Line 234 It could help to introduce an abbreviation for the “least squares algorithm” throughout the paper after you first introduced it.

Line 268 “additionally part”? Do you mean “additional observations during intercomparisons” Or special observations? Please explain.

Line 274 “Exemplary” – are these truly “the best days of the entire field campaign”? Or did you mean “examples of daily variability in TOC observations”?

Line 276 Did you mean “capture the same TOC variability with time/SZA”?

“winter times” -> “winter season” I also see that Dobson was able to capture the diurnal variability of July 9th observations shown in Figure 3, right panel. Although Dobson does not provide continuous observations, it is quite capable of capturing atmospheric changes. Please include this information in the text.

Also, in the legend on the right, the mean ozone value for Dobson is 308 DU. However, based on the data shown in the plot, it seems to be the wrong number – please check.

Also, is it correct that Dobson's observations on July 7th started before 8 am? What was this type of observation, probably not AD direct sun? Dobson data are typically reported in local time. How was the conversion to the UTC done?

You should also add the uncertainty of each observation to the plots to show how different

products compare.

Line 290 or part of Figure caption: "a worse performance" – why was the Dobson instrument's worse performance?

Line 293 "trends"-> results

Line 294 " the least square fit is within 1 % over the whole measurement campaign" – Are you saying that every spectral fit was within 1 % of the observed spectrum or you are saying that the retrieval method that uses the LSF derived the TOC that was within 1 % of the Brewer-derived TOC?

Figure 5 – why is the range of the individual differences (black squares) between Dobson and BTS is small in comparison to the Brewer/BTS comparisons (large spread in blue and green squares)?

This brings the question about the results shown in Figure 4. Does the histogram include the seasonal bias?

I wonder if you remove the seasonal bias (correct Dobson for the effective temperature bias) and repeat the histogram would the Gaussian shape be as wide?

Line 325 "percentual" -> percent?

"overestimation of Koherent of a mean" ->" overestimation by Koherent on average by 1.64%"

Line 327 "in the order as for" -> "comparable to"

Figure 9: Histogram shows two distributions and incorporates the seasonal offset. It is better to show comparisons for each season separately, similarly to what you are doing in Figure 10.

Line 323 "evidenced their performance" -> demonstrated instrument performance

Line 364 "simple modeling" – it would be useful to test the sensitivity of both TOC retrieval algorithms to the ozone profile shape. Most of the TOC retrievals (except in Antarctica during the spring ozone depletion) are not sensitive to the vertical ozone distributions except at large SZAs.

Line 370 change the to The at the beginning of the sentence

Line 377 "relevant atmospheric parameters" – explain what you mean. Are you saying that the retrieval will be improved if aerosols and SO₂ information would be available to constrain the spectral fitting?

Line 378 – "actual atmosphere" -> observed atmosphere

Line 387 "higher latitude"?

Line 392 define "slightly"

Line 402 "linear trend"-> slope

Line 404 "too high" – please define

Line 411 what do you mean by "calibration difficulty"? Please rephrase.

Line 425 and therefore comparable to Dobson?

I did not find information on where the data from these observational campaigns are archived or how these data can be obtained.