Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2017-460-AC1, 2018

Atmospheric Measurement Techniques Discussions

Interactive comment on "Stability of the Regional Brewer Calibration Center for Europe Triad during the period 2005–2016" *by* Sergio Fabián León-Luis et al.

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Received and published: 14 April 2018

We would like to thank Referee1 for all his constructive suggestions and comments. They have been quite useful to improve the paper. We include as additional information in a zip file which contains:

1) Answer-Referee1: Pdf file with the answers to your questions/suggestions.(We also show them here).

2) Stability-diff: Pdf file where all changes are highlighted. Note that it also contains the changes of the other referees.

3) Manuscript-final: Pdf file with all changes introduced (not highlighted)

4) Figures have been modificated in the manuscript, we incluided its last version (.eps).

General Comments

1 Figures

In all the figures a colour legend has been introduced. For this reason, these are slightly different to the previous version of the article submitted.

2 Section 2 "Theoretical approach"

All referee have indicated that the section 2, where an approach to ozone retrieval (DS routine, slits) and Langley-technique are introduced, is confused. Therefore, it has been rewritten taking into account all the suggestions. Also, a new figure has been introduced.

3 Grammatical errors

The authors appreciate the grammatical corrections indicated which have been introduced in the text. A co-worker, who is a native English speaker, has helped us with the use of language. In the new version, some paragraphs and sentences were modified to get a more fluid text .

We have used both "behavior" and "behaviour". In order to have a more consistent article we have replaced the word "behavior" by "behaviour" in the text.

-Similarly, "centre" by "center". - P1, l9: add ...from “two different” methods previously...

done

- P1, l10: it should already be mentioned here that the World Reference is the Toronto triad. **done**

- P2, l5: “on” instead “in”. **done**

- P2, l6: “cause” instead “produce”. **done**

- P2, l9 and in references P20, l4: “Varotsos” instead “varotsos”. **done**

- P2, l9: “. . .. . .which are considered to be reference instruments. . ..” Is not correct. The triads or Brewer #17 are references (or standards). May be “basic instruments in the global network” or similar is better. **done**

- P2, l10: “Brewer spectrophotometers are widely used” since when? **This sentence was rewritten.**

- P2, l12/13: “ozone concentration” is not correct, “TOC” is better. **done**

- P2, l16: Why is “although” used? Better “After the development of the first Brewer in the early 1980s it has had continuous...”**This sentence was rewritten.**

- P2, l21: 70 degrees as limit for single Brewer observations seems small, as it correspondsto μ-values of smaller than 3. Even single Brewers can measure reliable TOC up to 75 degrees (μ-values around 3.5) under normally clear air conditions. Perhaps it would be good, to describe the different stray light issues: internal straylight-problem, which is larger for single Brewers, and external stray light (diffuse sky light around the sun), which is similar for all Brewers, but larger for Dobsons. The effect is the same in both cases: drop of TOC, when the SZA (μ) increases and gets large depending on instrument and turbidity. **This sentence was rewritten. We think that is better to**

say that ".. decrease in the TOC measurement at large ozone slant column"

- P2, l24: The calibration of the Brewer “in the first years” is traceable.

- P2, l31: by the “manufacturer” Kipp & Zonen.**done**

- P3, l5: Add “triad” behind RBCC-E.**done**

- P3, l9: Replace “in the island” with “on the island”.**done**

- P3, l16: “These values have been”.**done**

- P3, l20: “more than 150 Brewers have been calibrated”. **done**

- P4, l13 ff, p5: see under general comments (SO2!). The reference Dobson 1957 is out of place here and I think anywhere in the text. So omit it in the references. The presentation of the corresponding absorption spectra (O3 and SO2) might be helpful.**This section was rewritten**

- P5, l15: DS observations are done in 6, not in 7 slits: 4 ozone, 1 SO2 and 1 dark, the seventh slit is for HG-test. **This section was rewritten**

- P4/5/6: Use of m instead of μ is not correct. **done**

- P6, l7: “clear” instead of “clean”-sky.**done**

- P6, l11: Why does the use of 1/m (should also be μ) allow obtaining two ETCs? I thought it is the splitting in fore- and afternoon observations.This section was rewritten

- P6, l 32-35: no complete sentence. **The sentence was corrected**

- P8, l6: Giving a number for the low standard deviation would be helpful.**done** - P8, l9: “Langley technique can be used” instead of “Langley-technique is used”.**done**

- P8, l18: correct “a an”.**done**

Chapter 4: - P10, 4: “mean of daily differences” or “daily mean of the difference”? **This sentence was rewritten**

- P10,l5: Replace “analyzed” with “analyze”.**done**

- P10, l 10; replace “inconvenient” with “inconvenience”.**done**

- P10, l11 and P11, l11: isn’t Izana a subtropical station? **This sentences were rewritten**

- P10, l15: “another” instead of “other”.**done**

- P11, figure 4: The “A” from Eq. 10 is missed. Shouldn’t it be placed behind “ozone reference value”? The colors are not assigned to the Brewers.**done**

- P11, last section, P12, first section: Sorry, but I have problems to understand what is meant. The beginning of two consecutive sentence with “Therefore” does not sound good. It is described that the polynomial method show similar results regardless of the data set and the order of the fit. Why is then the daily mean method more appropriate? **This paragraph was rewritten**

- P15, Figure 6: The order of the panels does not coincide with the order of the mentioned methods in the figure caption. **done**

- P15, l10: correct “surprissing”. **done**

4 Answers at your specific questions:

The description of the triad system is not profound and clear. Where is the second triad located? In Toronto too? How are this triad and in addition the travelling Brewer No. 17 calibrated? It is good to know how stable the RBCC-E triad is, but what about its accuracy? The agreement between this triad and the World Reference Triad is confirmed by the 0.5% - agreement with #017. But how good is the agreement of #017 with World Reference Triad? When was its last absolute Langley calibration performed? In the introduction we made reference to that

both (World Reference and the Second Triads) work in parallel in Toronto. In order to clarify this questions, a new reference has been included in the text. An oral presentation where is shown some graphic about the agreement between both triads, and also some photos of the Brewers have been added too. In addiction, V. Savastiouk, who operated the Brewer #017, have indicated that“Brewer #017 is regularly compared with the World triad Reference in Toronto it is also absolutely and independently calibrated at the Mauna Loa Observatory in Hawaii, US. Some history of such calibrations can be found at http://www.io3.ca/Calibrations/Brewer/017”.(see interactive discussion of our article.)

P2, l21: 70 degrees as limit for single Brewer observations seems small, as it corresponds to μ-values of smaller than 3. Even single Brewers can measure reliable TOC up to 75 degrees (μ-values around 3.5) under normally clear air conditions. Perhaps it would be good, to describe the different stray light issues: internal straylight-problem, which is larger for single Brewers, and external stray light (diffuse sky light around the sun), which is similar for all Brewers, but larger for Dobsons. The effect is the same in both cases: drop of TOC, when the SZA (μ) increases and gets large depending on instrument and turbidity. Yes, perhaps this value is a very extreme lower limit. This sentence was rewritten. We think that is better to say that "...decrease in the TOC measurement at large ozone slant column".

- P8, l6: Giving a number for the low standard deviation would be helpful. Following the suggestion of other referee this sentence was rewritten "despite this annual behaviour, the ozone presents a lower daily variability as indicated our measurements".

- P8, l17: The criterion lower than 0.6 under item 4 is not clear: standard deviation of 0.6 DU? Seems to be a very low standard deviation for a day with small ozone variation. Yes, this condition was introduced in the article by mistake. It was written in a previous version (internal draft) but it was not deleted from the uploaded article.

- P8, l20: what does “(condition 3 above)” mean in the context with simultane-

ous? Does it mean, that in addition to condition 3, these selected measurements should be simultaneous?. rephrased as additional condition.

- P10, l8/9: what does slight mechanical miscalculation mean? Sorry, maybe this sentence is not the best translation into English. The text has been modified as follows:

Old version: "... it should be noted that the presence of slight mechanical miscalculations in the instrument. . . ."

New Version: "... it should be noted that the presence of small drifts by its continued operation of the instrument. . . ."

- P11, figure 4: The "A" from Eq. 10 is missed. Shouldn't it be placed behind "ozone reference value"? The colors are not assigned to the Brewers A new figure with a colour legend has been upload. The "A" was included in the figure caption.

- P11, last section, P12, first section: Sorry, but I have problems to understand what is meant. The beginning of two consecutive sentence with "Therefore" does not sound good. It is described that the polynomial method show similar results regardless of the data set and the order of the fit. Why is then the daily mean method more appropriate? This paragraph was rewritten because, as you indicate, it is confusing. The "therefore" were replaced by other connecters.

P13, Fig.5: Again the colors are not assigned to the Brewers A new figure with a colour legend have been upload.

- P12 – P15: What about Brewer #183? Tables 3 and 4 (Data set 1) and Figures 5 and 6 show a larger ratio in 2007, which cannot be seen in the graph of Arosa method. Only the table 4 gives a negative shift median and larger percentile numbers for Brewer #183 data set 1. Is the reason known? The same is valid for the larger scattering of all RBCC-E Brewers around 2010. Thank you! If the data in this graph was wrong. We have reviewed our calculations and now the results are more coherent with the previous graphs.

2010: issues on 183, during that time only 157 and 185 were used for reference. In 2010, the brewer #183 had some problem with their micrometer during some months. As in the previous questions, the fit can hide this problem. We have introduced this reference where some plot about this are shown. *Roozendael, M. V., Köhler, U., Pappalardo, G., Kyrö, E., Redondas, A., Wittrock, F., Amodeo, A. and Pinardi, G.: CEOS Intercalibration of Ground-Based Spectrometers and Lidars: Final report. http://repositorio.aemet.es/handle/20.500.11765/8886 (Accessed 5 April 2018), 2013.*

- P14, l9 (and in abstract too): Where do the numbers for the RBCC-E triad come from? I cannot find them in the tables. The values are the serial numbers of the brewer

- P14, l10: how is 40% lower dispersion determined? This value was calculated as the ratio between both relative deviation (0.47-0.27)/0.47=0.42

- P14, l12: Is the 0.3% value for RBCC-E also calculated in the 2004 – 2012 period of the Stübi-paper We're sorry, but we cannot calculate that data. As we indicated in the introduction, brewers # 183 and # 185 were installed in 2005, hence there is not available data in the year 2004. In the article, the value reported corresponds with the period 2005-2016. In addition, it can be confusing to give values that do not correspond with the years defined in the datasets.

- P15, Figure 6: The order of the panels does not coincide with the order of the mentioned methods in the figure caption. We have rewritten the Figure caption in the correct order.

- P15/16: The explanation for the larger scattering at high sun is good and comprehensible. But the obvious difference of low sun in the forenoon and in the afternoon is neither mentioned nor explained. Is there also an explanation, why Brewer #183 shows larger scattering in the relative difference than the other two Brewers? Honestly, we think that the Brewer \#183 presents this large scattering because it was damaged in 2007, during the "Delta" storm and during 2008 it had an

irregular behaviour and this data was used in this analysis. In addiction, this difference is minimal or negligible and does not affect the calibration of the Triad. Moreover, this result is consistent with those presented in tables 3 and 4 where it is found that brewer 183 has the poorer values. It seems logical to think that if in average values (daily or monthly) this brewer is the worst, also depending on the SZA this difference is reflected.

- P16/17: The values in table 5 are not clear. Where do they come from? Fioletov daily of 0.47% is mentioned on P16, l8. In the same context the RBCC-E triad number is given as 0.41% in the Conclusion, but as 0.37 in the table, which is confusing.

In order to clarify this question, a new table was generated.

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2017-460/amt-2017-460-AC1-supplement.zip

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-460, 2018.