Reply on RC2
Gérard Ancellet et al.

Author comment on "Homogenization of the Observatoire de Haute Provence electrochemical concentration cell (ECC) ozonesonde data record: comparison with lidar and satellite observations" by Gérard Ancellet et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-7-AC2, 2022

Response to Reviewer 2

This document describes our responses to reviewer's comments and a revised version of the text attached to this response shows the new figures, the text changes in red and the deleted sentences using strikethrough text

This is an excellent paper, as I would expect from such an expert group of authors. It is a welcome addition to the global effort to re-evaluate ozonesonde records, and certainly appropriate for publication in AMT. I have just a few points that the authors should address before publication.

We warmly thank the reviewer for his/her suggestions and comments. We have modified figures 6 and 9 to 11 to add new data for a better characterization of the bias between homogneized ECC and other measurement techniques in the stratosphere. A careful copy editing of English writing has been made. The revised version of the text attached to this response shows the changes in red and the deleted sentences using strikethrough text

My major issue is with the confusing way that uncertainty is discussed, and often carelessly referred to as "error". For example in Section 3, 4.2 and Figures 5 & 6. The term "error" seems to be used interchangeably with "uncertainty". They do not mean the same thing, and in most cases where "error" is used, I think the authors mean "uncertainty". Since error is the difference between the measurement and the true value, No doubt the authors in fact mean the ECC (random? systematic? overall?) uncertainty. This is made worse by Figures 5b and 6b, where the captions to 5a and 6a state "Shaded areas represent the error on the mean difference." The text calls this an uncertainty. I expect the shaded areas should be described as confidence intervals, and it should be stated whether they show one standard error (more properly standard uncertainty) of the mean, or two (the latter being a conventional 95% confidence interval). If in fact they are standard deviations, then that should be stated.
We apologize for the confusion due to the inappropriate use of the word error in several sentences. We agree with the reviewer that error should be often replaced either by uncertainty in section 3 and 4.2 or confidence limit in section 4.4. It was corrected in several sentences. Captions of figure 5 and 6 have been also corrected. Description of the shaded area in Fig. 5 and 6. are now described by the following paragraph in section 4.2 line 188: "The uncertainty of the mean difference in a 1.5-km vertical interval for a single O₃ profile is based on mean absolute uncertainties (systematic and statistical) of both lidar and ECC measurements (see section 2 and 3) at each recorded altitude in the corresponding 1.5-km vertical interval. The statistical standard uncertainty of the overall mean difference is then retrieved assuming that the 40 comparisons are independent with uncorrelated uncertainties.”

The following sentence is also added in section 3 line 153 to clarify how the trend confidence limits are calculated:

"The trend uncertainties are calculated using the 95% confidence limit of the slope of the linear regression assuming that the residuals are not correlated for weekly (ECC) or 2/3 per week (lidar) observations."

The persistent 5% bias compared to total ozone measurements is larger than is seen at most stations, and quite surprising (and disappointing) after thorough homogenization. I think it deserves more discussion, perhaps in the context of Dr. Stauffer’s recent work, or JOSIE results. Are other stations just lucky, or are there undiagnosed problems with the OHP time series?

The total ozone measurement calculation method are now identical in section 4.1 and 4.3 and the negative bias with OHP SAOZ total ozone measurement decreases down to -3.7% (Fig. 4). This bias is also smaller (-1%±2%) for the comparison with satellite TOC observations (Fig. 8 now 9). Comparison with LiO3St is now also made with a larger data set of 366 sondes launched within 12 hours of the LiO3St observations during the 2005-2021 observing period of MLS (see new figure 6). For this data set ECC-LiO3St is only -2% in the 22-26 km altitude, while ECC-MLS and ECC-LiO3St do not have the same sign after the homogenization. So the homogenization did improve the data quality in the stratosphere. The following paragraphs are now included in section 4.2 line 217:

“ For the period 2005-2021 and using a time difference less than 12 hours, the negative bias between the homogenized ECC and the lidar decreases down to -2% between 22 and 24 km, but remains as large as -7% above 28 km (Fig.6b).”

and section 4.3 line 258

“The fact that the average ECC-MLS difference shown in Fig. 6b is slightly positive (+2%) in the 22-26 km altitude range, while the average ECC-LiO3St difference is slightly negative (-2%) means that homogenization is a good compromise for intercomparability with other techniques measuring O₃ in the stratosphere below 26 km. Above 26 km, both comparisons indicate a negative bias in homogenized ECC O₃ concentrations of less than -6%.”

The following paragraph has been added in the conclusion line 359 to compare our results with the benefits of homogenization performed in the SHADOZ network and in the Uccle/De Bilt sites in Europe:

“While the objective of this paper is to discuss the impact of homogenization on the OHP
dataset using lidar and satellite measurements, it is worth checking how such corrections have improved data quality at other sites. The impact of the homogenization is dependent on the site, because different homogenization steps have to be applied at different stations. In general, the additional corrections for the pump temperature will give higher ozone partial pressure amounts in the stratosphere. On the other hand, applying a constant background current subtraction instead of a pressure dependent background current and applying the transfer functions from EnSci-SST 1% will lead to lower ozone partial pressure values above 10 km. Witte et al. (2017) performed an extensive analysis of 7 SHADOZ network stations in the tropics, showing that the mean differences between ECC and MLS are reduced from -11.2±13.6% to -3.0±10% at 40 hPa (22 km) and from -3.2±4% to -0.7±3.1% at 17 hPa (28 km). In Europe, Van Malderen et al. (2016) observed that the O3S-DQA corrections actually give higher (+1%) and lower (-2%) ozone concentrations in the stratosphere with respect to standard processing for the Uccle 1997-2014 and De Bilt 1993-2014 ECC observations, respectively. This is mainly due to the fact that the pump temperature correction was a major correction for Uccle, while changing the background current correction has a major effect for De Bilt. O3S-DQA corrections reduce the relative O$_3$ difference between Uccle and De Bilt in the lower stratosphere. The analysis of homogenized ECC at OHP using LiO3St or MLS show similar improvements in the stratosphere below 26 km. The remaining bias of -2% to -3.7% between homogenized ECC and other techniques measuring O$_3$ in the stratosphere at OHP is also in the range of the remaining negative differences between homogenized ECC and MLS observed in the 22 to 28 km altitude range by 4 stations of the SHADOZ network (Witte et al., 2017).

Minor points:

Section 2: Were the OHP ECC data ever normalized to a total ozone measurement? (The Brewer-Mast data would have been.) In any case it would be worth stating here explicitly that the homogenized data are NOT normalized, even though a normalization factor is calculated.

This is correct there is no normalization. This is now said explicitly in section 2 line 97. "The homogenized data are not normalized with this normalization factor which is only used as a quality flag”.

Line 60: "No more vertical smoothing of the ozone partial pressure”. This seems to imply that this was done before. Correct?

Yes it was. Text is now "No more vertical smoothing of the ozone partial pressure while smoothing over 100 m was applied in the uncorrected data"

Line 67: “Only Komhyr86 is applied for the current to PO3 conversion of uncorrected data.” Do you mean that Komhyr86 was used for both sonde types previously?

Yes. Text is now: “Komhyr86 was applied for the current to P$_{O3}$ conversion of all the uncorrected data.”

Line 69-70: No, we don’t see that. There are too many points, many of them overlapping, to tell by visual inspection whether there is a trend. Please put a regression line through them.

The regression line would not be very useful here. Text has been changed in section 2 line 71: "The comparison of I$_b$ used before and after homogenization is shown in Fig.1. The standard deviation of the background current between 1991 and 2021 remains on the order of ±0.05 and only 17% of the I$_b$ values are greater than the mean of the uncorrected I$_b$ after homogenization.”
Lines 96-99: How is the uncertainty calculated? At least a brief description is necessary, and/or a reference to a comprehensive description.

Reference to Smit et al. (2021) has been added. Text in section 2 line 103 is now: “The detailed description of the uncertainty calculation is given in [cite{Smit2021}]. All the error terms have been included in our calculation except the bias due the sensor time response and the pressure uncertainty.’’

Line 117: I presume this is the correction proposed by the BIPM (which is now 1.23%, not the 1.8% suggested originally).

It is now said less than 2%

Line 155: "normalization factor NT": this should be defined.

It is defined in section 2 line 93

Line 174: “...assuming an independent error for the 40 comparisons taken into account.” Do you mean “...assuming that the 40 comparisons were independent, with uncorrelated errors.”?

Yes Text was changed (see answer to major comment #1)

Line 178: "It is due to the difference...” These are processing differences --- not really errors, especially since the assumption of a constant background current is also wrong (e.g. ASOPOS 2.0 report).

Yes we agree, wording is changed section 4.2 line 96: “It may be explained by differences introduced by not correcting the O₃ partial pressure for EnSci-SST 1% and by using a pressure dependent background current subtraction”.

Line 228-229: "No post 2013 drop off in TOC measurement by the ECC is seen at OHP as observed at other measurement sites in Stauffer et al. (2020). " Really? From your own Figure 8, I’d estimate the dropoff at about 2%.

Text has been changed in section 4.3 line 267 by:“A small post 2013 drop-off in TOC measurement of -2% by the ECC at OHP might be present, but is considerably less prominent than the drop-off observed at other measurement sites in Stauffer et al. (2020)”

Figure 8: Is the difference sonde-satellite or satellite-sonde?

Text line 224 (now 263) was correct but caption of Fig.8 (now 9) was indeed wrong. Fig.9 caption is corrected.

Line 230-231: “The differences are mostly negative and between ~4% and 1% after
homogenization. So the satellite/ECC TOC comparison is consistent with the time distribution of the normalization factor shown in Fig.4.” Not really --- the normalization factor averages 5% difference. I agree that Figure 8 (lower) looks pretty good. So what’s with Figure 4?

The difference in TOC between the ECC and the satellite is on the order of -1%±2%, thus effectively less than the average difference between the ECC and OHP TOC observations. As explained in response to major comment #2, the difference is less with the new ECC TOC calculation in section 4.1. The following sentences are now included in Section 4.3 line 270: “The ECC minus satellite TOC temporal evolution is consistent with the time distribution of the normalization factor shown in Fig.4. However TOC differences are close to zero between 2010 and 2016 using the satellite data, while a -3% bias is present using the OHP total ozone measurements. In this context, we mention that the expected bias between GOME and SAOZ is between -3% to +1% (Hendrick et al., 2011)”

and in the conclusion line 347: “Differences between TOC measured by ECC and by GOME or OMI/OMPS switch from 2%±2% for uncorrected ECC to -1%±2% for homogenized ECC. The negative bias is then smaller than the -3.7% obtained with the OHP TOC measurements, even though the time evolution is consistent with the $N_T$ time distribution”

Please also note the supplement to this comment: