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Interactive comment on "Accuracy, precision, and temperature dependence of Pandora total ozone measurements estimated from a comparison with the Brewer triad in Toronto" *by* Xiaoyi Zhao et al.

Anonymous Referee #1

Received and published: 10 October 2016

Review of the paper by Xiaoyi Zhao et al. titled "Accuracy, precision, and temperature dependence of Pandora total ozone measurements estimated from a comparison with the Brewer triad in Toronto." This is a well written paper that describes operations of several Brewer and Pandora instruments in Toronto, Canada during 2013-2015 time period. Pandora instrument does not rely on traditional methods of calibrations (i.e. use of a reference instrument traceable to the standard or Langley plot analyses), and thus it is imperative to evaluate accuracy and stability of its ozone product. Authors took advantage of co-located Pandora/Brewer datasets to evaluate the performance of Pandora-derived total column ozone with reference to the Environment Canada and Climate Change Brewer single and double reference instruments (so called triad).

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Discussion paper

Several approaches were developed to minimize effect of temporal ozone variability that can result from non-coincident measurements in compared datasets. In addition the stray light of Pandora was evaluated by comparisons against the single and double Brewers. Instrumental differences were addressed by comparing two Pandora instruments with 6 Brewers that vary by level of the stray light rejection. Stratospheric temperature sensitivity of Pandora total column ozone retrieval is assessed by comparisons against Brewer instrument, which is designed to use spectral channels that exhibit low sensitivity to variability in stratospheric temperatures. Corrections were derived and the reduction in the seasonal biases and offsets from the Brewer instrument were demonstrated. The results of this paper findings are also compared to other published comparisons of Pandora and it's evaluation of the temperature sensitivity in retrieved ozone column. The plots and tables are clear. Proper references are given to prior publications.

This paper should be published after several adjustments

p. 6, line 7. "model" should be replaced by "define" because word "model" usually means simulation of the ozone with a software and thus the beginning sentence in this section is confusing for the reader. "We define the small scale variability in the Pandora and Brewer observed TOC time series ()..." as a linear combination of the true ozone variability and the ..."

p. 6 lines 14-15, variance around annual mean or monthly mean or daily mean?

P 6 , line 26 is it daily mean difference?

p7, line 7. to remove variability - add daily in front of variability

p 7. Line 12-14. Are TCO measurements selected for each day and then compared to the daily mean for that day (mean(TCO lof-f(t)), where t is the time of individual TCO measurement for each day)?

p.7 line 22-24. Does equation (8) fitted to Brewer and Pandora data separately or all

data are aggregated and sorted by time to fit this equation?

p. 7 line 26 Add (Eq. 7 and Eq. 8) after " residual ozone "

p.7 line 27 – please give more details about "statistical variable estimation method" you use and reference. If you need more space you can use Appendix. It is hard to follow your approach without knowing how it was applied. The point here is that the paper should be written in such way that anyone can repeat your calculations and get the same answer.

p. 7 line 28 Add Table before 2

p. 7 lines 30-32. Please add more description on how you get your estimates of random error. Do you use Eq. 7 or Eq. 8 to calculate variance for B and P to get σMb and σMp? Do you use difference between dB and dP where dB and dP are residuals to get σMb-Mp ? How do you match B and P data in time? Not sure if the difference in panels a) and c) in Figure 2 is caused by the fit of Pandora time matching to Brewer measurements or interpolation of infrequent Brewer measurements to Pandora high frequency measurements.

p.8 , line 17-19. Is the lower random uncertainty for Pandora a result of the more frequent measurements as compare to Brewer?

P.8, line 21 – this is the first time that it is explicitly explained that residuals are used for analyses. It is better to do it at the beginning of the section 3.2.

p.8 line 23. For the type 1 fit the residual variability is a natural variability in ozone during that day, yes? Not clear in the text.

p. 11 lines 17-18. Herman et al. used temperature and ozone climatology, but interpolated climatological ozone profile to the observed TO in order to capture day-to-day variability.

p. 13 lines 30-32. How does global ozone variability compares to ozone variability over

Toronto?

Table 3 . It might be useful to have a temperature sensitivity for each Brewer listed in the Table. It could help to understand variability in results of comparisons (i.e. Figures 7, 10 and 11) when comparing Pandora to different Brewers.

Figure 1. The colors overlap, and it is hard to discern data for individual Brewer or Pandora. Would it help to plot comparisons as difference (from the mean)?

Figure 2. panel c) The difference in random uncertainties shown in red (Pandora #104) and black symbols (Pandora #103) is the largest when comparisons are done with Brewers #8,14 and 15, but not with # 145, 187, 191. Is it something to do with the first set of Brewers being single and the last three in the plot are double instruments? Is it discussed in the paper? You discussed differences in the uncertainty estimates due to lower sample available for comparisons of Pandora #104. However, when comparing to Brewer 191 both Pandora retrieve the same uncertainty when using method type 1. Please provide an explanation. Is it something to do with Brewer temperature sensitivity of stray light interference. . .

Figure 5. panel b) although the seasonal variability is reduced after applying temperature correction, there seems to be a large spread in the remaining data. Since Brewer #14 is a single Brewer – there may be a stray light interferences that contribute to the range of the daily Delta Ozone differences (vertically grouped dots). Is it possible to repeat these comparisons but use double Brewer data to test is the spread will be reduced?

Figure 7 and corresponding discussion on page 11. The tests are described, but no further conclusion is made on how these test change the values or uncertainty bars. Can you please add further discussion of how the choice for different combined and individual data sets can impact the derived Pandora RTDFs and biases. It can be discussed in regards to the instrumental parameters (single vs double) and sampling limitations.

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