Interactive comment on "Quality assessment of the Ozone_cci Climate Research Data Package (release 2017): 1. Ground-based validation of total ozone column data products" by Katerina Garane et al.

Anonymous Referee #1

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General Comments:

Data records of satellite borne instruments are only temporary in contrast to most of the ground based total ozone column (TOC) records. Thus the development of a method to compare the available satellite records and to merge them to create a long term, homogeneous TOC data set, is a very valuable contribution to the monitoring of the ozone layer. This publication gives a very good description of the validation of such merged data records with ground based records of Dobson, Brewer and SAOZ instruments.

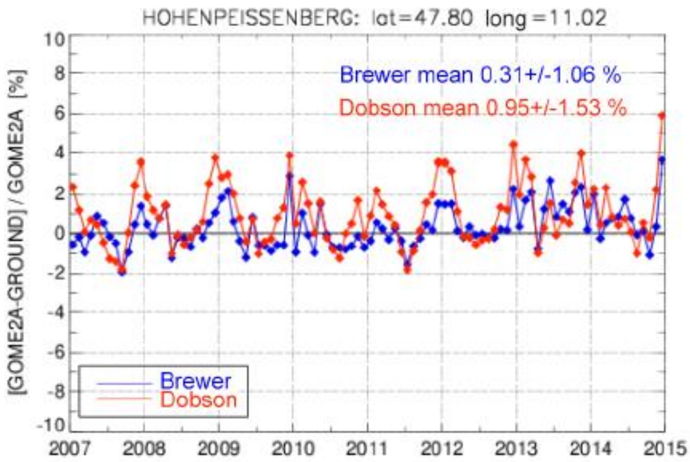
Specific Comments:

1. **Comment:**
   It should be mentioned that the used Dobson and Brewer TOC data records are still based on the "old" Bass and Paur ozone cross sections, whereas it seems that the satellite data are produced using the new ozone cross sections (Bremen, IUP?), good place for this explanation would be page 7 after line 25.
   REPLY:
   The explanation is added in section 2.3, as suggested. Thank you.

2. **Comment:**
   Dependence on effective temperature of the Dobsons (p 5- 6): Basher 1982 is not an appropriate reference, as it was written, when the ozone cross-sections after Vigroux had been valid. Current data sets are processed using Bass and Paur. Better and up to date references for this issue are: Koukouli et al., 2016 (cited later in the text, page 7) Scarnato et al., 2009: Temperature and slant path effects in Dobson and Brewer total ozone measurements, Journal of Geophysical Research: Atmospheres, Vol. 114, Issue D24 Kerr, J. B., I. A. Asbridge, and W. F. J. Evans, Intercomparison of total ozone measured by the Brewer and Dobson spectrophotometers at Toronto, J. Geophys. Res., 93, 11,129– 11,140, 1988. Kerr, 2002, New methodology for deriving total ozone and other atmospheric variables from Brewer spectrophotometer direct sun spectra, JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 107, NO. D23
   REPLY:
   The references are added. Thank you for the suggestions.

3. **Comment:**
The use of SAOZ might be seen a little bit problematically with its accuracy of 6% (page 6)
REPLY:
While this overall accuracy is poor in comparison to that of the direct-sun instruments, the added value provided by the SAOZ instruments is their ability to produce reference measurements at those locations and times-of-year where and when the satellite measurements occur under low-sun conditions and no reliable direct-sun measurements can be made. As such, they allow the validation of an otherwise inaccessible satellite measurement regime. This point was already made in the paper.
Moreover, it must also be noted that a significant fraction of this 6% total accuracy is made up of the (systematic) uncertainty in the O_3 cross sections (3%) and by the impact of clouds (3.3 %, Hendrick et al., 2011), both of which are of minor importance in differential analyses of cloud-free data. This note was added in the paper, in Section 2.2.

4. **Comment:**
On page 12 a correction for the Izana record due to the altitude is mentioned. Such a correction should make sense for other mountain stations too, especially when they are more or less isolated compared with the 150km footprint of the satellite data. A first guess of correction would be +0.1% per 100m difference of station altitude and environmental altitude. There are some mountain stations with significant differences (e.g. Arosa, Hohenpeissenberg, Mauna Loa). This information can be included in the tables S1 – S3.
REPLY:
The mentioned correction for the SAOZ measurements is an ERA-Interim-based estimate of the column below the instrument altitude in the immediate vicinity of the island and/or mountain top (see Verhoelst et al, 2015 for further details). For the SAOZ/ZSL-DOAS network, Izana and Jungfraujoch are the only stations for which a significant missing column was derived with this methodology (about 2.8% and 3.2% respectively, with some seasonal variation), due to their isolated mountain-top locations.
As for the ground based measurements performed by Dobson and Brewer spectrophotometers that are used in this work, since they are downloaded from the WOUDC database we are not able to correct them for the altitude issue, as suggested. Nevertheless, we can use the information to identify any discrepancies seen in our figures.
Furthermore, as seen in Koukouli et al. (2016), when a high altitude station like Hohenpeissenberg (where the gradient is not very steep and the instrument is exceptionally maintained and calibrated) is used, the satellite-to-ground comparison is excellent (Brewer bias ~0.3% and Dobson bias ~1%, see figure below). For the Mauna Loa station (10° - 20° N), on the other hand, where the gradient is much steeper, the satellite-to-ground comparison is about 2-4%. However, when considering zonal means of the differences, where all available stations in each belt are included in the calculations, the effect of the station altitude becomes less evident, which is the case for the 10-20° N belt in Figure 5 – panel (a) where Mauna Loa and Bangkok are co-calculated.
Thank you for the suggestion about this issue, we will take it seriously under consideration and use it as basis for a future study.
Some more information on the SAOZ measurements' correction is added in the manuscript, in section 2.3. We have also added the altitude information for each station in the Tables S1 – S3.



Koukouli et al. (2016) – Figure 1.

5. **Comment:**
Addition information in these tables about the lengths of the records would be informative, as not all stations have measured from 1995 to 2017.
REPLY:
We have added the time period for each ground based station in the Tables S1 – S3.

6. **Comment:**
The explanation on page 9, why the SZA-dependence for the Dobsons are not drawn is misleading. As reason a high correlation between Dobsons' large stratospheric effective temperature dependence and the SZA is mentioned. This correlation is physically not correct. The SZA of daily means of TOC is larger during winter season, when the sun is not very high. In addition in winter the Teff is lower than the used -46 degree Celsius. Thus it is an indirect correlation, which is e.g. not valid during summer season, when Teff is "normal" and Dobson TOCs drop at very high SZA (mue> than 3.5 depending on turbidity) -values because of straylight effects but not because of temperature dependence. In any case it is justified not to use Dobson data at SZA larger than 75 degrees, even if they were available.
REPLY:
Thank you for the suggestion. We agree with the comment and we have added two plots (SH and NH) in Figure 4 (and the respective comments) showing the dependence of the satellite-to-Dobson comparison on SZA. As for the cut-off at 75°, we did not apply it because the SZAs used for the binning and the plots are the satellite SZAs, since we use daily means of the ground based measurements. We have also added a sentence in section 2.3 making this clear.

7. **Comment:**
In figures 4, 5 and 10 Brewer observations are drawn above SZA of 75 degrees. The slant path mue of these measurements are larger than 3.5. Observations with larger mue-values

are not accurate enough, especially when using single Brewers. Double Brewers might be able to measure up mue = 4, before the TOC drops (reason see Dobson explanation of straylight effects in the bullet point before).

REPLY:

Thank you for the suggestion. As explained in the previous comment, please note that the SZAs used for the binning and the plots are the satellite SZAs, since we use daily means of the ground based measurements.

8. **Comment:**

Concerning the seasonality of SAOZ-difference mentioned on page 9 and seen in figure 3: Is there an explanation for this pattern?

REPLY:

It should be noted that seasonality seen on Figure 3 are observed at all latitudes and all instruments but,

i. the amplitude is larger in NH compared to SH on both SAOZ and Dobson
ii. the amplitude is larger with SAOZ compared to Dobson and Brewer
iii. the amplitude varies with the satellites, the largest being with GOME and SCIAMACHY in Northern hemisphere.
iv. the strongest minima are observed in the winter particularly on the difference between SAOZ and GOME.

The seasonality can be attributed to:

i) the cross sections dependencies on the effective temperature of the stratosphere impacting all measurements in the UV but not SAOZ analyzing in the visible.
ii) the number of stations used in the statistics in winter, limited in latitudes for Dobson and Brewer but being possible at higher latitude for SAOZ.

The SAOZ seasonality observed on panels (d) and (e) of Figure 3 comes from the latitude of the selected stations, which, in the case of SAOZ, allows to perform comparisons in winter at high latitude when the effect of the temperature on UV cross section is the largest.

We have modified the respective paragraph commenting on panels (d) and (e) of Figure 3, in Section 2.3, to give a more clear explanation of the seasonality effect.

Technical corrections:

1. In references Serdyuchenko on page 26 "‐ Part 2" is written instead of "- Part 2".
2. Kerr et al. 1988 is cited on page 5, line 18, but cannot be found in the references.

REPLY:

The references are corrected/added. Thank you!