The authors would like to thank referees for the time and effort to review this paper. It helped us to revise the manuscript to make it clearer and more concise. We have addressed all the referee comments as described below. The referee comments are shown in black and our responses are shown in blue (also italic).

Reviewer 2 comments

General comments:

The Authors present reprocessed, homogenized and overall improved datasets containing long-term Umkehr retrievals of Ozone profiles derived using measurements from Dobson spectrometers. The dataset is then formally compared against several satellite records while considering the Averaging Kernels of the Umkehr retrievals. The manuscript is quite long but comprehensive, and would serve as valuable reference for future works in this subject.

The implementation of the method is not trivial and probably beyond the current capacity of other groups operating Dobson spectrometers. Nevertheless, this work demonstrates the added value of these observations and their usefulness in the future. As improved instruments, algorithms and spectroscopy arise, long-term historical records such as those presented here become more important as benchmark in monitoring the history and evolution of the Ozone layer.

This manuscript fits well within the scope of AMT. Therefore, I recommend its publication after addressing the comments of Reviewer 1 and some of the comments and corrections below.

Specific comments:

Most of the figures are well-made, legible and contain the right amount of information. The Red and Green lines/markers can be difficult to distinguish for some readers (e.g. Fig. 1, 2, 4 ,5, etc.), but I think they are still bordering on OK in the plots where they appear. Some of the figure captions need to be checked for typographical errors.

Thank you for your comments regarding Figure colors. We addressed your concerns with changing the pure green and red colors to more color-blind acceptable hues.

We also updated Figure captions and checked for errors (please see figures in the revised manuscript).

P.9, Line 84: On the step change in the GMI CTM: I would suggest to provide at least one sentence of explanation on what this step change is, and why it happened.

Th reviewer is probably referencing text on Line 284 on page 9.

We addressed reviewers comment and modified the text.

“The step-change in the GMI CTM ozone record in 1998 was documented (Stauffer et al, 2019 and references therein). It was a result of the introduction of microwave radiance observations from a series of Advanced Microwave Sounding Unit (AMSU) sensors into the MERRA-2 observing system (Gelaro et al. 2017). The 1998 change as well as the addition of MLS temperature assimilation in the upper stratosphere in 2004 strongly impacted the MERRA-2 dynamical fields (Gelaro et al., 2017; Long et al., 2017).

We also added the reference below to the list of references.

Long, C. S., Fujiwara, M., Davis, S., Mitchell, D. M., and Wright, C. J.: Climatology and interannual variability of dynamic variables in multiple reanalyses evaluated by the SPARC Reanalysis Intercomparison Project (S-RIP), Atmos. Chem. Phys., 17, 14593–14629, https://doi.org/10.5194/acp-17-14593-2017, 2017.

P.10-11, Lines 325-325: The description of the Dobson optical system needs some revision, as already noted by Reviewer 1. Perhaps it is also worth to mention that the Dobson spectrophotometer is a double monochromator. Also important: the optical wedge attenuates the long wavelength signal, the Q-levers indicate the positions of the wavelength pairs (A, B, C or D), which depend on the temperature inside the instrument. The photomultiplier registers the alternating signals from the short wavelength, which is absorbed by Ozone, and the long wavelength attenuated by the optical wedge, resulting in a measureable current.

We appreciate comments from both reviewers with regards to the description of Dobson optical system description. At the beginning of section 3.1 we state that Dobson consists of two monochromators, thus it is a double monochromator. Here is the modified text.

"The Dobson consists of two monochromators and a slit plate for selecting two bands (pairs) of the UV solar spectrum approximately 20 nm apart. The Q-levers indicate the position of the wavelength pairs (A, B, C or D), which also depends on the temperature inside of the instrument. The photomultiplier tube registers the alternating signals from the short wavelength, which is absorbed by ozone, and the long wavelength attenuated by the optical wedge, resulting in the measurable current (see Komhyr and Evans, 2006 for further details)."

Also, in Section 3.1., The Umkehr N-values need a better explanation for the non-specialist reader.

Thank you for your comment. Section 3.1 is concerned with the measurement uncertainties in Dobson system. The Umkehr measurement technique is described in the Introduction section (line 72-86). We adjusted one of the sentences to add N-value definition.

"The **logs of** ratio of the observed radiances **(also called N-values)** increase with increasing SZA and at about 86° SZA reverse and starts to decrease up to 90° SZA, which grants the observation its name since "Umkehr" means reversal or change in German."

P.13, Section 3.3, First Paragraph

This is a long paragraph that could be divided into two or three paragraphs for easier reading.

Thank you for suggestion. We split the paragraph into two to separate the description of the forward model simulations.

Also, the Authors mention that the Umkehr N-values are simulated for an idealized Dobson instrument. So, I would like to ask:

Please see responses below questions.

1. How far or close to ideal are the Dobsons used here?

   There is no ideal Dobson. We replaced the "idealized" with the "generic". The word "idealized" is used here to refer to the slit function published by Komhyr (1993). The experimentally determined slit functions of the Dobson 083 instrument can be described as a triangle and trapezoidal shapes. The mapping method did not provide information about the out-of-band light rejection. Most Dobson instruments have very similar core band-passes as discussed in Kohler et al. (2018) paper. However, the nominal slit functions do not include the information about the out-of-band contribution of the light scattered into the instrument. As written in

Section 3.1, the full mapping of the band-pass of each instrument is rarely done as the focus of the Dobson network is on the total ozone observations that are limited to SZAs where contribution of the stray light is minimal. However, Umkehrs are using observations at low SZAs where contribution of the stray light becomes significant to offset simulations in the forward model that is using only the core band-pass information. The omission to include the contribution of the out-of-band light can create a vertically distributed bias (approximately +/- 5 %) in the Umkehr retrieved ozone profile (Petropavlovskikh et al., 2011).

2. Do the stations keep a record of the instrument characteristics mentioned in Sec. 3.1 (slit functions, response, etc.)?

   Not to my knowledge. As mentioned above, slit functions of only several Dobson instruments were mapped so far with the laser beam (Komhyr, 1993; Kohler et al, 2018). The mercury lamp tests are used monthly to assure that the slit spectral positions are not drifting away from the center of the nominal bandpass. If the drift is detected, the changes to the Dobson operations are adjusted and spectral stability of the instrument is verified during intercomparisons with the standard instrument.

3. Would it not be useful to include a Figure of these characteristics, perhaps in the Appendix?

   We do not have a full slit function for Dobson instruments at the analyzed station. The impact of the best-guess out-of-band light contribution to Umkehr profiles retrieval errors is already discussed in Petropavlovskikh et al. (2011) and Evans et al. (2009). We decided that due to the already long appendix, it is better to provide references to the published papers and let the reader read the discussions provided in those papers.

Appendix C: Umkehr Averaging Kernels:

It would be interesting to know the Degrees of Freedom for Signal (DOFs) as defined in Rodgers (2000). I think this should be an easy calculation.

Thank you for the question. The Umkehr method has between 3 and 4 degrees of freedom. It varies slightly with season and latitude of the station.

Technical corrections:

In addition to the comments of Reviewer #1, I would like to add these below.

Authors thank reviewer for finding errors throughout the manuscript

P.7, Line 211: COH acronym not defined

This is difficult to correct as COH is the name of the dataset.

We changed the sentence to the following

"The second record is **the NOAA COHesive (COH)** data set that combines records data from the SBUV/2 and OMPS (NOAA processing, further referred to as OMPS_NOAA) instruments on the many satellites using correlation-based adjustments providing an overall bias adjustment plus an ozone dependent factor (SPARC/IO3C/GAW. 2019)."

P.11, Line 355: "It is" -> "This is"

We made the change.

P.11, Lines 335-337: The sentences may need some revision, so that the non-specialist readers do not think that the original method used a Laser.

Thank you for the suggestion. We removed the sentence. The text now reads

"The measurement of a Dobson slit function is not a simple task. The original method used a model 783 McPherson spectrophotometer to determine he slit functions for Dobson 083 (Komhyr et al, 1993). The method restricted the slit function to the core band-pass and did not provide information about out-of-band light rejection."

P.11, Line 37: „Komhyr and Evns, 2006" -> Komhyr and Evans, 2006

Done

P.21, Line 76: space missing between the period and "This means that the retrieval is…."

Corrected

P.23, Line 725: "NRL climatological" -> NRL climatology

Corrected

P.35, Figure 1: The caption for c) is quite confusing, especially with the usage of multiple ")". Perhaps this can be simplified to:

"c-d) Standard deviations for the mean biases shown in panels a) and b). OPR is operational, and SLC is standard stray light correction."

Thank you for suggested improvement. We adopted your text.

P.37, Figure 4 Caption: "compare operational" -> "compared with operational"

Thank you , we made a correction in the Figure caption.

P.37, Figure 4 Caption: Is it "13-months running smoothing" or "13-month running average"?

Thank you , we made a correction.

P.37, Figure 5 Caption: "(old 6) a" seems misplaced.

Thank you for noticing the error. We removed the confusing reference.

References need to be checked, e.g. Rodgers (1990, 2000) are missing.

Thank you for letting us know we did not include reference to the Rodgers papers.
These references were added, and we checked for other missing references.

Citation: https://doi.org/10.5194/amt-2021-203-RC2

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