Review of "Total ozone column retrieval from OMPS-NM measurements" by Orfanoz-Cheuquelaf et al.
Anonymous Referee #2

This paper presents a modified version of the WFDOAS algorithm to retrieve total ozone columns from the OMPS-NM instrument. The ultimate goal is to combine the nadir and the limb OMPS instruments to derive tropospheric ozone columns. In addition to the realized algorithmic developments, the study also investigates the quality of the retrievals by comparing them with ground-based data as well as with independent OMPS and TROPOMI retrievals.
The topic of this work fits well for AMTD and, from the presented results, the product quality appears to be good. However, I find that the section on the retrieval algorithm description currently lacks of details, justification and illustrations for the different choices that have been made. Details are provided below as major comments. I encourage consolidating the manuscript and to submit a revised version to AMTD.

We appreciate your comments.

After investigations of the spatial patterns of the limb-nadir matching for retrieving tropospheric ozone, we extended the total ozone retrieval to cover FOVs ranging from 10 to 22. Therefore, the following figures have changed: Figs. 5-7, 9 and 10. The added FOVs do not change the main conclusions in the manuscript.

All your minor comments have been addressed and will be included in the revised version. With respect to the major comments, we detail the following points:

Major comments:
Retrieval algorithm:

- The modifications made to the retrieval algorithm should be better justified and illustrated. I understand that the lower spectral resolution of OMPS may lead to more important cross-correlation and that there is a need to extent the fitting window. However, why considering one every two wavelengths only, which is expected to reduce the benefit of extending the fit window?

For ozone total column retrieval from OMPS-NM measurements, the spectral range extension to shorter wavelengths and reduction of the sampling work in the same direction, namely reducing the weight of the ozone differential absorption features in the retrieval and increasing the weight of the broad-band spectral signature of ozone absorption. This is the main objective of the algorithm changes which are justified by a differential structure of ozone absorption being strongly smoothed at the spectral resolution of OMPS-NM, that is significantly lower than that of GOME, GOME-2, OMI, or SCIAMACHY.

Could you illustrate the cross-correlation between fitted parameters for the different options (small and large windows, wavelength selection)?

With respect to the small vs large window, this is not a matter of correlation. The point is that using a larger window enables us to use a zeroth-order polynomial (i.e. constant) instead of the cubic one. This

increases significantly the information content and makes the retrieval much more robust. For the wavelength sampling, we investigated correlations between the weighting functions of ozone and temperature. For all cases, correlations are high and do not differ much between the cases. Having, however, in mind that also the spectral signature of the rotational Raman scattering is included in the fit, the analysis of the correlations becomes challenging.

In addition, it seems very strange that taking all wavelengths or the other set of wavelengths has such an impact. How do you justify this? Is there any physical or instrumental reason to do so?

We do not think it is an instrumental artifact. This is rather caused by fitting three main parameters (ozone, temperature, Ring spectrum) with similar spectral structures, which can compensate one another. The justification of the wavelength sample selected is rather empirical. Our investigations have shown that the retrieval with the preferred wavelengths is least sensitive to the temperature as discussed in Appendix A2 of the revised manuscript.

It would be beneficial to present the product issues with the original WFDOAS algorithm and the impact of all individual changes and/or choices made.

We added an appendix section (Appendix A1) to the revised manuscript presenting details on the algorithm evolution from WFDOAS to WFFA and illustrating the impact of individual changes. We also demonstrate that the retrieval using the selected wavelength sample (odd-numbered) is less dependent on temperature (Appendix A2).

In addition, it is mentioned before that only the central FOV bins, 17 to 20, are used. Can you really assess the across-track variability using only 4 measurements?

As we mentioned above, the total ozone retrieval now covers FOVs from 10 to 22. The across-track variability is now clearly seen.

It is also unclear what is the additional fitted parameter to account for the slope of the ozone absorption signature? Is the polynomial of first order and not a constant? This parameter is not mentioned any longer in the list you give at line 136. Please clarify this.

There are no additional parameters in the WFFA algorithm. Using a cubic polynomial, as in the WFDOAS approach, removes the broad-band spectral signature and retains only the differential absorption structure to be exploited in the fit procedure. The change from the cubic polynomial to a constant allows us to further increase the information gain by including the broad-band absorption structure of ozone. We reworded the manuscript text to avoid confusion.

O3 profile climatology:

- While the total column dimension may reliably account for the O3 variability in the stratosphere, this is not the case in the troposphere. There may be significant longitudinal and time variability in the tropospheric ozone content, which is not covered by the climatology as currently built. For example, in Tropics, there is a significant wave-one pattern in the tropospheric columns with an amplitude of up to 20DU. This should be acknowledged and further discussed in the paper. What are the consequences of this limitation on the retrieved total ozone columns?

To investigate this issue, we scaled the lower part of the climatological ozone profiles (below 12 km) by factors 2 and 5 and repeated the retrieval. No significant differences in the resulting total ozone value were identified. This is discussed in Appendix A4 of the revised manuscript.

Validation:

- Why do you limit the validation to the period 2016-2018? In section 2, you mention that data from 2012 to 2018 have been processed. It would be beneficial to extend the ground-based validation to the full available period to better evaluate the product stability.

We intend to cover the period from 2012 to 2018. The retrieval is time-consuming; therefore, only the data from 2016 to 2018 are available for now. We modified the expression: “The period for that the ozone data are to be retrieved is intended to cover the years from 2012 until 2018. Currently, only the data from 2016 to 2018 has been retrieved” (now line 66-67).

The added-value of Fig. 8 is limited, especially for differences seen on the orbit edges where sampling differences likely dominate. I encourage making similar plots based on a larger amount of data. The latitudinal dependence aspect is already covered by Figure 9.

The intention of Fig. 8 is to demonstrate how different data sets agree along one sample orbit. The figure allows us to show all four data sets in one plot and demonstrate that the comparison made for the averaged data is consistent with the results for one single orbit.

In Figure 10, the discussion would be easier to follow if you would show similar time series of the relative differences in addition to the current panels. As for the ground-based validation, extending the comparison with the operational OMPS product for the full period 2012-2018 would be beneficial.

The panel of the relative differences that correspond to Figure 10 will be included in the revised manuscript as Figure 11. As explained above, only data for the years 2016 and 2018 are available so far.

Minor comments

- p. 2 Line 28: Chiou et al. does not include any DOAS algorithm, but relies on the GTO/Direct-fitting CCI (not DOAS-based) algorithm. The latter is not cited at all while applied to most of the sensors mentioned here. Please correct this and add proper references for DOAS algorithms for each of the sensors.

Only those algorithms related to our study have been mentioned. The references have been corrected.

First, we refer to the instruments in lines 25-28 of the revised version:
“The Global Ozone Monitoring Experiment (GOME, 1995-2011) (Burrows et al., 1999), the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY, 2002-2012) (Bovensmann et al., 1999) and GOME-2 (2006-present) (Munro et al., 2016) also provide TOC products using the differential optical absorption spectroscopy (DOAS) approach (Lerot et al., 2014).”

Then, in lines 38-39 of the revised manuscript, we refer to the WFDOAS applied to those instruments: "The retrieval approach adapts the Weighting Function-DOAS technique (WFDOAS), successfully applied for SCIAMACHY (Bracher et al., 2005), GOME (Weber et al., 2005) and GOME-2 (Weber et al., 2007)."

- p. 2 Line 41: please add a reference for GOME-2.

Done

p. 2 Line 56: replace as "a three-part instrument, namely a nadir mapper (OMPS-NM), a nadir profiler (OMPS-NP) and a limb profiler (OMPSLP), collecting data since January 2012."
Done

p. 3 Line 66: As the limb profiler is not described, it is not clear to the reader what are the implications to have only data "from the central of the three vertical slits". What does it mean in terms of coverage/spatial resolution?
The text has been reworded as follows (now lines 61-65):

" So far, the limb ozone profiles are only retrieved from the central slit of the three vertical slits of OMPS-LP (Arosio et al., 2018), resulting in a horizontal sampling of about 150 km along-track and 3 km across-track (Algorithm Theoretical Basis Document (ATBD) for the Environment Data Record (EDR) Algorithm of the Ozone Mapping and Profiler Suite (OMPS) Limb Profiler. https://ozoneaq.gsfc.nasa.gov/media/docs/EDR_ATBD_baseline_version1.pdf). In order to match our nadir TOC product to OMPS limb profiles for obtaining tropospheric ozone columns, only the central OMPS-NM across-track FOV bins, 10 to 22, are needed and were processed (approximately 50 km x 600 km wide swath)."

p. 5 Lines 110-115: Please better specify what temperature parameter you fit exactly since I do not think you fit a T° profile but most likely a single parameter.
The text has been changed as follows:

" In Eq. (1) the index i references the wavelengths, V^t is the true vertical ozone column, and b^t are true atmospheric conditions (pressure, temperature, albedo, etc.). $\bar{V}$ is the reference (i.e. used in the forward model) ozone column, $\bar{T}$ is the reference temperature profile and $\bar{b}$ is the atmospheric state as used in the forward model. ΔV and ΔT represent the corrections to the reference values which result from the fit. The scalar correction to the temperature profile (ΔT) is a shift applied to the entire vertical temperature profile"
(now lines 115-119)

p. 8 Line 192 : 3.5 km x 5.5 km since August 2019.
Done

p. 8 Line 192: Unclear sentence. OFFL and RPRO are produced similarly and both include a cloud correction. Heue et al., 2016 is not an appropriate reference for LIDORT I believe.
The text reads now as follows:

"The L2 product of S5P/TROPOMI used in this study is the offline (OFFL and RPRO) total ozone column product (Lerot et al., 2020). S5P/TROPOMI OFFL and RPRO total ozone are very similar and

are obtained using the GODFIT version 4 retrieval (Lerot et al., 2014). The algorithm performs a direct comparison with simulated radiances through non-linear least-square inversion, using the sun-normalized measured radiance from 325 to 335 nm. The modelled radiances and Jacobians are obtained with the RTM LIDORT (Spurr et al., 2018)." (now lines 203-207).

p. 10 Line 234: "De Bilt" instead of "Debilt »

Since we extended the range of the retrieved FOVs, the comparison with ground-based measurements has changed. This station is not mentioned anymore as the provided maximum negative difference value originates now from another station.

Original sentence:
"The mean relative differences vary from -1.6 % for Debilt (Brewer; 52.1° N, 5.18° E) to 6.0 % for Mauna Loa (Brewer; 19.53° N, 155.57° W)."

New sentence (now L. 243-244):
"The mean relative differences vary from -2 % for Rio Gallegos (Brewer; 51.60° S, 69.32° W) to 4.8 % for Mauna Loa (Brewer; 19.53° N, 155.57° W)."