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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieval of ozone profiles from OMPS limb scattering observations" *by* Carlo Arosio et al.

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Replies to Referee #1 on the manuscript 'Retrieval of ozone profiles from OMPS limb scattering observations' by C. Arosio et al.

We thank the reviewers for the time they spent carefully reading the manuscript and constructively commenting on the paper. In the text below, we address the comments from the Referee #1. Referee's comments are shown in italicized font and authors' responses are highlighted in blue.

General Comment *The overall parts of the paper are written unclearly and illogically.*

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Discussion paper

For example, vertical grids where OMPS ozone profiles are retrieved and the unit of ozone should be introduced in the algorithm description section, at once. However, I need to search from.
-In line8 on page 9, the vertical range between 12 and 60 km
-In line3 on page 10, unit of ozone: VMR
-In line13 on page 14, authors described "MLS are converted from VMR vs. pressure into number density vs. altitude, interpolated at the regular altitude grid of OMPS", in addition, the regular altitude grid is not mentioned before.
-In line 10 on line 16, 2.6 km corresponding to an average vertical resolution of the retrieval scheme.

We agree with the reviewer's comment, the information has been consolidated and put in the 'Algorithm implementation' section together with the altitude grid information. In SCIATRAN the state vector is used in terms of VMR (because the shape of the VMR profile is more suitable for use with smoothing constraints), whereas the retrieval results are provided in terms of both number density and VMR as a function of altitude. We choose to perform the comparisons with the other data sets in terms of number density, because the uncertainty on the number density profile is smaller (due to a less sensitivity to the temperature profile). In addition, plotting profiles in terms of number density is more interesting for the comparison with ozonesondes. The average resolution of 2.5 km is not related to the retrieval grid but to the resolution of the retrieved profiles as computed using AKs and as shown in Fig. 7 (old Fig. 6).

This article should be checked line-by-line to become more scientific. For example, in abstract, authors mentioned "ozone in the 12-60 km can be retrieved due to using spectral window in the Hartley, Huggins and Chappuis ozone absorption band" In the view of the spectral window, this instrument is optimized to detect ozone over the troposphere including surface rather than the stratosphere. Limb measurements has

lack sensitivity to troposphere due to its viewing geometry.

Looking at the weighting functions of ozone at different wavelengths, one sees that the Hartley band is appropriate to retrieve ozone in the upper stratosphere, Huggings (305 and 330 nm) in the middle stratosphere and Chappius band in the lower stratosphere and troposphere (as it is also shown in the NASA's ATDB document pg. 34). In accordance with the reviewer's comment about the lack of sensitivity of limb measurements to troposphere, a statement has been added in the introduction: 'With decreasing altitude the atmosphere becomes more opaque, which results in a decreasing sensitivity of the limb-scatter measurements in the troposphere.'

In addition, authors described the OMPS-LP official algorithm as an inversion scheme with a priori constraints and a Tikhonov regularization, but in OMPS documentation, it is based on an optimal estimation based regulated by a set of a-priori constraints. These two schemes are not same.

Thanks for the remark, we agree with the reviewer and have changed the manuscript text in accordance.

Please change "Level 1" to "Level 1b" because these two product are not same.

The notation L1G has been introduced, i.e. Level 1b gridded data, in accordance with the NASA's notations.

Insufficient analyses on retrieval/validation were performed, which is commented in the main comment section. I found the text not be precise enough concerning

unformatted types, grammatical error, English usage, which is commented in the minor comment section.

Comments in the main section as well minor comments have been addressed as described below. English has been proofread.

The following is the main suggestions for improvements.

0. Abstract

- Remove "this algorithm was originally developed ∼∼ to produce a combined data set" in the abstract part and add more about the retrieval related description or results. For example, the vertical resolution of retrievals vary from ∼ 2.5 km at lower altitude levels (<∼ 30 km) and ∼ 1.5 km to upper altitude levels (from 40 km to just below top levels). The theoretical retrieval precisions are estimated to be 1-5 % above 25 km, but rapidly increase to 15 % at 20 km.

In our opinion this statement provides an important introduction about the motivation of this study. This is why it has been kept. As suggested, additional information was added in the abstract about the retrieval characterization.

-"The optimization of the retrieval algorithm ∼∼ . → This algorithm use altitude-normalized radiances in the UV and VIS wavelength range.

The sentence has been accordingly changed as: 'The retrieval algorithm uses altitude-normalized radiances in the UV and Vis wavelength ranges to obtain ozone concentrations in 12-60 km altitude range.'

- indicating a good agreement → specify the altitude range showing a good agreement e.g.) a demonstrating a good agreement from 15 km to 58 km.

Some details about what 'good agreement' means are already in the following sentences: so 'indicating a good agreement' was deleted.

- did not mention about the comparison with OMPS/NASA product.

Added without details. Now the sentence, considering also the previous comment, is: 'OMPS ozone profiles are retrieved for seven months, from July 2016 to January 2017. Results are compared with NASA ozone profile product and validated against profiles derived from passive satellite observations, or measured by balloon-borne in situ sondes.'

1. Introduction

- Authors mentioned that the main objective of the study is to create the long-term dataset using OMPS and SCIAMARCH. To do this, how to overcome the discrepancy of two instrument calibration? It is very difficult because of little overlapping period between OMPS and SCIAMARCH. Please add shortly how to overcome the discrepancy of two instrument calibration.

The MLS measurements are planned to be used as transfer function to overcome the calibration discrepancy. A corresponding paragraph was added in the conclusion, as also suggested by the other reviewer: 'In light of the results presented here, an additional work for tuning of some retrieval settings is needed before processing the whole data set and attempting the merging with the SCIAMACHY time series. Since the same 1-D retrieval approach has been used for both data sets, we expect this to

ease the merging. Unfortunately, only a couple of overlapping months between the two instruments are available, so that a third product must be used for the merging. After the good agreement found in the comparison of our retrievals with MLS, we are considering the use of the latter instrument as a transfer function to handle calibration issues in the merging procedure.'

- Authors too much simplified the summery of the previous studies related to your data product compared to the history and importance of ozone chemistry. It might be better to remove the ozone chemistry-related part (this part is unclearly written) and to focus on 1) history of satellite ozone observation using limb instrument, 2) why we need limb instrument compared to nadir instrument for ozone observation 3) why we need solar scattered limb measurements compared to infrared/microwave emission limb measurements for ozone observation, 4) history of SCIAMARCHY limb ozone profile product; algorithm development/ validation, the long-term stability of both instrument and ozone dataset, 5)OMPS LP ozone profile product from OMPS science team at least and others if possible (e.g. Daniel et al. 2017 recently submitted to AMT), 6) the effort of this study to optimize the SCIAMARCHY algorithm for OMPS.

Following the reviewer's suggestions, the chemistry-related part has been reduced and more details added about limb observations and OMPS LP products.
In our opinion it is not important to explain the history of SCIAMACHY ozone product in this paper, since it would be off-topic.

- Line 33-35, page 2: the limb combines the advantage of the other two techniques ∼∼ with relatively high vertical resolution and horizontal coverage; reader who have no idea about satellite instrument could be confused that which instrument has higher vertical (horizontal coverage) resolution compared to Limb.

The sentence has been rewritten to avoid misunderstanding: 'The limb sounding technique, widely used by more recent satellite instruments, combines the advantage of these two: the long path through the atmosphere provides a high sensitivity to trace gases and the variation of the observation angle enables a better vertical resolution with respect to the nadir geometry, featuring a much higher horizontal sampling as compared to the occultation measurements.'

2. OMPS LP instrument

2.1 General features.

- Line 25 (page 3) "The main objective of the mission is to monitor the ozone vertical distribution within the Earth middle atmosphere at high accuracy level" → it is not true because the mission mentioned belongs just to the SNPP.

Corrected: 'The main objective of OMPS-LP is ∼∼'

- Move line 23-27 to introduction and focus just on OMPS LP.

Done.

- line 1, page 5: the spectral range between 290 nm and 1000 nm → the spectral range of 290 nm to 1000 nm.

Modified to: 'the spectral range of 280–1000 nm'.

- line 5-8, page 5: The use of such a technology (observation at the same time without vertical scanning and CCD) pose a great challenge as regards the SNR; indeed,

scattered solar radiance from the Earth limb decreases by at least five orders of magnitude along the considered vertical range, due to the decrease of atmospheric density. → It is illogically written, about the cause-and-effect.

The sentence has been reworded to be more logical and clear: 'The use of such a technology [CCD] poses a great challenge as regards the dynamic range: indeed, due to the decrease of atmospheric density, scattered solar radiance from the Earth limb decreases by at least five orders of magnitude along the considered vertical range.'

2.2 Calibration and main issue. *-This part should be simplified or removed and then move some parts in other sections. Example, 1) In algorithm description, we can delivery some calibration issues related to the treatment of this algorithm to overcome these issues 2) In lines 8-9 on page 15, authors mentioned the disagreement between OMPS and MLS can be partly related to pointing issues, due to the solar heating of the instrument at high latitudes or stray light in section 4.2. In this paragraph, this paper can provide more detailed calibration issues related to this discrepancy.*

The section was simplified. We currently don't use any other pre-processing steps related to pointing issues in our algorithm and we didn't split this section into the 'algorithm description' and 'MLS comparison' ones to avoid confusion.

-Line2 on page 6: Delete "Level 1B data are provided by NASA team" because the data is publically available.

Deleted at this point.

-Line 24 on page 7: delete "In the preparing time of this paper the new data version was not fully released and only seven consecutive months were available." This kind of sentence is not suitable in the scientific article. Move or re-mention "Retrievals were performed using data from the central slit of the instrument only because the lateral slits can still suffer from pointing issues" in the algorithm description or in the beginning of 4. Results.

It was deleted at this point and the sentence has been reformulate at the end of the section, where the data version is introduced, and in the 'Algorithm implementation' one. The expression 'at the time of writing this paper' has been kept since it is related to the chosen period of time and we don't find it inappropriate.

2.3 OMPS-LP geometry of observations.
-line 31 on page 7: Azimuth angles could be defined separately as solar azimuth angle and satellite azimuth angle.

For the algorithm only the difference between the two azimuth angles matters. We don't see the need of two separate definitions.

-line 34 on page 7: positive angles are East of the north, so that values are inside the -180 to 180 range → it is hard to understand this sentence.

'so that values are inside the -180 to 180 range' deleted: not necessary detail.

-Why this paper need this section? The information given in this part is never mentioned in other sections.

We kept the section as the figure shows the latitude coverage of the data set in different seasons and it might be useful to characterize the possible influence of the stratospheric aerosol which is strongly related to the scattering angle. A reference to it has been added also in the aerosol section.

3. Retrieval method

3.1 The retrieval algorithm

-Describe the theoretical inversion scheme first including from line 25 on page 9 to line 18 on page 10, generally and then describe how this algorithm prepare the measurement vector, measurement error vector, forward model vector, and state vector, it might be better to describe them in separated two sections.

The section was re-organized as suggested into two sections: 'Theoretical basis' and 'Algorithm implementation'.

-Move the retrieval characterization and error analysis including Figure 6 in section 4.1 with the changed section title from 4. Satellite data set comparison to 4. Results; 4.1. Retrieval Characterization and Error Analysis 4.2 Comparison with OMPS-LP Ozone Product 4.3 Comparison with MLS 4.4 Comparison with Ozonesonde.

Thanks, this helps the readability. This part was re-organized as suggested.

This study described that "The information content of the measurements as well as the sensitivity of the retrieval can be analyzed using $\sim\sim$ and the covariance of retrieval noise". It is true for AK, but not true for retrieval error. Sm is generally called "solution

error covariance" including random-noise retrieval error covariance and smoothing error covariance. It should be detailed in the paper and an example should be presented in the right panel of Figure 6. It is useful to add the retrieval characterization and error analysis for mid/high latitudes due to the dependence of the sensitivity of solar measurements on solar zenith angles.

In the right panel of Fig. 6 there is already an example of the solution error covariance due to measurements noise, and more examples at different solar zenith angles have been provided. Following (Clarmann, 2014) the smoothing error should not be included in the retrieval error budget.

- The DFS and solution errors of OMPS LP seems to be much better than OMI UV nadir viewing sensors in the troposphere (Liu et al., 2010). If it is true, we should use OMPS LP measurements for tropospheric ozone retrievals, but it is know that the limb measurements has lack sensitivity to lower troposphere, due to its viewing geometry. I think that the DFS and Retrieval errors are over/under estimated.

We don't retrieve ozone in the lower troposphere, Fig. 6 vertical axis starts indeed at 12 km. Looking at the paper (Liu et al., 2010), the AK peaks in the stratosphere are actually slightly higher in our case but the relative precision is comparable with the OMI one or worse in the lower stratosphere.

-The definition of normalized radiance is unclear → Measurement vector is defined as the logarithm of the altitude-normalized radiances to an upper TH for canceling calibration errors and reducing the effect of surface/cloud reflectance. Table 1 summaries ∼∼. In this paragraph, this paper should mention that this algorithm rejects the wavelength between 580 and 670 nm and between 620 and 630.0 to remove the

effect of water vapor and O2 absorption when you describe which wavelengths are implemented in this algorithm.

We added equation 4, that explicitly shows the measurement vector.
The cutting of the wavelengths was moved as suggested close to the definition of the chosen spectral ranges.

- Describe that ozone profiles are retrieved at which vertical grids; the number of levels, the vertical intervals, the unit of the grid in the same paragraph.

Done: 'The altitude range over which the retrieval is performed spans between 12 and 60 km above the sea level. The vertical grid is fixed throughout the processing and covers the retrieval range at evenly spaced steps of 1 km.'

-Authors described that ozone retrievals are retrieved from 12 and 60 km in the all sections, but analyzed the retrievals from surface and 60 km.

We never show or discuss results at altitudes below 12 km.

-Line 20-24, page 9: "A shift and squeeze correction is applied in the Chappuis band to the modeded spectrum with respect the measured one: this pre-processing is performed for each observation at each TH independently" → a. describe why the wavelength calibration is implemented just for VIS wavelengths. b. Probably the modeled spectrum is high resolution solar reference data?

a) Sentence added to the paper: 'As the shift and squeeze correction algorithm

works with the differential absorption structures, it cannot be applied in the UV range. Furthermore, as the UV retrieval uses either radiances themselves or their slopes, the influence of a possible spectral misalignment is rather small.'
b) No, we mean just the spectrum simulated with the forward model.

- line 23-25, page 10: → surface albedo is simultaneously retrieved with ozone using two spectral fitting windows (∼∼) where ozone absorption is weak.

We still mention the usage of sun-normalized radiance, since it is a new feature of v2.5. Sentence reformulated: 'Surface albedo is simultaneously retrieved with ozone using the sun-normalized radiance provided in the L1G data. Two spectral fitting windows at THs around 38 km are employed: 355–365 nm and 455–470 nm, where ozone absorption is weak. '

4. Satellite data set comparison
4.1 NASA retrieval and comparison

- Line 15: " At the moment of the submission of the paper, only version 2 of Level 2 (L2) NASA product was available, so a comparison with the most recent retrieval could not be performed" This description is not suitable. This study should use the version 2.5 or should confirm from OMPS science team that there is insignificant difference between v2.0 and v2.5 product. This paper mentioned that OMPS/NASA algorithm is based on an inversion scheme with a prior constraints and a Tikhonov regularization, which should be changed to "an optimal estimation based regulated by a set of a-priori constraints".

Only recently v2.5 L2 daily files have been produced and are now available, covering

the period 2014-2017. As a consequence, following the reviewer's comment, Fig.8 has been updated, using v2.5 L2 data of NASA.
As above mentioned the explanation of the algorithm has been changed.

-Based on Figure 8, there are significant differences between OMPS/NASA and OMPS/IUP products, which different implementations between algorithms causes these differences? Based on Figure 9, it seems that MLS shows better agreement with OMPS/IUP in the stratosphere (ozone peak layer) and with OMPS/IUP in troposphere. Both OMPS and MLS has lack sensitivity to lower troposphere so the retrievals determine mostly from a priori information, the similarity between two product might come from the similarity of a priori data between two algorithms.

As the retrieval implementations are different, biases at specific altitudes can not directly be linked to the algorithm differences. It is also impossible to "switch off" the differences step by step as most of the "mixed" algorithm version will not be stable and able to produce any reasonable results. Yes, the comparison between satellite data sets in the upper troposphere is difficult due to the lower sensitivity to ozone, as we also state in the paper.

- OMPS/NASA should be compared with MLS and ozonesonde to see which one provides better retrieval qualities.

We think that joint comparison between NASA-OMPS, IUP-OMPS and MLS/ozonesondes is not the target of this paper: NASA's v2.5 just became partially available and our retrieval is still in progress.

4.2 MLS comparison

-change the reference of Waters et al. (2006) to MLS v.2 data quality and description documentation. This doc specifies how to use MLS product as following. This study use this data screening method?

The reference has been added rather than replaced. Yes, the flags reported in this document were used in the comparison between the two data sets: a corresponding sentence has been added.

- In this section, we firstly give a description of the vertical grid and the unit of ozone profile used in comparison, but this part should be moved before comparison with OMPS/NASA. I think that this paper create one section to describe the comparison methodology.

The vertical grid has been now described in the retrieval section. However, as the comparison methodology slightly differs for different comparisons it was not moved to a dedicated section.

-This paper mentioned "an increase of the smoothing parameter is expected to partially attenuate the latter problem", about the large difference between OMPS and MLS profiles around 50 km. This explanation is so vague. Smoothing parameter indicates smoothing errors?

Smoothing parameter means Tikhonov parameter (changed): we were just addressing the oscillations seen at the top levels (58-60 km), not the one around 50 km.

- Figure 10 could be re-analyzed for several months (July and Dec or summer and

winter) due to sufficient collocation.

The original plot has been kept but 2 other plots for summer and winter months were added.

-This paper can mention about the validity of OMPS retrievals above ∼15 km and below 58 km based on comparison with MLS.

Added at the end of the paragraph: 'To summarize, this comparison shows a general validity of IUP-OMPS retrieval between 18 and 58 km, even if during different season the relative bias with respect to MLS exceeds by 10 % in some limited atmospheric regions.'

-Line 4 page 14: What is the modified potential vorticity?

The adjective 'modified' has been deleted.

-Line 9 page 15: "not screened polar mesospheric clouds" → based on the cases provided in this paper, it is hard to relate the large difference between OMPS and MLS to polar mesospheric clouds (PMC). That is because the presence of PMC is limited to polar summer season, but your analysis is performed for all seasons. This article did not mention that why the presence of PMC is important for OMPS retrievals and why MLS could be not impacted by PMC, maybe need some reference.

Thanks, this plot has been changed after the implementation of a PMC flag, consequently a short paragraph has been added in the Cloud Filter section, addressing the

issues and the flagging. The reference to (Bak et. al 2015) paper was added: the authors use MLS as a reference when OMI detects PMCs.

5. Ozonesonde comparison

-Convolution process of higher resolution profiles with averaging kernels could be described after equation (4).

We think that moving this to the retrieval section would lead to much more confusion: we don't use smoothing in other parts of the paper.

-This paper mentioned Figure 12 (a) as "averaging kernel smoothing and (b) as "vertical averaging". Please correct this way to "Comparison of OMPS ozone profiles with ozonesonde smoothed with OMPS averaging kernel and (b) without smoothing, respectively".

Also the Panel (b) shows smoothed profiles but instead of using the AK to smooth the high resolution sonde measurements, a direct vertical averaging over a range of 2.5 km was performed (kind of box-car averaging kernels).

-This paper can add about insignificant impact of the smoothing of ozonesonde profiles to OMPS vertical resolution on the comparison results in the stratosphere due to the comparable vertical resolution of OMPS LP ozone profile retrievals to ozonesonde, compared to the comparison between nadir UV ozone product and ozonesonde. This fact can emphasize the importance of limb instrument on the stratospheric ozone observation.

A sentence related to panel (a) and (b) of Fig. 12 has been added: 'Differences between the two panels of this figure show that the smoothing procedure can be critical in the comparison between 15 and 20 km, where the gradient in the ozone profile is usually strong'. We did not stress here the point related to the better resolution of limb sensors in comparison with nadir ones, because not on-topic. In addition, the difference of resolution between ozonesondes and OMPS-LP is still large: for sondes it's around 10 m, for OMPS in the order of 1 km.

-Should summarize the validation conclusion about the validity of OMPS retrievals above 15 km based on comparison with ozonesonde measurements.

We stressed the point at the end of the paragraph: 'Concluding, we find a general consistency of IUP-OMPS retrieval results with ozonesonde measurements in all considered latitude bands, except for the 12-20 km altitude range in the tropics, where the agreement with SHADOZ ozonesondes is ambiguous.'

-This paper should discuss the difference of comparison results between 2016 and 2013. The comparison with MLS provide same results between 2016 and 2013?

As stated in the paper the two periods were processed using the same settings. Yes, there are no substantial changes in the relative differences IUP-OMPS - MLS between the 2 periods, a sentence was added.

The following is the minor suggestions for technical corrections (I just suggest a few)

1)Please change "facilitate, overarching, exploit" to more proper words.

As the reviewer does not explain why (and where) the words are improper and which words he thinks suit better we did our best to go through all occurrences and use other words instead, if appropriate.

2)Many sentence is unnecessarily formatted like "very long subject" + "passive verb".
e.g) ozone concentrations in the 12-60 km altitude range can be retrieved → ozone concentrations can be retrieved from 12 to 60 km with valid precisions.
e.g) Observation at altitude where the measurement are contaminated by clouds are rejected by applying a cloud filter → We screen out cloud-contaminated measurements using the color Index ratio of the radiance at 754 and 997 nm.
e.g) the following molecular specifies with spectral signatures in the selected spectral ranges are considered. → The radiation calculation take account of NO2 and O4 other than ozone.
e.g) ozonesonde data from WOUDC and SHADOZ archives are used in this analysis → ozonesonde data is collected from WOUDC and SHADOZ archives.

The text has been checked and some sentences changed according to the reviewer's suggestion, to avoid recurrent 'very long subject' + 'passive verb' patterns.

3)Line 3, page 1: SCIAMACHY instrument → SCIAMACHY limb instrument

This statement is incorrect as, unlike OMPS, SCIAMACHY is one instrument working either in limb or in nadir observation mode.

4)Line 10, page 1: Results for seven months ∼∼ → OMPS ozone profile retrievals are validated against both satellite-based and balloon-borne measurements for seven month from July 2006 to January 2007.

Changed as 'OMPS ozone profiles are retrieved for seven months, from July 2016 to January 2017. Results are compared with NASA ozone profile product and validated against profiles derived from passive satellite observations, or measured by balloon-borne in situ sondes.'

5)Line 14, page 1: those from ozonesondes → ozonesondes or ozonesonde measurements

Done.

6)Line 23, page 1: a stratospheric ozone layer → the stratospheric ozone layer

Line deleted

7)Line 24, page 2: result in the depletion of stratospheric and mesospheric ozone → lead to the destruction of stratospheric ozone.

The statement mentioned by the reviewer is not present in the indicated line/page.

8)Line 25, page 2: both from ground-based instrument and satellite observations → from both A and B.

Done

9)Line 34, page 2: the former instruments point downward while the latter look directly into the solar disk : "whereas" is better than "while"

Done

10)Line 35, page 2: The same geometry of observation can also be → has been

Done

11)Line 1, page 3: ∼ limb emission measurements. With this latter technique a day and night coverage of the globe is feasible. → limb emission measurements can be taken during both day and night.

Sentence reformulated: 'Using the scattered solar light, measurements during daylight only are possible, whereas, using the emission signatures, observations can be performed during both day and night.'

12)Line 5, page 3: launched in March 2002 → launched in March 2002 on board the ESA ENVISAT satellite. Line 7 page 3: In early 2012 ground communication with the ESA ENVISAT satellite, carrying SCIAMACHY among other ozone science relevant instruments, was lost → SCIAMARCHY ended its operation in early 2012 due to the loss of their platform with ground communication.

Sentence slightly modified: 'SCIAMACHY made observations in the UV, Vis, Near

InfraRed (NIR) and Short Wave InfraRed (SWIR) spectral ranges till April 2012, when the platform-to-ground communication was lost.'

13)Indents when a paragraph changes. e.g in the lines 3, 22 on page 2, 14 line on page 6

Done

14)Edit the usage of reference: e.g line 5 on page 3, (Burrows et al. (1995, Gottwald and Bovensmann (2011)) → (Burrows et al, 1995; Gottwald and Bovensmann, 2011). These unformatted types are often found in this article.

References were checked.

15)Lines 11-13, page 3 → This paper presents ozone profile retrievals from OMPS limb observations. This algorithm was adapted from the SCIAMACHY v3.0 ozone retrieval algorithm (Jia et al., 2015) developed by the University of Bremen.

Reformulated as: 'This paper presents ozone profile retrievals from OMPS-LP observations performed at the University of Bremen. The algorithm we use was adapted from the SCIAMACHY v3.0 ozone retrieval (Jia et al., 2015).'

16)Line 13, page 3: For a description of SCIAMACHY v3.0 ozone retrievals refer to Jia et al. (2015) → readers are referred to Rodgers [2000] for more detailed description of ∼.

The line was changed accordingly with the previous comment but the citation kept: we want to refer to the SCIAMACHY data set not to the retrieval theory in Rodgers.

17)Line 14, page 3: delete "of this paper" after In sect.2

Done

18)Line 16, page 3: The applied cloud filter, the retrieval of aerosol extinction profiles and of the surface albedo → The applied cloud filter and the retrievals of aerosol extinction profiles and surface albedo

Changed into: 'A more detailed characterization of the retrieval procedure follows, including the applied cloud filter and the approach to consider aerosol extinction profiles.'

19)Line 20, page 3: In the latter section and in the conclusions → in the conclusions

Done

20)Line 21, page 3: OMPS-LP is not mentioned in the introduction before the title name of OMPS-LP instrument.

In the reviewed version it is mentioned in the introduction.

21)Line 27, page 3: A Nadir Mapper, a Nadir Profiler and a Limb profiler (LP) → the Nadir Mapper, Nadir Profiler, and Limb Profiler.

Done, now in the introduction.

22)Line 9, page 5: slower that → slower than

Done

23)Line 33, page 7: positive angles are East of the North : change from "are" to "represent"

Line deleted

24)Line 11, page 9: get rid of → remove

Done

25)Cross section of these gases are respectively taken from ∼∼ → taken from ∼∼, respectively.

Done

26)Line 18-19, page 9: delete "used in the radiative transfer mode" and "provided by the NASA team together with OMPS-LP L1 radiances"

'Provided by the NASA team' was kept.

27)Line 8, page 14: the geographic distance is required to be whine 1 deg. → limited to be

Done

28)Line 15, page 14: The number is in the order of 5000. → The number is ∼ 5000.

Done

29)Line 1, page 15: → the positive difference of larger than 30 % in the tropical lower stratosphere.

Changed as: 'Starting the discussion form the bottom of the plots, positive differences larger than 30 % are found in the tropical lower stratosphere.'

30)Line 15, page 15: Looser collocation criteria than for MLS → compared to MLS

Done

31)Line 16, page 15: because of the sparseness of the data set → because of the sparseness of ozonesonde station./ In particular → Therefore

Done

32)Line 18, page 15: remove "generally for each sonde profile ∼ found using these

loose criteria"

This part of the sentence was deleted and reformulated as: 'For each sonde profile, all collocated OMPS-LP observations are averaged before the comparison.'

33)Line 4, page 16: with respective standard deviations → with corresponding standard deviations.

Done

34)Line 14, page 16: for tropical and northern mid-latitude bands, around 120 and 160 sonde profiles, respectively are considered. → , which is ∼ 120 and 160 for tropical and northern mid-latitude bands, respectively.

Done

35)Line 1, page 17: As can be seen also from Fig.11 → As shown in Fig. 11, the excellent agreement is also found at northern mid-latitudes, with ∼∼.

Done: 'As shown in Figs. 11 and 12, an excellent agreement is found at northern mid-latitudes, with relative differences below 5 % between 14 and 30 km.'

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