We would like to thank the referee for their helpful comments and suggestions. Included below is each of the referee's comments (italics) followed by our reply.

Responses to Anonymous Referee 2

General Comments

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in the first algorithm description sections authors provide rather theoretical description of the inversion method without stating what physical quantities are used as measurement and what exactly are going to be retrieved. Only very late and in differenent places it is said that state vector may consist of various quantities in a sequence, e.g. logarithm of number density (stated only on page 13 of the manuscript), perhaps aerosol number density (but it is not clearly stated in Sect. 2.7.2). This makes it hardly possible to follow the arguments about practical considerations provided along the theoretical descriptions. I would strongly encourage the authors to restructure the manuscript to make its understanding straight forward.

Reply: Thank you for the suggestion, we agree in many places there was too much general information. In the revised manuscript specifics about the state vector (such as that it is logarithm of number density) appear much earlier. Some of the general information has been removed and/or replaced with specifics about the retrieval for OMPS-LP. We have also rearranged some sections so that information about the specific species retrievals (ozone, aerosol, albedo) appears earlier.

I have a feeling that more should be done with respect to the verification/validation, especially under strong gradient conditions. There is only one such orbit provided. Please add a study for a northern winter day with strong northern polar ozone deple- tion. For this case the Suns geometry is opposite to that of the gradient in the SH. Also gradient at high SZAs (see below) must be investigate to sustain statements in the manuscript. Additionally middle and high latitudes where much stronger ozone variations might take place as at equator must be covered in a more systematic way. One could at least provide comparisons for one orbit per season thus covering typical seasonal variations in ozone distribution.

Reply: We have added a second simulated orbit where there is strong ozone depletion in the northern hemisphere. We agree that there is a lot of potential validation work left to do for the dataset but we believe it is beyond the scope of the manuscript. As stated in the text, we are planning on doing doing an in-depth validation in a future study, what is presented here is preliminary efforts in this direction. We have replied to the referees comment concerning gradients at high solar zenith angles in the specific comments below.

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there is a constant signal to noise ratio 100 assumed for the whole scan profile for the

error estimation as given in conclusions of Jaross et al., 2014. Some sceptics is there due the natural illumination changes of several magnitudes along the tangent altitude and even despite the applied dynamical considerations, stray light and possible degradation of the instrument might be an issue.

Reply: This could certainly be the case, but currently the estimate given in Jaross et al., 2014 remains the best available estimate for the instrument performance. The effect of illumination changing by several orders of magnitude is somewhat mitigated by the OMPS-LP instrument which collects two interleaved images of the full scene with different integration times and aperture sizes. It does appear that the final error analysis results are however at least somewhat reasonable from the standard deviation of the MLS comparisons.

Specific Comments

P1L6 *Add some words that MLS measurements used for the comparison are as well 2D, tomographic.*

Reply: Added

P1L24 *add "and OClO" after "of NO2" since Pukite et al., 2008 did 2D retrieval for this gas as well.*

Reply: Added

P2L3 *"relatively fast along orbital track sampling": fast relates to speed or time, perhaps say "relatively fine resolved".*

Reply: Changed

Sect.2. *As said in general comments; it would help a lot to state at the beginning what physical quantities you are operating with.*

Reply: This is done in the revised manuscript.

P3L7 *"Between grid points bi-linear interpolation is applied to create a continuous representation of the atmosphere." It must be explained in detail how the interpolation is implemented. I.e. this could mean some subgridding or analytic constrains in model.*

Reply: This is a good point. We have moved this statement to the forward model section

to make it clear this is something internal to the forward model. The exact procedure in which this is done is described in detail in Zawada et al. 2015.

P3L15, F1 *Figure must be improved. Please use different colors as "white grey" and other grey since it is really impossible to distinguish in the figure.*

Reply: We have changed the two colors to red and gray.

P3L17 *"A common approach to minimize" Citations needed*

Reply: We have added a reference to Rodgers (2000).

P4L1-2 *"Under this approach we have not noticed unphysical effects at the edges of the retrieval." A prove for this statement is necessary. Given your verification and validation evidence (just one orbit with gradient at lower SZA) this has not been verified: Can this been tested with an example with a gradient condition at the orbit parts with SZA 88 deg and above? In such cases Pukite et al. 2008 reported problems for the first profile of the orbit. Please provide evidence.*

Reply: In the shown orbit there are natural gradients in the ozone field at gradients above 88 SZA, we have not artificially suppressed them. We have extended this orbit to the full range (rather than just the southern hemisphere) as well to see both edges of the retrieval. We have also added a second simulated orbit with gradient conditions in the northern hemisphere, and in none of these cases have we noticed significant edge effects. However it is true that if there was a large, ozone hole in magnitude, gradient occurring at 88 SZA (typically does not happen with the OMPS-LP geometry) we would expect some edge effects to occur. We have changed the offending statement to read "Under this approach for typical conditions we have not noticed unphysical effects at the edges of the retrieval, but this is still under investigation."

P4L10 *Related to general comments. Still on the 4th page of the manuscript there is no idea what is to be state vector and measurement vector.*

Reply: This should be better in the revised manuscript, see reply to the general comment.

P4L18 *A more concrete and exact description is needed. How the transformation is practically performed? What assumptions used? What has to be understood under "atmosphere specified on the retrieval grid is transformed", i.e. What is this atmosphere consisting from and characterized by? What and how it is changed due to transformation? How the Jacobian*

matrix is transformed?

Reply: This section was poorly worded and has mostly been removed at the request of the other referee. All that is done is a linear change of coordinates from the plane containing the lines of sight to the orbital track (retrieval grid). We have moved the information about the mismatch between the line of sight plane and the retrieval grid to the state vector section.

P4L21 *"These transformations are typically quite small in effect" Can you provide a number?*

Reply: We have added the statement that at the equator the mismatch between the line of sight plane and the orbital plane is approximately 5°.

P5L6 *And how much time resource do you need for one orbit?*

Reply: This information was stated later in the manuscript. In the revised manuscript we have moved the example retrieved orbit section (which stated the approximate time per orbit) into the algorithm section.

P6L16 *"Most atmospheric retrieval methods fall into two classes" Again, it is of course good to give some review about the background of inverse methods but it is difficult for a reader to follow your considerations and choices if it is still not stated what you are going to retrieve from what.*

Reply: This section has been removed at the request of the other referee.

P6L17 *"the resolution of the retrieved profile is determined by ... the resolution of the retrieval grid." This statement is generally wrong: The resolution is an ability to resolve some features. If there is not enough information one is not able to resolve the features even on fine grid. I think you wanted to say something else; perhaps one should skip the part of the sentence after "i.e."*

Reply: At the request of the other referee we have removed this section so this is not an issue anymore. However, if we define resolution from the averaging kernel then as long as $K^T S_\epsilon^{-1} K$ is invertible then this is a true statement. So the referee is correct in that the grid can not be made arbitrarily fine, but if $K^T S_\epsilon^{-1} K$ is singular then the retrieval cannot be done without regularization anyways.

Eq.3 *shouldnt all zeros be bold?*

Reply: We think it is correct the way it is. The non-bold zeros are needed to separate

different altitudes.

P7L16 *"ozone number density, stratospheric aerosol number density, and surface reflectance assuming a Lambertian surface" Later you state that the state vector for ozone retrieval is logarithm of number density. This is again the confusion here between the long theory description and rather imprecise and misplaced description of the practical stuff.*

Reply: This should be improved in the revised manuscript, these statements have been moved earlier with much of the general information changed to OMPS-LP specific information.

P7L19 *Does it mean solving 3 different separate inverse problems (Eq. 2)?*

Reply: Yes for three separate inverse problems, but the albedo retrieval does not use Eq. 2.

P8L20-21, Eq4 *In text you mention k to be used for both indexing tangent altitude and triplet, though in Eq. (4) indexing for triplets is missing.*

Reply: Thank you, this has been corrected.

P8L22 *What is meant by ozone sensitivity is minimal? Or perhaps effect of ozone absorption on spectra is minimal?*

Reply: We have reworded this to "where the effect of ozone absorption on the observed radiance is minimal."

P13L8 *"signal to noise ratio of 100"; "an upper bound on the error estimate taken from Jaross et al. (2014)." As said at the beginning this assumption might be much too optimistic.*

Reply: See the reply to the general comment

P13L9 *"state vector is the logarithm of number density". Only on page 13 there is finally mentioned the physical quantity all about the theory was. What about other quantities?*

Reply: Description of the state vector has been improved, this information appears much earlier in the revised manuscript.

P14 *Have you studied the effect different settings of the horizontal regularization. Is it not*

possible to do retrieval without any horizontal regularization because you also match the horizontal retrieval grid to that of the measurements?

Reply: We have been looking into this. It is possible to do the retrieval without regularization, however there end up being unphysical oscillations in the horizontal direction. The exact cause of the oscillations is still being investigated but it would not be unexpected for a retrieval where the sampling matches the retrieval grid to have oscillations in that dimension. We chose the current level of regularization somewhat conservatively to remove the oscillations, and we plan to further study this for a future version of the retrieval.

P15L28 *"orbit 27695" mention here day and time of the Eq. crossing.*

Reply: Added

P17L7 *"Figure 10 shows the result of these comparisons in the tropical* 5° *S to* 5° *N latitude bin." What is about systematic study for other latitudes where far more gradients appear?*

Reply: A full systematic validation of the dataset is intended for a future validation paper.

P19L10 *day, time for orbit?*

Reply: Added

P23L4 *"for the entire orbit" The retrieval is limited to SZA 88 deg. This should be stated.*

Reply: Thank you, we have added this.

P23L13 *"one orbit" You compared two orbits.*

Reply: Thank you, changed.

P23L18 *"tradiational"-¿ "traditional"*

Reply: Thank you, corrected