**Atmospheric
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Interactive comment on "Accounting for the effect of horizontal gradients in limb measurements of scattered sunlight" *by* J. Puķīte et al.

Anonymous Referee #2

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Review of

Accounting for the effect of horizontal gradients in limb measurements of scattered sunlight

by J. Pukite, S. Kühl, T. Deutschmann, U. Platt, and T. Wagner

General comments:

This is an interesting paper dealing with the effect of neglecting horizontal inhomogeneity in atmospheric minor constituent profiles on the retrieval of these constituents from satellite-based limb scatter measurements. This is an important aspect of all atmospheric remote sensing applications using limb viewing satellite instruments, and investigations in this direction will be very useful. I recommend the paper be published

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after the authors have given consideration to the comments (mainly minor and requests for more explanations/discussions) listed below.

I have several general comments:

1) I'm a little puzzled that the term "tomography" does not appear in the paper, because the basic approach is tomography, right? I suggest mentioning this in the appropriate sections of the paper. You may also mention that the IR channels of OSIRIS are specifically designed for tomographic retrievals (having a vertical FOV), although they are mainly used for measurements of terrestrial airglow emissions and not limb-scattered radiation. A relevant citation would be:

Volume Emission Rate Tomography From a Satellite Platform, Douglas A. Degenstein, Edward J. Llewellyn and Nicholas D. Lloyd, Applied Optics, 42, 8, 1441-1450, 2003.

and/or the references cited in this paper.

2) Another general aspect is related to the previous point. Your method allows reducing the retrieval errors if horizontal gradients are present in flight/viewing (roughly the same for SCIAMACHY) direction. Still, you have to assume horizontal homogeneity across flight direction. In terms of emissions the measurements are only affected by air masses within the FOV. However, this is not the case for limb-scatter measurements. An extreme case would be a solar azimuth angle close to 90 degrees, and low sun elevation, i.e., the sunlight has a fairly long light path through the atmosphere before reaching the LOS. If inhomogeneities in the absorber concentrations are present across flight/viewing direction, this will also lead to retrieval errors, because they are not accounted for in your retrieval. They don't have to - and cannot - be accounted for in your retrieval of course, but I think it would be worth mentioning this aspect.

3) I also think - in line with the other referee - that the paper should also include a more detailed description of the retrieval scheme, because (a) The Pukite et al. [2006] proceeding paper is not easily accessible, and (b) the paper would then be a more

stand-alone document.

4) I suggest using "tangent height" or "tangent altitude" rather than "elevation", because the latter is not really used in the limb-scatter community, and may lead to confusion.

5) This comment is related to the applicability of the 2D retrieval scheme to current limb-scatter instruments. You mainly discuss the first few SCIAMACHY limb states at high northern latitudes, where no nadir measurements are performed (and these few states will not necessarily coincide in space with the vortex). Little is said about the applicability of the method for the remaining parts of the orbit (2D-retrievals at lower latitudes are presented, but the issue of undersampling is not properly addressed in my opinion). Perhaps you can specify a minimum horizontal distance between two consecutive limb measurements required for the 2D retrievals to be appropriate.

6) The paper contains typos and grammatical errors (e.g., missing articles and use of present continuous). I suggest the manuscript be thoroughly proof-read by a native speaker or by one of the senior co-authors.

Specific comments:

7) Page 16156, line 24 - 26: The statement, that nadir observations provide only total column information is not correct. Both GOME and SBUV nadir measurement were/are used to retrieve vertical profiles of ozone. This method only works with really strong absorbers and has a fairly poor vertical resolution (about 10 km), but it provides vertical profile information. Relevant publications are, e.g.:

Hoogen, R., V.V. Rozanov and J.P. Burrows, Ozone profiles from GOME satellite data: Algorithm description and first validation, J. Geophys. Res., 104, 8263-8280, 1999.

Bhartia, P. K., R. D. McPeters, C. L. Mateer, L. E. Flynn, and C. Wellemeyer, Algorithm for the estimation of vertical ozone profiles from the backscattered ultraviolet technique, J. Geophys. Res., 101, 18,793-18,806, 1996.

8) Page 16157, line 16: " .. and consists of 4 pixels."

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This is not the case for all wavelength ranges and latitudes, I think. Perhaps you can add "for the spectral range used here" or something like that.

9) Page 16157, lines 23 - 25: I think von Savigny et al. [2005] (The ozone hole break-up in September 2002 as seen by SCIAMACHY on ENVISAT, J. Atmosph. Sci., 62(3), 721 - 734, 2005) must be added to the list, because it also includes a description of retrieval codes for O3, NO2, and BrO from SCIAMACHY limb measurements.

10) Page 16158, line 17: "For our retrieval we apply a two step method". I suggest adding a brief explanation what the two steps are (or omit this statement, because the two steps are explained in the next section). This is not obvious to people outside the limb-scatter community.

11) Page 16159, section 2: I suggest adding more details on the retrieval algorithm, since the Pukite et al. [2006] paper is not that easily accessible. What reference tangent height was used?

12) Page 16159, line 26: "Also, because of the slantness of the limb observations the measurements are practically insensitive to the atmosphere below the tangent height."

I'm not sure this statement is correct. If you refer to the raw limb radiances, when speaking of "measurements" this statement is wrong, because the surface albedo and clouds affect the limb radiances significantly (up to a factor of 2, roughly). I suggest specifying the meaning of this statement.

13) Page 16160, line 13: "In general the instrument exhibits higher sensitivity to air masses closer to instrument since the light contributing to the measurement integrates along the line of sight."

This statement can be (and should be) specified further. For high tangent heights - with a negligible line of sight optical depth - the difference in sensitivity between the near and the far side is also negligible (as you point our a few lines below). The asymmetry increases with increasing optical depth along the LOS and therefore with decreasing

tangent height. Also, the main reason for the asymmetry is the extinction along the LOS, and not directly the "integration of light along the LOS", I think.

14) Page 16160, line 16: "with different elevations". I suggest replacing "elevation" by "tangent height" here and throughout the paper. My first interpretation of "elevation" in this sentence was "solar elevation".

15) Page 16162, lines 10 - 15: "Also the spatial distance ... without nadir observations between them".

This is of course only a very limited part of the SCIAMACHY orbit, and the latitudinal spacing between the following states is about a factor of 2 larger. Are the 2 conditions you mentioned above also fulfilled for these, i.e. for the majority of the SCIA limb measurements? I think this should be discussed more in the paper. The 'problem' of alternating limb-nadir measurements does not occur with OSIRIS, so this instrument would be better suited for a 2D retrieval approach.

16) Page 16166, line 25: I don't understand the phrase ".. in one inversion constraint". You mean "in one inversion" or "simultaneous inversion" ?

17) References, Deutschmann, 2007: Is there a website, where the manual and the model can be downloaded from?

18) Fig. 2: Again, I suggest replacing "elevation" by "tangent height"

19) Fig. 4: I think the figure would be easier to read with reversed axes.

20) Fig. 6: "elevation" should be "tangent height"

Typos etc. (there are more, I didn't track all of them):

Page 16156, line 11: "full spherical" should read "fully spherical"

Page 16156, line 16: "ofhorizontal" should be "of horizontalLY"

Page 16156, line 24: add space after "observations"

Page 16156, line 24: remove "is"

Page 16158, line 20: "full" should be "fully"

Page 16159, line 14: "full" should be "fully"

Page 16166, line 12: "photochemical" should read "photochemically"

Page 16166, line 21: "horizontal" should be "horizontally"

References, Bovensmann 1999: "N\"oel" should be No\"el"

References, Butz 2006, Dorf 2006, and Sioris 2006: "Boesch" should be "B\"osch"

Caption, Fig. 4, 2nd line: "The Illustration IS" or "The Illustrations ARE"

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 16155, 2007.

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