

## ***Interactive comment on “A 3-D tomographic trajectory retrieval for the air-borne limb-imager GLORIA” by J. Ungermann et al.***

### **Anonymous Referee #1**

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The paper describes the development of a new technique to measure gas concentrations in the UTLS region using the spectrometer GLORIA performing 3-D retrievals taking into account advection (in the form of a-priori information). The work is an extension of the work already published by Ungermann et al. in AMT Vol. 3 pages 1647-1665 (2010).

All the work is done making use of simulated measurements and therefore it has to be considered an academic study. The work is original and it is well suited for publication in AMT.

However the paper neglects some critical issues (see comments below) that will need to be solved in order to successfully apply this technique to real measurements. The

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text is very long and not always clear, in part for the use of the language and in part for very long sentences. Therefore I recommend its publication in AMT after major text revisions.

### **Critical Issues**

- After reading the whole paper, we learn that trajectories are used as a-priori information, and NOT retrieved. I suggest the authors to change the title since as it is now it suggests that trajectories are somehow 'retrieved'
- The retrievals are all performed perturbing only the target molecule (ozone) in the region (latitudes, longitudes and altitudes) interested by the simulated measurements. All the rest (ozone outside the sampled range, temperature, pressure and all interfering species) is kept at the same values used to simulate the measurements. This in my opinion makes the reconstruction of the ozone fields much easier and generates the misleading conviction that this technique will easily work on true observations. No attempt is made to consider possible systematic errors due to the imperfect knowledge of the sampled atmosphere.
- The results are all presented for the 12 km altitude. This is understandable since the amount of data produced by the retrievals is very high. However no discussion is made for the rest of the vertical range sampled by the synthetic observations. Does the 12 km altitude behaves as the others? Or is the 12 km altitude the best?
- It seems that the authors confuse the retrieval error (due to the measurement noise) with the accuracy of the retrieval (that is the difference between the true atmospheric status and the retrieved one)
- Most of the work is performed using the  $778.5\text{ cm}^{-1}$  channel. GLORIA spectral resolution is  $1.2\text{ cm}^{-1}$ , and in the spectral interval of that width centered at  $778.5\text{ cm}^{-1}$  there are strong transitions of  $\text{CO}_2$  (5 lines) and water. This won't change

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the conclusion reached in the paper, since only ozone is perturbed, but it may pose serious problems when dealing with real observations. Surprisingly, the additional channels (1020, 1043.75 and 1055  $\text{cm}^{-1}$ ) used to complement the retrieval informations are free from strong interfering species. I suggest the authors to use one of those channels as the main one.

- The forward model (FM) makes use of Lookup Tables already convoluted with the Instrumental Line Shape. This makes the FM very fast, but given the spectral resolution of GLORIA, it may cause systematic errors due to the wrong evaluation of the absorption of interfering species.
- Only horizontal winds are considered in the work. The influence of vertical motion is completely neglected. This can affect the analyses in presence of strong vertical motion of airmasses

### Specific comments

#### Abstract

- Lines 12-13 please specify better the improvements to the achievable resolution and stability of the retrievals
- Lines 15 previously unused spectral samples? Unused by whom?

#### Introduction

I think the fact that this work is an extension of previous work should be stated clearly in the introduction

page 3807

- Line 5 what do you mean by bad resolution? which kind of resolution ?  
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- Line 6 'structures of interest' Interesting for whom?
- Lines 9-13 If small scale gravity waves are not measurable by GLORIA, why speak about them as an example? Moreover GLORIA has not been mentioned before, so please expand the acronym or describe the instrument before this part.
- Line 16 limb-sounding measures infrared but also MW, sub mm and visible radiation (i.e. MLS, ODIN, SCHIAMACHY).
- Lines 25-30 The statement it's true if across-track measurements are considered. If the measurements are along-track 2-D retrievals are possible

Page 3808

- Lines 23-26 the sentence is too long and very difficult to follow, please rephrase it.

#### Section 2

- Line 21 remove 'on the one hand'
- Line 22 remove 'on the other hand'
- Line 26 substitute 'whereby' with 'and'

#### Section 3

page 3810

- Line 6 add Ungermann et al. (2010) among the references

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- Line 8 missing ) after 1981
- Lines 9-11 As already said, don't you have problems with radiative transfer of lines that are well separated at high resolution but are merged into a single point by the ILS?
- Lines 26-27 A constraint in a retrieval ALWAYS introduces a bias in the result. It's entity depends on the strength of the constraint.

Page 3811

- Line 10 substitute 'simulations' with 'retrieval simulations'

### Section 3.1

The computation of numerical derivatives is not a common procedure for atmospheric retrievals. Usually analytical expressions are used, for example exploiting the Curtis Godson approximation and the use of LUT. The method described in the appendix is one solution, but not the unique one

Page 3812

### Section 3.2

- lines 22 and 23 - The inverse of the diagonal elements of A give the resolution in which units? For instance if no constraint is used the diagonal element of A are all unity, and their inverse is 1 therefore the resolution is 1 (sampling steps?). Please specify

Page 3813

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- lines 1-7 The whole paragraph is not very clear. In particular a sphere has only one diameter by definition. Therefore clarify what you mean by 'smallest diameter'. Again why since the vertical resolution is smaller the diameter is a measure of the horizontal resolution? Please clarify.
- line 8. Gradients affect trace gases as well as temperature.
- line 8. Change 'gasses' into 'gases'
- lines 25-26 there must be some typos because the sentence as it is is not clear

Page 3814

- lines 8-10 what do you mean by 'computationally much less involved'?
- lines 12-14 please explain better why this is the only method to incorporate the effects of horizontal gradients

### Section 4

page 3815

- line 9. What do you mean by 'starting at 0.73 deg going'?
- line 11. there is an unmatched parenthesis
- lines 15-17 Did you try to analyse spectra simulated with the Reference Forward Model or using LUT without convolution with the ILS?
- line 23 add the sentence 'and disregard systematic errors' (see general comment above)

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## Section 5

page 3816

- line 5 add a 'be' between 'always' and 'possible'
- line 6 change 'are' with 'is'

## Section 5.2

For the 3-D retrieval did you use only the measurements pointing North or all the measurements? If the latter is true, you are analysing a lot more measurements, and that is one of the reasons for a robust 3-D retrieval

page 3817

- line 8. You speak about relative error, but you never defined what relative error is. I assume it is retrieved minus reference in percent.

Page 3818

- line 11 - what do you mean with 'deliver'?
- lines 14-18. Not very clear, please rephrase the sentences.

## Section 6

page 3819

- lines 12-13 the fact that the volume towards the north shows lower improvement is due to the fact that lies after the tangent points, therefore the opacity of the atmosphere makes this region poorly known.

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## Section 7

All the test reported in this section are performed using a single channel or multi-channels?

page 3820

- lines 4-13 the whole paragraph is rather contorted, please make it clearer.

## Section 7.1

This is the first time that we learn that advection is taken into account as a-priori information.

Page 3822

- lines 4-9. Is the time step size related to the interpolation used to get the wind data? Here you speak about lookup-tables, but which lookup-tables do you refer to? Spectral or trajectories? If trajectories, you should say that you use trajectory LUT before this paragraph, not after

## Section 7.2

- line 26 The synthetic measurements have been generated with a 3-D or 4-D atmosphere?

page 3823

- lines 3-4 again you speak of relative error without defining exactly what you mean by that.

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- lines 26-28 I do not understand the whole sentence. Please clarify

Page 3824

- line 3 What do you mean by 'remnants of LOSs'?
- line 6 What do you mean by 'sweep over the data point'?
- lines 12-13 The first sentence of the paragraph is not clear. Please clarify the conclusion

Section 7.3

- lines 23-24 Figure 12 shows only one of the atmospheric situations listed here
- line 27 What do you mean with: 'The use case at hand'?

Page 3825

- line 5 please introduce 'described' between 'experiment' and 'in Sect.'
- line 8 Why this setup 'demonstrate how well the retrieval can compensate for advection' if you use perfect knowledge of it?
- line 10 please introduce 'described' between 'experiment' and 'in Sect.'
- line 15 please introduce 'described' between 'experiment' and 'in Sect.'

Section 7.3.1

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- line 25 "it is expected that those air masses'. Which air masses are you referring to?

Page 3826

- line 3 what do you mean with 'are even qualitatively well given'?
- line 17 please insert 'the' between 'of' and 'achievable'

Section 7.3.2

- line 23 You say slightly surprisingly you have no convergence problems. I assumed that convergence was not a problem in this case, since the retrieval will produce averaged fields that may cause a high chi-test but not a convergence problem.

Page 3827

- lines 1-16 You use a whole paragraph to say something that is expectable given the retrieval set-up. I will shorten the whole section. also because you draw similar conclusions to the ones already reported in section 7.2

Page 3828

- lines 18-20 Very bad sentence. What do you mean with 'state of affairs'?

Section 7.3.3

Page 3829

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- line 1 which units is 0.87?
- lines 23-26 the whole paragraph is not very clear. Please rephrase it

Page 3830

Conclusions

- line 21 calculate the Jacobian matrix 'algorithmically'?

page 3831

- line 8 substitute 'in the order' with 'of the order'

Appendix

I found the appendix very difficult to follow and understand

Figures

As a general comment I think that a map with the comparison of the 'relative retrieval error' with the 'noise error' will be more meaningful than a map with the retrieval results. This will tell if the achieved accuracy is due to retrieval shortages or to the intrinsic noise of the measurements.