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Atmospheric Measurement Techniques Discussions

Interactive comment on "Towards a 3-D tomographic retrieval for the Air-borne Limb-imager GLORIA" *by* J. Ungermann et al.

Anonymous Referee #2

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This is a nice solid paper introducing the next advance in retrievals of atmospheric composition fields from limb remote sounding observations. While it is a natural and unsurprising extension of previous work, it has, in this paper, been very well introduced, explained and demonstrated. I am happy to recommend this paper for publication, pending the clarification of a few points described below.

The standard of writing is very good and the figures are particularly clear and nicely composed. The number of equations has been commendably kept to a reasonably small level, and while some background is given, the author manages to avoid a wholesale revisit of well-established material (e.g., from Rodgers' book).

My only major concern with the work is the issue of temporal variations in the under-

lying fields. Aircraft observations can take several hours to be completed, and UT/LS composition fields can evolve significantly during this time (particularly, for example, during strong convection). For an introductory study such as this, it is perfectly reasonable to set aside this issue, but its existence should at least be acknowledged and your choice to ignore it for the moment stated explicitly.

Ultimately, I think one would probably have to invoke some kind of assimilation system to handle that issue 'correctly'. I recognize this is an oft-discussed topic. Some have said that assimilation should be all one needs these days, and that stand-alone retrievals should become a thing of the past. I'm generally not all that persuaded by such arguments, particularly for limb observations. However, assimilation would be a nice way to handle the temporal variation issue in this case (but it would place you at the mercy of model accuracy).

My minor comments follow.

—- Abstract

Line 8: 'The 45 (deg) to 135 (deg)' is not clearly stated, I presume 0 (deg) is the flight direction. Also (though less important) is it clockwise or anticlockwise from the aircraft (viewed from above or below)?

—- Page 2996

Line 25: If you're going to state that 'the processes involved are among the least understood of the atmosphere', following that up by citing a 15-year-old review paper is not a good idea! Since Holton wrote that paper there have been at least 3 satellite missions including limb sensors specifically targeting this region, plus countless airborne field campaigns, not to mention many many modeling studies. Surely those have answered many of the questions Holton identifies? What are the next decade's questions in this area? You'll need stronger language than this to get GLORIA funded and flown. It would help to update this material.

—- Page 2997

Line 1: This cascade is interesting perhaps, but why do we care? Why do we need to fill the observational gap? How will it improve our knowledge of things like radiative forcing etc.? Have people shown that it is this gap that makes our models wrong? It's not essential to include this kind of motivation detail in a paper like this, but it is nice to do so.

—- Page 2999

Line 8: 'an altitude' -> 'a tangent altitude'?

Lines 8-9: It would be helpful to also give these angles in terms of distances at the tangent point. I imagine it varies with altitude a little, so just giving typical values would be fine.

Lines 12-14: Just curious - some instruments look forward / backwards. It might be nice to discuss the relative merits of side viewing (apart from the mundane issues of shielding your optics from debris). Is the side-viewing geometry more favorable for these kind of tomographic observations? Your figures seem to make the case that it is - it would seem harder to do this kind of multi-vangtage point viewing in a forwards/backwards geometry.

—- Page 3000

Line 23: 'GLORIA allows *us* to implement'

—- Page 3002

Line 26: Russell has two 'l's

—- Page 3003

Line 10-15: Why do you not do analytic Jacobians, these are almost always more accurate and much faster?

—- Page 3004

Line 5: You don't make it clear which of alpha or L is unitless. I know it doesn't matter in the end, but I think it helps to be clear. So, does the L operator have numbers around one, with the alphas scaling them into state (mixing ratio) space, or is the L operator a variable with some kind of unit and the alpha is varied around unity? Appendix A1 doesn't make this clear either.

Line 25: 'Gladly' -> 'Fortuitously'

—- Page 3008

Line 25: I would have thought CO would be a better choice than O3 this time round, as there are fewer sources and processes affecting it. On the other hand, perhaps there is not a strong enough signal in your spectral region.

—- Page 3009

Line 9: I would have said 'resolution' rather than 'sampling'

—- Page 3010

Line 4: OK, so does alpha have units (see page 3004 line 5 comment)? Given that the value is as high as 8e8 I presume the answer is yes, (so L is dimensionless, or perhaps has dimensions of inverse length). I think it would be good to work out what the units on alpha are and quote them.

Line 10: 'L-curve optimal' - I think I know what that means (but only though having done similar work) - you ought to define it really.

Line 27: '... by this *simplification*.'

—- Page 3011

Line 17: So, are you saying you only do the 'outer' iteration twice? That seems quite a small number. Or do you do several outer iterations without recomputing the Jaco-

bians?

—- Page 3012

Line 7: Within 5 percent? It's hard to tell that from the figures - the continuous color scale makes it hard for the reader to interpret quantitatively. We'll take your word for it of course, but you might want to consider a more discrete color scale ($\sim$5 reds, grey, $\sim$5 blues)? This goes for all your plots.

Line 10: It would be good to be more quantitative here - what does our 5% become?

Lines 13-15: This sentence is a bit unclear, please give more details.

Line 29: Delete comma after 'measure'. Also, 'banana' shapes are not the only problems you could have - an ellipsoidal volume that was not aligned with any useful axes (vertical, along/across track) would be another (perverse I admit) example.

—- Page 3013

Line 18: 'future studies' -> 'the studies described in this paper'.

—- Page 3014

Line 25: 'In effect' -> 'In summary', and insert 'clearly' between 'is' and 'an'.

—- Page 3015

Line 11: 'Exemplary' -> 'For example'

—- Page 3016

Line 2: 'One seems' in this context is slightly ambiguous. I suggest 'We seem'.

Line 15: 'exemplary' -> ', as an example,'

—- Page 3018

Line 23: Why is 'LIMB' capitalized here?

—- Page 3021

Line 11/12: I would avoid 'first guess' here, as it may lead to confusion - people may thing you change the value each iteration. 'reasonable value'.

—- Page 3022

Line 13: I'd delete the comma after 'efficient'

Line 15: '... but *instead* to reduce ...'

—- Page 3023

Line 6: 'Depicted' -> 'Figure 17 shows...'

—- Figure 6:

The caption here has material that feels like it belongs in the main body of the document.

—- Figure 7/8:

These captions, on the other hand, are too short. At least say 'as for figure 5 but for vertical resolution' or something.

—- Figure 13:

All the points have black rings around them. If there is one that is broader than the others, I can't spot it. Please make this clearer somehow.

—- Figure 14:

Last sentence of the caption is unclear - what are we supposed to look at? Give us the altitude/distance of the region you're talking about. Is it everything from 400-800km, 4-16km or are there particular layers of interest?

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