Interactive comment on "A sensitivity study for far infrared balloon-borne limb emission sounding of stratospheric trace gases" *by* J. Xu et al.

Anonymous Referee #5

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The title sets up a clear aim, but the manuscript fails to reach it. In fact, I found the discrepancy between aim and the actual content of the manuscript so high that I must suggest to reject the paper. This in contradiction to the other open review here at GID by "Anonymous Referee #4". However, I agree with this referee in that the actual work done is nicely presented, it is just that I don't find it relevant for the stated aim. In the initial review phase (where I did not participated), Anonymous Referee #3 expressed basically the same criticism as I will do here. The authors wrote a long answer to Referee #3 but did not much to actually fix the problems raised.

If I should try to summarise my criticism, I see two main points

1 The work seems to have been performed in "isolation", or efforts by others are ig-

nored deliberately. Examples are given below. I don't say that this sensitivity study must be performed following exactly the pattern of all earlier similar studies, new approaches shall of course be investigated, but if related work is ignored it is not possible to judge the merits of a possibly alternative approach.

2 Advantages of Tikhonov regularisation over "OEM" is a popular topic for at least one of the co-authors. Here I give the advice to "kill your darlings". This topic is of no relevance for this study, and discussion of the topic is just distracting. If the choice of inversion method has an impact of a basic sensitivity study of this type, then one or both of the methods is used wrongly.

To continue on point 2, it seems that the authors considers to find the lambda parameters as part of the sensitivity study and shows that this step is successfully performed by showing example retrievals. This part constitutes a large fraction of the manuscript, but I found it irrelevant. If there exists still an uncertainty in selecting lambda, this is in fact a reason to not use Tikhonov regularisation. There should be no doubt about that the actual inversions can be performed without problems, as much more complex retrievals are performed routinely (by eg. satellite limb sounding groups). Anyhow, to show "successful" single retrievals is still no prove on that the retrieval set-up is sane. To prove this, an ensemble of cases, spanning all real conditions, must be inverted and the statistics of the results be analysed.

Despite the above, the authors end up with an inversion set-up that is relatively simple, probably too simple. The inversions deal only with species abundances, while it is today standard to retrieve instrumental variables in parallel. For example, a simultaneous retrieval of a pointing correction is performed for all satellite limb sounders, and I don't see why not this methodology could be applied for here. This would result in a lower sensitivity to pointing uncertainties than estimated in the manuscript. In addition, if I understand it correctly, both OH and O3 have transitions in both sidebands, and this fact should make it possible to retrieve the sideband ratio. Hence, a more final retrieval set-up should be used/considered, to obtain more final estimates of retrieval errors.

The option of a joint pointing retrieval is discussed at the end of Sec. 3.3.3, but the text does not reflect the general knowledge totally. The comments hint that it is possible to retrieve a pointing correction for each individual spectrum, but that should be a rare case. If the pointing must be fitted in this manner there exists so called "pointing jitter" and a substantial level of such jitter is known to "kill" useful retrievals (at least as long not oxygen is covered).

Here I suggest the authors to take a closer look at similar work elsewhere, to get input for an improved study. Beside the actual inversion set-up, it should then be clear that it is standard to also consider other errors, maybe most notably spectroscopic errors. Such errors are fundamental for Sec. 4, treating multi-channel retrievals. If perfect spectroscopic information is assumed, then such retrievals seem to work very well, but in practice the situation is very different.

Maybe the most problematic part of microwave measurements is so called baseline distortions. This issue is not discussed at all. Neither how this can be handled by the retrievals and to what extent the real measurements are affected.

This brings us to the actual measurements.The manuscript gives the impression that this part of the TELIS observations has been totally ignored. I could not find a single reference to earlier studies dealing with these inversions. At least I found it hard to believe that this "channel" was included in TELIS without any inversion simulations during the design phase. I am not familiar with TELIS so I could be wrong, but then the lack of relevant citations shall be expressed clearly. In summary, older work should be acknowledged, and it should be discussed of these results are consistent with older ones.

Most of my more detailed comments are in parts that I think shall be removed, or should disappear if my general comments are considered. If the editor decides to not follow my judgement, I would like to get the opportunity to add these detailed comments later, here in the open discussion.

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Some other smaller comments:

The estimation of smoothing error is not clear. I assume you use Sx-matrices as defined in Eq 4. Eq 4 corresponds to a 100% (1 sigma) natural variation of the gases. Do you really assume this high variability? And I don't find the values you apply for l_i and l_j.

You end up with low values of lambda. In Sec 4 even lambda = 0 for O3. This means that you are close to, or actually doing, least squares. In this case, the level of regularisation is effectively implemented by the grid spacing. Are you using a too coarse grid, and the smoothing error could in fact be lower?

Eq 9: This definition is only useful if the emission line covers only a single frequency channel. Anyhow, seems to a very indirect way to say that you set Tsys to 3800 K.

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