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Interactive comment on "Atmospheric composition and thermodynamic retrievals from the ARIES airborne FTS system – Part 1: Technical aspects and simulated capability" *by* S. M. Illingworth et al.

Anonymous Referee #1

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The paper by Illingworth et al. presents a data processing scheme for airborne spectroscopic measurements and uses this for retrieval feasibility and sensitivity studies. This paper will not only be an important reference for future studies with the ARIES instrument but also includes some information which seem to me to be interesting also to aircraft remote sensing scientists beyond the ARIES community. The analyses seem robust to me. Thus, I recommend this manuscript for publication in AMT. I have no general issues to criticize but only some specific comments which should be easy to fix (see the list below).

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Interactive Discussion

Discussion Paper

Abstract: It should be mentioned in the abstract that the paper is about nadir-measurements. Aircraft measurements are performed in four possible geometries/modes (nadir, limb emission, upward emission, upward absorption) and it is confusing for the reader not to know from the beginning which geometry/mode the paper is about.

Intro: The same applies to the body of the text: It is mentioned that T_s and ϵ_s are a prerequisite for the retrieval (p10837 l18), but this is only true for nadir retrievals. It has, however, not been stated yet that the paper is about nadir retrievals.

p10837 l10: The abbreviation OEM is used here but it is defined only on page 10839.

p10837 l24: I think (but I might have missed it) that the ARIES acronym is defined only in the abstract but not in the body of the text. This is not sufficient; both the abstract and the body of the text must be able to stand alone. Thus the ARIES acronym needs to be defined when first used.

p10838 l7-9 (a very minor issue): when reading the abstract I was confused about the name ARIES because I wondered what the term 'Evaluation System' means. This becomes implicitly clear on p10838 l7-9 which I understand shall tell me that ARIES is an evaluation system for IASI. This rationale of the naming could be made a little more explicite.

p10838 l18: The term 'scan' is ambiguous. It can be an interferometer sweep, it can be a geometrical scan over the swath, etc. Please be more specific here.

p10838 l22: Here the information is given that only nadir spectra are considered in this study, but this information is needed earlier.

p10839 l11: 'for the first time' is unnecessary and should be deleted.

p10840 l22: The threshold value of 85% does not tell me much if I do not know how the metric is constructed, thus it is pseudo-quantitative. Either remove the value or make it better traceable how this value is inferred.

p10842 l7: I am not sure if the term 'modulated' is ideal here. Modulation, I understand, modifies something which already exists, while the emitted radiance directly depends on the surface temperature and emissivity. I suggest 'which depends on T_s and ϵ_s'.

p10842 l8: The radiance is not attenuated at discrete wavelengths. Due to Doppler and pressure broadening, there is no attenuation at discrete wavelengths. Do the authors mean, that the numerical simulation is performed at discrete wavelengths?

p10842 l8: There is a third term missing: The emission of the atmosphere. Since the temperature of the atmosphere and surface are similar, both contributions are important (contrary to, e.g., solar absorption), particular in the case of a temperature inversions. I know that the RFM is designed to consider atmospheric emission; please make sure that this feature has not been inappropriately deactivated, and change the text accordingly. I suspect that the calculations with the RFM are ok and only the text is incomplete but this should be checked.

p10842 l26: I think the term 'theoretical' would be more appropriate than 'technical'. The latter, I understand, includes implementation issues etc.

p10842 l26: It is funny to see Rodgers 2000 as a reference for OEM. While this method is thoroughly discussed in that book, it is called 'maximum a posteriori' there. The term 'optimal estimation' was used in Rodgers' older publications only. Personally I have no problems with this but a student who is new in this business might be confused by the inconsistent naming. Perhaps it helps to add somewhere 'OEM, later renamed maximum a posteriori'.

p10842 l28: 'statistical knowledge' is too vague. Please add 'on the variability of the true state around x_a'.

p10843 l7: It is not generally true that the chi square is at a minimum equal to the number of measurements m. This is true only in a statistical sense, i.e. the expectation of chi square over a large number of retrievals equals m.

p10844 appr l17-22: I could not fully understand this. This should be reworded for clarity.

p10850 l6-7: The first sentence of this paragraph does not help. There is no need to be so defensive. Sensitivity studies are a kind of research in their own right. Just delete this sentence and concentrate on what you have done; don't start the paragraph with a statement on what you have not done.

p10854 l1: The formulation $1 - (S_a/S)$ is sloppy because it contains undefined matrix operations. I can see what you mean but a more careful formulation is needed, e.g. 'the diagonal terms of $I - S_a S^{-1}$ where I is unity'.

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