

General, specific and minor comments of the reviewer in Italic characters.
Replies of the authors in Normal characters.

Reviewer #1

General comments

In this paper an application is presented of data fusion obtained by using the MSS inversion technique. The considered observations were collected by a sub-mm wave (MARSCHALS) and an IR (MIPAS_STR) spectrometer that measure the same air masses on board of a stratospheric aircraft. The authors apply, for the first time, the MSS fusion in conjunction with Tikhonov-Phillips regularization and show results that demonstrate the better quality of level 2 products obtained by combining the fused MSS solutions with respect to the products derived from the separate MSS inversion of data from the individual instruments. Authors also compare the performance of the MSS-fused products with the results of an alternative fusion approach that consist in the inversion of MARSCHALS observations using the products of the MIPAS-STR inversion as a-priori information within the optimal estimation strategy. The subject of this investigation is relevant and the quality of the presentation is good. Overall, I consider this paper to meet the scope of AMT. However, before publication I recommend authors to address a couple of not negligible weak points that I raise in the following section.

Specific comments

The main objection I move to this paper is the lack of comparison (or at least of discussion) with the simultaneous inverse processing of the observed radiances. Authors mention the alternative strategy in the introduction, however this approach is no longer considered in the following discussions. Actually, I guess the simultaneous inversion to be the most efficient data-fusion method whenever level 1 data are available. I would have liked to see the comparison of simultaneous inversion with MSS data fusion in order to provide a strong indication to user community about the right direction to aim. I do not ask to include such a comparison in this paper but, at least, a sentence to point out the problem. The authors must admit that the products of MSS analyses (see also below) are not user friendly, hence the level 2 users must have solid motivations to prefer the MSS products. On the other hand, I would tend to consider the inversion of MARSCHALS observations using L2 products of the MIPAS-STR as a-priori information, a suitable choice for the optimal estimation rather than a data-fusion technique. An effective data fusion (as the MSS fusion is) is expected to be more effective than optimal estimation, so I consider of minor importance the comparison reported in this paper.

We agree with the reviewer that the simultaneous inversion of the radiances observed by the two instruments would be very useful to evaluate the performances of the two methods presented in the paper. However, the simultaneous retrieval is of difficult implementation because it requires a forward model that can simulate the observations of the two instruments and the retrieval algorithm has to deal with a large amount of data. For this reason, new data fusion methods are investigated with the purpose of identifying possible candidates to adequately replace the simultaneous retrieval. The direct comparison of one of these candidate procedures with the simultaneous retrieval is beyond the scope of the paper. As suggested by the reviewer #1, we modified the text of the paper, in particular, the introduction and the conclusion, to add this kind of considerations.

The common criteria to judge the quality of retrieved profiles are total error and vertical resolution (whose importance is also recalled by the authors in section 2.2 for IR observations). I understand that the MSS approach does not provide the second property. Some hint about vertical resolution can be derived from DOF and RID quantifiers but this is less than what can be derived from the AK of a standard inversion. Authors should address this point when introducing the adopted quantifiers.

Once that from the MSS we have built the profile using the Tikhonov regularization, we can calculate the AKs by means of Eq. (7) and from this we can calculate the vertical resolution. However, we think that the used quantifiers extensively describe the assessment of the performances of the instruments and of the methods and we prefer not to extend further the paper with information, which is redundant for the purposes of the paper.

Technical corrections

Apart from the considerations in the “specific comments” section, I have found confusing for the reader to call “data fusion” both the sequential inversion of MIPAS and MARSCHALS level 1 data and the MSS data fusion. I suggest to always refer to the first as “L1+L2 method” (as done in the abstract and elsewhere) and to the second as “MSS data fusion”.

Done

Page (P) 11674, line (L) 20. Change “O2” into “O3”.

Done

P 11675, L 14. “(Ingmann et al.,2012) should be “Ingmann et al. (2012)”.

Done

P 11676, L 17. “negative lapse rates”: specify “T lapse rates” if this is the case.

Done

P 11677, L 4. “millimetre” should be “millimeters” or “millimeters”.

Done

P 1677, L 9. “absorption lines” should be “emission lines” since this is our case.

Done

P 11677, L 13-17: this paragraph is a single period which is difficult to understand. Please try to write it more clearly.

We changed the period as follows: “The differences in spectroscopic properties, propagation through clouds and aerosols and surface emission features make profitable the synergistic use of infrared and microwave observations. These differences also exist - even if to a lesser extent due to the reduced gap in wavelength - between the infrared and millimeter and sub-millimeter wave (3 mm – 300 μ m) radiation.”

P 11679, L 6,7. “millimeter-wave and mm-wave”: please define mm-wave at the first occurrence and use it elsewhere.

Done

P 11682, L 19. Delete “covariance” because it is redundant with “off-diagonal”.

Done

P 11682, L 27.” either with” should be “with either” + delete “with” at L 29.

Done

P 11684, L 8. Close the parenthesis before “were utilized”.

Done

P 11684, L 12. “0.8 arcmin”: It would be useful to provide (also) an estimate of pointing accuracy in terms of kilometers at tangent point.

Replaced: ‘The pointing accuracy is estimated to be within 0.8 arcmin.’

With: ‘The total pointing accuracy is estimated to be within 0.8 arcmin (1σ) and includes uncertainties of the attitude information from the AHRS, the accuracy of the scan-mirror control and uncertainties of the line of

sight retrieval to correct systematic uncertainties. This corresponds to about 100 m at the lowest tangent altitude of 5 km, for details see (Woiwode, 2012).’

P 11685, L11. 5% error in CO2 VMR (about 20 ppm) seems too large. Is it correct?

The 5% uncertainty was adopted as an estimate to account for both, errors in the spectral line data and the CO₂ profile.

Replaced: ‘was considered to estimate the effect of errors in the spectral line data and CO₂ profile.’

With: ‘was considered as an estimate to account for both, errors in the spectral line data and the CO₂ profile applied.’

P 11687, L 11. “by calculating”. L 19 “by selecting. L 20 “by performing”.

Done

P 11688, L 22. “Differently by” should be “Differently from”.

Done

P 11690, L 9. Here and elsewhere. “performances” should be “performance”.

Done

P 11696, L 5. “o3” with capital “O3”.

Done

P 11696, L 8: SF has not been defined as acronym of Synergy Factor.

Done

P 11696, L 16 and elsewhere. cross-sections: this term has a specific definition in spectroscopy. If authors intend to use this term in a different context they should specify their definition. On the other hand, in the figures I see VMR profiles instead of cross sections. Cross-section is instead, used properly at P 11676, L 28. Following the recommendation of reviewer #1, at the first occurrence of the term “cross-section” (P.11696, 116), we have added the statement: “.. (i.e., in this context, the combined horizontal sequences of retrieved atmospheric parameter profiles) ...”

P 11696, L 21-22. This list of targets has been already defined in this page at L 5.

List of targets removed

P 11702, L 27. “up to about 60%”: A reduction of this entity cannot be appreciated in the top-right panel of Fig. 10. A plot of the average error at each altitude could help to support the 60% statement.

Here below, we provide the plot of the average error (total error) at each altitude as requested by reviewer #3.

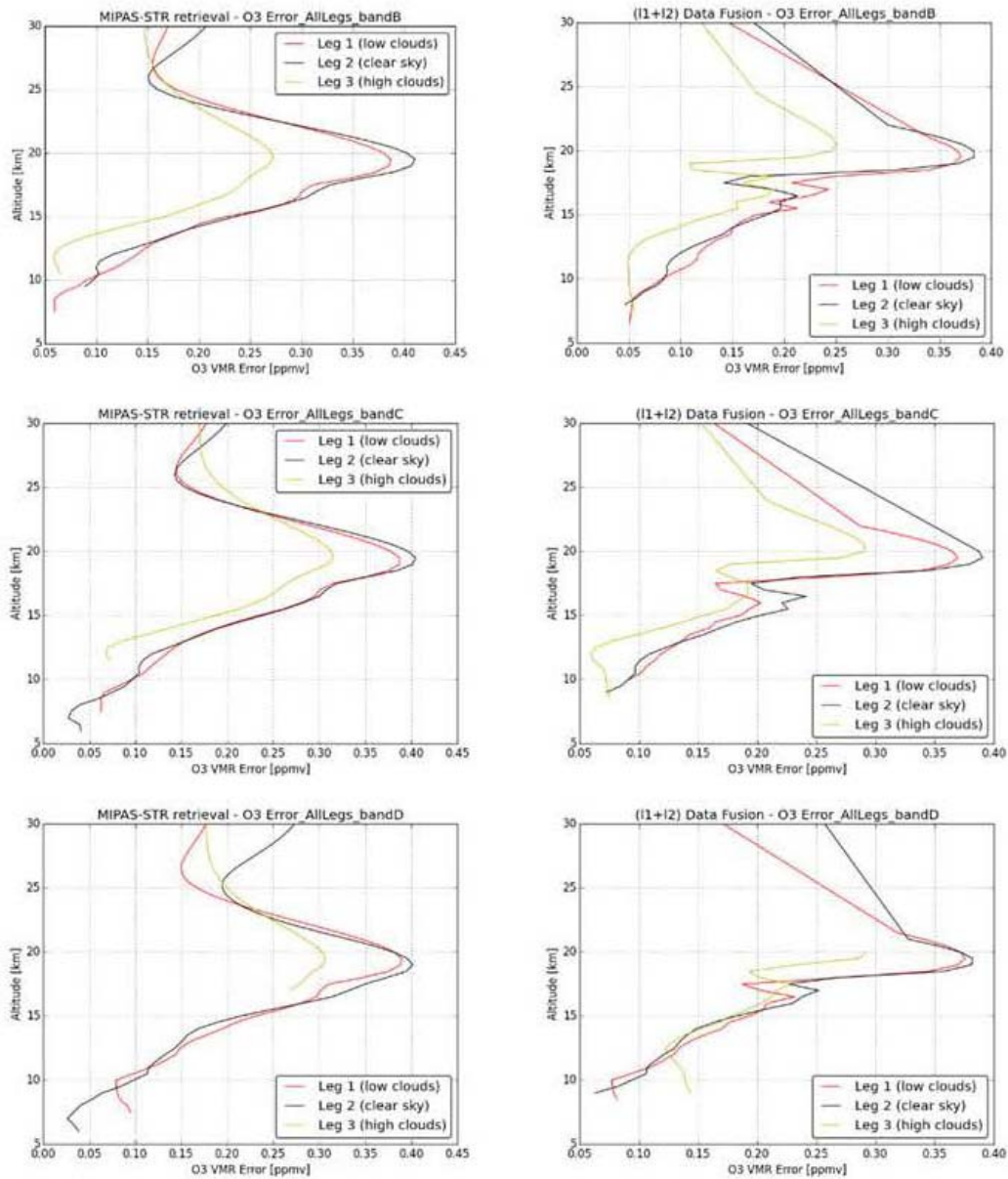


Figure – MIPAS-STR and (L1+L2) total uncertainty as a function of altitude in the three legs of the flight from Kiruna, Sweden on 10/03/2010.

In the text, we changed the statement “In particular, a reduction up to about 60%of the total uncertainty is observed, when combining MIPAS-STR data with MARSCHALS observation” to “In particular, a reduction up to 60% is observed in the plots (not shown here) of the total error vertical profile averaged for each band over the three legs of the flight”.

P 11703, L 22. “to both” should be “both to” + delete “to” at L 23.
Done

P 11703, L 25. “in context of” do you mean “in the context of”?
Yes, we changed “in context of” to “in the context of”

P 11704, L6. Delete “,” after “conclusion”.
Done

P 11706, L 2. “when both combining” should be “when combining both”.

Done

P 11718, Figure 1. The dots of band B and those of band D are not distinguishable in the figure. I suggest to use a different color (green?) for one of the two.

Done

P 11718, Figure 1 caption. Please explain what you intend for “scan position”. I exclude it is the tangent altitude because I see dots well below 5 km while in sect. 4 it is stated that tangent altitudes are between ~5 km and flight altitude. Moreover some dots in Figure 1 seem to be at 0 km (refer to nadir observations?).

The statement “between ~5 km and flight altitude” refers to the MIPAS-STR tangent points (not to the MARSCHALS tangent points). The dots in Figure 1 (MARSCHALS observations) at 0 km refer to tangent observations with the line of sight just touching the earth surface.

Added in P11694/L22: ‘The tangent points of the MARSCHALS observations covered the vertical range from 0 km to flight altitude.’

Added in P11695/L13: ‘ (see also Fig. 4)’

Replaced caption figure 1: ‘The flight altitude and MARSCHALS scan position plotted vs. the acquisition time (UTC).’

With: ‘The flight altitude and MARSCHALS tangent points plotted vs. the acquisition time (UTC) for the Arctic Geophysica flight on 10~March 2010.’

P 11722, Figure 5. I suppose the black line across all the maps represents the flight altitude. If this is the case it should be specified at least in the caption of the first figure where it appears.

Correct, this is the case. We have added the statement “The black line across the maps in this figure, as well as in other figures of this paper represent the flight altitude.” At the end of the caption of Figure 5.

P 11724, Figure 7 caption. “H3O” should be “H2O”.

Done

P 11726, Figure 9 caption. Add “(left panel)” after “products” and “(right panel)” after “SF”.

Done.