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Atmospheric Measurement Techniques Discussions

Interactive comment on "Synergy between middle infrared and millimetre-wave limb sounding of atmospheric temperature and minor constituents" *by* U. Cortesi et al.

Anonymous Referee #3

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Synergy between middle infrared and millimetre-wave limb sounding of atmospheric temperature and minor constituents

Cortesi et al

SUMMARY

The paper describes methods of combining data retrieved from two limb-viewing instruments, MIPAS-STR and MARSCHALS, carried on the same aircraft. The first method (MSS) separates the measurements and constraints from each retrieval, combines just the measurement components and adds a new constraint, in this case Tikhonov regularisation, to produce stable output profiles. The second method is sequential: the

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MIPAS-STR profiles are first retrieved using regularisation, and the resulting profiles are then combined using optimal estimation with the MARSCHALS data. In principle, the results ought to be the same but significant differences are noted due to the implementation.

A second aspect of the paper is the demonstration of synergy between instruments using the infrared and millimetre spectral ranges, showing that under conditions of thin cloud, the MARSCHALS instrument can make a significant contribution. However, this is hardly surprising.

GENERAL COMMENTS

Any retrieval can be considered the sum of measurements and constraints (a priori estimates or regularisation) weighted by their inverse covariances. In principle, the results should be the same whether two sets of measurements are combined simultaneously with the constraint (the MSS method), or if one set of measurements is combined with the constraint, and the second set of measurements then added using optimal estimation (the L1+L2 method). The fact that the results are different are therefore simply due to differences in the details of the implementation, primarily the grid representation. It would have been better to have a consistent retrieval throughout.

A second criticism is the rather loose definition of what constitutes a synergistic retrieval. If, as the title suggests, the aim is to demonstrate synergy between the two types of instrument, beyond the obvious fact that microwave instruments are less sensitive to clouds that infrared instruments, I was left unconvinced. Probably the most important issue when combining data from two different types of observation is whether the absolute accuracy of the product is improved, and that was not discussed. The introduction of unecessary and unhelpful new diagnostics (RID, MQQ, SF - detailed below) did not help matters.

Overall, this paper demonstrates a successful practical application of two different methods of combining profiles with different retrieval characteristics but in terms of

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showing the 'Synergy', as in the title of the paper, adds very little to what is immediately obvious: infrared is generally better than millimetre, but not when it comes to cloud.

SPECIFIC COMMENTS

1) P11676, L15 - P11676, L11677: This list of pros and cons of IR/MW seems to be applicable to nadir sounding rather than limb sounding (eg negative lapse rates, surface emissivity) and comments about the 4.3um (2300cm-1) CO2 band seem irrelevant if MIPAS-STR only measures up to 2100cm-1. I suggest this list is reviewed and amended to make only the points relevant for this experiment. But it should perhaps also be noted that there are molecules, most notably O2, which have significant spectral features in the MW but not in the IR.

2) Section 3.1 The MSS solution is described at considerable length, and rather confusingly, in section 3.1, as if it were some complicated transform. However, looking at Eq(1), it appears to be simply the standard unconstrained least squares fit solution and, to most readers, that would be a much shorter and simpler description. Substituting the standard LSF covariance (KˆT Syˆ-1 K)-1 (the inverse of the Fisher information matrix defined in Eq8) for the S_MSS in Eqs (1)-(7) seems to give the standard equations for regularised inverses.

3) P11690 - discussion of Total Retrieval Error I found this very difficult to follow.

4) P11692 - Relative information distribution. I don't understand why this RID diagnostic is introduced here at all. With equal profile spacing it is basically just the inverse of the square of the retrieval error expressed as a fraction of the profile value, thus there is a 1:1 relationship between RID and %retrieval error. So the RID panels in Figs 5-7 show exactly the same information as the error panels above, but with different and obscure contour values. I have no idea what a RID value of 4000 means, but I do understand a retrieval error of 0.5% or 0.5K.

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5) Synergy Factor The original use by Aires was to investigate combinations of nadir-sounding instruments where the error could be measured with respect to a defined 'truth', and some combinations could clearly be worse than single instruments. It seems a misuse to apply the same statistic to these results where the errors are now just the predicted retrieval errors which can, by definition, never get worse. Thus everything appears to prove 'synergistic' to some degree. If you are going to use this definition of synergy, then the results should be compared to some independent truth.

6) The Shannon information gain is, I think, too easily dismissed as an alternative. Firstly, it can be defined wrt to *any* 'a priori' covariance, not necessarily the one actually used (if any) within the retrieval. As such it can provide a sensible weighting of each profile retrieval error in the context of an expected uncertainty in the quantity. For example 10% accuracy in tropospheric ozone is much more useful than 5% accuracy in stratospheric ozone but the RID would weight them the other way around. Secondly, the Shannon information can also be defined level-by-level (replacing the covariance matrices with variances) so can provide altitude discrimination. It also has the useful property of being additive, so in my opinion would provide a better measure of the relative contributions of the two instruments than the Synergy Factor or RID.

MINOR COMMENTS

a) 'Inverse Processing' there are a number of occurences of this phrase eg P11674, L24, Section header 2.1.2. This confused me at first since I thought it might refer to simulating L1 radiances from L2 products (ie the 'inverse' of the usual 'processing'). I would suggest replacing with 'Inversion', but that's just my preference.

b) P11679, Section 2.0. Given the equal weight here applied to all three flights in this section, I was expecting results from all three to be shown rather than just the 2010 campaign. Please adjust the text accordingly to make it clear at this point which of the various datasets are to be investigated in the remainder of this paper.

c) P11680, L4-5: I suggest 'In the upper troposphere, at millimetre wavelengths, prob-

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lems can be posed by ...'. However I didn't understand the point that was being made in the following sentence about 'residual absorption'. Is this a reference to the MARSCHALS field-of-view extending to the mid-troposphere where water vapour concentration is even higher?

d) P11683, L21 (also P11695, L7) 'along flight track'. Are the measurements along the actual flight track or parallel to it? I assume that both instruments look sideways to the flight direction although that hasn't been stated so far (in fact, only evident in Figs 2 and 3, and not mentioned in the text at all). Horizontal gradients have more of an impact if the viewing direction is orthogonal to the flight direction, so it is an important distinction.

e) P11684, section 2.1.2/2.2.2. It would be better to have an equivalents to Table 1 and 2 to describe the MIPAS-STR instrument and error characteristics.

f) P11694 L1-9: Synergy Factor It is not obvious here, but Aires only defines synergy factor for a scalar quantity, ie a profile level rather than complete profiles. Otherwise there is the question of how to compute a synergy factor for vector quantities.

g) P11696 L5 'These included ....' Not clear if this is the list of all the targets retrieved from both instruments, or just the subset of common targets studied here, or just some examples of common targets.

h) P11697 & Figs 5-8 I am unclear on what is being shown on the DOF panels for the MARSCHALS data. Does 'B and B' refer to band B data only? And for the B+C and B+D data are data from successive scans being averaged together to retrieve a single profile?

i) P11698 and subsequently Discussion of 'factors' when applied to intrinsically dimensionless quantities such as DOFs is confusing. Better to refer to absolute increases. In any case, if the changes are associated with the change in the number of cloud-free profile levels, it really is a change in the number of DOFs rather than a fractional

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increase.

j) Figs 5-8: Since the text refers to changes for different 'Legs' of the flight, these should also be marked on the figures (perhaps just the DOF panels).

TYPOGRAPHICAL/GRAMMATICAL POINTS

Throughout: inconsistent spelling 'vapor' and 'vapour'

P11674 L6: change 'is focusing' to 'focuses' L20: change 'O2' to 'O3'

P11675 L5: change 'is providing' to 'provides' L18: remove comma after 'sounders'. I think what the authors are trying to say here is: either using different spectral regions or using different observation geometries.

P11678 L1: change 'embarking' eg to 'carrying' L2: change 'was composed by... and by...' to either 'comprised' or 'was composed of ... and ...'

P11680 L12-13: change 'an uniform' to 'a uniform'

P11681 L10: No need for definition of IMU acronym if it does not appear elsewhere.

P11681 L16: (pedantically) MARC retrieval code is a tautology since the 'RC' also means 'retrieval code'

P11682 L9: ILS acronym apparently not repeated elsewhere

P11682 L10: change 'uncertainties on' to 'uncertainties in' L12: change 'MARC algorithm provides also ' to 'The MARC algorithm also provides '.

P11683 L13: change 'allows to observe' to 'allows the observation of ' L15: suggest changing 'tropospheric altitudes' to 'tropospheric tangent altitudes' to clarify that the point refers to the target rather than the observing instrument. L21: change 'allow to resolve' to 'allow the resolution of'

P11684 L8: missing ')' after '990 cm-1'

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P11685 L8: change 'inverted' to 'retrieved'

P11686 L10: Section 3.1 MSS should be expanded here on its first use in the main part of the paper.

P11690 L26: change 'we remind here' to 'we recall here' (remind is a transitive verb so requires a direct object, eg 'we remind the reader').

P11693 L1: change 'independent on' to 'independent of' L8: change 'in alternative' to 'as an alternative' L24: change 'allows to evaluate in detail' to 'allows the detailed evalauation of'

P11695 L7: change 'scenery' to 'scenes'

P11696 L5: change 'o3' to 'O3' L12: change 'remind' to 'recall' L14: (pedantically) 'alternate' refers to just two cases, not three.

P11697 L5: change 'cfr.' to 'cf.' L9: change 'fucntion' to 'function'

P11703 L20: change 'capable to evaluate' to 'capable of evaluating'

P11704 L2: change 'allow separating' to 'allow the separation of'

P11715 (Table 1) 'Band A' listed as header for first column. Also, there should be some mention of noise characteristics.

P11716 (Table2) change 'hundredth' to 'hundredths'

P11718 (Figure 1) Since several MARSCHALS datasets are mentioned here, it should be made explicit in the figure caption the date/latitudes of this particular flight.

P11724 (Figure 7) change 'H3O' to 'H2O'

P11728 (Figure 11) change 'Sinergy' to 'Synergy' on right axes.

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 11673, 2015.