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Atmospheric Measurement Techniques Discussions

Interactive comment on "Profiles of CH_4, HDO, H_2O, and N_2O with improved lower tropospheric vertical resolution from Aura TES radiances" *by* J. Worden et al.

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The paper "Profiles of ..." by J. Worden et al. fits well in AMT. Relevance, scientific quality and presentation are good, except for issues mentioned below. I recommend publication after consideration of the following minor comments.

p. 6680 l. 20 and elsewhere: MIPAS retrieves CH_4 in a similar spectral region and has also a problem with a high bias in the upper troposphere and lower stratosphere (von Clarmann et al., AMT 2, 1-17, 2009). This supports the hypothesis that there indeed is

a problem with spectroscopic data.

p. 6680 l. 16 "greater resolution": If the number becomes larger, the resolution becomes worse. It is the "resolving power", not the "resolution" which becomes greater (at least this is the terminology I have learned, I may be wrong). If you replace "greater" by "better" the statement will be unambiguous.

p. 6668 l. 4: It is a good idea to discuss the scientific relevance of the gases retrieved also in a technical paper like this. However, the inclusion of Fig. 1a might be a little bit too much, particularly because it is never referred to the contents of this figure in other parts of the paper.

p. 6681 l. 18: You might wish to include MIPAS in this list, in order to achieve a better correspondence between list of instruments and the scientific studies mentioned in lines 13-16.

p. 6681 l. 21 Fig 1b: same as for Fig 1a. The text is fine but I do not consider the inclusion of such a schematic figure necessary in the context of this paper.

p. 6682 l. 7-20: I find this paragraph confusing because it describes TES retrieval issues in pretty much detail before TES has even been introduced. I suggest to shorten this paragraph considerably or even to delete it. The reader who is in a hurry finds this information in the abstract, and the more interested reader will find this information below, where it is placed much better into context.

p. 6683 Eq. 1: I find this equation confusing because it is not clear to me which values are vectors and which are scalars. Shouldn't 'x' be bold face because it is a vector (i.e. a profile)? Or do you really refer to one element of the profile? A_{xy} is italic in the Equation but bold face in the text. Please take care to use consistent type-setting and in addition clarify in the text for each symbol if it is a scalar, a vector, or a matrix.

p. 6684 Eq. 3: and related text: Attention: there is a trap in the smoothing error, because it depends on which altitude grid it is evaluated. Evaluation of the smooth-

ing error for the old retrieval with the coarser retrieval grid will ignore smoothing error components related to small-scale variation which can only be presented on the finer grid. Thus smoothing errors may not be intercomparable. The more formal problem mentioned later, that a priori covariance matrices are often singular just reflect this problem: These might have been evaluated on a too coarse grid. TSVD inversion as suggested by Mathias Schneider solves the problem only formally. The core of the problem, however, is that no information on climatological small scale variability and correlations is available, and this leads to an inappropriate estimate of the smoothing error. The problem with the smoothing error is two-fold: First, a priori variability on small scales may be unknown, and second, the estimate of the smoothing error depends on the grid on which it has been evaluated. For this paper, it is only important to make sure that smoothing errors of the two intercompared retrievals are evaluated on the same altitude grid, using the same a priori covariance matrix, and that the latter actually contains real information on the variances and covariances on a grid as fine as the retrieval grid.

p. 6685 l. 19: This is interesting because also for MIPAS it was found that in this spectral region joint retrievals (in this case: N_2O and CH_4) perform better than single species retrievals (A blind test retrieval experiment for infrared limb emission spectrometry, T. von Clarmann et al., J. Geophys. Res., Vol. 108, No. D23, 4746, doi:10.1029/2003JD003835, 2003.)

p. 6685 l. 24: Is it really a CFC line? Heavy molecules have their lines so close together that I suspect it is rather something like a Q-branch.

p. 6686 l. 4: where the COLUMN vectors x... (This is because people not familiar with this formalism tend to build a matrix when several vectors are put in a matrix, but you build a column vector of several column vectors).

p. 6687 l. 10-24: Is this new $\mathbf{S}_a$ matrix used also to evaluate the smoothing error? If so, is it also used to evalute the smoothing error of the OLD retrievals? If smoothing errors

between the old and new retrievals are compared, it is essential that both smoothing errors are evaluated on the same grid, using the same $\mathbf{S}_a$.

p. 6688 l. 2-3: This over-defensive statement on validation does not help the paper. I suggest to simply remove it.

p. 6688, Eq. 6: Again the formalism is a bit sloppy: What are scalars, what are matrices?

p. 6688 l. 20 “mean biases”: Isn’t the attribute “mean” obsolete? Aren’t biases always average differences?

p. 6710 Fig 3b: “is the sum of” is misleading because it is the quadratic sum.

p. 6690 l. 15: It is mentioned only here that a log based retrieval is used but this information is needed much earlier, eg. near Eq.5. A lot of the text and figures (e.g. averaging kernels) is easily misinterpreted when one does not yet know that the retrievals are logarithmic.

p. 6693 bottom: Can issues with the pressure broadening coefficients be excluded?

p. 6696 l. 8 (possibly also elsewhere): “second order statistics”: Wouldn’t the correct term be “second moment statistics”? kth order statistic seems to be something entirely different (c.f. http://en.wikipedia.org/wiki/Order_statistic)

p. 6697 l. 11: Mathias Schneider argues that the improvement might be caused by a different $\mathbf{S}_a$ rather than the use of a wider spectral range. However, these choices are not independent: Certainly a weaker regularization by larger a priori variances alone will improve the altitude resolution but in turn the observation error of the retrieval will increase. I think the improvement of the altitude resolution at the cost of larger error bars can easily be predicted and does not need an additional test. Better resolved profiles at equal or better (smaller) observation errors, however, indeed can only be achieved if more measurement information is fed into the retrieval, e.g., if a wider spectral range is used. This is directly linked to the “law of large numbers” in probability

theory. Perhaps it helps to reword the conclusion in a sense like "...by using a wide spectral range, allowing a weaker constraint without loss of precision" or something similar.

Regards, Thomas von Clarmann

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