Referee's report on amt-2011-127 paper «Characterization of profiles of CH4, HDO, H2O, and N2O with improved lower tropospheric vertical resolution from Aura TES radiances» by J. Worden et al.

GENERAL

This paper presents a new algorithm for retrievals of trace gases from TES/Aura measurements, which provides vertical profiles with an improved vertical resolution and reduced uncertainties. The paper is interesting, well organized, rather clearly written. It certainly deserves publication in AMT.
Hereafter, I present comments that could be taken into account by the authors if they agree.

COMMENTS

Please check and correct the matrix-vector notation in equations. I believe the vectors are not in bold italics in the current version.

Introduction: Figures 1a and 1b illustrating the sources, sinks, and processes controlling tropospheric H_2O, CO_2 and CH_4 are nice, but, because this is not the topic for the paper, can be simply replaced by the corresponding references.

Eq.(3): Should the 3rd term be $\mathbf{S}_M$?

Smoothing error: the authors state that the term $(\mathbf{A}_{xx}-\mathbf{I})\mathbf{S}_a(\mathbf{A}_{xx}-\mathbf{I})^T$ in Eq.(3) represents the smoothing error. However, the smoothing error is $(\mathbf{A}_{xx}-\mathbf{I})\mathbf{S}_e(\mathbf{A}_{xx}-\mathbf{I})^T$, where $\mathbf{S}_e$ is the covariance of an ensemble of real atmospheric profiles about the mean profile (detailed discussion of this issue can be found in the book [Rodgers, 2000]). When true $\mathbf{S}_e$ is unknown, using a priori covariance matrix $\mathbf{S}_a$ instead of $\mathbf{S}_e$ introduces the corresponding limitations in estimates of the smoothing error. I absolutely agree with T. von Clarmann that the smoothing error in new and old retrievals should be estimated on the same grid using the same $\mathbf{S}_a$. Please stress this and clarify what $\mathbf{S}_a$ have you used.

I think, it is important to demonstrate that the improved vertical resolution is not at the price of degraded accuracy, but the new retrieval is indeed presents the better estimates. For this, I suggest the following modifications in Figures 3b and 5b:
- Left subplot: combine two current subplots into one. Mirror on negative part is not needed, use only positive part, and use different line notations (solid- dashed or similar) for old and new retrievals.
- Right subplot: present the error estimates for old and new retrievals, when profiles are presented in the same vertical resolution. The presenting profiles in the same vertical resolution can be done via (i) convolving low-resolution profile with the averaging kernel of a high-resolution profile and the other way round, or (ii) degrading high-resolution profile down to a resolution of low-resolution profiles by corresponding smoothing. The first approach is more accurate.

Comparison of rms uncertainty for old and new retrieved profiles presented in the same vertical resolution will indicate clearly the advantages of the new algorithm.

Fig.3b and Fig. 5b: Please indicate units on horizontal axis.(Relative error?)

Figure 10: Above 100 hPa, the total error is larger than a priori uncertainty. It looks very strange for me: measurements worsen a priori knowledge? Please provide a comment/explanation.

Figure 6, bottom: the figure is hardly readable. Please try to improve vertical scaling or consider including the data statistics.

P.6684, l. 24: “to a decreases uncertainty” -> please change into “to a decrease in uncertainty” or “to a decreased uncertainty”

P.6688 line 19: Please explain/discuss shortly the increased uncertainty at 700 hPa.

P.6690, line 13: I think it is better to define δ-D immediately after the first appearance of this notation in line 13, and simplify the text below.

P.6690, line 15: It is written that the data with DOF>1.0 are used, while the caption of Fig.6 states that DOF threshold is 0.7. Which one is correct?

P.6690, line 18, “than”-> “then”