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Atmospheric Measurement Techniques Discussions

Interactive comment on "Tomographic retrieval of water vapour and temperature around polar mesospheric clouds using Odin-SMR" *by* O. M. Christensen et al.

Anonymous Referee #2

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General comments

The paper illustrates a tomographic retrieval approach designed for the inversion of SMR/ODIN limb measurements. The aim of the algorithm is to fully exploit the information contained in the measurements to determine the two-dimensional atmospheric distribution of water vapor and temperature with high vertical- and horizontal- resolution. This is a very important feature needed to study the physical processes connected with Polar Mesospheric Clouds (PMCs).

The subject of the paper is certainly suitable for publication in AMT.

I have only one main comment. The authors show the good spatial resolution achieved with their 2-dimensional (2D), tomographic inversion scheme. The method, however, represents a significant complication compared to the conventional 1D scan-by-scan profile retrieval. The complication is worth only if the performance of the tomographic approach is superior (in terms of both accuracy and spatial resolution) compared to the traditional 1D approach. For this reason I strongly recommend that, before final publication in AMT, the authors include a new Section dedicated to the comparison of the performance of their method against the conventional 1D approach.

At some instances the language used in the text appears too colloquial. Furthermore there are many syntax errors, like singular exchanged with plural and vice-versa. I recommend a language revision by an expert.

In general the methodology used is scientifically sound. The paper could be significantly improved if modified/integrated according to the specific comments reported below.

Specific comments

p.11857, l.6: The tomographic retrieval from satellite limb-sounding measurements was first proposed by Carlotti et al. in Appl. Opt. **40**, 1872-1885 (2001). I would at least cite this paper.

p.11864, l.24: the used convergence check is not very clear. Do you normalize also by the length of the state vector $\mathbf{x}$? The explicit formula used would be useful. Also: a false positive convergence could be triggered by a very large value of γ. How do you handle this possibility ? Did-you try to quantify the convergence error (with the 0.01 threshold) using synthetic retrievals ?

p.11867, l.17: the correlation is assumed to change linearly with altitude and AAO,

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however, then it seems calculated using the correlation length, that is defined for an exponential decay...

p.11868, l.4: from this Section it is not clear to me how you set up the apriori error covariance. If there are two contributions to the variability of the apriori profile, then the two covariance matrices representing the two contributions of the error should be summed-up. Here it seems that you calculate the product of the correlations. Which is the rationale behind that ?

p.11868, l.14: what is applied here is a *constraint*, not really a *regularization*. The term *regularization* refers specifically to a constraint on the smoothness of the retrieved profile.

p.11869, l.5: from Sect. 3.2.1 I understand that your convergence criterion stops the iterations if in two subsequent iterations the norm of the state vector $\mathbf{x}$ changes by less than a fraction 0.01 of the apriori error. This criterion seems already conservative if compared to the perturbation of 50% introduced in the reference atmosphere used to generate synthetic observations. Therefore I do not quite understand the need to introduce the more conservative threshold of 0.001 in the simulated test. If this is really necessary then you need to make sure that the threshold 0.01 does not introduce a significant convergence error in the real cases.

p.11869, l.28: to show the self-consistency of the retrieval scheme one should check (e.g. with a chi-squared test) the consistency of the retrieved state $\mathbf{x}$ with the reference (true) atmospheric state used to generate synthetic observations, taking into account the error covariance matrix of the retrieved state. Figures 4-5 do not really "*show*", they only "*suggest*" that the retrieval scheme used is self-consistent.

p.11870, l.19-20: it is not clear what you do with the spectral points near the centre of the line. You exclude them from the fit or just ignore the problem ?

p.11870, l.25-26: if you retrieve the Volume Mixing Ratio (VMR), conventional units are

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parts per million by volume (ppmv), this is useful to distinguish from the Mass Mixing Ratio (MMR).

p.11871, l.21: Regarding Fig. 7: units are missing in the horizontal axes. From the caption of this figure it seems that in this case there is no co-location with the ACE-FTS measurements.

p.11872, l.4: the averaging kernels are the rows of the averaging kernel matrix. Therefore the acronym AVKs is misleading. The FWHM is a meaningful quantifier only if the averaging kernels have a single peak. In case of oscillating and/or multi-peaked averaging kernels one can find specific formulas that provide the FWHM when the averaging kernels have a single peak and are an estimator for the spread of information in case of more *shaped* averaging kernels.

p.11872, l.14: which formula do you use to calculate the averaging kernel matrix ? If you use the approach of Ceccherini and Ridolfi (2010), then the calculation is correct also if the final value of γ is not zero. Otherwise I would show the formula used and would cite Ceccherini and Ridolfi (2010) at line 17, after “approximation”.

p.11872, l.20: a definition of horizontal and vertical averaging kernels must be included here.

p.11873, l.23: is this finding in agreement with the earlier discussion about the horizontal resolution ?

p.11874, l.11-12: later you explain (correctly) why you do not include the smoothing error in the error budget. I do not understand why here you state that you calculate the smoothing error using $\mathbf{S}_a$ and the formula of Rodgers (2000). Is the smoothing error calculated and then not used ?

p.11881, l.3: I would repeat here if the observed discrepancies are consistent with the combined error of the compared measurements.

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Technical corrections

p.11856, l.24: move “in” after “used”.

p.11856, l.27-28: hard to read, I suggest to reword the sentence.

p.11869, l.13: larger than than...

p.11870, l.22: units are missing in the horizontal axis of Fig. 6 (deg.).

p.11872, l.12,15: “Levenberg-Marquardt”.

p.11872, l.20: badly structured sentence.

p.11873, l.2-3: please reword the sentence.

p.11880, l.21: can be retrieved from the measurements...

p.11889, Caption of Fig. 1. *The spectra are retrieved in processed in batches...* ?

p.11890, Figure 2. Units should be “ppmv”. Also, the standard convention is to report units within round brackets, like “(ppmv)”. This comment applies also to most axis labels of other figures.

p.11983, Figure 5: missing units in vertical axes.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 11853, 2014.