Atmos. Meas. Tech. Discuss., 7, C4306–C4311, 2014
www.atmos-meas-tech-discuss.net/7/C4306/2014/


Atmospheric Measurement Techniques
Open Access
Discussions

AMTD
7, C4306–C4311, 2014

Interactive Comment

# *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 #1**

Received and published: 22 December 2014

GENERAL COMMENTS The paper describes the tomographic processing the ODIN SMR data, thus producing 2-D cross-sections of water vapour and temperature in the vicinity of polar mesospheric clouds. The water vapour and temperature data are compared against co-located measurements of other satellites and agree within expectations.

The paper is well structured and written and its scope fits well into AMT. However, the paper has some shortcomings listed below, which should be addressed before publication. Primarily, while the tomographic processing and the validation of its results are the main feature of the paper, the technical description is not well developed compared to and distinguished against the publications of other tomographic efforts of Livesey et al., Carlotti et al., or Steck et al. Second and related, the advantages of employing a tomographic retrieval over a conventional one using the same measurement set are not demonstrated.

SPECIFIC COMMENTS

page 11863, line 1: The large computational demands are not clearly specified. The problem size with respect to number of simulated measurements and the state size of the retrieval vector is not given. It is not stated what kind of matrices are used, presumably dense ones (this may be what is related with by the also fuzzy "data reduction techniques"). It is also not clear what part of the retrieval process is the limiting factor. Is it simply the storage of employed (dense) matrices or computational demands of equation system solvers?

page 11868, line 3: The separability is a rather strong and dangerous assumption here, which in effect drastically reduces the effect of the smoothness constraints.

In effect, a 2-D cross-section that agrees very well with either the horizontal or vertical constraint may behave rather arbitrary in the other dimension. The cost induced is determined by ||(x - x_a)^T S_v^{-1} S_h^{-1} (x - x_a)||. If *either* of the precision matrices has a (quasi) Nullspace, the vector will incur only a small cost. As the joint Nullspace is the combination of the individual Nullspaces, any more-or-less horizontally or vertically homogeneous vector will provide a rather low cost. This is especially dangerous as most encountered atmospheres will be horizontally rather homogeneous thus allowing for vertical oscillations, just as found in the Figures 6, 7, and 12.

Possible remedies include a true 2-D covariance matrix (e.g. a_ij = exp(- delta_v - delta_h), e.g. Tarantola, Inverse Problem Theory, 2005) or the sum (not product!) of partial derivative matrices (i.e. Tikhonov like in Livesey et al., 2006). It should be demonstrated that the vertical oscillations visible in the shown cross-sections are not simply an effect of the employed (weak) regularisation scheme.



AMTD
7, C4306–C4311, 2014

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

page 11869, line 18f: The wave like structure in temperature is surprising as no measurement errors were added in the processing. This implies a significant correlation in the retrieval between water vapour and temperature.

Seeing the temperature artifacts of noise-free simulations it should be determined what kind of artifacts can be expected due to noise. The gain matrix could have some "interesting" eigenvectors.

page 11872, line 11-18: The averaging kernel matrix must always be computed without the Levenberg-Marquardt parameter since this corresponds to the cost function that is being minimized (this should become clear as the cost function that is evaluated to determine the current chiˆ2 also doesn't contain the lambda parameter). Using the lambda-term is merely a convenient way of identifying a step towards the local minimum (see e.g. Nocedal, Numerical Optimization, 2006) and generally does not influence the identified minimum. The current text implies that one would need to do otherwise and should thus be corrected.

The lambda parameter only goes towards zero under certain conditions, specifically in case that the cost function is continuously differentiable, that the exact derivative is used. For the typically employed forward model, neither is the case implying that close to the local minimum the gradient of the cost function often doesn't even present a descent direction anymore thereby wreaking havoc with the whole algorithm.

In either case, the averaging kernel matrix is only an approximation due to the used linearisation in general and specifically due to the employed mean state in the case presented in the paper. The value of the Levenberg-Marquardt parameter has nothing to do with that and may be fully disregarded as long as the retrieval converged to a sensible chiˆ2 value as suggested elsewhere in the paper (around 1).

page 11872, line 20: It is not clear what vertical and horizontal AVKs are. The averaging kernel matrix is (under simplifying assumptions) a linear map of the 2-D true state onto the 2-D retrieved state. A 2-D pseudocolor plot of a single row of the averaging



AMTD

7, C4306–C4311, 2014

kernel matrix would be very interesting to identify certainly given diagonal elements and probably existing "ripples" induced by the overlapping line-of-sights. The vertical and horizontal FWHM may be derived from this either by summing the (2-D) row up vertically or horizontally or by cutting through the 2-D field at the location of the derived entity for this row. Which method (or something else?) was employed here?

page 11872, line 24: Such a displacement is a common occurrence for 1-D retrievals and can also be diagnosed together with the horizontal resolution (see von Clarmann, The horizontal resolution of MIPAS, 2009). Its presence in 2-D retrievals is quite surprising as the main cause (low transmissivity and the thus displaced peaking of sensitivity of some channels) should be better handled by tomographic retrievals. It would be thus interesting to see if there is a connection between horizontal displacement and measurement location, i.e. are the parcels in between TPs distorted towards the closes measurement, or is this an independent effect?

Further, to motivate the use of the computationally costly tomographic retrievals, it should be demonstrated that the tomographic results are better than simply assembling a series of conventionally retrieved 1-D profiles to a cross-section. Potential benefits are an improved horizontal resolution (which can be computed for 2-D and 1-D retrievals and compared rather straightforwardly) and an increased robustness against gradients in temperature and trace gasses in the along line-of-sight direction, which are encountered in the scientific use case of given PMCs. The latter could be demonstrated using the synthetic example used for Fig. 4 or by showing differences between 1-D and tomographically retrieved cross-sections for actual measurements.

MINOR/TECHNICAL CORRECTIONS

page 11857, line 17: spacial -> spatial

page 11862, line 20f: The notion of grids and resolution is confusing. In this section the grid employed for performing the forward model is discussed, which seems to be different from the grid on which the derived state vector is kept. Presumably, some kind



AMTD

7, C4306–C4311, 2014

of (linear?) interpolation is employed to convert one to the other. Some terminology should be used to clearly distinguish between the different grids (e.g. forward model grid, retrieval grid, and measurement grid) and the used grid spacing. The term resolution is notorious for meaning different things to different people and may be used also for specifying the grid spacing, but it should also be clearly distinguished in nomenclature between the spacing and the resolution of retrieved quantities where applicable. For example the retrieval grid has a certain spacing, but the retrieved data points have usually a coarser resolution determinable from the averaging kernel matrix.

page 11864, line 15: Marquard -> Marquardt also below.

page 11863, line 20: What is the reason of combining JPL and HITRAN parameters?

page 11864, line 23: This is the original version described in the original paper by Marquardt, 1963. More recent (i.e. from the 70s and 80s) research connecting the method to trust-regions prescribe more robust schemes modifying lambda based on the prediction capabilities of the Taylor-approximation used in the quasi-Newton step, thereby speeding up the computation under certain circumstances.

page 11872, line 4: The use of AVKs for averaging kernel matrix is confusing due to the "s" which implies plural. Probably AVKs shall be short for "averaging kernels"? In the following it is often not clear if AVKs refers to multiple rows of the matrix for one 2-D retrieval or toe the (differing) matrices of different retrievals. This should be clarified.

page 11873, line 2-5: A figure showing the vertical/horizontal resolution for the target quantities for all altitudes would be interesting and communicate this essential information better than the vertical/horizontal AVKs.

page 11878, line 9: SOIFE -> SOFIE

page 11892, Fig. 4: overlaying the tangent points of measurements as crosses or similarly in this and following cross-sections would give a much better impression of the size and quality of retrieved structures in relation to the measurement sampling.



AMTD

7, C4306–C4311, 2014

page 11894, Fig. 6: Using contour plots presents a continuous state, which is inconsistent with the one used in the forward model.

It would be better to either use a pseudocolour plot with boxes for the retrieved air parcels to visualize the retrieved state vector, or alternatively pseudocolour plot the 2-D field generated by using the interpolating scheme employed to map the state vector x onto the 2-D atmospheric field needed for the forward model. Using a discrete instead of a continuous colourscale is however a good idea to distinguish features.

page 11896, Fig 8bd: The plot of the horizontal averaging kernel matrix row (be it a cut or some average of the 2-D averaging kernel matrix row) exhibits seemingly a shift 18 degrees latitude, i.e. 2000 km. At least the title suggests that this the averaging kernels for the profile located at latitude 100, while the centre of sensitivity is located around 118 degrees of latitude. This is a much larger displacement than expected and most likely an error of labelling.

page 11897, Fig. 9: The red dashed line should be explained in the caption, not (solely) in the main text.

page 11899, Fig. 11: It is assumed that SOFIE does not use frequency modes 13 and 19, but that SOFIE profiles corresponding to SMR profiles in those modes are averaged.

---

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



AMTD

7, C4306–C4311, 2014

Interactive Comment