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Atmospheric Measurement Techniques Discussions

Interactive comment on "A non-iterative linear retrieval for infrared high resolution limb sounders" *by* L. Millán and A. Dudhia

Anonymous Referee #2

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General comments: The paper presents a retrieval method for optically thin atmospheres which is based on the linearization of the radiative transfer equation, allowing for a non-iterative linear retrieval within one single retrieval step. This method is favorable since the computational cost of the retrieval could significantly be reduced, allowing for the use of wider spectral regions, or even an on-line retrieval approach. The paper is over large parts written in a clear and well structured way. Although the results are not as promising as one would hope, the method deserves publication since it could be the basis for further developments in this direction.

Although publishable in general, I have a number of points which I would like to see addressed before the paper can go into AMT. In particular, the gain of knowledge by the linear approach, in comparison to a climatology which is assumed to represent

the true state quite well already, needs to be made more obvious. The authors need to discuss the consequence in case the used climatology simply does not represent the true state of the atmosphere. The error estimates need to be interlinked with the observed biases between the iterative non-linear retrievals and the linear approach. Please find below my specific comments.

Specific comments: Abstract: The abstract should be more specific; instead of saying "we determine how close the linearization point needs to be ..." the authors should give precisely this information. Similar applies to the sentence "... suggest an adjustment to the forward model and Jacobians to propagate the change in pressure and temperature on the gas concentration retrievals." As it stands, it is not clear what the authors wanted to say with this sentence.

p723, l3-5: I would say here: "... linearization point, and the atmospheric estimate is corrected according to a recipe (e.g. minimization of least squares) until the given ...".

p723, l16ff: In other words, how close any previous estimation must come to the final result which can be reached within one iteration step of the least-squares approach. This is nothing different that the iterative non-linear approach described before, the paper describes the conditions to be met within the one-but-last iteration step.

p724, l5: The Tikhonov regularization approach in the framework of retrieval of atmospheric trace species from spectral measurements was first introduced by von Clarmann et al. (2003), and it is definitely not described by Rodgers (2000).

p724, Eq 1: Eq 1 is incomplete; the second term after the () brackets should read: (K_iˆTS_yˆ{-1}*(y-F(x_i)) -gammaˆ-1*R*(x_i - x_a)) (check von Clarmann et al. JGR, 2003, Eq (1))

p724, l15: Eq 2 is incomplete as well. Check for von Clarmann et al. JGR, 2003, Eq 2 for the full form of this equation.

p725, l11-14: Please clarify if the perturbations in pressure and temperature has been

AMTD

6, C394–C399, 2013

applied simultaneously, or if two subsequent test cases are described. In case they were applied simultaneously, could there be a crosstalk between the two perturbations?

p726, l10ff: Do you have any explanation for the oscillations occurring in this retrieval? Is it a regularization issue? I think some comments are necessary.

p728, l10: I think it must still read F(x_o) at the left-hand side of the equation (as long as you don't introduce a K_xo(x-x_o) term on the right-hand side.

p728, l19: The deviation is almost 70% at 45 km; could you, again, comment on the oscillations, and whether you consider a profile oscillating as much as this one as useful?

p731, l22: The analysis of CH4 variability was done for a single month, January, which does not allow for a generalization as made here - that a climatology with a latitudinal resolution of at least 20 deg is required. This may vary with season, and, in particular, for other trace species.

p732, Eq 15: why is the third term dimensionless [(p-p_o)/p_o] while the others are not?

p733, l10ff: Does this mean that you improve your "knowledge" of the true state from 20 % uncertainty (from climatology) to just 14 % uncertainty (after linear retrieval)? In this case, I would just start from the climatology with a non-linear retrieval which should converge quickly if set-up appropriately. I think your argument wrt using the linear approach as a step prior to an iterative scheme is a bit weak and should be rethought.

p735, section 7.2.1: Could you provide a number which percentage of the available spectral grid points finally was used within the retrieval after application of the criteria given in Eqs. 16 and 17?

p738, section 7.4: In all what follows now the limitation to an optically thin atmosphere where linearization might be less serious (and the linearization as developed in the

AMTD

6, C394–C399, 2013

appendix relies on) has given up, and comparisons are shown down to almost 100 hPa. Has this been done on purpose? Has the impact on the retrieval results been assessed?

p738, l19-24: If the plots show (linear - MLS/MORSE) as indicated in the header, I'd read them the other way round: the linear approach overestimates temperatures for pressures < 0.03hPa and underestimates temperature in a band between 0.1 and 1 hPa for (linear - MORSE) and around 1 hPa for (linear - MLS). Further, the underestimation is up to 9 K, so I wouldn't say there is good agreement at pressures larger than 0.1 hPa.

Although indirectly deducible from the Figures 16 and 17 shown, I'd appreciate seeing an additional comparison MORSE - MLS. This would help to cancel out the instrument and forward algorithm effects.

Fig 18 and related text: A direct comparison (linear - climatology) and (MORSE - climatology) would be helpful to judge if the retrieval indeed provides information not already contained in the 20% threshold for the variability in the climatological latitude bins. The difference between linear and MORSE sometimes exceeds 50% and is between 10 and 30% over wide latitude/altitude regions. In order to judge if this comes from strong deviations between the true atmospheric state and the climatology, or if the linear approach does not add information to the climatology, I strongly suggest to add these difference plots to the figure.

This figure, however, poses an inherent problem of the approach: what if the climatology is biased and the chosen linearization point is not a good representative of the true state around which the 20% variation is allowed? This is a question which could and should be discussed on basis of Fig 18.

Fig 19: The bias between the MORSE-retrieved CH4 vmr and the linearly retrieved vmr comes close to or exceeds the 20% limit from the climatology over wide regions. Again we would need the deviation between climatology and the MORSE retrieval to

AMTD

6, C394–C399, 2013

judge if the observed situation is simply not part of the climatology ensemble (in this case the linearization point is questionable) or if the linear retrieval deviates as much or even more from the real atmosphere as the climatology does. I consider a thorough discussion of this point as absolutely necessary.

p742, l6: As already mentioned earlier this might be an improper generalization since the latitudinal variability of CH4 vmr has been tested for one case only, namely the month of January.

p742, l12: The comparisons have shown that the linear retrieval is within a 3 K range difference on average, and not "for most of the time"! Individual differences might be by far larger than 3 K, but may cancel out in the mean.

Appendix: you should be careful not to mix up the symbol for wavenumber (as used in the appendix) and the symbol for vmr (as used in the main part).

Minor and technical comments: p723, l7: typo "Fischer"; Fischer et al., ACP, 2008 would probably better suit as a reference here (also p733, l17)

p726, l7: shouldn't this be dB... instead of \deltaB...?

Figs 6-8: You should mention in the figure captions that these climatologies have been derived from MIPAS data (and not from a model etc.)

p729, Eq. 6 and 7: explain the meaning of v_j

p735, l9: Clarify "Due to the high *spectral* resolution ..."

p738, l1-3: This sentence is difficult to understand, consider re-phrasing.

References: von Clarmann, T., et al. (2003), Retrieval of temperature and tangent altitude pointing from limb emission spectra recorded from space by the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS), J. Geophys. Res., 108, 4736, doi:10.1029/2003JD003602, D23.

AMTD

6, C394–C399, 2013

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Interactive comment on Atmos. Meas. Tech. Discuss., 6, 721, 2013.