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Atmospheric Measurement Techniques Discussions

Interactive comment on "Information operator approach applied to the retrieval of the vertical distribution of atmospheric constituents from ground-based high-resolution FTIR measurements" *by* C. Senten et al.

Anonymous Referee #1

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The manuscript under consideration deals with a very relevant topic: further optimization of the analysis procedures applied to ground-based solar absorption spectra as taken at various sites around the globe in the framework of the NDACC. The authors investigate the "information operator" retrieval approach (IOA) which has been applied to satellite data by other investigators before and compare retrieval results generated by application of IOA and two other standard methods, Tikhonov regularization (TR) and optimal estimation (OEM). Although the authors make quite some effort and re-

trieve several species (O3, N2O, CH4, and CO) from a considerable set of spectra, in my feeling no clear conclusions concerning the additional benefit of the IOA can be derived from the material presented in this study. To quantify the additional benefit that can be expected from the IOA, either a theoretical study based on synthetic spectra or empirical tests using independent data (e.g. H2O or O3 from sondes) or a combination of both kinds of investigations is required. In the theoretical study, an ensemble of virtual measurements should be generated (assume a certain a-priori VMR + a-priori covariance, add noise to spectra) and all retrieval methods should be applied on this ensemble to quantify e.g. by which extent each method is affected by incompatible a-priori assumptions (wrt the true choice which was used for generating the ensemble). In a comparison with independent data one could unambiguously decide whether IOA allows a significantly superior reconstruction of the true atmospheric state in practice. If the authors want to avoid such extensions and prefer to submit the study essentially in its present form, then at least the concluding section needs a revision, since in my impression not all of the claims are verified by actual results (see comments below).

Comments in detail:

Page 2:

Please add a few references to clarify the significance of the NDACC.

Page 7:

Please correct phrasing before Eq 9, "as function of".

End of page: this should refer to Eqs 10 + 11, not Eqs 13 + 14

Page 8:

In the discussion of TR, you state "the parameter alpha we have used ... is ... the best compromise between DOFs and the total random error" - the total random error of which target quantity? Total Column? The standard tuning method is the L-curve method: does the L-curve suggest a similar choice for alpha?

Page 9:

"The off-diagonal elements [of spectral noise covariance matrix] are set to zero,..." This is not valid unless care is taken that the spectrum is sampled on an appropriate spectral grid.

Page 11:

Figure 1: Would you please note which DOF results for the OEM solution, shown in the upper left corner? It would be very instructive for the reader to show OEM solutions adjusted for the same NDOF as the IAO solutions. The current figure only tells that oscillations are reduced when NDOF is reduced, which is a rather trivial result.

Page 12 (+ Figure 2 + Table 2):

If I correctly combine the results reported in Figure 2 and Table 2 the 0.8 threshold for g results in the use of e.g. 12 eigenvectors for O3 and even 22 (!) eigenvectors for CO. It is surprising to me that so many eigenvectors of the information matrix need to be taken into account to construct solutions which finally offer NDOF in the range of 3 (CO) to 4 (O3). Can such a scheme termed numerically effective? - If one would apply a truncated SVD, I would expect that the number of relevant contributions would equal NDOF.

Figure 6: The IOA sensitivity curve shows considerable stronger overshooting at 18 km than does OEM?

Figure 8: All the IOA kernels look essentially the same - this retrieval seems to offer significantly less DOFS than OEM and TR (the table states DOFS 2.2/2.1/2.3 - hard to believe)? Why do the sensitivity curves show these sharp kinks (Fig 8a, c) and huge amplitudes (Fig 8b)? - In contrast, the CO sensitivities in Fig. 10 look plausible.

Table 1:

CH4 variability: "variable" What does this mean - variable as function of altitude? Or

different settings used for different spectra?

Table 4:

It would be appropriate to include TR for N2O and CO as well.

Conclusions:

"Our findings proof that the IOA allows more stable vertical profiles". I do not see that the material proofs this claim, see, e.g. Fig 11, where TR solutions are obviously more stable over the relevant altitude range

".... and with generally lower error budgets" This also is an optimistic resumee. The smoothing errors given in Table 5 are generally smaller for OEM and TR, so obviously the solutions preserves more detail about the true state and this is probably the reason for less favourable partial column errors - essentially the same behaviour would probably be observed in the comparison of two OEM setups with different DOFS.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 3739, 2011.