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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Water vapour profiles by ground-based FTIR spectroscopy: study for an optimised retrieval and its validation" *by* M. Schneider et al.

**Anonymous Referee #2**

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General comments:

Water is the most important greenhouse gas. However, its long-term trends at the different altitudes are not well understood. Remote sensing techniques offer the possibility to retrieve the water vapour concentration profiles throughout the atmosphere. Of special importance are microwave and infrared observations. The microwave radiometry allows to measure the volume mixing ratio up to the mesosphere, but most instruments cannot give sufficient information between the surface and about 15 km. On the other side, the infrared spectroscopy allows to retrieve the concentration profiles throughout the troposphere, but are limited above approximately 10-15 km. The important tropopause region between approximately 10 and 15 km can only hardly be analysed and requires a careful retrieval.

The work by Schneider et al. describes the water vapour retrieval from solar absorption spectra, recorded by the FTIR-spectrometry. The manuscript is well written and I have only a few detailed comments.

Specific comments:

2.1 Characterisation of a-priori data

Paragraph 1, lines 7-9: The statement "... instrument's site (for the lowest layer)..." is less informative. I suggest the range of the lowest layer is specified and the kind of in-situ instrument be described.

The same paragraph, line 9-11 states how part of the a-priori covariance matrix above 16 km is constructed. Using the covariances at 16 km for all higher altitudes might lead to singular Sa. As a result BTB = Sa-1 a may not be determined with normal matrix inversion procedure. Moreover, the matrix BTB + KTSy-1K, which must be inverted in the retrieval equation, has the same structure above 16 km as the matrix BTB. This is due to weak sensitivity above 16 km and hence the contribution from KTSy-1K is nearly constant. Therefore, in the first place inversion namely of BTB = Sa-1 might not be successful, even then it is highly unlikely that inversion of the matrix BTB + KTSy-1K will be successful during the retrieval. In view of this, the authors should seriously consider this comment and indicate and explain how they overcome this problem.

The authors prefer to determine the a-priori covariance matrix from correlation matrix when they can determine it directly from their data, which is quite common. The purpose for this should be clearly stated.

Paragraph 2, the x used in equation 5 is not the same as the state vector x used in equations 1-4. Therefore, I would suggest that equation 5 is adapted to the notation



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used in the paper. One way of doing this is to write it as (x-xm)TSa-1(x-xm), where xm is mean of the a-priori ensemble of states.

3.5 Characterisation of posterior ensembles The a-priori state follows log-normal distribution and is nicely shown in Fig. 2 in section 2.1. This analysis, which was carried on to the retrieved state in section 3.5 for posterior ensemble, encountered inversion problem due to the smaller ensemble size as well as similar content of a-priori contribution to all member state vectors of the posterior ensemble (at least the same Sa), not only the dimension as stated by the authors in paragraph 1, lines 11-13. To overcome the inversion problem, the authors can apply X2 =X02+(x-x0)TSx-1(x-xo) to individual retrieved state vectors, where X2o is the value at the minimum (solution) and xo is the solution vector in contrast to the mean xm for a-priori ensemble. Sx=(BTB+KTSy-1K)-1 is the covariance matrix of the retrieval. Then the discusion in this section will be based on average CDF or if the authors decide to keep their posterior ensemble, a separate subsection could discuss average CDF. The advantage of average CDF is that one can work on a single or only a few profiles with out the need to justify the posterior profiles constitute ensemble in the strict statistical sense, which is required in the case of posterior ensemble covariance matrix. This alternative has already been applied and extensively discussed in a paper by Mengistu Tsidu in J. Quant. Spectrosc. Rad. Transfer, Vol. 96, No. 1, 103-121, doi:10.1016/j.jqsrt.2004.11.014, 2005 under title " On the Accuracy of Covariance Matrix: Hessian versus Gauss-Newton Methods in Atmospheric Remote Sensing with Infrared Spectroscopy, ". The author has already reported non-Gaussian distribution of water vapor retrievals for both retrieval methods used in that paper, though for limb observation and synthetic spectra. Therefore, the paper should be refered to.

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Interactive comment on Atmos. Chem. Phys. Discuss., 5, 9493, 2005.