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

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The monitoring of upper tropospheric/lower stratospheric (UT/LS) water vapor is an important pre-requisite in order to gain a better understanding of trends in atmospheric radiative forcing and feedback mechanisms related to the earth water cycle. Measurements comprising longer time series and wider spatial coverage are still sparse due to instrumental problems of the standard in situ operational radiosonde measurements at low temperatures. Satellite limb measurements are affected by clouds and pointing deficiencies in the UT region and nadir measurements are affected due to the strong signal of lower tropospheric water vapor content. These issues have so far prevented a better empirical assessment of an important climate forcing parameter.

The paper evaluates the potential of ground-based FTIR spectroscopy in monitoring the upper tropospheric water vapor content and provides an important contribution for establishing future ground based, low cost, networks for improved monitoring of climate change. To the best of my knowledge this is indeed the first time that this has been presented in such detail using the applied measurement technique. In addition, the evaluation of new nadir-viewing satellite-instrument data records like those from AIRS on Aqua and forthcoming IASI on Metop, can greatly benefit from these kind of detailed assessments of the UT/LS water vapor information content in the infra-red region.

The authors have identified most of the so far known potential error sources and deficiencies of standard water vapor profile inversion techniques and present a rigorous and in so far complete assessment of the individual error contribution to the overall sensitivity and accuracy of the method. They have suggested two major improvements to standard applications of water vapor profile retrieval: the simultaneous retrieval of the temperature profile and the transformation into logarithmic scale. The authors show from their theoretical assessment that, employing both improvements, the retrieval will benefit from improved sensitivity, but not necessarily from improved accuracy. In addition, from comparisons with in situ sonde measurements the authors conclude that the retrievals may even gain in accuracy however, due to so far unknown reasons. Generally it can be concluded from this work that the UT/LS water vapor content remains an atmospheric parameter difficult to access with any remote sensing technique.

General comments

I) The authors provided a thorough evaluation of the scaling impact and the impact of simultaneous temperature retrievals on the performance of the presented technique. However the main remaining source of error, the contribution of deficiencies in correctly modeling the pressure broadening on the retrieved UT information content and

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the overall accuracy, remains untouched. It is quite correct that the gauss contribution to the spectral line-shape and the temperature dependence of the line-intensity is dominant to the over all line-shape in the UT/LS regions and in the employed spectral window. However, and as becomes evident from the results, the lower tropospheric spectral response is only accurately modeled taking pressure broadening into account. The latter gains importance in the lower troposphere even in the employed infra red region and may contribute to spectral residuals (sometimes miss-interpreted as spectral information) in the same way as the authors refer this to the temperature impact on the line-shape. It is not clear from the manuscript what kind of pressure profiles have been employed (e.g. from a climatology, or from the sondes). The question therefore is how the retrieval is affected from employing different pressure profiles since lower to mid tropospheric contributions significantly affect the upper tropospheric information content.

II) A sensitive issue of any optimal estimation technique is the choice of the a priori. Even though it may be beyond the scope of the paper to assess operational issues of the discussed technique, the impact of the choice of the a priori should always be considered as a systematic contribution to the overall precision of the technique. The a priori and covariance matrices have been constructed from on-site ptu soundings and surface measurements (Section 2.1). In contrast, the retrievals are compared to sondes 35 km north and 12 km south of the observatory (Section 4.2) introducing the discussed unknown contributions of temporal and spatial correlation, as well as potential residual contributions of clouds and aerosols, which, I think, have not been mentioned in the manuscript (since they are probably not included in the forward model). For an operational situation employing the presented technique the problem would basically be reversed. The a priori would potentially be constructed form past reanalysis NWP data at the geolocation of the instrument. To evaluate instrument performance one would then best launch a number of in situ measurements next to the instrument in order to evaluate the overall precision of the technique. Have the authors considered in doing so and what would be the impact on Figure 16?

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Specific comments:

Introduction: Since ground based profile measurements avoiding the usual operational sonde deficiencies are sparse the authors could mention that FTIR spectroscopy can be used to validate satellite derived profiles from AIRS, IASI and GRAS especially in the UT/LS region.

For my general understanding: at the end of section 2.2 the authors state that the linear retrieval tends to ‘underestimate the values of the real state far above and far below the mean state’. How is this reflected in the comparison between Table 4 to 5 and 6 to 7?

Page 9502, l. 13: are performed -> is performed

Page 9502, l. 24: normed kernels -> normalized kernels

Page 9505 l.5 and 9: The authors state that the incorrect altitude contribution is ‘less pronounced in the logarithmic retrieval’ and ’strongly disturbed’ for the linear retrieval. However for the logarithmic retrieval the situation seems to be not much different than for the linear one in Figure 5, since the relative weight of the information content from different altitudes within each retrieval seems only to be marginally different. It is therefore stated correctly in line 16 that the logarithmic retrieval performs only marginally better, which is contradicted by stating, in line 18, that the disturbances are ‘significantly reduced’.

Page 9506, l. 15ff: In line with my general first comment it would be interesting to know how the pressure coefficients are applied. Are they based on empirical corrections employing a Voigt-profile line shape?

Page 9514, l.13: ‘the surface’ -> sea-level.

Page 9514, l.16: ‘the criterions’ -> the criteria

Page 9515, l. 27: ‘somehow’ ->? Somewhat (?)

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Interactive Comment

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