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Atmospheric Chemistry and Physics Discussions

Interactive comment on “$H_2{}^{16}O$ and HDO measurements with IASI/MetOp” *by* H. Herbin et al.

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IASI on MetOp will provide global measurements of nadir infrared spectra (with good resolution) during the next 15-20 years. It offers unique perspectives for investigating the long-term evolution of the Earth's atmosphere and is of great interest for the atmospheric research community. Water vapour is the most important greenhouse gas and there are uncertainties about its response to a warming troposphere. In particular uncertain are the processes that determine the water vapour amounts in the middle/upper troposphere and in the lower stratosphere (UTLS). At these altitude regions water vapour is especially effective as greenhouse gas. The deficits in the knowledge of the atmospheric water cycle are an important source of uncertainty in current climate

models. Observations of the isotopologue ratios of water vapour (e.g. HDO/H216O) are a powerful tool for constraining the atmospheric water cycle. Monitoring these ratios from space would allow for an investigation of UTLS water vapour source regions on a global scale.

The paper of Herbin et al. documents the potential of IASI in monitoring tropospheric H216O and HDO profiles. Such documentation is important. The authors show that the IASI spectra allow the retrieval of H216O and HDO profiles with about 6 and 3 degrees of freedom (DOF), respectively. Due to the importance of space-based H216O and HDO measurements for climate change research and due to the unique long-term perspectives of the IASI instrument a paper documenting the IASI H216O and HDO capabilities is very interesting and absolutely worthwhile to be published in ACP. However, in my opinion there are several aspects in the Herbin et al. manuscript that need to be revised. I will address the two most important aspects in the following:

1. EMPIRICAL QUALITY ASSESSMENT OF THE RETRIEVED PROFILES: It is good that the authors not limit the quality assessment to theoretical estimations. They perform an empirical quality check of the retrieved IASI H216O profiles. Therefore, they compare IASI retrievals for different geographic sites and seasons with coincident radiosonde profiles. This seems at a first glance a good approach, but the problem is that the IASI retrieval applies different a priori profiles for these different geographic sites and seasons. It is not clear how much of variability as observed by IASI comes from the IASI measurement and how much comes from the variable a priori data. This a priori data is calculated from radiosondes, to which is subsequently compared with. So the argument, given by the authors on page 9273 and 9275, that the IASI captures well geographic and seasonal variability is not convincing. It is not clear how much of this variability comes from the measurement and how much is introduced by the variable a priori data. Fig 3: geographical variability, in my opinion the retrieval follows mainly the a priori. Do these graphics document the IASI H2O profiling capabilities? We don't think so. Fig 4: seasonal variability, same as Fig. 3: the retrieval follows the

a priori. SUGGESTION: In order to improve the empirical validation it would be better to restrict the radiosonde-IASI intercomparison to one latitudinal belt and one season. Then the IASI a priori is always the same and the variability in the IASI profile comes from the IASI measurements. This would clearly demonstrate that IASI introduces new information.

The authors claim that the general decrease with height of the retrieved dD profile validates the method. Can this conclusion really been made? In our opinion such a decrease is already prescribed by the applied H216O and HDO a priori data, and the plot does not demonstrate if IASI introduces new information. SUGGESTION: Validate the dD profiles with dD profiles measured by TES (Worden et al., 2006) or by ground-based FTIR spectrometer (Schneider et al., 2006). Concerning ground-based FTIR data we can offer continuous tropospheric HDO/H216O profile observations for the Kiruna (Northern Sweden) and Teneriffe (Canary Island). HDO/H216O observation from further NDACC FTIR stations will follow. Furthermore, in our opinion the method applied in the paper does not allow the measurement of dD profiles (see next item 2).

2. OPTIMAL ESTIMATION OF dD PROFILES: A separate retrieval of H216O and HDO and subsequent rationing (HDO/H216O) to calculate the dD values is no good approach!

A demonstrative consideration: The H216O profile error is about 15% and the HDO profile error is about 30%, with the smoothing error being the dominating error source. The authors retrieve the H216O and HDO profiles independently (what the authors call uncorrelated retrieval), i.e. the averaging kernels of H216O and HDO are very different (see e.g. Fig. 3). In this case the smoothing errors of H216O and HDO are largely uncorrelated. It is the same situation as comparing remotely sensed profiles with different vertical resolutions (Rodgers and Conner, 2003). The smoothing error in the HDO/H216O (and dD) profile should then be 30% (or even larger). However, the typical variability of dD is only about 10%. We think that the large uncertainty of the produced dD profiles can be well observed in the Figs. 3 and 4: occasionally

there appear very high positive (up to +200 permil, which is unphysical) dD values. Applying an uncorrelated H216O and HDO retrieval we cannot calculate reasonable dD profiles. This is only possible when constraining HDO against H216O. Retrievals constraining HDO against H216O are suggested by Worden et al., 2006 and Schneider et al., 2006. Both methods are equivalent to an optimal estimation of dD profiles. According to our experiences and theoretical understanding the method applied by the authors will produce dD profiles, whose errors are larger than the expected dD variability (Schneider et al., 2006). We think that the authors cannot claim that they observe dD profiles. In order to observe dD profiles by nadir sensors with a reasonable precision it is mandatory to apply the methods suggested by Worden et al. 2006 and Schneider et al. 2006. SUGGESTION: We would suggest to focus the paper on a quality documentation of IASI's HDO and H216O profiles. By this documentation the authors demonstrate the principle capability of IASI to observe dD profiles. This should be briefly discussed. Therein it should be mentioned that the IASI retrieval will be further refined in order to retrieve dD profiles.

SUMMARY: In our opinion the paper is of great interest for the atmospheric research community and should be published if accordingly revised: The authors present optimally estimated H216O and HDO profiles, but not optimally estimated dD profiles. Consequently they should limit to a theoretical and empirical documentation of the quality of the H216O and HDO profiles. The empirical error estimation (by comparison to radiosondes) is not optimal and in our opinion it should be revised as suggested in item 1. A nice quality documentation of IASI's H216O and HDO profiles would already be interesting and demonstrate that IASI can measure dD profile if methods as suggested by Worden et al., 2006 and Schneider et al., 2006 are applied. With the method applied by the authors and according to our theoretical knowledge and experience, reasonable dD profiles cannot be retrieved (Schneider et al., 2006). As a consequence any scientific interpretation of dD profiles (as in Section 4) should be avoided. We are very excited about the potential of IASI in observing dD profiles and we would like to encourage the authors to continue with the required retrieval developments. In this context we would be happy to collaborate with them by discussing our experiences with dD profile retrievals and by providing dD profiles observed within the ground-based FTIR NDACC network for a future IASI dD validation study. Currently we can offer dD profiles for Kiruna (68N;20E) and Izaña (28N;16W), profiles for other NDACC sites will follow.

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