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Interactive comment on “Mid-tropospheric δD observations from IASI/MetOp at high spatial and temporal resolution” by J.-L. Lacour et al.

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General Comments. This paper is generally well written but is missing some critical elements as discussed in the “Specific Comments”. Most notably, the document needs a description of the retrieval quality, e.g., χ^2 , a description of the a priori state vector used for the retrievals and a description of the a priori covariance. The authors also need to discuss the Risi et al. 2012a paper in more detail as the results in Risi et al. 2012a provide for an indirect comparison of the TES and SCIAMACHY data with the IASI data.

Specific Comments

1) Please add a section or statement of the χ^2 values typical of a retrieval as well as

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data selection. Do you use all the data or only data that is less than a threshold χ^2 value.

2) Page 13058 Line21: Use of the phrase “constrained approach” is confusing as all retrievals have some form of constrained approach. What distinguishes this approach from the previous retrieval discussed in Herbin et al. is the use of correlations between (log) HDO and (log) H₂O in order to presumably obtain more physically realistic distributions of HDO/H₂O estimates. Perhaps call this retrieval the “HDO/H₂O correlated approach”? Make sure to define this jargon early in the document.

Page 13058 Line 22: The paragraph beginning with “While the constrained. . .” is technically correct but confusing to the reader as several disjointed points are being made. I think what you are trying to say is “Use of correlations between (log) HDO and (log)H₂O helps to constrain the joint HDO/H₂O retrieval to physically plausible solutions as demonstrated by Worden et al. and Schneider et al. . . . ; the choice of cross-correlations is discussed in Section 3.3. The choice of retrieval parameters also affects the vertical resolution and error characteristics of the retrieval; the set of retrieval parameters is discussed in Section 3.2.

3) Page 13060 Section 3.3 What is the a priori state vector? Is it output from the LMD model? Does the a priori vary?

4) Page 13060 Line Sentence starting with “A simple” Im surprised that it was necessary to relax the correlations between HDO and H₂O in order to improve the residuals between model and measurement as it appears that the constraint is already quite loose. For example, the original TES retrieval had a much tighter constraint (from what I can tell from this paper) and also much higher spectral resolution and the residual of forward model and radiance fits almost to the noise level. Consequently, it is possible that a poor residual is indicative of other parameters not being well fit, such as temperature. Again, some description of the a priori covariance for the HDO/H₂O ratio and an improved description of the temperature uncertainties would be useful for

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understanding this issue better.

5) Page 13062 Line 9 Sentence beginning with “The Construction. . .” Could you provide a description of the a priori HDO/H₂O covariance? Following Equation 21 in Worden et al. 2006, this covariance should be $SR = SHDO - SH_2O$. Also, could you show the square root of the diagonal of the HDO/H₂O covariance in Figure 5 for comparison to the a posteriori errors?

6) Page 13064 Line 24: Worden et al. 2006 or Schneider et al. 2006 are the correct references here. Risi 2012b used this equation from Worden et al. 2006 for the model/data comparisons. In addition, equation 11 is not technically correct as it does not include the error terms due to noise, temperature etc. The other error terms need to be included here or alternatively indicate to the reader that you are specifically excluding them and to refer to prior equations.

7) Page 13065 Lines 11 through 25 starting with “First, we performed” I would strongly encourage the authors to remove this section or move it to an Appendix with additional explanation. Basically, you do not need to do these kinds of tests unless you have reason to believe that your retrieval algorithm is not mechanically robust (that is, the retrieval has software bugs or incorrect equations). Instead, use (or calculate) the posteriori temperature covariance from the temperature retrieval and apply the gain matrix from the HDO/H₂O retrieval to this covariance to obtain the impact of temperature on the HDO/H₂O estimate.

8) Page 13065 Line 27 paragraph starting with “To determine. . .” This paragraph is confusing because you say “not in agreement” which implies that the error calculations contradict each other. Perhaps state “The altitude region where the retrieval has the most sensitivity is inferred by the reduction in smoothing error shown in Figure 4. The total error is shown in Figure 5 and includes uncertainties from noise, temperature etc., is reduced throughout. However, the IAIS HDO/H₂O estimates cannot distinguish the HDO/H₂O variability in the lowermost troposphere from that in the middle troposphere

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where sensitivity peaks.

9) Page 13066 Line 17. Do you need to augment the previous sentence to indicate that average of the averaging kernels is robust for grid boxes that include land and ocean points? Otherwise your conclusion in Line 16-17 is confusing.

10) Page 13066 Line 19: What is a “pattern correspondence”? I think you mean “comparison”?

11) Page 13066 Line 3 Sentence starting with “This can be explained” Again, you need to show the a priori covariance. If I look at the total error in Figure 5 I would expect that the a priori covariance is quite loose (> 100 per mil) at the surface. Please explain.

12) Page 13066 The advantage of comparing the IASI data to the LMD model is that the LMD model has been compared to the TES and SCIAMACHY data, as discussed in Risi et al. 2012a. Consequently, it would be useful to the reader for you to review the results of 2012a at the start of Section 4 so that it is more clear to the reader that you are using the LMD model to indirectly compare IASI data with TES and SCIAMACHY data. Thereafter, you can include a more in-depth discussion on whether the differences between LMD and IASI are consistent or inconsistent with LMD and TES, when applicable; this discussion would then address my criticism during the initial review about using the LMD model as a transfer between TES and IASI.

13) Page 13068 Line 27 Sentence beginning with “At Darwin”. Im not yet convinced that IASI captures the “short-term” variability as represented by the LMD model (Also, does short-term variability mean approximately monthly variability?). If I examine the figures I would conclude “by eye” that IASI delta-d values generally captures the seasonal variability and sometimes it captures variations at monthly time-scales and sometimes not. The metrics used for this conclusion are insufficient because it is not obvious that these metrics are or are not driven by the overall agreement to the seasonal variability versus “short-term” variability. If you want to make this a result for the paper you will need a way to filter the seasonal variability from this comparison. Thereafter, you

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could then quantify the difference between the seasonally detrended time series and compare to the averaged mean variability of the IASI data. Also, is it possible that you are capturing the LMDz variability because you are using the LMDz model as a priori ? (see previous query about your a priori state vector choice)

14) Page 13069 Line 18 Sentence starting with “Note. . .” Im not convinced of this argument. Application of the averaging kernel to the model field will take into account the variability allowed by the constraint if the retrieval is well characterized. In addition, you are making an inference about the ability of TES data to capture short term variability relative to the IsoGCM model by comparing the IASI data to the LMD model; for this conclusion to be robust you need to now compare the LMD model to the IsoGCM model. Consequently, you either need to perform this additional IsoGCM/LMDz model comparison or remove this conclusion.

15) Page 13072 Line 9 Sentence starting with “More generally” This is a relative statement. You need to say very good performance relative to something else (e.g. previous retrieval algorithms?).

16) Page 13079 Figure 1. Please add another panel or figure showing the comparison between the radiance, forward model and noise.

17) Page 13082 Figure 4. If I interpret this figure as described it says that the smoothing error is 2% of the a priori covariance for the HDO/H₂O ratio. I am guessing that this is not the case

18) It might be useful for the authors to plot the DOFS for the HDO component of the retrieval because HDO is generally the limiting component (with respect to the sensitivity) to the HDO/H₂O retrieval. However, please review the language in Worden et al. 2012 AMT as the use of HDO DOFS as a proxy for the HDO/H₂O retrieval is not completely robust as pointed out by Dr. Matthias Schneider during review of the Worden et al. 2012 paper.

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