

## ***Interactive comment on “Comparison of Optimal Estimation HDO/H<sub>2</sub>O Retrievals from AIRS with ORACLES measurements” by R. L. Herman et al.***

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Final Author Comments to reviewer RC1 of amt-2019-195,

To anonymous Referee #3 We thank the referee #3 for constructive comments on the manuscript amt-2019-195, “Comparison of Optimal Estimation HDO/H<sub>2</sub>O Retrievals from AIRS with ORACLES measurements.” We have addressed all comments from the referee here. These comments are very similar to previous AC1, but now all changes have been incorporated into the manuscript.

Below are (1) comments from the referee, (2) our author’s response and (3) author’s changes in the manuscript.

Specific comments Comment 1:

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(1) I48-57: Another instrument that provided HDO measurements was Envisat MIPAS. For instance: Lossow, S., Steinwagner, J., Urban, J., Dupuy, E., Boone, C. D., Kellmann, S., Linden, A., Kiefer, M., Grabowski, U., Glatthor, N., Höpfner, M., Röckmann, T., Murtagh, D. P., Walker, K. A., Bernath, P. F., von Clarmann, T., and Stiller, G. P.: Comparison of HDO measurements from Envisat/MIPAS with observations by Odin/SMR and SCISAT/ACE-FTS, *Atmos. Meas. Tech.*, 4, 1855–1874, <https://doi.org/10.5194/amt-4-1855-2011>, 2011.

(2) We agree and will add a citation to Envisat/MIPAS and other contemporary satellite instruments that measure stratospheric HDO. This will be placed in the text immediately before the paragraph on satellite retrievals of tropospheric HDO.

(3) Changes to text, new paragraph added (I48) and the new references have been added to the end of the manuscript. “Early remote sensing of atmospheric HDO was made by the ATMOS (Atmospheric Trace Molecule Spectroscopy) mission on the Space Shuttle (Rinsland et al., 1991; Irion et al., 1996; Moyer et al., 1996; Kuang et al., 2003), retrieving in the upper troposphere/lower stratosphere. Global stratospheric HDO measurements have been provided by satellite instruments including Envisat/MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) (Steinwagner et al., 2007, 2010; Lossow et al., 2011), Odin/SMR (Sub-Millimetre Radiometer) (Murtagh et al., 2002; Urban et al., 2007), and SCISAT-1 (Scientific Satellite)/ACE-FTS (Atmospheric Chemistry Experiment fourier transform spectrometer) (Bernath et al., 2005; Nassar et al., 2007; Lossow et al., 2011; Randel et al., 2012). Atmospheric columns densities of HDO and H<sub>2</sub>O have been retrieved from Sentinel-5 Precursor/TROPOMI (Tropospheric Monitoring Instrument) (Schneider et al., 2020).”

Comment 2:

(1) I130-131: Are these mean winds and surface pressure during the aircraft campaign (September 2016) or do they refer to a specific date and time?

(2) These are mean winds and surface pressure from MERRA2. We will modify a

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sentence in the Figure 1 caption.

(3) Changes to text, modified Figure 1 caption: "Superimposed on the map are the September 2016 monthly mean 700-hPa winds (white vectors) and surface pressure (white isobars), along with the approximate biomass burning region (green rectangle)."

Comment 3:

(1) I243-256: If it is not too much extra work, I would suggest to combine Figs. 2 and 3 in a single figure, e.g., by using different colors for the different matching criteria.

(2) We will combine Figures 2&3 with loose-constraint AIRS FOV (open squares) and close-constraint AIRS FOV (solid black squares).

Comment 4:

(1) I291-292: Adjust y axis range to -200 ... +6200 m (or similar)?

(2) We have changed the y axis range accordingly.

(3) Revised Figure 4 (formerly Figure 5).

Comment 5:

(1) I299-300: The caption says "RMS (standard deviation)", but  $RMS_2 = BIAS_2 + STDDEV_2$ , I think? Are these numbers standard deviations or RMS errors?

(2) These numbers are standard deviations. The convention in our community has been to not include bias in the RMS. We will clarify in the text that bias is not included in our RMS calculations.

(3) New sentence added to Table 2 caption: "The reported RMS here is the standard deviation, not including the bias."

Comment 6:

(1) I315: It may help the reader to say that  $G_R$  refers to the gain matrix of the

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HDO/H<sub>2</sub>O retrieval.

(2) We have modified the text accordingly.

(3) Text modified to, "where  $G_R$  [...] is the gain matrix of the HDO/H<sub>2</sub>O retrieval".

Comment 7:

(1) I316: Which systematic errors and interference errors have been considered here?

(2) We have considered random error due to noise, and radiative interference errors due to CH<sub>4</sub>, N<sub>2</sub>O, surface emissivity, effects of temperature, and clouds.

(3) New sentence added: "Interference errors are due to CH<sub>4</sub>, N<sub>2</sub>O, surface emissivity, effects of temperature, and clouds."

Comment 8:

(1) I316-318: Looking at the averaging kernels, there are likely quite significant correlations being found in retrieval covariance  $S$ ?

(2) Yes, the reviewer is correct. All of our retrieval products have significant covariation between levels and species but these are taken into account for process studies by appropriate use of the supplied uncertainties and in assimilation studies through use of the averaging kernel and observation error covariances in the assimilation cost function.

(3) No change to the text.

Comment 9:

(1) I333-334: [Figure caption] Maybe say again that the estimated error is obtained from optimal estimation retrieval theory and the empirical error is obtained from the satellite-aircraft comparison, to help the reader?

(2) We have modified the text accordingly.

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(3) New sentence added to figure caption: "The empirical error is obtained from the statistics of the satellite-aircraft comparison, while the estimated error is obtained from optimal estimation retrieval theory."

Comment 10:

(1) l344-348: Based on these error estimates, can the AIRS HDO/H<sub>2</sub>O ratio retrievals be considered useful for further scientific analysis?

(2) Yes, the AIRS HDO/H<sub>2</sub>O ratio retrievals are useful for scientific analysis. We will clearly state this in the Conclusions.

(3) New sentence added to end of Conclusions, "The errors are sufficiently small that the AIRS HDO/H<sub>2</sub>O ratio retrievals are useful for scientific analysis. This long term global data record has much potential utility."

Comment 11:

(1) l357-359: Not sure the team list is actually needed?

(2) The AMT publication guide specifies to use this format.

(3) No change to the text.

Technical corrections - We have made all technical corrections as listed below:

l24 and l44: ... HDO/H<sub>2</sub>O \_ratio\_

l81: D/H -> HDO/H<sub>2</sub>O

l85, l138, l226, l270 and other places: use lower case section headings

l151: \_the\_ forward model

l169: DeSouza-Machado

l176: of \_the\_ satellite retrievals

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l213: completed \_by\_ applying

l258-259: Labels (a) and (b) are missing: We have added labels (a) and (b) to Figure 3 (formerly Figure 4).

l332: shows \_that\_ the empirical error

l340-341: acronym for WISPER does not need to be repeated: acronym deleted.

l467: paper title is formatted as a hyperlink: hyperlink removed.

We have also discovered the following typographical errors and corrected them:

p. 3, line 55 and p. 5 line 96: change Level 1b to Level 1B

p. 4, line 71: Change Fu et al., 2013 to R. Fu et al., 2013.

p. 5, line 96: Change Level 1b (L1b) to 'Level 1B (L1B)'

p. 8 line 141: Change Fu et al. 2013 to D. Fu et al., 2013).

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-195, 2019.

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