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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Estimate of bias in Aura TES HDO/H_2O profiles from comparison of TES and in situ HDO/H_2O measurements at the Mauna Loa Observatory" *by* J. Worden et al.

Anonymous Referee #2

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Paper: Estimate of bias in Aura TES HDO/H2O profiles from comparison of TES and in situ HDO/H2O measurements at the Mauna Loa Observatory Authors: Worden et al. doi: 10.5194/acpd-10-25355-2010

Summary:

The authors make an estimate of the bias correction necessary for observational estimates of lower tropospheric HDO from TES using observations of HDO and H2O atop Mauna Loa. The Mauna Loa observations are mapped onto the TES H2O sounding according to the H2O amount, and the corresponding HDO amounts are used to compute TES estimates using the vertical averaging kernel of TES. Different bias corrections are

explored, and a single value is recommended.

Recommendation:

Major revisions.

I have a few questions regarding the construction of the H2O and HDO soundings from the in situ observations at Mauna Loa Observatory and the degree to which such profiles would be representative of the TES bias in general. I do not claim to have the answers to all or even any of these questions, but I feel that they would merit some discussion or mention in the paper even if they do not lead to a change in the approach taken in the paper.

Major comments:

1. How representative are the data at the Mauna Loa Observatory (MLO) to the subtropical free troposphere? The TES observations shown in the paper were taken during daytime and have a strong gradient in deltaD and likely also in water vapor above Mauna Loa. While moist layers at various heights are not uncommon in the tropics, there is also a warm surface in the center of the range of heights to which the lower/mid-tropospheric TES HDO/H2O measurement is most sensitive. Would any of these effects – in particular the presence of the surface in the middle of the region of sensitivity – make the bias estimate from MLO less than representative of general subtropical or global measurements?

2. The "Constructed True" water vapor profile is taken from the TES H2O profile. TES seems to have limited vertical resolution, so that I would interpret this profile as being a smoothed version of the "true" profile. I would have expected a nearly-well mixed layer near the surface at mid-day close to the in-situ value, with drier free tropospheric air above whose mixing ratio would be close to that of the Hilo sounding at the level of MLO. (See e.g. the MLO radiosonde sounding in figure 1 in Barnes et al (2008) at http://www.agu.org/pubs/crossref/2008/2007JD008842.shtml which has a relatively

well-mixed layer near the surface. My impression is that TES smooths the sounding even more than the Lidar does in that figure at lower layers.) Would your HDO/H2O retrieval be much different if your "Constructed True" sounding had a different shape, with a contrast between a well-mixed layer near the surface and a drier free troposphere? Also, in my view, the study would have benefitted greatly from having launched radiosondes from MLO itself synchronized with the five TES overflights. Perhaps, this wasn't done for manpower, cost or other reasons. However, it would have removed a significant source of uncertainty in my view. It may be that the broad vertical averaging inherent in the TES HDO/H2O estimate renders it insensitive to the issue raised here, but I believe that this should be mentioned in the paper.

3. How representative is the air sampled at MLO over a day to the air observed above MLO during the TES overflight? There are three parts to this question:

- Are the night-time MLO H2O/HDO values characteristic of free tropospheric air above MLO at mid-day? Perhaps, checking Hilo soundings 12 hours before and after the TES overflights could shed light on this for H2O if not HDO. Also, MLO is about 800m below the top of Mauna Loa, so that even nighttime air is likely blowing down the mountain rather than subsiding directly from the free troposphere. Is this important?

- Are the daytime MLO H2O/HDO values characteristic of those in the moist layer above MLO? This seems quite plausible.

- Are the intermediate mixtures of dry and moist air (and their HDO/H2O) ratios observed at MLO characteristic of the mixtures above MLO during the TES overpass? Of these three, this seems the least likely to be true. The mixtures seen by the TES flight are between free tropospheric air blowing in and the plume of boundary layer air rising over the mountain, not between different proportions of boundary layer air advecting up the mountain during the morning and early afternoon (themselves probably representing mixtures of boundary layer air and entrained free tropospheric air from lower down the mountain). If you had a radiosonde sounding with a well-mixed surface

layer capped by a strong inversion, this issue would be much less important because the mixtures would occupy only a small range of pressures. However, with the smooth TES H2O profile, these mixtures seem to be dictating at least the lowest two levels of the sounding.

I think it would be interesting to see if your HDO and H2O in situ data form a mixing line. This would at least tell us something about the mixtures you observe at MLO. Could you make additional scatter plots of HDO (vmr) vs. H2O (vmr) for the data in figures 5, A2 and A6 to show whether these mixtures lie on a mixing line between your night-time (nominally free tropospheric) values and your mid-day values?

4. The strength of the wind atop Mauna Loa could change the composition of the air atop the mountain (and that observed during the TES overflight) considerably. On a still and sunny day, a plume of boundary layer air advected up the mountain could accumuluate above the top of the mountain. On a windy day, such a plume would blow off much more readily if it ever reached the top of the mountain. As a result, free tropospheric air would likely have more influence on the composition of the air above MLO. Based on the H2O VMR observed on 5 Nov, I would infer that that day was windier than the other two. It seems worth mentioning the wind conditions on each day.

Minor comments/suggestions (all page numbers start w/253):

p. 56, l21: Specify whether the 1 percent uncertainty of the bias correction is absolute or relative. Similarly for p. 60, l6 (abs. or rel. precision) and l8 (abs. or rel. bias).

p. 57, bottom: Boxe et al 2010 not in references.

p. 58, l20: "... to _profiles_ of HDO and H2O."

p. 58, l23: "... kernel and _an_ a priori constraint ..."

p. 60, l20: Give a number (3.2?) instead of saying "the next section".

p. 62, l21: "error on this estimate" – I assume this is an upper bound on the error. If so, it would be useful to say "error bound" or "uncertainty". It would also be useful to make clear that this whether this is a relative or absolute uncertainty.

p. 62: Could you show the TES-inferred variability in H2O and possibly HDO/H2O for the curtain of observations passing over MLO to make this clear to the reader? You should also include a depiction of Aura's path over MLO in figure 2.

p. 63, eqn 2: Do you need equation 2? Can't you just say "We map the in situ H2O and HDO data onto a vertical pressure grid using the H2O values and pressure levels observed by TES during its overflight. The set of in situ values which lie within 5% of the H2O value observed by TES at a particular TES pressure level are averaged to give the constructed true values of H2O and HDO at that level." or something like that. I found the P_{TES}(H2O_{in situ}) notation a bit confusing.

p. 63, l14: Should be figure 5, not 4.

p. 63, l18: I think you mean to say "lower than 0.001 VMR are not _seen_ by ..." Saying "are not measured" could be confused for asserting that the instuments are not capable of measuring such concentrations.

p. 63, l20: Is 5% big enough? Should you use a filter (other than top hat) in H2O VMR space to compute the averages? Would it be more robust to average observations onto a H2O mixing ratio grid and then construct your true sounding by sampling/averaging from there? Are you oversampling from relatively steady periods in your in situ measurements?

p. 63-64: Could you give some indication of what fraction of the integrated sensitivity to HDO/H2O comes from the region spanned by the five points shown in figure 3?

p. 64, l17-18: Fig. 3, not figure 2.

p. 64, l28: The line looks more pink or magenta to me than red.

p. 66, l21: Insert q_HDO as in "where q_HDO is the volume mixing ratio ..."

p. 71, l25: "preparation" not "preperation"

p. 74, fig 1: Is the data around day 305 missing? If so, don't plot it.

p. 75, fig 2: Add locations of MLO, top of Mauna Loa, Hilo and Lihue along with box for footprint of TES observation above MLO and line for path of Aura overpass. Same for A1 and A5.

p. 76, fig 3: The HDO/H2O prior seems pretty far off. Does this affect the quality of the HDO/H2O estimate from TES?

p. 76, fig 3: Could you plot the full height of the Hilo and Lihue sounding, rather than cutting them off at the height of Mauna Loa? Would these soundings look much different if you plotted them at full resolution?

p. 78, fig 5: Could you show local time as well as UTC and mark with a vertical line the time of the TES overflight? If the TES overflight was at day 294.0, the corresponding in situ deltaD looks to be about -130, rather than the -180 shown in figure 3. Clarification about this point (or just the vertical line showing the time of the TES overflight) might be useful.

p. 79, fig 6: What is the time resolution of the in situ data in fig 6? I am assuming that this is the raw in situ data and has not been processed into a TES estimate as in fig 3. Is this true?

p. 81-88, fig A1-A8: I would encourage you to merge these figures, pairing A1 and A5 into a single figure, and so on.

fig 5, A2 and A6: There are times in the HDO/H2O plots in each of these figures (twice each day: near 293.6, 294.1, 295.8, 296.3, 309.7 and 310.2), where it appears that data is missing and the line connects the observations before and after this period. If the data is missing, do not plot anything at those times.

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