REPLY TO REVIEWER #2

We thank the reviewer for his helpful comments, which help to improve the paper. The reviewer's comments are written in italic while our replies are in standard font. Within the manuscript all changes from the submitted version are highlighted in red.

MINOR COMMENTS OF REVIEWER #2:

- L291: The authors choose to use as input to the Optimal Estimation Method (OEM) a mix of retrievals (RL absolute humidity) and direct observations (MWR Tb). I'm not against this approach, but I suggest the authors explain the reason behind this choice in Section 3.3

The manuscript was modified and states in Section 3.3:
"The measurement vector y is composed of the TBs from the MWR and the water vapor mixing ratio (WVMR) profile from the RL. We choose the TBs to be part of the measurement vector instead of the MWR-derived profile of humidity in order to give the OEM the freedom to distribute the water vapor information to those heights where the lidar provides no information. In addition, for future applications, it allows us to extend our algorithm to simultaneous, physically consistent retrievals of temperature and liquid water. WVMR is used as the lidar measurement (with uncertainties given in Sec. 2.1.), which allows to avoid the use of a complex lidar forward operator."

- L313: Maybe this is stated before, but it would be worth reminding here: how was the prior knowledge estimated?

The a priori knowledge is calculated from a set of 217 radiosondes (see line 230). A reference to the previous information is introduced now in the manuscript:

"The a priori profile is the prior atmospheric knowledge (Sec. 3.2), and also the starting point (first guess) for the algorithm iteration."

- L396: there are few cases in which the joint IWV differs more than MWR only from GPS. Particularly one point at 22 kg/m2 while GPS is 14 kg/m2, where it seems that the joint retrieval has followed the lidar IWV. Could you comment on the nature of these few cases?

The aforementioned IWV outlier in figure 5 (from the manuscript) presents values of 22.2 and 13.8 kg/m^2 for the JOINT and the GPS respectively. In this specific case, there was a problem with the error estimation of the lidar signal. As can be seen in figure R2.1, the lidar data from 3.5 km up to 4.5 km presents a unexpected/unphysical strong increase. This fact would not represent a problem for the optimal estimation as soon as the uncertainty associated to these data would be large enough. But, in this case, the error associated to the data at these altitudes has been underestimated and consequently, the retrieved atmospheric state is incorrect.

This outlier has been removed from the statistics and an updated figure 4 (here Fig. R2.2) is presented in the manuscript.

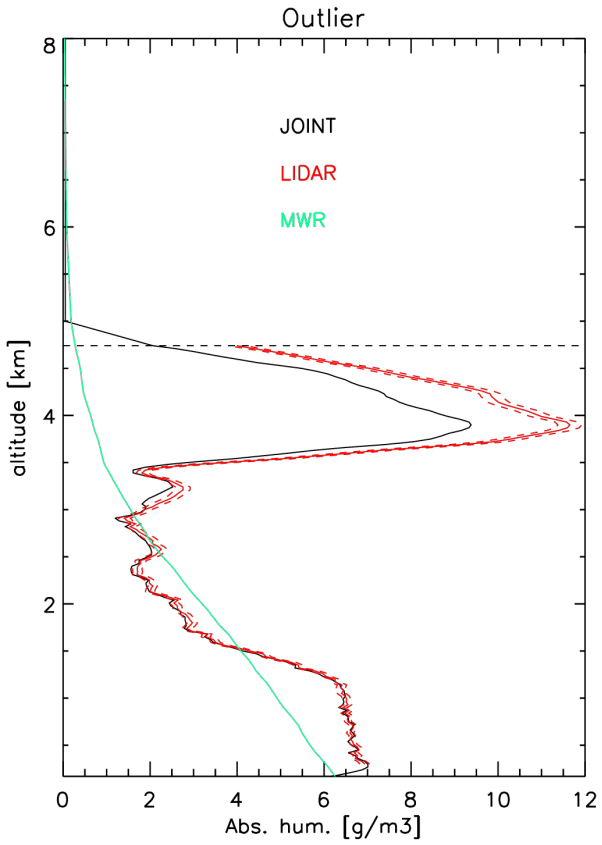

Figure R2.1 Absolute humidity (g/m3) for the outlier in figure 5 (manuscript).

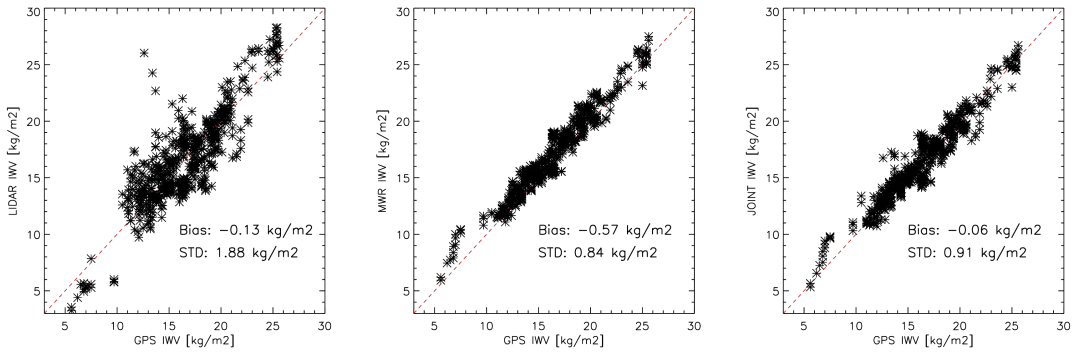

Figure R2.2 New figure 5 (manuscript).

- Figure 2: The caption miss to explain what the horizontal blue lines mean. I guess these indicate the estimated retrieval error, but it should be explained.

Thanks for catching this. Indeed they indicate the estimated error. The explanation is now included in the figure caption:

"Absolute humidity profiles for a priori (yellow), only-RL (red), only-MWR (green) and MWR+RL (blue). The horizontal blue lines correspond to the theoretical retrieval error for the MWR+RL case. The RS is used as reference (black). The dashed horizontal grey lines enclose the region where the lidar data is used. The inset is a zoom for the region close to the ground, between 0 and 250 m."

- Figure 4: It would be useful to see the same time-height cross section as seen from the two separated instruments (preferably with the native retrievals) to appreciate visually the added value of synergy.

A very good visual example is presented in figure R2.3. The example corresponds to a time series in the afternoon of the 4th of May 2013, from 18 to 18.7 UTC.

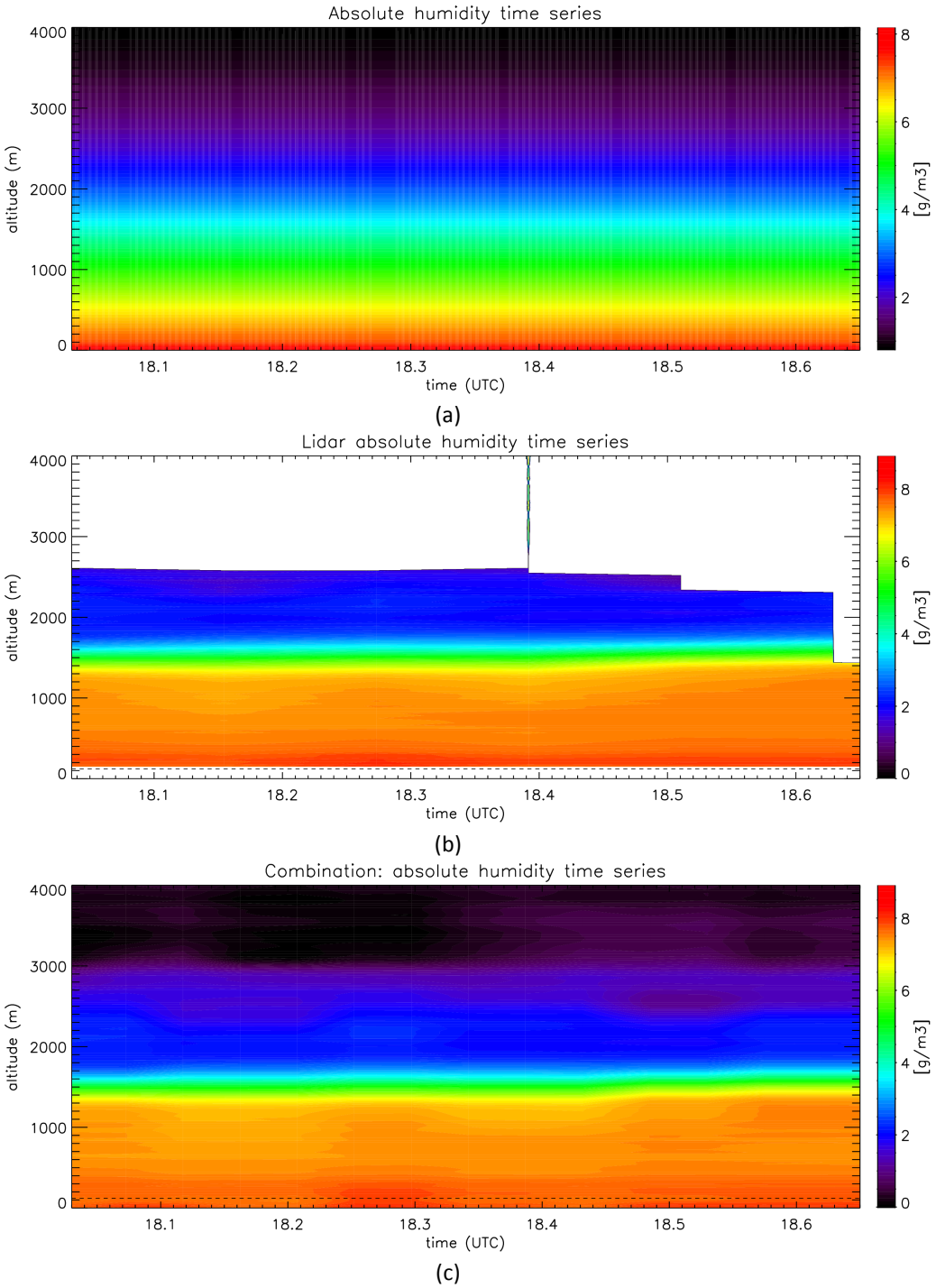

Figure R2.3 Absolute humidity time series for (a) only-MWR (statistical retrieval), (b) only-RL and (c) MWR+RL (joint retrieval).

- Figure 5: Panel a: It says clear-sky data only are presented, but I don't see any gaps for cloudy-sky periods. Gaps were shrunk or is it a 25-day clear-sky period? Not clear. Please explain in the

caption. Panel b: I guess the first and last panels should be switched. Or alternatively the caption should say from right to left.

Unfortunately the caption was misleading. It has been rewritten as follows:

"(a) Time series of IWV during the whole HOPE period from the continuous GPS estimation (black) and the one calculated from the joint retrieval, which is available only in clear sky cases (blue)."

TYPOS:

- L50: calibrated.This
- L62: where there lidar data
- L89-91: section -> Section (or the other way around, just pick one)
- L258: way to due lack
- L263: can to lead
- L285: "in different heights" -> "at different heights"
- L330: be expected 2.
- L381: therefor
- L406: simplies -> simplifies?
- L478: than -> as
- L526: regular -> initial
- L545: Therefor

All the typos have been corrected in the manuscript.