Responses to Review #2

The authors would like to thank the reviewer for his valuable comments which helped in improving the quality of the manuscript. Our point-by-point responses to the reviewer's comments appear in bold below.

P1-L27-29: What RMSE, bias and correlation coefficientes do the authors refer to? please specify.
The abstract has been modified to make it clearer what the statistical criteria refer to.

P2-L1: What does "..there are no operational constraints" means? please specify.

This point has been clarified: "Furthermore, the use of re-analyses can be an interesting option for calibration if the lidar profiles are not used in the models themselves, e.g. by means of assimilation."

P2-12: Please replace "Only recently has the need for better coverage of the lower troposphere emerged to improve constraints on the new generation of mesoscale models dedicated to weather forecasting " by "Only recently the need for better coverage of the lower troposphere has emerged to improve constraints on the new generation of mesoscale models dedicated to weather forecasting"

The correction has been made.

P3-L15: Tha authors assert that: "Intrinsically, Raman lidar measurements have no bias". What does it means? can you provide a more detailed explanation?

For a lidar correctly aligned, with a check on the atmosphere, no vignetting from the various internal optical elements, and detectors in the pupil plane, the biases in the water vapour content retrieval from a Raman lidar are essentially due to the calibration process. The ratio of Raman H2O to Raman N2 channel signals eliminates molecular contributions. There remains a residual contribution related to aerosols (Chazette et al., 2014), the magnitude of which depends on the spectral response of the particles. It can be around 3% of the for pollution aerosols, but tends to 0 for desert-dust aerosols. This is in contrast to DIAL measurements, which are biased by pressure shift or laser line drifts.

In the introduction 'no bias' has been replaced by 'little bias', which is more correct. The reference Totems et al. (2021) has also been added because it confirms what is said above and includes a full discussion of instrumental biases, rarely found elsewhere in the literature.

P6- can you homogenize the format of the equations, in terms of the the way of writing the divisions?

The correction has been made.

P6-L10: should OR be writen with R as subindex as appear in equation 3?

The correction has been made.

P7-L12: please homognize the way to OR should be writen, in the text and equations.

The correction has been made.

P12-L12: How the authors reach that the uncertainties in WVMR is ~0.3 g Kg-1? I there any refference supporting it? The authors do not provide the way to derive WVMR from meteorological probes and therefore is not possible for the reader to address the propagation of uncertainties. Therefore, I think that this should be clarified, by refferences or more detailed explanation.

We have added the equations and a reference:

The final absolute error on the WVMR is thus ~0.30 g kg^{-1} in the planetary boundary layer (PBL) by considering the equation that relates WVMR to relative humidity *RH* and atmospheric pressure *P*:

$$\mathbf{r_x = 0.622 \cdot \frac{RH_x \cdot e_w}{P_x - RH_x \cdot e_w}} \quad \textbf{(21)}$$

where $\mathbf{e_w}$ is the partial pressure of water vapour at saturation given by the relationship proposed by Buck (1981), which is related to the air temperature *T*:

$$\mathbf{e_w = 6.1121 \cdot \exp\left[\left(18.678 - \frac{T_x}{234.5}\right) \cdot \left(\frac{T_x}{(257.14 + T_x)}\right)\right]} \quad \textbf{(22)}$$

P12-L26: Is the same question that I explained just in the lines above, but in this case for radiosonde probes. It should be highlighted that the uncertainties of the reference measurements are really important because it will determines the uncertainty of the WVMR from lidar.

The same procedure is used as for the situ meteorological probes, with equations 21 and 22. This is added in the text:

« This leads to an uncertainty of ~1.8 g kg^{-1} on the WVMR when considering Eq. 21 and 22."

P13-L19: What is the uncertainty associated to the WVMr derived from ERA5?

The ERA5 uncertainties are derived from the Ensemble of Data Assimilations (EDA) system, but not all uncertainties are taken into account. One approach to estimate the uncertainties is to compare the WVMRs with observations of which biases and rms are known. In this article we see that the uncertainties can change considerably depending on the meteorological conditions. The uncertainties on the reanalyses include those of the data used for the assimilation, but also those associated with the model parameterisations. It is therefore difficult to give a value for the uncertainty using ERA5, but an assessment for given situations can be made by comparison with calibrated lidar measurements. It

should be noted that the radiosondes are assimilated, so the uncertainty is lower at these grid points compared to the radiosondes, but it may be higher outside the hours or geographical locations of the radiosondes. More details can be obtained in Hersbach et al. (2020, 2023) cited in the paper.

P21: Fig. 8 - 15. What is the vertical resolution used to perform the vertical comparisons between Lidar derived WVMR and in situ-aircraft, or ERA5 model?

The comparisons are made at a vertical resolution of 50 m, as explained in section 2.4.

P21-L11: How do you evaluate that the lower atmosphere had weak vertical gradient on the WVMR?

To determine if the vertical gradient of the WVMR is low, simply calculate the gradient on the signal ratio $\frac{S_H^V(z)}{S_N^V(z)}$. There is no need to perform an inversion. In this case, the altitude range of atmosphere under consideration can be considered to be in mixing equilibrium. We have added this explanation:

"This corresponds to a slight vertical gradient in the ratio $\frac{S_H^V(z)}{S_N^V(z)}$ and the atmosphere can be considered to be in mixing equilibrium in the layer under consideration."

P36-L32. If the authors are talking about absolute uncertainty of k0, it should be follow by its units.

The correction has been made.