Response to author comments

My apologies for the delay in this response. The authors should be commended for the considerable amount of additional work that they have done to address my previous comments. I have one major comment and some minor ones. The major comment is significant and, in my opinion, requires that this paper have another review iteration before consideration for final publication.

Major Comments:

1. Concerning my previous major comment 3 that related to the method of normalizing the lidar calibrations through comparison with ERA5. It is very appealing to use satellite retrievals for calibration normalization in a study like this where an intercomparison of instruments was not done prior to the measurement campaign. To my knowledge this application of satellite measurements as a kind of transfer standard has not been done previously. For this reason, this manuscript could well become a seminal reference for performing such analysis in the future. It is therefore very important to clearly justify the technique used. As it stands, I still do not see how it can be justified to use only part of the regression analysis (the slope and not the intercept) between lidar and ERA5 for the calibration adjustment.
    1. In their response authors state: “As we explained in our response to Reviewer 1, the lidar-ERA5 mean bias is highly correlated with the intercept. We decided to correct only the slope using ERA5 to avoid differences in the way all lidars were calibrated.”
        1. I really do not follow this logic. Correcting only the slope does not “avoid differences in the way all lidars were calibrated”. Instead, by not utilizing the full regression equation to correct each lidar it makes the technique for calibration in fact *different* for each system since a differing amount of bias is unaccounted for in each separate lidar calibration adjustment.
    2. Authors state “the offset remained uncorrected in order to maintain natural differences in the data independent of calibration.” How does not making an offset adjustment maintain natural differences in the data while making the slope adjustment would presumably not do so? Both slope and offset come from the same regression. I don’t see how they can be validly separated in a calibration adjustment.
        1. This is a critical point to rigorously justify and I am not persuaded by the current arguments. What does the calibration adjustment look like if the full regression equations are used or if the mean/median ratio of ordered pairs used as described in my previous comments?
2. To fully justify this technique so that it is able to be referenced in the future the authors really must spend more time critically studying this calibration adjustment. Please show the reader the effect of performing the full calibration adjustment using slope and intercept (or mean/median ratio of calibration constants) and compare with what the authors prefer to do (only use the slope) and argue more persuasively why this partial calibration adjustment is acceptable to do.

Minor Comments

The paper is considerably more detailed on the issues of biases due to particle differential transmission and the temperature sensitivity of Raman scattering. Thank you for this considerable amount of effort; I believe the community will benefit.

1. Please include a clear statement that both of these biases lead to an apparent moistening of the water vapor profile and that these biases add together.

    1. It should also be stated that this is an explanation for some of the difference between lidar and satellite noted in the manuscript so please also quantify the magnitude of these combined biases using similar units. Currently the bias between lidar and satellite is generally given in terms of g kg-1 while these biases are expressed in percentage. It would aid the reader to have, somewhere in the manuscript, the magnitude of these uncorrected biases expressed in g kg-1.
2. Table B1 is very helpful. One can do the math and see that for RL2 and RL8 the combined effect of these neglected biases might reach almost 7% depending on their separate height dependence. Please also convert these biases to g kg-1 in a representative example so that comparison with the rest of the paper is easier to do.
3. Figure B1 is quite helpful. Please clarify which RL this plot pertains to. Or does this figure somehow present an average effect for all RLs? If this figure is somehow an average, the figure would be aided by plotting bands that show the range of biases for all lidar systems. Somehow the full range of the bias should be represented.
    1. Please add to this figure the already calculated temperature dependence as a function of altitude. This need only be estimated but it would be very helpful to show the combined effects of the two biases.