Dear Referee #2,

We highly appreciate your comments and thank you very much for your time and for reading our manuscript. We hope that we could answer all your questions below.

Replies to referee #2:

I suggest early in the description of the wet-dry correction problem to cite the early papers on the approach of using simultaneously measured water vapor and long-lived gases for accurate correction of wet to dry air mole fractions (Chen et al., 2010; Rella et al., 2013):

Chen, H., Winderlich, J., Gerbig, C., Hoefer, A., Rella, C. W., Crosson, E. R., Van Pelt, A. D., Steinbach, J., Kolle, O., Beck, V., Daube, B. C., Gottlieb, E. W., Chow, V. Y., Santoni, G. W., and Wofsy, S. C.: High-accuracy continuous airborne measurements of greenhouse gases (CO2 and CH4) using the cavity ring-down spectroscopy (CRDS) technique, Atmos. Meas. Tech., 3, 375–386, doi:10.5194/amt-3-375-2010, 2010.

Rella, C. W., Chen, H., Andrews, A. E., Filges, A., Gerbig, C., Hatakka, J., Karion, A., Miles, N. L., Richardson, S. J., Steinbacher, M., Sweeney, C., Wastine, B., and Zellweger, C.: High accuracy measurements of dry mole fractions of carbon dioxide and methane in humid air, Atmos. Meas. Tech., 6, 837–860, doi:10.5194/amt-6-837-2013, 2013.

Answer: *We have now included the two references at an earlier stage in chapter 3 in the newer revised version of the manuscript.*

It might be easier for the reader if the setup of the experiments (section 3.1) are presented first, and then the different approaches (lines 250 – 280).

Answer: *We appreciate your suggestion. However, we would still like to keep it in that order due to the following reason: If the explanations for the different versions are introduced bit by bit in the text while explaining the experiment and its results in chapter 3.1, we think that it could be difficult to go back to the definitions of the different versions, especially if they differ in only one aspect.*

On the calibration of the H2O measurements: I was a bit confused about the term “one-point calibration”, and then see that dry air cylinders where used for this. I would not consider this a calibration, but rather a zero measurement. A one-point calibration would be providing a known amount of water vapor with (single) value to the instrument to determine the sensitivity. In addition, the influence of self-broadening of H2O on the linearity of the H2O Measurement should be discussed (see e.g. Chen et al., 2010, Rella et al, 2013).

Answer: *We understand the confusion with the one-point calibration. Now, when speaking of H2O, we say "zeroing of the H2O measurements"*

Regarding the discussion of the influence of the self-broadening of the H2O, we have added that it has an influence on the H2O measurements, leading to deviations of the actual value in chapter 3.1 and also possibly leading to differences in the measurements between the MGA3 and DLH in chapter 3.3.

Given the overall length of the manuscript, I suggest removing the section from Line 550 to Line 575 on interpretation of N2O measurements in the context of simultaneous NH3 measurements. This would be better included in the mentioned upcoming study on source attribution.

Answer: *We appreciate your suggestion. However, we would still like to keep it in the manuscript. We think that this demonstrates how well the N2O measured by the MGA3 can be compared with other species that play an important role in the chemical processes leading to N2O. Since it is almost always wished to also measure NH3 in the context of N2O coming from agriculture and industry, we think that showing this capability would be very interesting to the reader.*

Specific comments

L28: "agricultural sector which is, in particular, relevant" > "agricultural sector, which is particularly relevant"

Answer: *We changed the paragraph accordingly to the suggestion.*

L184: This is a bit unclear. If the calibration gases are dry and should not contain any water, why is there a non-zero "known actual value", and were does this come from?

Answer: *We have changed the "known actual value" to "assumed value of 0" to make it clearer.*

L191: add a comma after "calibration cycles", unless you meant to say that you excluded values less than 1 ppb

Answer: *We added the comma.*

Eq. 3-6: it would be helpful to use different symbols for N2O mole fraction and water vapor

Answer: *We have changed the symbols from X to N2O and H2O, respectively.*

L236 "an already" -> "and already"

Answer: *We changed the paragraph accordingly to the suggestion.*

Eq. 7: please clarify if C_H2O is the dry or wet air mole fraction for water vapor.

Answer: *We added clarifications to the symbols in the equations 7 and 8.*

L 286: “is provided only” may be change to “is provided with only”, not clear otherwise

Answer: *We changed the paragraph accordingly to the suggestion.*

L342: note the same equation was also used earlier in Chen et al., 2010. I suggest citing this (as well or instead).

Answer: *We added the citation of Chen et al., 2010.*

L359-360: is it the mean of all curves, the curve using the mean of the coefficients, or the result of a fit to all data? The mean of the many curves would behave quite different given the different ranges of H2O in each curve.

Answer: *We used the data of points of all curves with their respective H2O ranges and then calculated a fit through the all the data via an orthogonal distance regression. The term “mean” is indeed misleading in this case.*

We added a short explanation to the figure and the text.

L366: “correlation … diverge” please reformulate. The values diverge, correlation is not discussed for each line.

Answer: *We removed the “correlation” phrase. It did not make sense in this sentence.*

L369: “unless … not” I guess you need to remove the “not”

Answer: *That is true. We removed the “not”.*

L380: “to assure, that all” remove “,”

Answer: We removed the “,”.

L401: is the precision error aggregated to the 0.01% H2O bins? This should be done, given there are many independent measurements at 5Hz within each of the bins.

Answer: *We are not quite sure if we can follow the question regarding the aggregation of the precision error. Do you mean that for the error of each bin we should add up all the single errors of each measurement point in one bin?*

We use the bins only to be able to better show the trend of the differences. Otherwise, we would not be able to see much of the trend because of the many points at 5Hz. However, we still show the uncertainty of the 5Hz data to give a feeling of the actual data not the binned data.

L402: "and the uncertainty of our own cylinders" why is this needed, given they were cross-calibrated against the cylinders of DACOM?

Answer: *The "uncertainty of our own cylinders" is, in this case, the error that is produced while cross calibrating our cylinders against the cylinders of DACOM. It is simply the uncertainty of our instrument used for the cross calibration propagated through the calibration equations.*

*To make it clearer, we changed "*uncertainty of our own cylinders" *to* "the uncertainty of the cross calibration procedure".

L404-419: is the uncertainty meant as a one-sigma or two-sigma uncertainty? This is important when interpreting the significance of the differences.

Answer: *The uncertainties we use are always 1σ. We have added this information now at the end of the previous paragraph.*

L413: "water dependencies found in the pressure regulator" can you elaborate on this? Does it mean the pressure depends on the amount of water vapor?

Answer: *The pressure controller in our model of the MGA seems to have unwanted cross correlations with different water vapor contents that are not always clear. In the newer models of the MGA there is a new kind of pressure controller which does not have this kind of interference with water vapor. It is not so much of a clear dependency between the pressure and water.*

In the text we now tried to explain that it is not so much a dependency but unwanted behavior which is not really understood.

L420-424: Does any of the three options mentioned potentially indicate that the uncertainty estimate is wrong for one or both instruments?

Answer:

With the first option, we think that there could be issues coming from the setup of both devices. Here we do not know if the Nafion-dryer somehow influences the sample air at high humidities and mass flows greater than 5slpm in the DACOM system. Also, we do not know what influences the inlet tubes of the MGA system can have on the sample air at high humidities. This could be a potential source for additional uncertainty.

With the second option both systems use different calibration methods, which use different amounts of gas cylinders and which calibrate with different frequencies. This could, in our opinion, lead to a systematic error. To make the measurements more comparable and to deduce any errors resulting between these two methods, we would need to characterize the behavior of both devices with both calibration methods.

With the third option (distance between inlets) we think that it might be actual differences between the air samples due to their shifted locations.

For the first and second options we added to the text that there are potential sources for uncertainty.

L425: Was a cross-correlation performed to check for misalignment in sample time, to rule out errors due to different airmasses being sampled?

Answer: *Yes, a cross-correlation had to be performed for all ASIA-AQ data to establish a time synchronization for all data sets.*

L441: "lowest determined in-flight precision" does this mean the worst or the best precision?

Answer: *The "best" precision is meant. We changed that in the text.*

L506: Is it possible that the vibrations or accelerations on the Cessna compared to the much heavier DC8 are causing the larger variability, rather than the lack of cabin pressure control? This should at least be discussed in this context.

Answer: *Yes, it is possible. Also, the DC8 can fly more stable due to its larger size compared to the Cessna, which makes it less prone to turbulences.*

We added that to the discussion.

Caption Fig 10: „The change in water vapor mole fraction while entering does not show any effect on the water vapor corrected v1-β-off-DLH data" This statement should be formulated somewhat weaker. This cannot be concluded from ambient air measurements as it cannot be ruled out that compensating effects occur.

Answer: *That is true. We somewhat weekend the statement accordingly and say that it seems that there are no significant influences* of water vapor on the data.

Eq. A1: there is something wrong here: the right side has indices i,j while the left side does not. So what is α? Note in Gordon et al. (2022) the left side does have the indices.

Answer: *Yes, the indices i and j are missing. α is the absorption coefficient and the indices in the appendix got lost because we used it already for the specific N2O line determined by i and j in chapter 2.4 for the Beer-Lambert law.*

We added the indices to be correct in the appendix.