The authors would like to thank to the reviewer for helping to improve our manuscript with her/his comments and questions.

Our answers for the questions and comments can be found below:

Section 2.1: *PA cell acoustic resonance frequency is sensitive to temperature, therefore the cell is temperature stabilized to 318.0 ± 0.1 K. What is the sensitivity of PA signal, at constant water vapor mixing ratios, to changes in temperature? Specifically, can the uncertainty in measurement derived from the measurement uncertainty of the temperature of the PA cell be evaluated and discussed?*

In a given gas sample the sound velocity is proportional to the square root of the temperature and the resonance frequency in a given (longitudinal) acoustic resonator is proportional to the reciprocal of the sound velocity. Therefore $f_{resonance} \sim \mathrm{T}^{-1/2}$. In our case the resonance frequency of the PA cell is 4500 Hz at 318 K. ±0.1 K temperature variation generates ±0.3 Hz variation of the resonance frequency. The PA cells we use have practically flat characteristics in the ±5 Hz range around the resonance frequency – there the sensitivity variation is less than 0.5 %. Altogether we can state that the allowed temperature instability of the PA cells has no effect on the measured PA signal. We want to note that there are other types of PA cells which are much more sensitive against temperature variations.

Section 2.1: *Can the authors describe (and/or include a figure) the specific timing characteristics of the laser waveform. The wavelength of the online peak position is stated as being at 1392.535 nm, what is the offline wavelength? What waveform is used to dither between online and offline positions? At what frequency is the online/offline dithering performed?*

The laser is driven by a waveform: $I(t) = I_0 + A \cdot \sin(2\pi \cdot f \cdot t)$, where $I_0 = 110mA$ and $A = 5mA$. The current tuning coefficient of the laser is 5 pm/mA, therefore the offline wavelength is 1392.485 nm, which is at the very side of the absorption line at 200 mbar pressure.

This has been included in the manuscript at section 2.1.

The dithering frequency is the same as the resonance frequency of the PA cells in case of the sensitivity modes 1&2 and in case of the not applied SM3 the dithering frequency is set to a value where the PA cell is about 1 order of magnitude less sensitive. This latter is usually around 1.5 times of the resonance frequency. With the applied PA cells this value is 7950 Hz.

The dithering frequencies have been introduced at the description of the sensitivity modes (section 2.2.2).

Section 2.1: *Given that a single absorption line is used and the PA instrument can span 5 orders of magnitude, are there are any issues (e.g., non-linearities) encountered due to saturation of the absorption line at high WV VMR?*

The pathlength in one PA cell is about 9 cm so the attenuation of the laser beam is weak even in case of very high concentrations so classical saturation issues like at multipath direct absorption techniques are not present at PA spectroscopy. The referee is right: there are some nonlinearities, at higher VMR-s but the calibration curve (surface) contains this information.

Now the nonlinearity have been mentioned in the manuscript at the introduction of the PA technique and at the analysis of the calibration curves/surface. These are sections 2.1 and 3.1.

Section 2.1: *Can the authors comment as to why the PA cells are not maintained at a constant (reduced) pressure. While burdening the experimental setup and gas handling systems with additional complexity, this would ease calibration and VMR calculation requirements.*

The referee is right. A constant pressure approach would result in simpler calibration and VMR calculation. However, with the current setup we have the possibility to use the system without pump with slight modification of the flow regulation: With a forward facing total water sampler and a Rosemount-TAT water vapor sampler the ram pressure can be sufficient to maintain appropriate gas flow. Now the mass flow controllers would block the flow but those can be replaced with critical orifices or with motorized needle valves.

Section 2.2.2: *What determines the switching point of the SM switching algorithm? Specifically, when does SM switching occur? What type of hysteresis control is applied to prevent rapid switching when rapidly changing WV VMRs are encountered?*

The sensitivity is lowered whenever the PA signal is greater than 66% of the saturation value of the AD converter and still can be lowered while increased whenever the PA signal is lower than 10% of the saturation value of the AD converter and still can be increased. This have been clarified in the manuscript at section 2.2.2.

Section 2.3: *What is the equilibration time when using the calibration system. Specifically, what is the equilibration time for the calibration system in response to pressure changes at constant saturator temperatures. Presumably the temperature of the saturator cannot be held constant using the warm-up method described here, yet I'd expect that the equilibration time for pressure changes would be much faster than changes in the temperature of the saturator and effectively rendering it constant. Additionally, how is the calibration system evaluated as being equilibrated? Please comment.*

During the calibration the pressure setting time is 2-4 seconds and at one constant pressure 5-5 data points are recorded for each sensitivity mode. This lasts about 22 seconds. During this ~30 second period the temperature variation of the humidity generator is not significant but individually recorded for each data point. During a calibration we have five data points at each pressure level and at each sensitivity mode every five minutes.

The corresponding part of the manuscript has been updated in section 2.3.

Section 2.5: *The temporal resolution of the instrument to sudden changes in relative humidity is stated as being 2 seconds in duration. This includes effects from both the PA cell and the inlet system. Is this the same inlet system as used during airborne measurements? If not, what is the response time of the instrument in an aircraft configuration?*

The tubes between the sampler and the system have some delay effect but do not affect the temporal resolution. Actually our latest results with new, just being published, controlling electronics showed that the temporal resolution of the PA cell and of the gas handling is definitely below 1 second. With this hygrometer we couldn't show such fast response times due to the limitations of its controlling electronics.

Section 2.5: What are the instrumental specifications (e.g. precision & accuracy) of the WSCRDS system? Please include this information in the paper.

An accuracy better than 10 ppmV for mixing ratios less than 100 ppm and better than 200 ppmV above 10000 ppmV was estimated from the chilled mirror hygrometer specifications (accuracy 0.2 °C dewpoint at 20 °C dewpoint, linearly increasing to 0.4 °C dewpoint at -60 °C dewpoint) assuming typical dewpoint/pressure combinations. Precision was estimated to be 4 ppm or 1% (whichever is larger).

Section 2.5 has been updated.

Section 3.1: *In general, the relationship between calibration at constant pressure and the multi-dimensional calibration surface used to derive VMR (i.e., Figs. 3 & 4) can be expanded upon.*

The calibration curves which can be seen on figure 3. were measured individually at constant 200 hPa pressure for better visualization. The 200 hPa data of the periodic pressure stepping calibration overlaps this within noise level.

This have been clarified in Section 3.1.

Section 3.1: *What is the PA signal offset between the two cells?*

The PA signal offset between the two cells highly depends on VMR. As the laser beam attenuates in the first cell at higher VMRs less optical power is introduced into the second cell. Therefore at same VMR the absorbed light power is lower in the second cell and hence the generated PA signal is also lower. This is also a reason for nonlinearity and mentioned in the manuscript at the analysis of the calibration curves in sect 3.1

Figure 4: *It is not clear that a unique solution to VMR can be derived from the calibration surface at pressures approximately less than 150 hPa. It's also unclear in Fig. 4 as whether both SM or only one are represented by this figure. Can the SM be explicitly stated in the figure?*

Below 150 hPa pressure calibrations were made at two levels (at 130 and at 80 hPa). In this pressure range the highest sensitivity, as a function of VMR, shifts a little bit but this has no significant effect on the behavior of the calibration surface and the data evaluation algorithm still can be applied. This is especially true for low mixing ratios. Of course the signal to noise ratio lowers in the lower pressure ranges. Our other measurements with practically the same experimental setup showed that precise measurements can be done down to approximately 10 hPa pressure.

On figure 4. the curves are from both sensitivity levels, the separator is at 5000 ppmV. This is clarified in the text and in the caption as well. The sensitivity values determined for SM2 were upscaled by 10 which is the difference of the microphone gain difference.

This is now stated both in the figure and caption.

Figure 5: *Above 1500 ppmV a systematic offset between the ESF and WaSul-Hygro is seen. Can this be explained? It appears that this occurs near theswitching of SM in both subplots (~1500 ppmv).*

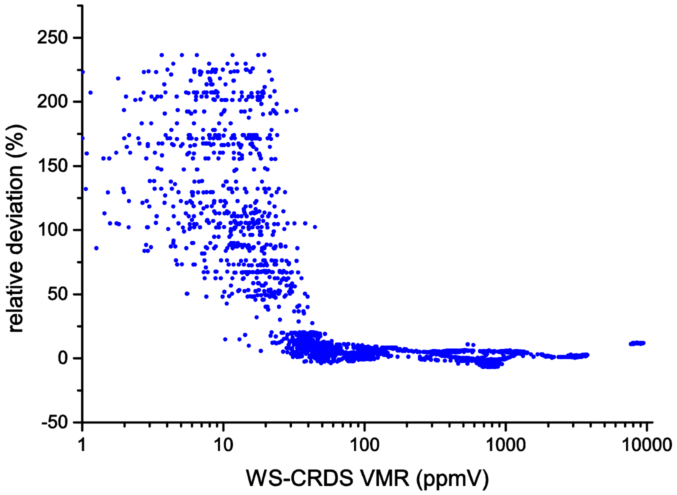
The significant deviation from the ESF chamber happened during periods when the VMR was increasing fast and the chamber was not in equilibrium.

Figure 7: Does the corresponding cross plot (Fig. 5B) draw from the same dataset as the flight time comparison (Fig. 5A)? It's unclear as to why WS-CRDS values below 20 ppmv are seen in the correlation plot but in the time series plot minimum WS-CRDS values are ~50 ppmv.

The authors think that the referee intended to write Fig. 7A and Fig.7B.

The two plots are made of the same dataset. As it can be seen on Figure 7B the deviation between Wasul Hygro and the WS-CRDS system below ~50 ppmV increases and reaches even more than 100%. For better visibility the Y axis of Figure 7.B was limited to ± 15%. This have been clarified in the caption of the figure.

Below you can find Figure 7.B without Y axis limitation:



p.6362, l.17: The amplitude of the acoustic signal at the frequency of the modulation of the light source usually determined by using lock-in signal processing technique is proportional to the concentration of the light absorbing molecules (McDonald and Wetsel, 1978). This sentence is difficult to follow, it contains a lot of information and is a key point towards how concentration can be derived from this technique. Consider rewriting for clarification.

The updated version is:

The amplitude of the acoustic signal at the frequency of the modulation of the light source is proportional to the concentration of the light absorbing molecules (McDonald and Wetsel, 1978). This amplitude is usually determined by using lock-in signal processing technique.

p.6364, l.10, 20: The upper limit of WVMR is set by the combination of the temperature of the gas handling system and the PA cell. This should be clearly stated in the text. Condensation on the walls of the gas handling system would manifest as a pronounced increase in uncertainty in measured water vapor mixing ratio. Given that the gas handling system has coarser control than the PA cell, it effectively limits the upper limit of the VMR that can be achieved.

The content has been clarified based on the referee’s comment.

p.6365, l.16: As most of the setup (controlling electronics, laser) are common for the two cells small differences between the VMR values in the sampling lines are expected to be measurable more accurately with the presented system rather than using separate systems for each sampling line. Expand on this statement (e.g., systematic errors and instrumental offsets are minimized with such a configuration).

The referee pointed on the advantages of the setup, the related sentence has been expanded in the manuscript at section 2.2.1.

p.6367, l.16: The PA cells are held to ±1 hPa accuracy. What is the calibration uncertainty that can be attributed to this?

During the test of the VMR calculation algorithm the pressure dependence was also tested: We added constant offset (from -25 to +25 hPa) to the measured presure values and found that the calculated VMR starts varying significantly (above noise level) when the added pressure offset is greater than ±10 hPa. So the ±1 hPa accuracy during the calibration is appropriate.

p.6367, l.19: Thanks to an overpressure reduction tube, which is long enough to avoid back diffusion of water vapor from ambient air and installed to eliminate the non-synchronizability of the MFC-s just before the saturator ... What is meant by the non-synchronizability of the MFC-s?

In the calibration setup (Figure 2.) there is an MFC right after the synthetic air bottle and two others inside WaSul-Hygro. If we set the flow rates equal, e.g. 1000 sccm after the gas bottle and 2*500 sccm in WaSul-Hygro, than due to the uncertainty of the MFC-s the pressure inside the humidity generator would start increasing or decreasing instead of staying at 1000 hPa.

p.6370, l.2: The inlets of the PA cells were again joined together ...
Consider rephrasing this statement for clarity (e.g. During the campaign the PA cells were configured to simultaneously sample water vapor from a single backward facing aircraft inlet.).

The content has been modified based on the recommendation.

p.6370, l.8: For the Wasul-Hygro the flow was provided by a pump ...
Describe location of pump (e.g. downstream of PA cell). Can the authors provide a make and model number of the pump or state the vacuum pump's throughput or pumping speed?

The model number of the pump was MD1 (Vacuubrand) and was used as a downstream one.

This content has been added to the text.

Supplementary: the pumping speed is 23 liter/minute and the end vacuum is 1.5 hPa absolute.

Section 2.5: From the FISH dataset all measured values above 350 ppmV had to be neglected. Can an explanation be provided for why FISH data where WVMR > 350 ppmV had to be discarded?

The FISH data above ~350 ppmV had to be neglected because in that range there was either cloud presence or data loss due to the crash of the central data logging PC (this latter issue did not affect the FISH dataset as it has its own built-in data logger). The period when
the two systems were comparable and the VMR was above 350 ppmV lasted only four minutes covering the VMR range up to 600 ppmV. This short period for such a wide VMR variation did not provide statistically significant amount of data.

This has been clarified in the text.

Section 2.5: How was the presence of clouds determined?

On the airplane there were several other systems mounted: some other also experimental phase hygrometers on different samplers, and microphysics probes. Before the comparison of the hygrometers all data were collected together and whenever significant deviation was observed between water vapor and total water VMR the microphysics data were also checked for the presence of particles. Actually this had to be done only for three short periods.

Section 2.5: Can the authors state the amount of suitable data (e.g., 5 hours) and under what general conditions (e.g., upper trop., lower strat., continental mid-latitude, near convection) the intercomparison data was collected?

During the flight campaign 13.3 hours data were collected. From this amount 3.6 hours were together with FISH and each with the WS-CRDS. Each flight was performed in the north-European airfield: above north-Germany, north-Poland, Denmark, south-Norway and the North Sea. Data was collected at different flight levels up to 13 km so WaSul-Hygro was tested under tropospheric and lower stratospheric conditions as well.

This have been added to the text at section 2.5.

p.6371, l.13: *The dependences are very similar for the two cells. It can be clearly seen that the use of the simplifying assumption of VMR independent sensitivities (as done previously, Szakáll et al., 2006) would lead to highly inaccurate VMR determination. These statements seem to contradict one another.*

Our statement needs to be clarified more in details:

The dependences are very similar for the two cells, but at higher VMR-s the sensitivity of the second PA cell is definitely lower due to the light attenuation in the first cell. Previously (Szakáll et al., 2006) during the calibration procedure only one calibration curve at a defined pressure was determined per PA cells and the pressure dependent sensitivity was determined at a certain VMR per PA cells. The results plotted on Figure 4 indicate why this assumption leads to significantly inaccurate VMR determination.

The corresponding text have been modified.

Minor corrections

The minor corrections have been accepted and applied in the text except of the last one since the new controlling electronics will be an integrated unit, not the combination of separated components.