August 31th, 2018

"Atmospheric CO2, CH4, and CO with CRDS technique at the Izaña Global GAW station: instrumental tests, developments and first measurement results" by Angel J. Gomez-Pelaez et al. (https://www.atmos-meas-tech-discuss.net/amt-2017-375/)

Author's Replies to the Comments of Referee #3

Gomez-Pelaez et al. present both laboratory and field test results of a commercially available CO2/CH4/CO cavity ring-down spectrometer (CRDS). The authors discussed the results within the context of several relevant international programs, e.g. Global Atmosphere Watch (GAW) and the European Integrated Carbon Observation System (ICOS). Being aware of recent development of greenhouse gas measurements using the same type of analyzers, the authors tried to improve the water vapor corrections for CO2 and CO, and to determine the drift rate for the pressure and temperature sensors located inside the CRDS cavity.

R3.M1) As the development presented here is some sort of changes to or confirmation of the published methods and results, it is therefore in several places an overstatement for novelties. Furthermore, several methods and results are not (yet) convincing based on the presented results, see below.

We disagree with this comment.

R3.M2) I do agree with the second reviewer that the manuscript will benefit from English editing by a native speaker.

This is going to be done before submitting the revised version of the manuscript.

R3.M3) The authors tried to present a way of explaining the dependence of the CO2 measurements on the flow rate, i.e. the outlet valve number, in Sect. 3.1. More information is needed to explain how Eq. 1 was derived. Was it derived from 2-point inlet pressure measurements? Appendix A gives a very nice theoretical analysis; however, I do not find it convincing to support the linear relation between actual CO2 and raw CO2. The equation apparently corrects the flow effect, which may actually reflect changes in something else, e.g. cavity temperature or pressure. Please show the raw measurement data to support this empirical equation.

Since the effect is quite small, two "extreme" pressures were used to maximize the signal to noise ratio. The test was repeated two different days with the same results. When accounting for this effect the fitting to the CO2 response function improved significantly in the first calibrations, when we were not so skilled adjusting precisely the CRDS inlet pressure corresponding to each gas cylinder. Therefore, intermediate pressures had been tested indirectly.

We have performed additional tests to determine this correction, including intermediate pressure points and even a larger pressure range. They confirm our previous findings. In the revised version of the manuscript we are going to detail these new tests and expand the information about the previous tests. We also are going to show raw measurements data to support the empirical equation, as requested by the referee.

Concerning the referee´s sentence: “The equation apparently corrects the flow effect, which may actually reflect changes in something else, e.g. cavity temperature or pressure”, we disagree. The CRDS controls “perfectly” the temperature and pressure of the cavity, with very short transient periods, and these variables are continuously monitored by the CRDS and recorded in the acquired raw data files. Temperature or pressure drifts in the cavity sensors can only have an effect on long-term periods (several months or years). The flow effect due to changes in the inlet pressure affects on short timescales, due to the switching between different “air sources” (ambient air, laboratory standards, and target gas) at slightly different pressures.

R3.M4) Water vapor correction for CO: the authors rearranged (combined) the existing equations to fit a single equation to the experimental data. Statistically, the use of the 4000-data running mean should not change the results? Have the authors tried to fit the equation to the raw data?

The H2O experiment lasted many hours. We have checked that using a 39-minute running mean for CO has no significant impact in the accuracy of the data for that experiment. Using a 39-minute running mean instead of a 1-minute running mean, the random noise is reduced by a factor 6 approximately. Least-squares fitting is very sensitive to outlayers (they have a large weight in the computation of the coefficients to be determined). Therefore, the smoothing of the CO data (in a safe way) through a running mean makes the fit more robust and the determined coefficients have less uncertainty.

R3.m1) With all the efforts to improve the water vapour equations, why did the author decide to include a cooler to dry the air?

Till we got all the materials necessary to install the final plumbing configuration detailed in Sect. 6, we needed to use during one year a simpler configuration without drying. During the first year in which our CRDS was in operation, no drying was performed. This made necessary the H2O correction.

R3.m2) The use of a large number of symbols makes it difficult to read. I would recommend simplifying them and showing only the necessary ones.

Almost all the symbols shown are necessary. The few ones remaining are shown by completeness and for helping readers to “disentangling” the CRDS raw files

R3.m3) The Fortran 90 code does not make the work novel, and there is even no need to mention it in the main text.

We are going to remove the words “Fortran 90” in the main text, keeping them only at the end of the manuscript in the paragraph called “Code availability”.