

August 31th, 2018

**“Atmospheric CO<sub>2</sub>, CH<sub>4</sub>, 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 #2**

In this paper, the authors present their instrumental set-up to measure greenhouse gases continuously at Izaña global GAW station. The instrument performances are tested and interferences are studied. First ambient air measurements are compared against the historical NDIR and GC systems. **This paper should be published after corrections as detailed below.**

[We acknowledge the comments of the referee.](#)

General comments:

**R2.M1)** The paper would benefit from an English proofing.

[This is going to be done before submitting the revised version of the manuscript.](#)

Specific comments:

**R2.m1)** p4: It would be great to have a plot of the inlet pressure tests. Did you only varied between two pressures? Also, it would be good to make this test several time to see if drifts occurs over time and if the results are reproducible as you are using them to correct data.

[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 CO<sub>2</sub> 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. Also, we are going to include a plot as requested by the referee.](#)

**R2.m2)** p4: You mention using smaller inlet pressures differences, does that lead to smaller RMS residuals? Is then the inlet pressure correction useful?

[Being able to get smaller inlet pressures differences decreases the impact of the pressure correction, of course. Keeping small the inlet pressure differences between ambient air and standards is quite difficult. We do think that taking into account the pressure correction keeps us in the safe-side to obtain high-accuracy CO<sub>2</sub> measurements.](#)

**R2.m3)** p5 l25: From experience, the outletvalve value change with time, depending on the T<sub>das</sub> temperature, after restarting the instrument or when the filters get clogged. It seems safer to operate as you said yourself by reducing the difference in inlet pressure between cylinders and ambient air to avoid the need for an empirical correction.

Note that if Eq. (1) is expanded, only the slope term in OV is kept fixed, since the independent term is, in practice, combined with the independent term of Eq. (6), and the latter equation is updated each time a mole fraction calibration is performed. Therefore, it automatically takes into account hypothetical drifts in the independent term of Eq. (1). The impact in the slope (in OV) by hypothetical drifts in the outlet valve controller is quite limited as it is going to be shown in the revised version of the manuscript.

**R2.m4)** Section 5: did you perform more than one test to assess the variability? It would be interesting to plot the biases between the assigned dry value and the wet values depending on H<sub>2</sub>O for Picarro and your own correction for the three species. On the same subject: p15 l22: what is the level of residual water? Why not invest in a -60 C cryocooler and get rid of any correction as you are using already a cryocooler system? Especially if you refer yourself to the paper of Reum et al. in discussion in AMT (Reum, F., Gerbig, C., Lavric, J. V., Rella, C. W., and Göckede, M.: An improved water correction function for Picarro greenhouse gas analyzers, Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2017-174>, in review, 2017.) that shows that the H<sub>2</sub>O correction is biased when almost dry due to the sensitivity of the pressure sensor with H<sub>2</sub>O.

We performed a few, but kept only this one due to its superior design and performance. We are going to include the plots you mentioned in the revised manuscript. During the first year in which our CRDS was in operation, no drying was performed. This made necessary the H<sub>2</sub>O correction. We are going to include a short paragraph in the revised manuscript providing the information you asked for when partial drying is performed. We had a -40 C cryocooler available. Funds are always scarce.

Concerning the Discussion paper you mentioned (Reum et al., 2017), the AMT website indicates: “This discussion paper is a preprint. It has been under review for the journal Atmospheric Measurement Techniques (AMT). The revised manuscript was not accepted”. Therefore, we can not use the results of that manuscript.

**R2.m5)** Section7: Can the ambient air difference be due to the non-linearity of the RGA-3 or to the fact that the H<sub>2</sub>O correction is not good enough? The difference does not seem to increase strongly over time but more to vary around a bias.

We do think the non-linearity of the RGA-3 is well characterized and is taken into account. We discard this might be due to the H<sub>2</sub>O correction: the amount of H<sub>2</sub>O has been very small since November 2016 due to the -40 C cryocooler. We have no explanation for the bias between the CO measurements you mentioned. Perhaps the explanation might be in the problems detected recently by the CCL in the CO WMO-X2014A scale ([https://www.esrl.noaa.gov/gmd/ccl/co\\_scale\\_update.html](https://www.esrl.noaa.gov/gmd/ccl/co_scale_update.html) ).

Technical comments:

**R2.m6)** p1 l29: not clear, please rephrase

Done.

**R2.m7)** p2 l7 replace “being.. much lower” by reducing

Re-phrased following the indications of Referee 1.

**R2.m8)** p2 l3 replace “ones” by “techniques”

Done.

**R2.m9)** p2 l26: add “of” after “physical discussion”

Done.

**R2.m10)** p2 l27: “as follow”

According to the WordReference dictionary, it is correct written as “as follows”.

( <http://www.wordreference.com/es/translation.asp?tranword=as%20follows> )

**R2.m11)** p3 l6 “serial number” should go before the actual serial number

Done.

**R2.m12)** p3 l7: remove “to the CRDS”

We do think it is necessary to keep it in order to have a sentence with full sense.

**R2.m13)** p3 l9: cite as well here Yver Kwok et al. As the tests are described in this paper while the specifications gives the tresholds.

Indeed, the mentioned ICOS-ATC report also describes the recommended tests in the year in which it was published (2016), whereas Yver Kwok included all the CRDS tested along the years since 2008. Along these years the methods were not kept constant but they evolved.

Therefore, we are going to re-write the sentences to state clearly that the report also describes the test method.

**R2.m14)** p3 l11: In Yver Kwok et al. the terminology for the precision test is continuous measurement repeatability (CMR), rephrase for example as “The first test, defined in Yver Kwok et al; as the CMR test consists...”

In the revised manuscript, we are going to include the sentence: “(this test is called continuous measurement repeatability -CMR- by Yver Kwok et al., 2015)”. So, by the way, we are going to cite Yver Kwok et al., 2015, here.

**R2.m15)** p3 l12 put “being” after “the first hour”. This type of exchange appears throughout the text, please check.

We have changed it following the advice of Referee 1.

**R2.m16)** p3 l15: Replace precision by CMR

We are going to include both terms.

**R2.m17)** p3 l18: this test is what was called reproductibility before and in ICOS-ATC LTR or long term repeatability. Add ATC after ICOS as ecosystem or ocean could have defined other terms.

In the revised manuscript, we are going to include the sentence: “(this test is called long-term repeatability -LTR- by Yver Kwok et al., 2015)”, and to add ATC after ICOS.

**R2.m18)** p3 l24: thresholds

Done.

**R2.m19)** p4 l2 Replace “Repeatability test” by LTR

We are going to include both terms.

**R2.m20)** p4 l5 use proper units, mbar not mb

You are correct. We are going to use hPa (= mbar).

**R2.m21)** p4 27-28 delete “to” before “the computation”

We have re-written the sentence as advised by Referee 1.

**R2.m22)** p6 l2 delete “tot” before “the raw CH4”

According to an Oxford dictionary, the usual structure is: “call somebody/something + noun”. However, we are using “call noun to somebody/something” since in the other way the sentence might be confusing because the used “somebody/something” is quite large. We are going to check it during the English proofing.

**R2.m23)** p6 l12-13 you multiply p84sw by 1000, then p84sw’ should be in ppb contrary to what is mentioned.

Please, look Eq. (5) and the last plot of Figure 3. The coefficient  $b$  is approximately equal to 2.32. This explains why p84sw’ has no ppb units but it is a raw value.

**R2.m24)** p6 l28: numerical

Done.

**R2.m25)** p7 l28 It is a new paragraph and the transition is not smooth, please add a transition.

We are going to write it as a new paragraph and make the transition smoother.

**R2.m26)** p11 l15 Refer to section 7 for more investigations.

Agreed.

**R2.m27)** p14 l 7-8: move “being” after “CH4”, add “s” to coefficient

Done.

**R2.m28)** p15 l7 what is pph?

This was defined in p13 l3-4: “parts per hundred in mole fraction”. Now it is complemented with: “i.e., millimoles per mole of air”.

**R2.m29)** p15 l16: why is there two inlets, what is the purposes of switching between the two every day?

This has two purposes: 1) to provide a lot of time to change the flask used to trap H<sub>2</sub>O in the air line not used at this moment; 2) to check the consistence between both lines after every switching: a bias between them might indicate a leak in one of the lines (especially in the general inlet, which has a few large unions and several instruments connected to it; or at the flasks connections). We are going to add this explanation in the revised manuscript.

**R2.m30)** p16 l8: Rephrase “For not discarding” in “To keep”

We have re-written it following the advice of Referee 1.

**R2.m31)** p18 l18: Can you comment on the reason of the larger differences for CO<sub>2</sub> and CH<sub>4</sub> for these particular months? As it is both for CO<sub>2</sub> and CH<sub>4</sub>, it seems to indicate that the CRDS would be the cause?

The larger differences took place in October and November 2016. We do think they were produced by a small leak in the general inlet used by the CRDS (the NDIR and the GC-FID used another general inlet). We are going to add this explanation in the revised manuscript.

**R2.m32)** p20 l10: Replace “for comparing” by “to compare”

Done. Thanks.