Interactive comment on "Comprehensive laboratory and field testing of cavity ring-down spectroscopy analyzers measuring H2O, CO2, CH4 and CO" by C. Yver Kwok et al.

Anonymous Referee #1

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General comments:

This study is impressively comprehensive in the breadth of its testing of Picarro model cavity ring-down spectroscopy (CRDS) analyzers. Further, due to the scope of the ICOS infrastructure, the sheer number of units tested by the MLab (47) means that this data set is likely to be representative of the performance of these instruments in general and therefore of considerable interest to many users of this new generation of instruments for atmospheric measurements. The authors present a clear account of a large range of tests across different models, different chemical species and in both laboratory and field conditions. This elucidates a range of issues relevant to the CRDS technique including the water vapor correction, and pressure and temperature effects. They eventually formulate a series of practical recommendations for obtaining high quality data from these instruments. Such recommendations are likely to be of practical use for many new (and existing) users of these instruments as the number of relatively inexpensive units proliferates. Section 4.4 'Calibration and linearity', is a clear illustration of the ability of this new technique to shed light on the accuracy of the assigned calibration scales. The referee recommends publication in AMT and looks forward to the forthcoming publication focusing further on water vapor effect in these instruments.

We would like to thank the reviewer for having reviewed the paper and formulated helpful comments.
We answer each of them hereafter and add when needed what will be the modifications in the text.

Specific comments:

The definition of the short-term drift has altered between generations of instruments. Could the authors comment on why this change has occurred, noting that one of the authors is based with the manufacturer? Also, since the raw data must exist, is it possible to standardize this measure by recomputing the short-term drift of the older generation of instruments with the new definition?

Regarding the change in the short-term drift definition, it was motivated by an attempt to separate short term noise from longer term drift, and since many researchers use hourly averages, we wanted to better represent the performance of the instrument under the conditions used in the field.
It is however very difficult to recompute in a short amount of time the short-term drift using the new definition. Indeed for the older instruments, the raw data are not readily available but stored on tape. Moreover as the tests were not done for a long-term research purpose but as initial compliance tests, it is not simple to separate the raw data that corresponds to the different tests.

On page 4225, lines 24 & 25: "The isotopic composition of these last cylinders is controlled to correct for any bias compared to natural air." Do the authors mean 'controlled to correct for' or do they mean that the isotopic composition is matched to natural air to avoid bias? I would like clarity on this and think many readers could benefit from a sentence or two as to why this is necessary. I.e. that the CRDS instruments are sensitive only to the major isotopologue and therefore the measurement of 'CO2' or 'CH4' is actually a measurement of 12C16O2 or 12CH4 that is scaled to total CO2 or CH4 based on

the isotopic composition of the calibration standards.
We measured the isotopic composition to check if a correction was needed. Up to now, on all the controlled cylinders, the isotopic composition was matching the natural air and no correction was needed. We will clarify the importance of the measure as suggested.

P4225 l25 Indeed, as the CRDS instruments are sensitive only to the major isotopologue (12C16O2 or 12CH4), a bias in the isotopic composition would lead to a bias in the mixing ratio.

There are a lot of figures in this paper and many of them are currently of insufficient size or resolution for a reader to easily make sense of them. They are detailed and busy, but small. I recommend moving some of this detail to the Appendices. For instance, Figures 3, 4 and 5 could be moved to an Appendix and Figure 6 (essentially a summary of the preceding three figures) enlarged so as to be more legible. Table 1 could also be moved to an Appendix.
We will enlarge the axes and legends of the figures to make them more legible but keep the figures at their actual places. Indeed we think that Figures 3, 4, 5 convey the performance evolution over time even for one model contrary to the next figure.

Technical corrections:
The technical corrections will be made as suggested.
p. 4220, l. 16, insert ‘project’ after ‘infrastructure’. l. 24, add ‘s’ to budget
p. 4221. l. 4, delete ‘order of magnitude’ l. 21, delete ‘s’ from end of requires
p. 4222, l. 10, delete second instance of the word ‘first’ l. 20, add ‘s’ to the end of follow
p. 4224, l. 16, add ‘s’ to the end of ‘follow’
p. 4226, l. 7, insert ‘to’ after ‘referred’
p. 4228, l. 18, replace ‘answer’ with ‘response’
p. 4229, l. 8, replace ‘during’ with ‘for’ and delete the instance of ‘for’ after ‘min’
l.17 ff, This sentence is unclear to me. I suggest it becomes, ... “evaluated through the same calibration cylinders for the first instruments (4 calibration plus a lower and higher concentrated cylinder”: : : if this is indeed what the authors mean.
We meant that for the first instruments, the same set as for the calibration was used (only 4 cylinders) but for the latest instruments, 2 cylinders (high and low) were added. This will be clarified.
P4229 l17 The linearity of the instrument is also evaluated. For the first instruments, the same cylinders as for calibration (4 cylinders) were used. Then, two cylinders (low and high concentrated cylinders, see Fig. A5 in the Appendix) were added to the set.
p. 4230, l. 12, insert ‘to’ between ‘and’ and ‘estimate’ l. 24, replace ‘than’ with ‘as’
p. 4232, l. 3, insert ‘us’ after ‘allow’
p. 4234, l. 8, replace ‘in’ with ‘on’
p. 4238, l. 29, replace ‘in’ with ‘on’
p. 4239, l. 13, replace ‘that’ with ‘than’
p. 4240, l. 16, insert ‘us’ after ‘allows’ and replace ‘of’ with ‘for’
p. 4241, l. 1, insert ‘us’ after ‘allow’ l. 6, replace ‘to note’ with ‘notable’ l. 18, insert ‘in’ before MHD41 and replace ‘is’ with ‘are’
p. 4242, l. 17, insert ‘for CH4’ after ‘fractional change’
p. 4248, Table 1 caption. Suggest, “The 47 analyzers considered in this study. Their serial number, model, ICOS number and date of purchase: : :”