Reply to Referee #1

We would like to thank the Referee for a useful review and for the suggestions of further interesting work related to our manuscript. In the following, we break down the Referee's text and address each comment individually.

Comment 1:

… *[ ] there is little practical information about how this work applies to real-world systems such as TK3, EasyFlux, EdiSol, HuskerFlux, or SmartFlux. This work would be of greater value if the authors could review some of these systems and comment on whether or not the issues they explore are present or absent in any of these packages*

This is an important point that we also considered while preparing the manuscript. With this article, we wanted to present the problem of synchronization in fully-digital systems and characterize and quantify the corresponding errors. The aim was to reach out to developers of acquisition systems (industrial- or research-grade) as well as to EC practitioners in order to highlight the importance of this issue and its impact.
In addition, synchronization issues are relevant not only to CO_2 and H_2O but also to other gases. In fact, it can be presumed that they are even more relevant for gas species that to date received less industrial investment in terms of system integration, with the result that usually the data acquisition system must be designed and assembled by the researcher, given what is made available by the instruments' manufacturers.
For this reason, instead of undertaking an analysis of the compliance for each acquisitions system today available or a quantification of its errors - which would have been extremely long, time consuming, incomplete and soon outdated - we focussed the manuscript on the description of the issue itself and propose a simple test for the evaluation of each given system. It can be noted, in fact, that even the acquisition system developed and commercialized by the company of two of the coauthors (SmartFlux™ by LI-COR Biosciences) is never cited in the paper.
In addition, since some of the solutions mentioned are commercial products, their evaluation could only be undertaken by involving all involved parties. This is something certainly outside the scope of our work, but our hope is that this article will now enable such an analysis, providing a reference framework.

Comment 2:

One issue that the authors identify in serial data communications are the FIFO buffers used by many operating systems to ingest RS232 data. While these do exist and would create problems, well designed programs often get around this by lowering the size of these buffers and/or running independent program "threads" that handle individual character-received interrupts to pass the data along in near-real time

We do agree with the Referee that "well designed systems" can avoid the problems we present. In the Introduction, we also point out that "commercial solution exist […]". In the revised manuscript, we will add and better clarify that well engineered solutions also exist and can be developed (by both commercial companies and non-commercial institutions), provided the appropriate engineering skills (electronics, computer science, digital signal processing, etc.) are available.

Comment 3:
The authors also imply that many of the synchronization problems outlined in the manuscript are absent from analog data acquisition systems, but this is not exactly true. Because of the "sample and hold" nature of A/D systems, many of these issues while present are masked.

The Referee is correct. The measurement principle of the instruments covered by this paper is generally discrete-time (i.e. there is a defined "measurement interval" in each instrument). There is, in fact, an unavoidable zero order hold in any analog output from such an instrument, which will be governed by the clock of the source instrument. When subsequently sampled by a "sample and hold" A/D system running on an independent clock, the sampling error that will occur will be of random nature (RTEs), and inversely proportional to the output rate of the analog signal (i.e. the higher the output rate, the smaller the resulting RTE). We will add this and correct our statement in the new version of the manuscript.

Comment 4:
Finally, in developing a method to check any particular system for timing errors, the authors suggest using a signal generator to inject a single waveform into the A/D input of both instruments while having one instrument also send the same signal from it's D/A outputs to the second instrument. While this will work in principle, it must be cautioned that this is only strictly true if the D/A task and the A/D task are both synchronized with the measurement task and the serial output task in both instrument firmware. Will this always be the case, or is this only true in some instruments such as the LiCor and Gill units tested by the authors? If these tasks are only loosely synched or are running asynchronously, then some issues could be masked by the internal asynchronicity.

It would seem that the Referee partially misunderstood the proposed test: "using the signal generator" and "using the analog signal of one instrument" are proposed as two *alternative* ways of reaching the same objective, they don't need to occur together. The important point in evaluating synchronization performance is to craft a means of producing a known signal, sampled independently by the two clocked systems. The resultant dataset, as captured by the proposed sampling system, can be directly evaluated, as the correlation should be perfect under these conditions. Nonetheless, the raised concern on the first solution in particular (using the signal generator) holds true and may indeed limit applicability of the test to other instrumentation and to teams inexpert in data acquisition systems design. In the revised manuscript we will add a cautionary note highlighting this point .

Minor Comments:

We will modify the manuscript to accommodate the Referee's comments and suggestions. In particular, we will de-emphasize the "novelty" of fully-digital data acquisition in EC, which are indeed not so "new" as we initially presented them, although the widespread use of digital acquisition in the EC community is relatively new.