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Atmospheric Measurement Techniques Discussions

Interactive comment on "A multi-year record of airborne CO_2 observations in the US Southern Great Plains" *by* S. C. Biraud et al.

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General comments:

This paper describes an aircraft-based CO2 measurement program which has been regularly gathering vertical profiles above continental USA since 2002. The authors describe the multiple techniques used to obtain parallel measurements of CO2, compare these data sets to assess the data quality, and provide a first glimpse of some of the main features of the data record, e.g. altitudinal, horizontal and seasonal signals.

Vertical profile data of the type presented here are critical for constraining regional carbon budgets. They supplement ground-based and column CO2 measurements to help

quantify the roles of surface exchange and atmospheric transport in defining atmospheric CO2 distributions. There are relatively few programs of this type in existence, and the one reported here has made a substantial contribution to scientific progress in this field. I think the paper is well suited to AMT and I would recommend publication with minor revisions.

Specific comments:

Having previously been involved in similar experimental programs, I am familiar with some of the difficulties in achieving high data quality from an aircraft platform subject to large ranges in ambient temperature and pressure. I like the approach used here of comparing measurements from multiple instruments/techniques for data quality assessment and diagnosis of artifacts. The main suggestion I would make is that the paper could be strengthened by further exploring and detailing the causes of the reported data anomalies. The authors state in section 2.5 that "the use of multiple technologies. . ..allowed detection and diagnostics of problems in all parts of the system". Details of those problems would be particularly useful to other researchers in the field and would be very appropriate for AMT.

I also suggest that the quantification of differences and uncertainty be revisited. The claim of mean differences between techniques of < 0.1 ppm (e.g. lines 17-21 in the abstract) is not justified in my view. To me it seems that 0.2 ppm or above is more realistic. There are several items in the paper that either suggest larger uncertainty and/or are worthy of further discussion:

* Section 2.4 mentions a flask storage effect which has not been corrected for but which may lead to a bias of 0.2 ppm. Can you be more definitive about this bias, or apply a correction? If a 0.2 ppm bias exists, this by itself exceeds the <0.1 ppm difference claimed in the abstract.

* The strategy of comparing data from two continuous analyzers, but with an intentional 15 s delay in one analyzer, is an interesting one. What did you learn from this? Can

you provide examples of any effects that were identified by this strategy?

* There are several data sets assessed in terms of the RM0-RM12 difference, which yield a range of results > 0.1 ppm. Section 2.4 describes on onboard cylinder test where RM0-RM12 = 0.19. Section 2.5 quotes a difference of -0.08 ppm for 37 flights in 2011. Figures 4 and 7 show data from individual flights with small mean differences but systematic differences of up to several tenths of a ppm during each flight. Can you comment on what might be causing the in-flight variability? Is this a typical or regular feature?

* Figure 6b shows a mean RM0-flask difference above 3500 m altitude of 0.22 ppm averaged over 480 points, with a standard error of only 0.02 ppm. I would view this as strong evidence of an altitude-dependent difference between techniques. This should be examined further.

The presence of larger differences or artifacts should not preclude publication. The measurements are not straightforward and it may not be possible to explain the causes, but I think it's important that these items are acknowledged and discussed.

Technical corrections:

Page 7188, line 20 – The term "broadband validation" is first mentioned here and given some prominence again later in the paper, however I am not familiar with this term. Can you please define its meaning early in the paper?

7188, 25 – the word "annual" is unnecessary here and should be deleted

7188, 28 – PBL should be defined here

7189, 19 – the term "mixing ratio" is used here instead of "concentration", and "mole fraction" is also used later in the paper. The paper would read better if the same term was used throughout.

7189, 26 – tower observations

7189, 26-27 – PBL and FT acronyms suffice if the terms have already been defined; the same applies to SGP and possibly other terms elsewhere in the paper.

7190, 2 – I would delete the second use of "As a result"

7190, 14 – for context, annual

7190, 15 – define NEE

7191, 8 – delete "researchers and", leaving "a broad set of research questions"

7191, 15 – delete "(a.m.s.l.)" as it appears twice

7192, 7 – I'm not sure that it's accurate to say these were "the first" such measurements "in the world" but perhaps it depends on how one defines flux measurements, and I don't think the claim is important to the paper anyway. CSIRO at least were routinely collecting vertical profiles and continuous ground-based CO2 measurements above or near Cape Grim in the 1970s and 1980s. I would suggest stepping back and restricting this discussion to the history of such programs in the US and/or continental sites more generally. Then there would be no need to reference the Australian programs, but if you choose to do so I would replace the Langenfelds et al., 1999 reference with the following: Langenfelds, R. L., Francey, R. J., Steele, L. P., Dunse, B. L., Butler, T. M., Spencer, D. A., Kivlighon, L. M. and Meyer, C. P., Flask sampling from Cape Grim overflights. Baseline Atmospheric Program (Australia) 1999-2000, eds. N.W. Tindale, N. Derek and P.J. Fraser, Bureau of Meteorology and CSIRO Atmospheric Research, Melbourne, Australia, 73-75, 2003.

7192, 17 – add full stop after US

7194, 13-14 – It would be helpful to briefly describe the meaning of responsivity and target gases. Also, I assume the intended term is responsivity, not responsitivity.

7194, 20 – "Reduction" does not seem to be the right word to use here. The sentence could just start with "Decomposition into vertical profiles..."

7195, 2-8, What are the reasons for the elaborate warm-up procedure?

7195, 3 – Instead of 10 sccm, it may be better to say 0.01 slpm for consistency of units in this section.

7195, 13 – lower case m in maintenance

7195, 17 – field-standard cylinders

7196, 12 – O-ring seals

7196, 17 – The date of 16 March 2011 is inconsistent with the 3 March 2011 date given in the Figure 4 caption.

7196, 24 – performance

7197, 5 – flask observations

7197, 5-6 – pair of flask samples

7197, 7 – measurement quality control

7197, 18 – flask samples

7197, 22 – RM0 observations

7198, 24-25 – delete “by RM0 analyzer and flask” as this is repeated later in the sentence

7199, 2 – difficulty

7199, 2-3 – differences

7199, 10 – summer

7199, 11 – atmosphere

7199, 19 – across

7200, 3 – flask observations

7200, 11 – the two heights

7200, 21 – concentration

Figure 1 – (a) - the text is too small to read comfortably; (b) - the blue lines are hard to see; choose a color for better contrast; caption – the 5500m altitude quoted here contradicts the 5300 m figure given in the text.

Figure 3 – Some more detail may be helpful: 1) show the valves used to isolate the target and responsivity gases, 2) what components are used for flow/pressure control?, 3) define MP and DPT.

Figure 5 caption, line 3 – pressure and flushed continuously by a stream

Figure 6 – 1) how were RM0 data processed to match flask data in time?, 2) caption, line 3 – collected, 3) caption, line 6 – shown in panel (d).

Figure 7 caption , line 5 – difference. . ...bottom

Figure 11 caption, line 2 – concentrations

Figure 11 caption, line 7 – shaded

Figure 12 caption, line 2 – FT (black)

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 7187, 2012.