Bradley A. Flowers
Earth and Environmental Science Division
MS D462
Los Alamos, New Mexico 87545

Date: January 09, 2011

Atmospheric Measurement Techniques Editorial Staff :

Thank you for handling the review comments for our manuscript and including it in the special issue **"Carbon dioxide, other greenhouse gases, and related measurement techniques - 16th WMO/IAEA meeting (GGMT-2011".** The reviews were most instructive and helpful and addressing the reviewer concerns has strengthened our manuscript. In light of the comment from P. Werle, we would like to change the title of the manuscript to "Intercomparison of two high-accuracy fast-response spectroscopic sensors of carbon dioxide: a case study". Additionally, we have re-organized the manuscript considerably to establish the operating characteristics of both sensors in the Methods section and the results of those characteristics in the Results section (per Reviewer #1). We have added additional analysis relating to the public comments. Additionally, we removed the final figure from the manuscript, as per the original reading by the Associate Editor. I must personally apologize for not taking his advice directly, I was enamored with the figure and thought it useful to demonstrate the different data available from either sensor. However, I do agree that it is superfluous and beyond the scope of the now more focused manuscript.

Response to comments from Anonymous Reviewers 1-3 for "Field Intercomparison of two high-accuracy fast response spectroscopic sensors of carbon dioxide", B. A. Flowers et al. AMTD 4, 5837-5855, 2011.

1. **Anonymous Reviewer #1** We re-organized the manuscript according to the suggestion of Reviewer #1. All of the discussion of the ambient observation and calibration procedures were moved to the Methods section. Parts of the discussion we felt helpful to the reader was repeated in the Results & Discussion section but this is minimal.
2. Abstract: The mean difference was calculated between TDL and CRDS data sets that has been averaged for 1 minute and 60 minutes. The abstract, text and tables have been re-written to more clearly describe which mean difference was being referred to.
3. Abstract: The text in the abstract has been changed to the appropriate value, 1.003.
4. Abstract: The abstract has been re-written to more clearly describe the averaging time associated with the reported mean differences.
5. Abstract: Reference to the water vapor correction as applied to produce the ambient observation has been added.
6. Methods: The CRDS wavelengths have been reported in the literature cited and are now included in this manuscript.
7. Methods: The subscripts have been added.

8. Methods: The methods section has been substantially re-organized to include more detail about the operation of each sensor and the local conditions that were used in the experiments.
9. Methods: See above reply
10. Methods: See above reply
11. Results and Discussion (3.1): We are grateful to the reviewer for their comments on humidity and its effect on the CRDS sensor. The appropriate equations have been added to the text in the methods section
12. Results and Discussion (3.1): We have re-written this section to eliminate the confusion about cross calibration and calibrating with respect to the TDL sensor. The purpose of the laboratory portion of the experiment was to observe the response of both TDL and CRDS sensors to the same gas. Because of the manner in which the TDL operates, we measure two other responses as we measure the target response. This allows us to make a three point intercomparison. Because two of the points are reference gases cross calibrated to WMO standards, we originally referred to this as calibrating the CRDS with respect to the TDL, but should have written this as calibrating the CRDS with respect to the tertiary standards.
13. Results and Discussion (3.1): The reference to the private communication with van Pelt has been added.
14. Results and Discussion (3.2): We have re-scaled the figure to alleviate confusion. The peak in the histogram occurs at 1.003.
15. Results and Discussion (3.2): In response to the previous comment, we have added text and formulas describing the CRDS response to water vapor.
16. Conclusions: The linear regression slope between the two sensors is 1.000. We have re-worded the text to back of the statement of perfection.

Anonymous Reviewer #2

General Comment: We have removed the linearity check from the manuscript. These were performed with CO2 in dry nitrogen and though the effect of O2 and additional air components would likely be similar across the studies, we have removed the linearity checks from the description of the performance of the sensor. Additionally, referring to the calibration of the CRDS sensor with respect to the TDL sensor has been removed because it is confusing. We calibrated the CRDS and the TDL using the same standard gases.

1. p5840 L1: The wavelengths are given for the CRDS sensor both in this manuscript and in literature cited in the manuscript.
2. P 5840 L6: near-IR has been substituted for mid-IR
3. P5840 Methods: Additional information about the sensors has been added to the text.
4. P5841, L25: The calibration section has been re-written. References to calibrating the CRDS sensor with respect to the TDL are removed and in reality what occurred was the CRDS sensor was calibrated with respect to the tertiary gas standards used to operate the TDL sensor.
5. P5842 L21: Additional description of these phenomena and their effect on the allan variance analysis has been added.
6. P5843 L18: the van Pelt reference has been added
7. P5844 L6: The inlet was run at 5meters and the manuscript has been changed to make that consistent throughout.

8. P5845 L9: The zero intercept has been tested for the CRDS sensor, it has been assumed for the TDL sensor as the manufacturer does not recommend operating the TDL in absence of CO2.
9. P 5846, L26: The data in the table are shown for 1 hour averaged data. We are stating that the instruments are compatible on a 1 minute time scale.
10. P 5846, L18. We chose not to state weight and size because they are not comparable. We chose to focus on the intercomparison statistics instead of physical dimension as the point of comparison between these two sensors.

Anonymous Reviewer #3 General Comments: Figure 3 has been remade to include the ambient CO2 response and its difference between the two sensors.

1. Page 5838 line 4, pg. 5839 line 10: compatibility has been used throughout the modified version of the manuscript.
2. Page 5838 lines 7-9: time constant for mean value determination has been specified.
3. Page 5838 line 10: This line has been removed.
4. Page 5838 line 11: the word relative has been removed.
5. Page 5838 Line 17: We have added text further describing the relevance of the gaussian distribution of the ratio and the 1 sigma designation has also been made.
6. Page 5839 Line 4: The manuscript has been re-written to refer to compatibility instead of comparability, references to relative precision remain and additional references to linearity and stability are further included.
7. Page 5839 Lines 5-7: see above comment
8. Page 5840 section 2: We thank the reviewer for bring those particular references to our attention. The scope of this paper is to compare the two $^{12}CO_2$ data from the TDL and CRDS sensors and I do not see a compelling reason to cite 13CO2 results from NDIR sensors. However, we have included NDIR sensors in the introduction section of the manuscript.
9. Page 5840 Line 16. We have added canopy height and forest density to the description of the ambient sampling site.
10. Page 5840 Line 21: The section regarding linearity checks has been removed.
11. Page 5841 Line 2 & 17: The tanks were sourced from the NOAA laboratory responsible for providing the so-called gold standard reference gases. The precisions stated here are provided by NOAA at time of purchase.
12. Page 5841 lined 10-13: A description of the automated calibrated procedure has been added to the methods section
13. Page 5841 Line 19: The tanks were sourced from the NOAA laboratory responsible for providing the so-called gold standard reference gases. The precisions stated here are provided by NOAA at time of purchase.
14. Page 5841 Line 28: The values are difference because the gases are different. These are the values of the tertiary standards, not WMO standards. The text has been improved to make this point more clear.
15. Page 5841 Line 28-29: The description of the performance of both sensors to the reference and unknown gases has been improved for clarity.
16. Page 5842 Line 3: This section and sentence in particular has been rewritten for clarity.
17. Page 5842 Line 16: The calibration experiment was performed after the ambient monitoring. The data has been post-calibrated.

18. Page 5844 line 1: The allan variance is used to establish the averaging time at which the variance in the signal is minimized. The variance is the standard deviation^2, which is related to precision and stability.
19. Page 5844 Lines 18-24: Additional text has been added in reference to the reviewers comments about compatibility.
20. Page 5844 line 27 – Page 5845 line 28: We found the clocks on both instruments drifted forward and backward in time. The TDL protocol accounts for flushing the optical cell. This has been added to the text.
21. Table 1: This data is 60 minute averaged from the 1 minute data set. Both CRDS and TDL data sets were comprised from the same number of points. The relatively large deltas arise from averaging more natural variability into the reported CO2 diurnal number. That the deltas are largest at 6 am is related to the increased variability in the real CO2 concentration in the atmosphere at this time of day.
22. Page 5845 Line 5-7: These are regression statistics for one particular subset of the 1-minute data used to illustrate the effects of time synchronization.
23. Page 5845 line 2: We thank the reviewer for pointing out the issue of time scale with reference to compatibility. It is unlikely, for 60 minute averaging of an ambient data set, that any two CO2 sensors would be considered compatible by the WMO metric.
24. Page 5846 Line 2: The correlation analysis should give 1.0 for a perfectly correlated system.
25. Page 5847 Line 4: The statistics are for 1 sigma and the time constant used is given. However, the value 0.04 for the standard deviation was wrong and has been changed to 1.8 ppm.

Thank you for handling the editing of our manuscript. We look forward to publishing the manuscript in Atmospheric Measurement Techniques.

Sincerely,
Bradley Flowers, Los Alamos, NM USA.