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Measurements of CO2 and H2O Fluxes with New Enclosed Design and with Modified Open-path Design of Fast Gas Analyzers

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In this presentation two novel approaches to designing fast CO2/H2O gas analyzers (e.g., new enclosed short tube enabled design and modified open-path low temperature controlled design) are discussed in comparison with two conventional approaches (e.g., traditional closed-path and open-path designs) in terms of their field performance for Eddy Covariance flux measurements.

Closed- and open-path designs of the fast gas analyzers are two well-established sampling cell configurations widely utilized for measurements of CO2 and H2O fluxes and concentrations. Each configuration has advantages and deficiencies. Open-path analyzers have excellent frequency response, long-term stability, and low sensitivity to window contamination. They are pump-free and require infrequent calibrations. Yet they are susceptible to data loss during precipitation and icing, and may need instrument surface heat flux correction when used in extremely cold conditions. Closed-path analyzers can collect data during precipitation, can be climate-controlled, and are not susceptible to surface heating issues. Yet they experience significant frequency loss in long intake tubes, especially problematic when computing water vapor flux. They may require frequent calibrations and need powerful pump.

The study presents field data from an alternative new design: a compact enclosed CO2/H2O analyzer, the LI-7200, enabled for operation with short intake tube, intended to maximize strengths and to minimize weaknesses of both traditional open-path and closed-path designs. Also presented are data from a new open-path CO2/H2O gas analyzer, LI-7500A, based on the LI-7500 model modified to produce substantially less heat during extremely cold conditions.

Four prototypes of LI-7200, were extensively field-tested in three experiments over contrasting ecosystems in 2006-2009. Instantaneous temperature fluctuations were attenuated, on average, by about 85-90% with 0.5 m intake tube, and by about 90-95% with 1 m intake tube, minimizing sensible heat flux portion of Webb-Pearman-Leuning term. The remainder was measured directly eliminating open-path heating or any other temperature issues. Fast temperature and pressure measured inside the cell of LI-7200, and low sensitivity to window contamination allowed for the use of short intake tube (0.5-1.0 m or less), leading to a low power demand for the pump and entire system. The power demand of the tested blower with flow control was about 15 W, which is considerably less than that of traditional closed-path systems (about 50-100 W).

New LI-7200 gas analyzer utilized strengths of both open-path and closed-path designs. Similar to the closed-path LI-7000 analyzer, it has minimal data loss during precipitation events and icing, and it does not have surface heating issues. Similar to the open-path LI-7500, the new LI-7200 has good frequency response (close to that of LI-7500) due to small flux attenuation loss in short intake tube, it does not need frequent calibration, has minimal maintenance requirements, and can be used in very low power configuration with short intake tube.

Two prototypes of LI-7500A were tested in the field and the lab in 2009-2010. Two regiments of the temperature control for internal electronics were examined across wide range of temperatures: (i) the traditional control at about 30C, and (ii) new regiment controlling parts of internal electronics at 5C. Both external heat dissipation and the system power demand were significantly reduced when 5C regiment was activated under

extremely cold conditions. The availability of a new low-temperature control improved the performance of the open-path analyzer in extremely cold conditions, which allows continued and expanded use of this ultimately lowest-power remote solution for fast measurements of CO2 and H2O.