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Field examination of low temperature control setting for mediating surface heating effect in open-path flux measurements under cold conditions

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Open-path gas analyzers are extensively used for measurements of CO_2 and H_2O fluxes and concentrations. They have advantages of excellent frequency response, long-term stability, low sensitivity to window contamination, low-power pump-free operation, and infrequent calibration requirements. They also have limitations such as susceptibility to precipitation and icing, and a potential need for instrument surface heating correction in extremely cold environments. In spite of these limitations, open-path measurements often provide data coverage that would not have been possible using traditional closed-path approach.

Losses from precipitation and icing may not always be prevented for the open-path instruments, while heating effect does not pose a problem for CO_2 flux in warm environments. Even in cold environments, the impact of heating on CO_2 flux is much smaller than other well-known effects, such as WPL terms, or frequency response corrections for closed-path analyzers. Nonetheless, instrument surface heating effect in cold environments could be addressed scientifically, via developing the theoretical corrections, and instrumentally, via measuring fast integrated air temperature in the optical path, or via enclosing the open-path instrument into a low-power short-intake design.

Here we provide an alternative way to minimize or eliminate open-path heating effect, achieved by minimizing or eliminating the temperature gradient between the instrument surface and ambient air. Open-path low temperature controlled design is discussed in comparison with two other approaches (*e.g.*, traditional open-path design and closed-path design) in terms of their field performance for Eddy Covariance flux measurements in the cold.

This study presents field data from a new open-path CO_2/H_2O gas analyzer, LI-7500A, based on the LI-7500 model modified to produce substantially less heat during extremely cold conditions. 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 a wide range of temperatures: (i) the traditional control temperature of about +30^{o}C, and (ii) new regiment controlling parts of internal electronics at +5^{o}C.

When new +5^{o}C regiment was activated, the following changes were observed: heat dissipation from the surface reduced several folds, surface-to-air temperature gradients reduced 2-50 times; and the number of false uptake hours were reduced by 3.5 times, to the same level as a closed-path standard. Significant advantage of the new regiment was also observed in the magnitude of CO_2 fluxes, especially in cold weather below -10^{o}C. At such cold temperatures, CO_2 fluxes from a +30^{o}C controlled LI-7500 were 19% below those of the closed-path standard, while fluxes from a +5^{o}C controlled LI-7500A were, on average, within 1% of the standard.

Strong experimental evidence are presented demonstrating that open-path instrument heating could be substantially reduced or eliminated via such a simple hardware-based solution. This allows continued and expanded use of the open-path gas analyzer design, the ultimately lowest-power remote solution for fast gas measurements.