Geophysical Research Abstracts
Vol. 17, EGU2015-2333, 2015
EGU General Assembly 2015
© Author(s) 2014. CC Attribution 3.0 License.

On the importance of high-frequency air-temperature fluctuations for spectroscopic corrections of open-path carbon dioxide flux measurements

Ivan Bogoev (1), Manuel Helbig (2), and Oliver Sonnentag (2)

(1) Campbell Scientific, Inc., Research & Development, Logan, United States (ivan@campbellsci.com), (2) Département de géographie, Université de Montréal, Montréal, Québec, Canada

A growing number of studies report systematic differences in CO_2 flux estimates obtained with the two main types of gas analyzers: compared to eddy-covariance systems based on closed-path (CP) gas analyzers, systems with open-path (OP) gas analyzers systematically overestimate CO_2 uptake during daytime periods with high positive sensible heat fluxes, while patterns for differences in nighttime CO_2 exchange are less obvious. These biases have been shown to correlate with the sign and the magnitude of the sensible heat flux and to introduce large uncertainties when calculating annual CO_2 budgets.

In general, CP and OP gas analyzers commonly used to measure the CO_2 density in the atmosphere operate on the principle of infrared light absorption approximated by Beer-Lambert's law. Non-dispersive interference-based optical filter elements are used to select spectral bands with strong attenuation of light transmission, characteristic to the gas of interest. The intensity of the light passing through the optical sensing path depends primarily on the amount of absorber gas in the measurement volume. Besides the density of the gas, barometric pressure and air temperature are additional factors affecting the strength and the half-width of the absorption lines. These so-called spectroscopic effects are accounted for by measuring barometric pressure and air temperature in the sensing path and scaling the light-intensity measurements before applying the calibration equation. This approach works well for CP gas analyzers with an intake tube that acts as a low-pass filter on fast air-temperature fluctuations. Low-frequency response temperature sensors in the measurement cell are therefore sufficient to account for spectroscopic temperature effects. In contrast, OP gas analyzers are exposed to high-frequency air-temperature fluctuations associated with the atmospheric surface-layer turbulent heat exchange. If not corrected adequately, these fast air-temperature variations can cause systematic errors in the CO_2 density measurements. Under conditions of high positive or negative sensible heat flux, air-temperature fluctuations are correlated with fluctuations of the vertical wind component and can lead to significant biases in the CO_2 flux estimates.

This study demonstrates that sonically derived fast-response air temperature in the optical sensing path of an OP gas analyzer can replace the slow-response measurements from the temperature sensor as a scaling parameter in the calibration model to correct for these air temperature-induced spectroscopic effects.

Our approach is evaluated by comparison between different OP and CP gas analyzer-based eddy-covariance systems in ecosystems with low CO_2 uptake under a range of sensible heat flux regimes and varying meteorological parameters. We show that ignoring high-frequency spectroscopic effects can lead to false interpretations of net ecosystem CO_2 exchange for specific site and environmental conditions.