Improved eddy flux measurements by open-path gas analyzer and sonic anemometer co-location

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Introduction
Eddy fluxes are optimally underestimated because of:
Spatial separation between measurements of w’ (vertical wind) and ρ’ (air density)
Temporal asynchrony between measurements of T’ (air temperature) and ρ’ (air density)
Open-path gas analyzers introduce biases in the flux estimates attributable to:
Instrument-induced surface heat exchange (Grelle et al., 2007)
The IRGASON addresses these problems with the following features:
Unidirectionally measured w’, T’, and ρw in the same volume of air
Redundant instrument self heating and solar radiation loading due to low power consumption and streamlined aerodynamic housing
Implicitly accounts for air density effects with the ability to compute CO2 flux using point conversion to mixing ratio

Materials and methods
Operate the IRGASON and CSAT3 in the field under different environmental conditions.
Calculate fluxes from the IRGASON using instantaneous point-by-point conversion of w’ CO2 mixing ratio

Results
1. Effect of sensor spatial separation on eddy fluxes
Eddy flux is computed when co-located measurements of w’ and T’ from the IRGASON are replaced with equivalent measurements from the CSAT3.

1A. Effect of spatial separation on H
A 1.4% loss in cumulative net interco located w’ and T’ is displayed by CSAT3 whereas no measurement was observed. The loss increased to 23.5% in the CPW (co-located w’ and T’ from the adjacent CSAT3).

1B. Effect of spatial separation on w’
The cumulative uncorrected water vapor flux ρw w’ from the IRGASON vs. axial co-located is 0.6% higher than the same flux computed using w’ from the IRGASON and w’ from the adjacent CSAT3.

1C. Effect of spatial separation on ρ’
The magnitude of the cumulative uncorrected CO2 flux ρw’ from the IRGASON is 1.8% larger than the cumulative flux from the spatially displaced measurements ρw’ from IRGASON and w’ from the adjacent CSAT3.

Materials and methods

2. Comparison of sonic temperature
IRGASON and CSAT3 sonic temperatures Hs w’ T’ co-located with ρ’ ρw’ c’ all co-located

3. Comparison of sonic temperature

Future work
Validate the mixing-ratio method with flux measurements by a closed-path eddy covariance system.

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Further information
More details and specifications of the IRGASON instrument can be found at: www.campbellsci.com/irgason.

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Conclusions
1. Co-locating the open-path gas analyzer and sonic measurement parameters reduces the time variance between variables associated with the eddy fluxes with the open-path gas analyzer biases in the eddy flux estimates. The correction factors accounting for the loss of correlation due to spatial separation in the individual CPW. Errors (Massman, 2004) are 6.5% and 3.2% for w’ and T’, respectively.

2. IRGASON temperature agrees with the ambient thermometer probe and CSAT3 sonic temperature to within 0.6% and 1% respectively, which indicates that the cooling surface adjacent to the open-path sensing volume are not necessarily warmer or cooler than the ambient air where the ambient air is cooled for humidity. IRGASON sonic temperature is accurate and reliable for calculating CO2 mixing ratios for more frequent response times, and it is not affected by solar radiation.

3. Compared to the CSAT3, the IRGASON underestimates hourly and cumulative sensible heat flux by 0.3% and 0.5% respectively.

4. Calculating CO2 flux using point-by-point conversion to mixing ratio is feasible for an open-path gas analyzer and a co-located sonic anemometer/ thermometer. The air density ρ’ terms can be implicitly accounted for with this approach. Differences between CO2 flux calculated using point-by-point conversion to mixing ratio and flux computed following the traditional approach are statistically significant (Zhang et al., 2011). The correction factors (Zhang et al., 2011) is small for this site and does not explain the difference between IRGASON and MOZAIC-based results.

No apparent CO2 update was observed even in the presence of cold periods over snow-covered surfaces, which also suggests negligible instrument induced basal flux in the sensing path of the gas analyzer.

Literature cited

