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Significance of High-Speed Air Temperature Measurements in the Sampling Cell of a Closed-Path Gas Analyzer with a Short Tube

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Eddy covariance gas analyzers measure gas content in a known volume, thus essentially measuring gas density. The fundamental flux equation, however, is based on the dry mole fraction. The relationship between dry mole fraction and density is regulated by the ideal gas law describing the processes of temperature- and pressure-related expansions and contractions, and by the law of partial pressures, describing the process of dilution. As a result, this relationship depends on water vapor content, temperature and pressure of the air sample.

If the instrument is able to output precise high-speed dry mole fraction, the flux processing is significantly simplified and WPL density terms accounting for the air density fluctuations are no longer required. This should also lead to the reduction in uncertainties associated with the density terms resulting from the eddy covariance measurements of sensible and latent heat fluxes used in these terms. In this framework, three main measurement approaches may be considered:

Open-path approach

Outputting correct high-speed dry mole fraction from the open-path instrument is difficult because of complexities with maintaining reliable fast temperature measurements integrated over the entire measuring path, and also because of extraordinary challenges with accurate measurements of fast pressure in the open air flow.

Classical long-tube closed-path approach

For instruments utilizing traditional long-tube closed-path design, with tube length 1000 or more times the tube diameter, the fast dry mole fraction can be used successfully when instantaneous fluctuations in the air temperature of the sampled air are effectively dampened to negligible levels, instantaneous pressure fluctuations are regulated or negligible, and water vapor is measured simultaneously with gas or the air sample is dried.

Short-tube closed-path approach, the enclosed design

For instruments with a short-tube enclosed design, most - but not all - of the temperature fluctuations are attenuated, so calculating unbiased fluxes using fast dry mole fraction requires high-speed, precise temperature measurements of the air stream inside the cell. Fast pressure and water vapor content of the sampled air should also be measured in the sampling cell, and carefully aligned in time with gas and temperature measurements.

This presentation examines data from the three different sites equipped with enclosed short-tube analyzers in order to evaluate the significance of high-speed, precise air temperature measurements in the sampling cell of the analyzer. Short-term and long-term effects are examined using half hourly fluxes of carbon dioxide and water vapor, as well as long-term carbon and water budgets.