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Measuring Fluxes with Better Certainty without a Need for Density Corrections or Pressure Term

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Eddy Covariance flux measurements using gas analyzers of an enclosed design rely on the covariance between instantaneous vertical wind speed and instantaneous output of gas mixing ratio, such that density data are corrected on-the-fly using instantaneous water vapor, temperature and pressure measurements in the cell, collected and aligned with CO_2 or other gas of interest.

This approach implicitly accounts for the effects of fluctuations in water vapor, temperature and pressure on the density of the gas of interest. Therefore no sensible heat or latent heat portions of Webb-Pearman-Leuning density corrections (WPL) are required, and the pressure term, which is usually neglected in traditional WPL implementation, is accounted for in these mixing ratio-based measurements.

A somewhat similar way of calculating fluxes has been used frequently with traditional closed-path analyzers, with some assumptions: (i) slow temperature measurements were used to convert from density to mixing ratio, assuming fast fluctuations of the air temperature to be fully attenuated in the long intake tube; (ii) slow pressure measurements were used, assuming negligible instantaneous pressure fluctuations.

Nine field experiments were conducted in a wide range of environmental conditions from Florida to Alaska using an enclosed CO_2/H_2O gas analyzer. These experiments presented an opportunity to verify the performance of the mixing ratio approach, and examine the differences from traditional density-based measurements.

Results indicate that the mixing ratio-based approach helps to minimize or eliminate a number of uncertainties associated with traditional density-based approach, including: (i) uncertainties associated with correcting the product of fast covariances of gas density using sensible and latent heat flux calculated over half-hour or an hour; (ii) uncertainties in the magnitudes of the sensible and latent heat fluxes used in correcting gas flux; (iii) bias in long-term accumulated CO_2 flux due to the neglected pressure term.

The latest findings on the importance of fast temperature and pressure measurements for CO_2 flux on hourly and long-term scales for open-path, closed-path and enclosed designs are discussed. Fundamental differences between gas density and gas mixing ratio for flux measurements are also examined.

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