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IMPROVED EDDY FLUX MEASUREMENTS BY OPEN-PATH GAS ANALYZER AND SONIC ANEMOMETER CO-LOCATION

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A novel instrument design combines the sensing paths of an open-path gas analyzer and a 3-D sonic anemometer and integrates the sensors in a single aerodynamic body. Common electronics provide fast-response, synchronized measurements of wind vector, sonic temperature, CO_2 and H_2O densities, and atmospheric pressure. An instantaneous CO_2 mixing ratio, relative to dry air, is computed in real time. The synergy of combined sensors offers an alternative to the traditional density-based flux calculation method historically used for standalone open-path analyzers.
A simple method is described for a direct, in-situ, mixing-ratio-based flux calculation. The method consists of: (i) correcting sonically derived air temperature for humidity effects using instantaneous water vapor density and atmospheric pressure measurements, (ii) computing water vapor pressure based on water-vapor density and humidity-corrected sonic temperature, (iii) computing fast-response CO_2 mixing ratio based on CO_2 density, sonic temperature, water vapor, and atmospheric pressures, and (iv) computing CO_2 flux from the covariance of the vertical wind speed and the CO_2 mixing ratio. Since CO_2 mixing ratio is a conserved quantity, the proposed method simplifies the calculations and eliminates the need for corrections in post-processing by accounting for temperature, water-vapor, and pressure-fluctuation effects on the CO_2 density.
A field experiment was conducted using the integrated sensor to verify performance of the mixing-ratio method and to quantify the differences with density-derived CO_2 flux corrected for sensible and latent-heat fluxes. The pressure term of the density corrections was also included in the comparison.
Results suggest that the integrated sensor with co-located sonic and gas sensing paths and the mixing-ratio-based method minimize or eliminate the following uncertainties in the measured CO_2 flux: (i) correcting for frequency-response losses due to spatial separation of measured quantities, (ii) correcting sonically-derived, sensible-heat flux for humidity, (iii) correcting latent-heat flux for sensible-heat flux and water-vapor self-dilution, (iv) correcting CO_2 flux for sensible- and latent-heat fluxes, (v) correcting CO_2 flux for pressure-induced density fluctuations.