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Comparison of CO_2 and H_2O eddy fluxes derived from density and from mixing ratio measured by an enclosed gas analyzer

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Enclosed gas analyzer with short intake tube is a blend of a traditional long-tube closed-path design and a traditional open-path design. Analogous to closed-path, the enclosed design leads to minimal data loss during precipitation events and icing, and it does not have surface heating issues. Analogous to the open-path design, the enclosed design has good frequency response due to the short intake tube, does not require frequent calibration, needs minimal maintenance, and could be low power when used with short intake tube.

In addition to these advantages, enclosed design could provide measurement of fast mixing ratio, or dry mole fraction, because native density measurements can be converted to mixing ratio units using fast measurements of temperature, water vapor and pressure inside the sampling cell. Fast mixing ratio implies that the thermal expansion and water dilution of the sampled air have been accounted for in such a conversion. Thus, no density corrections are required to compute fluxes when the fast mixing ratio is used.

Such a way of calculating fluxes has been used frequently with traditional closed-path analyzers (e.g., LI-6262 and LI-7000), because fast fluctuations in the air temperature of the sample were attenuated in the long intake tube, and because water vapor was simultaneously measured and dry mole fraction was output from the instrument. In an enclosed design, such as the LI-7200 used with short tube, most but not all of the fast temperature fluctuations are attenuated, so calculating fluxes using the mixing ratio output of such an instrument requires validation.

The CO_2 and H_2O Eddy Covariance fluxes of from eight experiments with new LI-7200 enclosed analyzer were examined here: five deployments of the Ameriflux Roving Intercomparison Station in California, Arizona, New Mexico and Oregon; one deployment at a USDA flux site in Arizona; and two deployments at the LI-COR flux test facility in Nebraska. Fluxes were computed in two ways: (i) via the traditional way using the density corrections, and (ii) via a mixing ratio output from the instrument without applying the density corrections.

The results of these comparisons have important implications for future gas flux measurements, because avoiding half-hourly or hourly density corrections could help to minimize at least two kinds of uncertainties: (i) the 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; and (ii) the uncertainties in the magnitudes of the sensible and latent heat fluxes used in correcting gas flux.

When used alongside fast measurements of sample air temperature, water vapor and pressure, fluxes could be computed from raw covariance of mixing ratio and vertical wind speed, multiplied by a frequency response correction. There are some unknowns associated with the latter, especially when applied to mixing ratio, and primarily related to tube attenuation. It is because the related functions, parameters and coefficients for the correction were originally developed and tested using gas density and not mixing ratio, so caution should be used in this step of the flux data processing. However, such unknowns did not seem to significantly affect resulted fluxes at the studied sites.

The absence of a need for density corrections in the flux calculations using mixing ratio brings the advantages of increased flux measurement quality and temporal resolution, and may reduce the magnitude of minimum detectable flux.