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# Consideration of the Webb-Pearman-Leuning theory for closed-path eddy covariance measurements: What should be done?

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When calculating turbulent fluxes from scalar densities, density fluctuations due to sensible heat and water vapour fluxes have to be considered (Webb et al. 1980, WPL). The original work only considered open-path eddy covariance (EC) systems - we discuss here the effects for closed-path EC systems.

Contrary to open-path sensors, which measure scalar density more or less unchanged, a closed-path EC system acts as a physical low-pass filter to the atmospheric scalar concentration signal. Large part of the low-pass filtering effect is caused by gas specific, microphysical or/and chemical reactions of the scalar with the surfaces of the EC system. This is why cut-off frequencies differ for different atmospheric scalars.

Whereas temperature fluctuations are effectively dampened in the system, fluctuations of water vapour still contaminate scalar measurements('dilution effect'). The problem arises how to correct for the dilution effect given the scalar specific degree of low-pass filtering in a closed-path EC system. During the last years, four different recommendations were given with regard to the procedure how to correct for the dilution effect:

$1^{st}$ Applying the spectral corrections to all relevant measured scalar concentrations prior to applying the WPL theory (as, e.g. mentioned in an unpublished erratum to

Leuning (2007),

$2^{nd}$ correcting only for passive spectral attenuation as opposed to active attenuation by the EC system before applying the WPL theory (Massman 2004),

$3^{rd}$ avoiding the necessity for correction of the dilution effect by converting mole fractions ($\chi$) into molar mixing ratios ($r$) at the raw data level (Ibrom et al. 2007) or,

$4^{th}$, using the uncorrected covariance of $\chi_{H2O}$ with the vertical wind speed that is calculated at the same time lag as for the scalar in consideration in the WPL correction (Ibrom et al. 2007).

At the example of a data set of closed-path EC $CO_2$ flux measurements from the Sorø beech forest EUROFLUX site, we investigate the uncertainties and inaccuracies that are introduced by either way of consideration. From this, recommendations will be derived, how to best consider dilution effects for $CO_2$ flux measurements in closed-path EC systems.

References:

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