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Implications of underestimated eddy covariance evapotranspiration at high relative humidity for partitioning into transpiration and evaporation

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While eddy covariance is a well established method for measuring energy, carbon and water fluxes, it is still susceptible to known biases and uncertainties. One such issue is the underestimation of latent energy (LE) under high relative humidity (RH) conditions (> 70%) due to the attenuation of fluctuations of water vapor concentration (Mammarella et al., 2009; Massman & Ibrom, 2008), known as 'the high RH error'. This high RH error coincides with the theoretically expected steep increase in water use efficiency (WUE) such that the systematic LE underestimation has unknown and potentially large implications for evapotranspiration (ET, converted from LE) partitioning and the derivation of WUE parameterisations. We diagnose the high RH error for sites in the FLUXNET2015 dataset, a global eddy flux database, focusing on the difference in error response by different measurement systems (i.e. systems using open, closed, or enclosed gas analysers). Then we propose a method to correct the high RH error and test its implications for partitioning ET into transpiration (T) and evaporation (E) using WUE based methods (Nelson et al., 2018; Zhou et al., 2016) and compare it with T estimated from sap flow measurements (Poyatos et al., 2021).

Overall, we found that closed-path sites experience more severe high RH error than open-path sites, as diagnosed by the residual ratio of LE to available energy and sensible heat. After correcting the high RH error, T estimated from TEA algorithm (Nelson et al., 2018) based WUE (the ratio of GPP to T, where GPP is the gross primary productivity) has an approximately 25% decrease at high RH from closed-path sites, whereas this decrease is only 5% in open-path sites. Correspondingly, T/ET has an approximately 10% and 2% increase from closed-path and open-path sites, respectively. Considering these systematic errors in the FLUXNET2015 dataset is therefore crucial when describing the interactions between water and carbon cycles, especially for

closed-path sites during high RH conditions. Furthermore, future studies which implement both open-path and closed-path analysers, as well as sap flow measurements on the same site, will help to better understand the systematic differences caused by gas analysers and to constrain the uncertainty caused by such differences.

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