Tagungsnummer
V300

Thema
Kommission I: Bodenphysik und Bodenhydrologie

Evapotranspiration und Gasaustausch an der Grenzfläche zwischen Boden und Atmosphäre - Messung und Modellierung

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Titel
Measuring Evapotranspiration of five Alley Cropping systems in Germany using the Eddy-Covariance- and Bowen-Ratio Energy-Balance methods

Abstract
Measuring evapotranspiration (ET) of heterogeneous ecosystems using methods like the eddy-covariance- (ECEB) and Bowen-Ratio energy-balance (BREB) methods is challenging due to their restrictions to horizontally homogeneous terrain and steady state conditions. The unfavorable ambient conditions lead to a site-specific non-closure of the energy-balance, which is a balance between the incoming net radiation and the ground-, latent- and sensible heat fluxes. Thus, an underestimation of measured heat fluxes leads to an overestimation of the latent heat fluxes inferred from the ECEB method.
The aim of our study is to 1) quantify the site-specific non-closure of the energy-balance and 2) characterize the performance of both methods, compared to direct eddy-covariance measurements using a high-frequency infra-red gas analyzer (LI-7200, Licor Inc.). To assess continuous ET rates on a 30-minute time scale we installed a combined ECEB and BREB system at five alley cropping and five agricultural reference sites across Germany. For time periods of four weeks, we performed direct eddy covariance flux measurements for H_2O and CO_2 over one crop- and one grassland alley cropping- and their respective reference systems during the growing season of 2016.
We found a non-closure between 21 and 26 % for all sites, with the residual energy being highest during the morning and lowest in the afternoon. Related to that the energy-balance ratio (EBR), i.e. the ratio between the turbulent heat fluxes and available energy, was below one in the morning hours and increased slightly during the day up to 1.8, until the EBR decreased sharply after sunset. The EBR correlated to the daily cycle of solar radiation, the main driver of turbulent fluxes.
Corresponding, we found an increasing EBR with increasing friction velocity, indicating, that the energy-balance closure improves under turbulent condition. Further our analysis reveal that turbulent fluxes estimated by the BREB method compared well with direct eddy-covariance measurements. An accuracy improvement was found with increasing sensor distance.
We conclude, when calculating ET rates on a 30-minute time scale using the ECEB method the site-specific non-closure should be assessed beforehand by eddy-covariance. In the current study, ignoring the non-closure would have lead to an overestimation of the ET rates of about 25 % for the ECEB method.