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Energy balance closure methods of eddy covariance data tested by a coupled land surface – crop growth model

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Eddy covariance (EC) flux data are used worldwide to test and parameterize land surface and crop growth models. A hitherto unsolved problem is, however, that the energy balance of EC flux data is typically not closed, so that, at least in modeling studies, the measured fluxes must be corrected. Typical gaps range between 20% and 30%. Gaps are usually most frequently filled up on the assumption that the missing turbulent fluxes have the same Bowen ratio as the measured ones (Twine et al., 2000). There is, however, an ongoing debate about the validity of this assumption (Foken, 2008, Ingwersen et al., 2011). Recent studies suggest that the gap should rather be assigned to sensible heat flux (H-correction). The fill-up procedure may heavily affect model calibration (Ingwersen et al. 2011).
The aim of the present study was to test the fill-up procedures against independently modeled turbulent flux data. For the comparison, we used EC flux data measured from 2009 to 2011 at four winter wheat stands in Kraichgau, Southwest Germany. In addition, we regularly measured plant data such as BBCH development stage, leaf area index, plant height, and the biomass of straw and grain. The average energy balance closure of the EC flux data was between 70% and 85%. The energy gap was filled up either by the Bowen ratio method or the H-correction. Latent and sensible heat fluxes were simulated using our new coupled land surface – crop growth model (NOAH-GECROS). The crop growth model GECROS simulates photosynthesis with the well-known Farquhar approach. The Farquhar model was mainly parameterized in the 1980s, based on leaf chamber measurements. The NOAH-GECROS model was calibrated against the observed plant data, but not the EC flux data. In other words, the modeled latent heat fluxes are independent from the measured and corrected EC flux data. The simulated latent and sensible heat fluxes matched the H-corrected EC fluxes very well, but totally mismatched the Bowen-ratio corrected fluxes. In the latter case, the simulated latent heat fluxes were, on average, up to 30% lower than the Bowen-ratio corrected fluxes. Although our findings cannot be regarded as a proof for the validity of the H-correction, we take our results as a further indication that the Bowen ratio correction cannot be sustained. Further research on the nature of the energy closure gap of EC flux data and possible corrections is urgently needed.

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