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Multiple constraints on grassland evapotranspiration: implications for closing the energy balance

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When using the eddy covariance (EC) method for measuring the ecosystem-atmosphere exchange of sensible and latent heat, it is not uncommon to find that these two energy fluxes fall short of available energy by 20-30%. As the causes for the energy imbalance are still under discussion, it is currently not clear how the energy balance should be closed. The objective of the present paper is to use independent measurements of evapotranspiration (ET) for empirically devising on how to best close the energy balance. To this end ET of a temperate mountain grassland was quantified during two measurement campaigns using both an open- and a closed-path EC system, lysimeters and an approach scaling up leaf-level stomatal conductance to canopy-level transpiration. Our study showed that both EC systems underestimated ET measured independently by lysimeters and the up-scaling approach. Best correspondence to independently measured ET was achieved by assigning the entire energy imbalance to ET and by adjusting ET according to the average energy balance ratio during the first and second measurement campaign, respectively. Due to a large spatial variability in ET during the first measurement campaign and given large differences in spatial scale between the EC and the independent methods, we are more confident with the comparison of approaches during the second measurement campaign and thus recommend forcing energy balance closure by adjusting for the average energy balance ratio.