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Comparison of estimates of terrestrial evapotranspiration using the Penman-Monteith equation and specific humidity profile gradients algorithms in land surface models

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The Penman-Monteith equation and specific humidity profile gradients algorithms are two common strategies for estimating terrestrial surface evapotranspiration based on different mechanisms. While previous studies have adopted these two methods widely, a systematic comparison between these two methods among multiple plant function types has not been presented. In this study, the latent heat fluxes were comparatively modeled using the Penman-Monteith equation in the Dynamic Land Model (DLM) and specific humidity profile gradients algorithm in the Community Land Model (CLM). The former separates the canopy into sunlit and shaded parts (i.e. two-leaf model) while the latter is a "big-leaf" model in estimating canopy evaporation and transpiration. In order to fairly evaluate the application of these two widely used algorithms, we carefully selected 18 FLUXNET sites which cover various plant functional types (PFTs) (i.e. needleleaf evergreen, needleleaf deciduous, broadleaf evergreen and broadleaf deciduous trees, as well as broadleaf deciduous shrub) across different ecoregions, such as boreal, temperate and tropical zone. The results show that the specific humidity profile gradient algorithm mainly underestimated the observed latent heat flux for most PFTs, as evidenced by an average slope of 0.85±0.21, explaining about 60-85% of flux tower observations with root mean standard error (RMSE) of 20-60 W m̂-2 among the study sites, while the Penman-Monteith equation more closely predicted both the magnitude and day to day variability of the flux tower measurements, which can explain about 81-95% of variance of observations with RMSE of 10-40 W m̂-2. The underestimation by the former approach is mostly caused by its exclusion of the contributions from leaf temperature gradients and the differences between sunlit and shaded leaves. Our results indicate that accurate considering sensitivity factors and upscaling of canopy evapotranspiration are required across a broad array of ecosystems in land surface models.