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Estimating land-surface evapotranspiration based on a first-principles primary productivity model

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Evapotranspiration (ET) links the water and carbon cycles in the atmosphere, hydrosphere and biosphere, and is of great important in earth system science, hydrology and resource management researches. Commonly used ET estimating approaches usually contains type-based parameters, which requires calibration and associates with land cover product. Parameterization structure, representativity of training group and accuracy of land cover information all influences the performance of model extrapolation. In this study, we develop an ET modelling framework based on the hypothesis that canopy conductance acclimates to plant growth conditions so that the total costs of maintaining carboxylation and transpiration capacities are minimized. This is combined with the principle of co-ordination between the light- and Rubisco-limited rates of photosynthesis to predict gross primary production (GPP). Transpiration (T) is predicted from GPP via canopy conductance. No plant type- or biome-specific parameters are used. ET is estimated from T by calibrating a site-specific (but time-invariant) ratio of modelled average T to observed average ET. Predicted GPP were well supported by (weekly) GPP records at 112 widely distributed eddy-covariance flux sites (FLUXNET 2015 dataset), with R^2 = 0.61, and RMSE = 2.73gC/day (N = 30129). ET were also well supported at site scale, with R^2 = 0.65, and RMSE = 0.73mm/day (N = 30129). Global ET mapping was carried out with the help of Google Earth Engine (GEE). Basin-scale water balance validation in several globally distributed watersheds also indicates the robustness of our model.