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Coupling the water and carbon cycles using transpiration and primary production data for improved global land-surface modelling

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Improving the accuracy of coupling of water and carbon cycles in land surface models has been emphasised in recent studies as a major priority for research. Reliable quantification of carbon and water balances is required in order to effectively estimate gross primary production (GPP) and evapotranspiration (ET) across space and time.

The P model (for 'production') is grounded in plant functional ecology and links the carbon and water cycles via a theory of stomatal optimization and photosynthetic acclimation. It has the mathematical form of a LUE model while being traceable to first principles, including the standard model of photosynthesis, for the prediction of GPP. The model has only three free parameters, of which two are estimated from independent observations on leaf stable carbon isotopes and leaf-level electron transport capacity. The model requires only elevation, CO_2 concentration, solar radiation, vapour pressure deficit (VPD) and temperature as input.

We will present a demonstration application of the P model using a novel approach that extends the algorithm to create a prototype of a universal transpiration (T) product using Sentinel 3 data. Both GPP and T outputs will be evaluated against FLUXNET observations. Stomatal conductance will be calculated based on the model's predictions of GPP and the ratio of internal to external CO_2 partial pressure, allowing transpiration to be calculated from VPD.

The P model has many advantages, including its strong theoretical and empirical basis, extremely parameter-sparse nature, and the fact that it does not require the prior specification of plant functional types or land cover types. The research presented here will extend its application from primary production monitoring to include carbon-water cycle coupling and water resources assessment.