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Use of plant trait data in the ISBA-A-gs model

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ISBA-A-gs is a CO_2-responsive LSM (Calvet et al., 1998; Gibelin et al., 2006), able to simulate the diurnal cycle of carbon and water vapour fluxes, together with LAI and soil moisture evolution. The various components of ISBA-A-gs are based to a large extent on meta-analyses of trait data.
(1) Photosynthesis: ISBA-A-gs uses the model of Goudriaan et al. (1985) modified by Jacobs (1994) and Jacobs et al. (1996). The main parameter is mesophyll conductance (gm). Leaf-level photosynthesis observations were used together with canopy level flux observations to derive gm together with other key parameters of the Jacobs model, including in drought conditions. This permitted implementing detailed representations of the soil moisture stress. Two different types of drought responses are distinguished for both herbaceous vegetation (Calvet, 2000) and forests (Calvet et al., 2004), depending on the evolution of the water use efficiency (WUE) under moderate stress: WUE increases in the early soil water stress stages in the case of the drought-avoiding response, whereas WUE decreases or remains stable in the case of the drought-tolerant response.
(2) Plant growth: the leaf biomass is provided by a growth model (Calvet et al., 1998; Calvet and Soussana, 2001) driven by photosynthesis. In contrast to other land surface models, no GDD-based phenology model is used in ISBA-A-gs, as the vegetation growth and senescence are entirely driven by photosynthesis. The leaf biomass is supplied with the carbon assimilated by photosynthesis, and decreased by a turnover and a respiration term. Turnover is increased by a deficit in photosynthesis. The leaf onset is triggered by sufficient photosynthesis levels and a minimum LAI value is prescribed. The maximum annual value of LAI is prognostic, i.e. it can be predicted by the model. LAI is derived from leaf biomass using SLA values. The latter are derived from the leaf nitrogen concentration using plasticity parameters.
(3) CO_2 effect: the photosynthesis model is able to represent the antitranspirant effect of CO_2. The plant growth model represents the fertilization effect of CO_2. However, the nitrogen dilution triggered by the CO_2 increase has to be represented. A pragmatic solution consists in decreasing the leaf nitrogen concentration parameter in response to CO_2, using existing meta-analyses of this parameter (Calvet et al., 2008).
The TRY database could be used to improve the current parameterizations, together with the mapping of the model parameters.