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The Jena Diversity Model: Towards a richer representation of the terrestrial biosphere for Earth system modelling

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Current state-of-the-art terrestrial biosphere models usually do not account for biodiversity, representing the diversity of vegetation form and functioning using only a small number of plant functional types. This coarse representation of functional diversity might lead to overly pessimistic projections regarding terrestrial ecosystem under scenarios of global change (e.g. Amazon dieback). In the Jena Diversity (JeDi) model, we introduce a new approach to vegetation modelling with a richer representation of functional diversity, based not on plant functional types, but on plant ecophysiological trade-offs.

The JeDi model tests a large number of plant growth strategies. Each growth strategy is simulated using a set of randomly generated parameter values, which characterize its functioning in terms of carbon allocation, ecophysiology, and phenology, which are then linked to the growing conditions at the land surface. The model is constructed in such a way that these parameters inherently lead to ecophysiological trade-offs, which determine whether a growth strategy is able to survive and reproduce under the prevalent climatic conditions. Kleidon and Mooney (2000) demonstrated that this approach is capable of reproducing the geographic distribution of species richness. More recently, we have shown that JeDi is also able to reproduce the relative abundances of species within communities and the large-scale gradient of ecosystem evenness (Kleidon et al. 2009), as well as the global patterns of biomes (Reu et al., submitted).

Here we present an evaluation of the simulated biogeochemical fluxes against a variety of site, field, and satellite observations following a protocol established by the Carbon-Land Model Intercomparison Project (Randerson et al. 2009). We conclude that the global patterns of biogeochemical fluxes and land surface properties are reasonably well simulated using this bottom-up trade-off approach and compare favorably with other state of the art terrestrial biosphere models. This approach sets the foundation for future applications, in which the simulated vegetation might show greater resilience to environmental changes than in other models, due to its greater ability to adapt through changes in ecosystem composition.