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Using natural selection and optimization for smarter vegetation models - challenges and opportunities

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Dynamic global vegetation models (DGVMs) are now indispensable for understanding the biosphere and for estimating the capacity of ecosystems to provide services. The models are continuously developed to include an increasing number of processes and to utilize the growing amounts of observed data becoming available. However, while the versatility of the models is increasing as new processes and variables are added, their accuracy suffers from the accumulation of uncertainty, especially in the absence of overarching principles controlling their concerted behaviour. We have initiated a collaborative working group to address this problem based on a 'missing law' – adaptation and optimization principles rooted in natural selection. Even though this 'missing law' constrains relationships between traits, and therefore can vastly reduce the number of uncertain parameters in ecosystem models, it has rarely been applied to DGVMs.

Our recent research have shown that optimization- and trait-based models of gross primary production can be both much simpler and more accurate than current models based on fixed functional types, and that observed plant carbon allocations and distributions of plant functional traits are predictable with eco-evolutionary models. While there are also many other examples of the usefulness of these and other theoretical principles, it is not always straight-forward to make them operational in predictive models. In particular on longer time scales, the representation of functional diversity and the dynamical interactions among individuals and species presents a formidable challenge.

Here we will present recent ideas on the use of adaptation and optimization principles in vegetation models, including examples of promising developments, but also limitations of the principles and some key challenges.