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Next generation dynamic global vegetation models: learning from community ecology

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Dynamic global vegetation models are a powerful tool to project the past, current and future distribution of vegetation and associated water and carbon fluxes. However, most models are limited by how they define vegetation and by their simplistic representation of competition. We discuss how concepts from community assembly theory and coexistence theory can help to improve vegetation models. We further present a new trait- and individual-based dynamic vegetation model (the aDGVM2) that allows each individual plant to adopt a unique combination of trait values. These traits define how each individual plant grows and competes with other plants under given environmental conditions. The performance of individual plants in turn drives the assembly of a plant community. A genetic optimisation algorithm is used to simulate the inheritance of traits and different levels of reproductive isolation between individuals. Together these model properties allow the assembly of plant communities that are well adapted to a site's biotic and abiotic conditions. Simulated communities can be classified into different plant functional types or biome types by using trait data bases. We illustrate that the aDGVM2 can simulate (1) how environmental conditions and changes in these conditions influence the trait spectra of assembled plant communities, (2) that fire selects for traits that enhance fire protection and reduces trait diversity, and (3) the emergence of communities dominated by life history strategies that are suggestive of colonisation-competition trade-offs. The aDGVM2 deals with functional diversity and competition fundamentally differently from current dynamic vegetation models. We argue that this approach will yield novel insights as to how vegetation may respond to climate change and we believe that it could foster fruitful collaborations between research communities that focus on plant functional traits, plant competition, plant physiology, systems ecology and earth system science.