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Impacts of observation-driven trait variation on carbon fluxes in an earth system projection

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Climate projections are still highly uncertain and differences in predicted terrestrial global carbon budgets by earth system models (ESMs) are large, both with respect to the size and direction of change. Part of these uncertainties in the land carbon dynamics are caused by differences in the modeled functional responses of vegetation in reaction to climatic drivers.

In reality, changes in vegetation responses to the environment are driven by processes like species plasticity, acclimation, (genotypic) adaptation, species turnover and shifts in species abundances. These processes can cause shifts within community mean trait values, which in turn are will affect carbon fluxes to and from the system. Because most current dynamic global vegetation models (DGVMs, the terrestrial part of ESMs) are not species based, these processes are not or poorly modeled.

The recent availability of a large trait database (TRY-database), including both field measurements and experimental data, enables parameterization of the models with observational trait data. Many community mean trait values correlate with local environmental conditions. Such trait-climate relationships can be used to model variation in traits in DGVMs and allow for spatial and temporal variation in functional vegetation responses.

The aim of this study was to identify the impacts of observation-driven trait variation on modeled carbon fluxes in climate projections. We determined and incorporated relationships between observational trait and climate data for each plant functional type (PFT) in the DGVM JSBACH. Within each grid cell, traits were varied every year, based on the local climatic conditions in the model. We also included CO_2 acclimation of traits based on FACE-experiments, as projections concern elevated CO_2 concentrations.

Impacts on global carbon budgets were large; in the simulation with variable traits the high latitudes (temperate, boreal and arctic areas) were stronger carbon sinks and the tropical latitudes were stronger carbon sources around 2100 compared to these regions in the default simulation with fixed traits. These regional differences resulted in a smaller global land carbon sink with variable traits (about 2.3 Gton C per year around 2100), meaning current estimates of the size of the future land carbon sink might be overestimated.