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Model-data integration to improve the LPJmL dynamic global vegetation model

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Dynamic global vegetation models show large uncertainties regarding the development of the land carbon balance under future climate change conditions. This uncertainty is partly caused by differences in how vegetation carbon turnover is represented in global vegetation models. Model-data integration approaches might help to systematically assess and improve model performances and thus to potentially reduce the uncertainty in terrestrial vegetation responses under future climate change. Here we present several applications of model-data integration with the LPJmL (Lund-Potsdam-Jena managed Lands) dynamic global vegetation model to systematically improve the representation of processes or to estimate model parameters.
In a first application, we used global satellite-derived datasets of FAPAR (fraction of absorbed photosynthetic activity), albedo and gross primary production to estimate phenology- and productivity-related model parameters using a genetic optimization algorithm. Thereby we identified major limitations of the phenology module and implemented an alternative empirical phenology model. The new phenology module and optimized model parameters resulted in a better performance of LPJmL in representing global spatial patterns of biomass, tree cover, and the temporal dynamic of atmospheric CO_2. Therefore, we used in a second application additionally global datasets of biomass and land cover to estimate model parameters that control vegetation establishment and mortality. The results demonstrate the ability to improve simulations of vegetation dynamics but also highlight the need to improve the representation of mortality processes in dynamic global vegetation models. In a third application, we used multiple site-level observations of ecosystem carbon and water exchange, biomass and soil organic carbon to jointly estimate various model parameters that control ecosystem dynamics. This exercise demonstrates the strong role of individual data streams on the simulated ecosystem dynamics which consequently changed the development of ecosystem carbon stocks and fluxes under future climate and CO_2 change. In summary, our results demonstrate challenges and the potential of using model-data integration approaches to improve a dynamic global vegetation model.