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Parametric sensitivities of the terrestrial biosphere model JSBACH: A step towards a carbon cycle data assimilation system

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Uncertainties in the projections of coupled-carbon cycle climate models are strongly influenced by the uncertainties in the simulation of land ecosystem processes. Understanding and reducing these uncertainties is important to reduce the spread in future climate projections and requires a systematic evaluation of model results with Earth observations. The Framework for Inverse Analysis of Land / Atmosphere Carbon Exchange (FINALACE) is a project to develop an inversion framework around the land component JSBACH of the MPI-Earth System Model, as used for the CMIP5 simulations. The goal of this approach to systematically confront model output with observations is to provide estimates of JSBACH model parameters and their uncertainty ranges that are consistent with Earth observations for the simulation of carbon-cycle climate interactions and the assessment of the robustness of these interactions.

One step towards such an assimilation system is the identification of the most important model parameters: A sensitivity analysis of JSBACH 2.0 parameters has been performed for various global ecosystem types. The rank transformed partial correlation coefficient (RPCC) has been used as sensitivity index. RPCC is a correlation based measure with simultaneous variation of all parameters. It allows identifying those parameters that mostly contribute to uncertainties of the model results. The ensemble results of the sensitivity study have been compared to eddy-covariance based flux observations and satellite derived FAPAR estimates (Fraction of Absorbed Photosynthetically Active Radiation) to gauge model performance.

Modelled gross primary production (GPP) is mainly influenced by parameters of the photosynthetic submodel (e.g.: maximum carboxylation rate), while net land-atmosphere CO_2-fluxes are also controlled by parameters of the carbon allocation and respiration submodels. Both, GPP and the net CO_2-flux are partly controlled by uncertainty in the model's phenology. Despite the uncertainties of satellite FAPAR-products, the parametric sensitivities confirm their potential to constrain phenological parameters and hence to reduce model uncertainties. The analysis also shows the importance of water-cycle parameters under water-stressed conditions and the differences in parameter importance ranking between different ecosystem types.

These results provide insight, which observations constrain which parameters and hence give a first impression of what can be expected from a carbon cycle data assimilation system (CCDAS). Especially the added value of using multiple data streams (remote sensing, flux observations and CO_2-concentration measurements) to simultaneously constrain important model parameters can be assessed.