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An evaluation of the carbon-cycle climate relationships in the JSBACH land-surface model in half-coupled and offline model configurations

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In order to reduce uncertainty in climate projections due to carbon cycle feedbacks it is of paramount importance to identify the skill of coupled carbon-cycle climate (C4) models and the source of the uncertainty in carbon-cycle related processes. One key challenge in the evaluation of Earth system models is to isolate errors in the representation of key processes in one specific Earth system model component from biases introduced due to biases in the coupled model system. In this presentation, we demonstrate how the information contained in Earth observations can be used in a synthetic and robust way to evaluate coupled models with respect to their carbon-cycle representation by considering coupled and uncoupled model simulations.

Land-related biogeochemical uncertainties and climate-induced uncertainties both contribute to the spread among model projections.Hence we compare the JSBACH model, the land surface module ofthe MPI-ESM in its CMIP5 version in two different configurations (offline and online). Our starting point is the evaluation of carbon cycle dynamics during the 1980-2010 period as simulated by JSBACH driven by observed meteorological forcing (offline model). We then compare this offline simulation of JSBACHfor the same period to:(1) JSBACH-online results from a standard CMIP5 run in AMIP2 set up (land-atmosphere model driven by observed sea surface temperatures); and (2) JSBACH-online in the fully coupled, concentration-driven CMIP5 MPI-ESM run.

We evaluate the model performance with observation of satellite-based vegetation activity data and atmospheric CO_2 concentrations, providing a comprehensive set of metrics and diagnostics to quantify the mismatch between observed and modeled data at different temporal and spatial scales. The consistency of the benchmarking results between the offline and online model experiments will be discussed. A particular focus will be given to quantification of the contribution of misrepresentations in either land-surface feedbacks or the land-atmosphere coupling to the discrepancies between simulated and observed C-related processes. Presented evaluation framework can be easily applied to any other CMIP5 model.