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Effects of regional differences in the long term carbon balance on predicted net CO_2 fluxes

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The Carbon Cycle Data Assimilation System (CCDAS) allows the current fluxes of CO_2 to the atmosphere to be mapped and the evolution of these fluxes into the future to be predicted. In this work we concentrate on the calibration mode of CCDAS where an optimal parameter set is derived from 10 years of atmospheric CO_2 concentration observations using an adjoint approach. Global and regional process parameters are considered via a mapping routine. The parameters are then optimised by calculating the mismatch of the observations and prior knowledge of the parameters via a defined cost function. Further, parameter uncertainty estimates, which are obtained during the parameter optimisation step, can be propagated in order to estimate uncertainties of any given output such as of the predicted net CO_2 fluxes.

The process based terrestrial biosphere model BETHY is the core of CCDAS. It simulates carbon assimilation and soil respiration within a full energy and water balance and phenology scheme. Produced fluxes are then mapped onto atmospheric concentrations using the atmospheric transport model TM2. BETHY has 20 parameters for each plant functional type (PFT). There is a choice from a single global description up to independent parameter sets for every grid point. In the base case, all parameters are applied globally. Additionally, the key photosynthetic parameters (maximum electron transport and maximum carboxylation rate) and the key carbon storage parameter β vary with each of the 13 PFTs which gives a total of 56 control parameters.

The β parameter is a scaling parameter for a constraint that exists for the long term carbon balance. This constraint is implemented in BETHY in order to consider unknown processes such as climate forcing and disturbance. On the contrary to the other process parameters, β is not necessarily a global parameter. In fact, there might be a strong regional dependency, because β represents information about the history of the site and the impact it has on the long term carbon balance. We therefore investigate the effects of regional differences in the long term carbon balance on predicted net CO_2 fluxes by varying the key carbon storage parameter β according to both, the 11 land regions as defined in the Transcom Atmospheric Inversion Intercomparison Experiment and the 13 PFTs as used in BETHY. This results in an extended set of 155 control parameters. We compare these results with the base case, where we assume that β is a universal parameter with no regional differences.

We find that the β parameter is sensitive to the regionalisation process. Optimised parameter values differ for both scenarios which also results in differences in the spatial flux pattern. The results using the extended set of control parameters confirms, that regional differences exist and therefore the same PFT can act as a sink or a source, depending on the region where they occur. The results also demonstrate the capability of CCDAS to combine process modelling and parameter regionalisation in one tool.