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Land surface data assimilation in a climate context

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Data assimilation is originally designed to generate optimized initial conditions for NWP, while climate prediction is usually regarded as boundary value problem.

However, medium-range climate projections partly remain an initial value problem due to slowly varying subsystems, which exhibit the potential of seasonal and decadal predictability. A prominent example is the long-memory of the low-frequent deep soil state. To exploit this predictive potential, also medium-range climate projections can benefit from a data assimilation cycle, and in our case we aim at an optimal estimation of the soil state to prepare climate runs. Additionally, this offers the possibility of dynamical parameter estimation, which tackles the problem of parameter sensitivity.

For longer periods, it remains a major challenge whether the information in the "fast" atmospheric and near surface observations can be transferred to the slow, unobserved deep soil. First, we show the impact and mechanism of data assimilation in such a coupled, partially-observed system in a more general context by performing experiments in a highly-nonlinear toy model environment. Under mild conditions, the hidden slow subsystem can be estimated reliably by assimilating observations into the fast, coupled subsystem. This is confirmed by assimilation experiments with the weakly-nonlinear prognostic equations for the vertical transport of soil heat and moisture.

This encourages the application to an operationally-used model. Within the regional climate model COSMO-CLM, the soil state is calculated by the multi-layer soil model TERRA. To concentrate on the soil part, we implemented an offline version, driven by atmospheric forcing, into a sequential data assimilation system, currently running at a test site with optimal data availability. First results and issues of its performance are discussed, concentrating on long assimilation periods to estimate the complete soil state and parameter estimation.