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Development of a data assimilation system for the integrated terrestrial system modelling platform TerrSysMP

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Integrated hydrological models are increasingly applied in hydrological studies because they allow a better physical representation of processes and feedbacks across compartments and a more integrated view of the hydrological cycle. An example of such an integrated modeling approach is the recently established integrated modeling platform TerrSysMP consisting of individual component models for variably saturated subsurface flow (ParFlow), land surface processes (CLM3.5) and weather forecast (COSMO). The component models are dynamically linked by the exchange of state variables and fluxes with the coupling software OASIS-MCT in a scale-consistent, modular manner.
While integrated models may provide better estimates of state and flux variables, model predictions remain to be impacted by a considerable degree of uncertainty due to uncertain initial conditions and forcings, and the poorly known subsurface and vegetation properties. Data assimilation methods allow to better constrain the model predictions and parameters and the associated uncertainties.
In a first step, we constructed a data assimilation framework for the land surface-subsurface part of TerrSysMP (CLM and ParFlow) by linking TerrSysMP with the PDAF (Parallel Data Assimilation Framework) software which is specifically designed for parallel simulation models and provides several global and local filter algorithms (e.g., EnKF, LETKF). The data assimilation framework uses a memory based communication between model and data assimilation routines and avoids frequent re-initializations of the model and is thus highly scalable and applicable to large scale hydrological systems. Currently, data assimilation is restricted to the subsurface part of TerrSysMP (i.e. ParFlow) in which pressure (or soil moisture) data can be assimilated.
The feasibility of this approach is demonstrated with a synthetic model setup where groundwater levels and soil moisture data are assimilated with the ensemble Kalman filter into a regional-scale hydrological model of the Rur catchment (TERENO/TR32-monitoring site, Germany). The impact of the performed assimilation is monitored with respect to the assimilated state variables as well as changes in discharge and land surface fluxes. Results indicate an improvement of the overall prediction capability of the integrated land surface–subsurface model.