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Variational data assimilation for a coupled land surface - atmosphere model using the Mosaic approach

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The Mosaic approach is well-established in coupled land surface - atmosphere simulations to account for sub-grid scale heterogeneity. The data assimilation problem under this approach remains challenging due to the different scales, which the coupled models act on, and, in particular, the diverse representativity of available information which is to be assimilated. The nature of observational information ranges from mean values over up to a few atmosphere grid cells in the case of remote sensing data, down to in-situ observations, which are valid for patches of sub-grid cells.

While information on land-use and soil/vegetation properties is available on scales as fine as approximately 100 m, the grid resolution of state of the art nested mesoscale models is in the order of 1 km. This results in a number of one hundred sub-grid cells per atmospheric grid cell with a corresponding increase in the dimension of the model state vector. Furthermore, for some model variables, the errors of the background field (model forecast) are expected to show a strong correlation between areas of similar land-use type. This results in a highly patchy background error correlation structure with sharp boundaries and gaps. Hence, the assumption of spatial homogeneity and isotropy of background error correlations, often made in meteorological applications, is clearly invalid for land surface model variables or parameters. These challenges necessitate new approaches in the assimilation system design, especially the implementation of a flexible and efficient parameterisation of the background error covariance matrix (BECM).

An assimilation system is presented, which aims to address the above mentioned issues in a statistically rigorous way. A core element of this new system is an efficient BECM implementation, which is capable to reproduce the structures introduced by heterogenous land-use and soil/vegetation patterns. The benefit of the new formulation compared to a more traditional one is demonstrated by means of case studies simulating water fluxes between soil/vegetation and the atmosphere in the River Rur catchment area in Western Germany.