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Optimization of a catchment-scale coupled surface-subsurface hydrological model using pilot points

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Transient coupled surface-subsurface models are usually complex and contain a large amount of spatio-temporal information. In the traditional calibration approach, model parameters are adjusted against only few spatially aggregated observations of discharge or individual point observations of groundwater head. However, this approach doesn't enable an assessment of spatially explicit predictive model capabilities at the intermediate scale relevant for many applications.

The overall objectives of this project is to develop a new model calibration and evaluation framework by combining distributed model parameterization and regularization with new types of objective functions focusing on optimizing spatial patterns rather than individual points or catchment scale features.

Inclusion of detailed observed spatial patterns of hydraulic head gradients or relevant information obtained from remote sensing data in the calibration process could allow for a better representation of spatial variability of hydraulic properties. Pilot Points as an alternative to classical parameterization approaches, introduce great flexibility when calibrating heterogeneous systems without neglecting expert knowledge (Doherty, 2003).

A highly parameterized optimization of complex distributed hydrological models at catchment scale is challenging due to the computational burden that comes with it. In this study the physically-based coupled surface-subsurface model MIKE SHE is calibrated for the 8,500 km2 area of central Jylland (Denmark) that is characterized by heterogeneous geology and considerable groundwater flow across topographical catchment boundaries. The calibration of the distributed conductivity fields is carried out with a pilot point-based approach, implemented using the PEST parameter estimation tool. To reduce the high number of calibration parameters, PEST's advanced singular value decomposition combined with regularization was utilized and a reduction of the model's complexity was obtained without unreasonable loss of the model's accuracy.