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Automatic estimation of parameter transfer functions for distributed hydrological models - a case study with the mHM model

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The estimation of parameters for spatially distributed rainfall runoff models is a long-studied, complex and ill-posed problem. Relating parameters of distributed hydrological models to geophysical properties of catchments could potentially solve some of the major difficulties connected to it.

One way to define this relationship is by the use of explicit equations called parameter transfer functions, which relate geophysical catchment properties to the model parameters. Computing parameter fields using transfer functions would result in spatially consistent parameter fields and the potential to extrapolate to other catchments. A further advantage is that the dimensionality of the parameter space is reduced because the transfer function parameters are applied to all computational units (i.e., grid cells). However, the structure and parameterization of transfer functions is often only implicitly assumed or needs to be derived by a laborious literature guided trial and error process.

For this reason we use Function Space Optimization (FSO), a symbolic regression approach which automatically estimates the structure and parameterization of transfer functions from catchment data. FSO transfers the search of the optimal function to a searchable continuous vector space. To create this space, a text generating neural network with a variational autoencoder (VAE) architecture is used. It is trained to map possible transfer functions and their distributions to a 6-dimensional space. After training, a continuous optimization is applied to search for the optimal transfer function in this function space. FSO was already tested in a virtual experiment using a parsimonious hydrological model, where its ability to solve the problem of transfer function estimation was shown.

Here, we further test FSO by applying it in a real world setting to the mesoscale hydrological model (mHM). mHM is a widely applied distributed hydological model, which uses transfer functions for all its parameters. For this study, we estimate transfer functions for the parameters porosity and field capacity, which both influence a range of hydrologic processes, e.g. infiltration and evapotranspiration. We compare the FSO estimated transfer functions with the already existing mHM transfer functions and examine their influence on the model performance.

In summary, we show the general applicability of FSO for distributed hydrological models and the advantages and capabilities of automatically defining parameter transfer functions.