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The optimization of hydrological simulations using dynamic clustering

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The simulation of hydrological systems and their interactions requires an advanced representation of water-, energy- and mass cycles in high spatio-temporal resolution. This kind of modeling is required to support water-related predictions and decision-making. Such a high-resolution, distributed and physically based modeling demands high performance computing (HPC) and parallel processing of the model units in order to function fast and efficiently. However, parallel running of the whole model is not always possible, since the interactions among the model units are not strictly independent, which requires either sequential or iterative processing. On the other hand, the development, test, execution and update of such a model on HPC Clusters involves potentially large configuration overhead and requires special knowledge.
To circumvent the above mentioned issues, Ehret et al.[1] suggested using landscape properties to reduce model redundancies and computation complexities. The underlying paradigm to this approach is that, structurally similar model units should behave similarly if departing from similar initial states and being exposed to similar forcing. We present here the implementation of this idea by applying machine learning methods to dynamically cluster functionally similar model units and run the model only on a small yet representative subset of each cluster. The main challenge of this approach is the evolution of the identified clusters dynamically based on the forcing changes. For our clustering approach we separate time-invariant from time-variant aspects. For the time-invariant grouping, we use the time series of discharge from "hillslope" model elements obtained from drainage tests. These are integral signatures of hillslope size, slope, soil and drainage properties, which we then express by two key indices that are "active storage" and "time to equilibrium". For the time-variant grouping, the clustering is based on the signatures, current state (current water content of hillslope) and current forcing (current rainfall volume/current state) of the model units. In this work, the results of ongoing evaluations using different clustering methods such as K-means and DBSCAN will be presented. Additionally, using the concepts of information theory, the correlations between signatures will be addressed to understand underlying patterns of the catchment structure. Finally, plans for the further refinement of the algorithms will be described.

[1]Ehret, U., Zehe, E., Scherer, U. and Westhoff, M. (2014, September 26). Dynamical grouping and representative computation: a new approach to reduce computational efforts in distributed, physically based modeling on the lower mesoscale. Available: https://agu.confex.com/agu/14chapman1/webprogram/Paper2093.html.