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Investigating dynamic parameter importance of a high-complexity hydrological model and implications for parameterization

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Deeper insights on internal model behaviors are essential as hydrological models are becoming more and more complex. Our study provides a framework which combines the time-varying global sensitivity analyses with data mining techniques to unravel the process-level behavior of high-complexity models and tease out the main information. The extracted information is further used to assist parameter identification. The physically-based Distributed Hydrology-Soil-Vegetation Model (DHSVM) set up in a mountainous watershed is used as a case study. Specifically, a two-step GSA including time-aggregated and time-variant approaches are conducted to address the problem of high parameter dimensionality and characterize the time-varying parameter importance. As we found difficulties in interpreting the long-term complicated dynamics, a clustering operation is performed to partition the entire period into several clusters and extract the corresponding temporal parameter importance patterns. Finally, the clustered time clusters are utilized in parameterization, where each parameter is identified in their dominant times. Results are summarized as follows: (1) importance of selected soil and vegetation parameters varies greatly throughout the period; (2) typical patterns of parameter importance corresponding to flood, very short dry-to-wet, fast recession and continuous dry periods are successfully distinguished. We argue that somewhere between “total period” and “continuous discrete time” can be more useful for understanding and interpretation; (3) parameters dominant for short times are much more identifiable when they are identified in dominance time cluster(s); (4) the enhanced parameter identifiability overall improves the model performance according to the metrics of NSE, LNSE, and RMSE, suggesting that the use of GSA information has the potential to provide a better search for optimal parameter sets.