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Identification of bedrock leakage areas using joint parameter and state estimation

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A common assumption in models of subsurface stormflow is that transient groundwater infiltrates into the underlying bedrock according to a homogeneous pattern. In reality, this assumption is unlikely to be valid –fractures and joints in the underlying bedrock will most likely determine where the major bedrock infiltration areas are located. In this study, we show how bedrock infiltration areas can be identified from hillslope discharge data and transient groundwater levels. To avoid issues relating to measurement errors, we use artificial data, which we generated using a simple model of subsurface stormflow. This model uses an arbitrarily chosen heterogeneous bedrock infiltration pattern. After generating the artificial data, the model was changed to represent bedrock infiltration as a spatially homogeneous process. We then calibrated this altered model version to the artificial data using a parameter optimization algorithm (MOSCEM-UA). With the best parameter set identified by MOSCEM-UA, we were able to reproduce the discharge, while minimizing the error on transient groundwater. This parameter set, however, was biased relative to the true parameter set, and the errors on transient groundwater were auto-correlated in space and time. In the second part of this study, we repeated the analysis, this time using SODA. SODA is a combination of MOSCEM-UA and the Ensemble Kalman Filter, and can be used to simultaneously estimate parameters and states. Perhaps most importantly, SODA yielded a time series of how the states had been updated. This time series was then used to identify the areas where leakage had occurred. Furthermore, the parameters were less biased and the errors much less auto-correlated.