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# Estimation of bedrock groundwater contribution with a distributed rainfall-runoff model and Time-Space Accounting Scheme

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Recent field studies with deep groundwater wells in headwater catchments have demonstrated the importance of groundwater in weathered bedrock in mountainous regions for controlling the dynamics of streamflow. On the other hand, currently used distributed rainfall-runoff models typically simulate for flows in subsurface soil and on surface by assuming impermeable bedrock. This may hamper the reasonable representation of rainfall-runoff process at a catchment scale, especially in terms of temporal and spatial source of water.

This study proposes a simple Boussinesq-type distributed rainfall-runoff model simulating for groundwater in weathered bedrock and unsaturated, saturated subsurface flow in a soil layer as well as overland flow. We apply the model in a Japanese catchment in Rokko mountain region underlying by weathered granite bedrock. We introduce also Time-Space Accounting Scheme (T-SAS) for analyzing temporal and spatial sources of water in simulated hydrographs. In particular, this study extends the original T-SAS algorithm to evaluate flowpath within the model to quantify the contribution of bedrock groundwater. The case study suggested the importance of the interaction between bedrock groundwater and saturated subsurface flow and the considerably high ratio of groundwater contribution especially during a low flow season. The developed model with T-SAS can be a useful tool to understand hydrologic processes including bedrock groundwater in mountainous catchments.

Keywords: groundwater, bedrock, Boussinewq equation, storage, granite, flowpath