Impact of bedrock depression storage on hydrological simulation in humid headwater hillslopes

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The close relationship between experimentalist and modeller is crucial to the development of hydrological models. In this study, we conducted an intensive field observation in a 0.42 ha hillslope located in the upstream of the Taihu Basin in southeastern China. Surface topography was surveyed by a total station (1676 points in total). Depth to bedrock measurements were taken by ground penetrating radar (GPR) and hollow cylindrical gasoline-powered drill. Surface and subsurface flow processes were recorded respectively by a special weir. The XAJ model was selected to reproduce the observed hillslope behavior. The analysis of the field observation and simulation results illustrated the need for model structure adjustment. According to the field study, it was found that the hillslope bedrock topography played an important role in flow generation and pathways, especially for subsurface flow. The bedrock depression storage of soil free water produced a threshold for subsurface flow generation, accounting for a delayed response of subsurface flow in a rainfall-runoff process. Therefore, the model structure was modified by adding a specific storage, bedrock depression storage (Sa), at the bottom of the free water reservoir. The parameter Sa was determined by GPR measurements. The adjusted model had a good performance in subsurface flow simulation, although it had a slight effect on the total flow simulation. This approach to developing hydrological models in conjunction with field observation made the structure and parameters have physical meaning.