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Analytical solutions for recession analyses of sloping aquifers in alpine catchments

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Analytical solutions for the discharge recession of sloping aquifers are commonly used to simulate the runoff of shallow aquifers with slope angles of a few degrees and in particular hillslopes. However, in alpine catchments, potentially deeper aquifers represented by debris accumulations such as relict rock glaciers can be found in areas with much steeper slope angles. These aquifers might be important for flood reduction and drought prevention and the discharged water can be used for drinking water supply and small hydroelectric power plants. Here it is attempted to reproduce the recession behavior of such highly inclined aquifers by applying existing analytical solutions for sloping aquifers.

More specifically, an analytical solution for the discharge recession of a sloping aquifer is compared to a numerical model (MODFLOW) for a variety of slope angles. In addition a sensitivity analysis is made to reveal the effects of the various approximations introduced in the analytical solution, such as homogeneity, parallel side boundaries and a straight profile.

The results show that the deviation between the analytical solution and the numerical model depends on the hydraulic properties and is in general acceptable for all tested slope angles. However, the sensitivity analysis shows that the simplifying assumptions and especially the initial condition have great impact on the discharge recession. Therefore, only the long-term behavior of the analytical solution should be considered if the model is employed for aquifer characterization. In summary, the combined use of analytical solutions and simple numerical models helps to better understand the opportunities and limitations of the recession analysis of sloping aquifers.