



Hillslope Hydrologic Similarity

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Similarity between hillslopes with regard to subsurface groundwater flow can be evaluated by performing a dimensional analysis on the equations that govern this process. Such an analysis of the linearised version of the hillslope storage Boussinesq (hsB) equation, results in the formulation of the hillslope Peclet number. This dimensionless number consists of different dimensionless groups describing plan and profile shape of the aquifer. The Peclet number, together with the hydraulic properties of the hillslope, predicts the characteristic hydrological response function for designated initial steady-state saturated storage corresponding to a constant recharge rate. In a previous study (Berne et al., 2005), a functional form was derived that relates the Peclet number to the dimensionless moments of the hydrologic response. However, that derivation is based on the linearised version of the hsB equation, which for some hillslopes does not accurately describe the subsurface groundwater flow over time. In this research, subsurface groundwater flow and hydrologic response of 10.000 different synthetic hillslopes was simulated numerically using the full non-linear version of the hillslope storage Boussinesq equation. Simulation results were used to calculate the first four dimensionless moments of the hydrologic response and their relation with the hillslope Peclet number. Results show that the limitations of the linearised version do not propagate into the derivation of the Peclet number and the dimensionless moments. The relation between hillslope Peclet number and dimensionless moments for the 10.000 hillslopes was largely similar to that predicted by the analytical expression derived from the linearised version. It shows the possibility to characterize the hydrologic response of a hillslope without the need to run elaborate simulations. In addition, it illustrates the usefulness of the hillslope Peclet number as a similarity parameter.