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Similarity analysis of subsurface flow response of hillslopes with complex geometry

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Recently, *Troch et al.* (2003) introduced the hillslope-storage Boussinesq (hsB) equation to describe subsurface flow and saturation along complex hillslopes. The hsB equation can be linearized and further reduced to a diffusion-advection equation for hillslopes with constant bedrock slopes and exponential width functions. This paper presents a dimensional analysis of the latter equation in order to study the pure drainage flow response, which, once normalized by the flow volume, is defined as the characteristic response time distribution (CRTD). In the Laplace domain, an analytical expression for the discharge is obtained and used as moment generating function to derive the analytical expressions for the CRTD moments. These moments, in a dimensionless form, can be expressed as function of a subsurface flow similarity parameter, hereafter called the hillslope Peclet number, and a group of dimensionless numbers accounting for the initial condition effects. The analysis of their respective influences on the first four CRTD central moments shows that the first studied type of initial condition (uniform water table depth) has a strong impact on the dimensionless mean response time of the CRTD but negligible effect on the higher order moments, while the second studied type of initial condition (steady state water table profile) has a limited effect on all first four CRTD moments and hence, in this case, the hillslope Peclet number completely defines the subsurface flow similarity between hillslopes.

Bibliography

Troch, P., C. Paniconi, and E. van Loon, Hillslope-storage Boussinesq model for subsurface flow and variable source areas along complex hillslopes: 1. Formulation and characteristic response, *Water Resour. Res.*, 39(11), 1316, doi:10.1029/2002WR001728, 2003.