Climate, landscape and vegetation controls of behavioral catchments on dominant runoff response and catchment travel time distribution

Chatchai Jothityangkoon[1] and Haruetai Maskong[1]

[1]Suranaree University of Technology

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Abstract

The three dominant processes contributing to runoff as proposed by the Dunne diagram are Hortonian overland flow (HOF), Dunne overland flow (DOF) and subsurface storm flow (SSF). Using a theoretical perspective, we investigate the impact of climate, soil, topography and vegetation on catchment water balance and the probability distribution of the travel times of each runoff generation component in respect of the connected instantaneous response function (CIRF) including the interaction of a partial contributing area connecting to the outlet. A simple distributed hydrologic model is used to capture the effect of the catchment response and to estimate the CIRFs under different possible integration of combined effect of climate, soil, topography and vegetation. A set of dimensionless similarity parameters represent catchment functions and provide a quantitative explanation of the conceptual Dunne diagram. Behavioral catchments are defined from the empirical range of the Budyko curve and mainly compatible to the physical relationship as illustrated in the Dunne diagram. The results consistent with the Dunne diagram are: (1) DOF and SSF dominates in humid for behavioral sand and silt catchments, (2) HOF dominates in arid for behavioral silt and clay catchments. Inconsistent results are: (1) SSF dominates in arid for behavioral sand, silt and clay catchments, (2) HOF dominates in humid for behavioral clay catchment and (3) no dominant HOF for behavioral sand catchment. For HOF and DOF dominates, the distribution of CIRFs can be grouped into similar shapes, which depend on the relative contribution of hillslope scale and catchment scale. For SSF behavioral catchments, the shape of the CIRFs depends on the dryness index. The combined catchment CIRFs of mean travel time for runoff responses consists with the higher first peak from the HOF and/or DOF and the second peak from the SSF.

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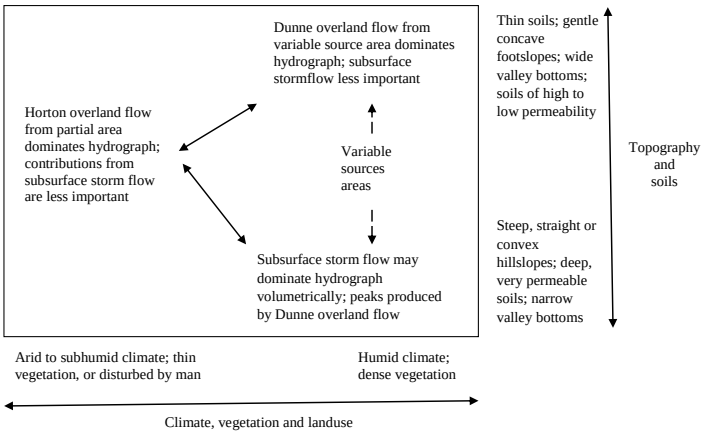
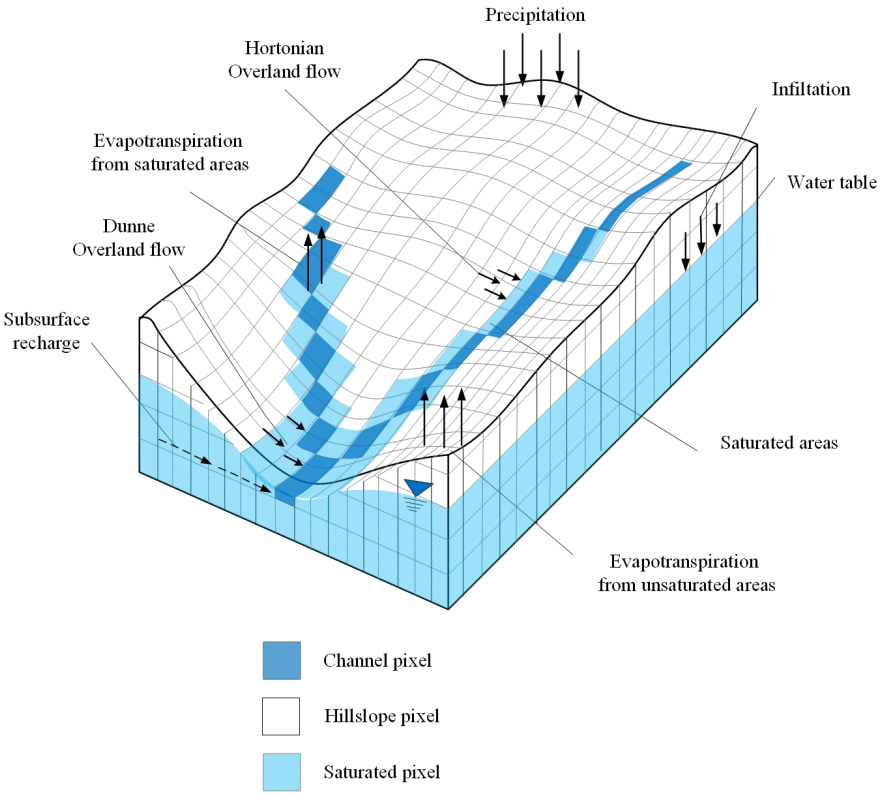


Figure 1 Dominance of different mechanisms of runoff generation processes governed by various combinations of climate, soil, vegetation and topography (Dunne, 1978).



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