THEORETICAL ANALYSIS OF TOPOGRAPHICAL, GEOLOGICAL AND CLIMATIC CONTROLS ON THE GROUNDWATER SYSTEM

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Most of the rainfall infiltrate as groundwater before flowing to rivers or to oceans. The groundwater paths, fluxes, and residence times, which are key data for watershed management, are quite complex functions of rainfall intensity, topography, and hydraulic conductivity (i.e. geological) structures.
Basing our work on the numerical modeling of free surface groundwater flow and water table-ground surface interactions, we derive theoretical results on the combined control of topography, geology, and climate on the groundwater system. Quantities of interest are: Total groundwater contribution to the hydrologic cycle; Water table-ground surface interactions; Main flow structures; Flow paths lengths; Residence times.
We first study a two-dimensional elementary basin, defined as an isolated basin with a monotonous ground surface topography. In this system, results reveal that the main features of the groundwater system depends linearly on the depth of the impervious boundary up to a characteristic influence depth. The characteristic influence depth is smaller than the basin length L and decreases as a function of s0-1RL/K, where s0 is the slope close to the outlet, R is the recharge rate and K is the homogeneous hydraulic conductivity. We then show how the results extend to a three-dimensional elementary basin.
Theoretical results of the elementary basin form the basis for a more complex study of three-dimensional composite basins. Our objective is to establish a complete theory on the formation of local, intermediate and regional groundwater flow systems and its characteristics. This work is fundamentally different from existing theories on regional groundwater flow systems that have been based on simulations where the water table is imposed.