Geophysical Research Abstracts
Vol. 21, EGU2019-8543, 2019
EGU General Assembly 2019

On the water age variability in hillslopes

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We present a theoretical approach for analyzing the water age in catchments, with emphasis on hillslopes under variable rainfall regimes. The age or residence time of water (or solutes) within a catchment system is a key variable which strongly affects the hydrological fluxes and the chemical concentration at the catchment outlet. We develop a general analytical procedure, which combines the three-dimensional flow equations with the age equation, allowing the determination of the mean and variance of the spatially averaged water age as function of time and space, along the hillslope. The model is simple, although physically based, and it can be an useful tool for assessing the dynamics of water age in natural systems. For the sake of illustration, we present results from the application of the linearized Boussinesq equation with constant parameters and a more advanced application employing the Hillslope Boussinesq Equation. Through different meaningful examples, we perform a sensitivity analysis on key parameters such as the rainfall intensity and the hillslope geometrical properties, like e.g. the basin slope and its shape . The proposed method and the application examples serve as basis for a discussion on the spatial and temporal variability of water age, the role of key parameters and the prediction capabilities of lumped models vs distributed ones.