An investigation of the effect of hysteresis in a simple rainfall-runoff model

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Multiphase porous media such as soils are known to exhibit hysteresis, e.g. in soils there is a strong hysteretic relationship between the moisture content and the matric potential and to date the Preisach model has been successful in modelling this relationship. Subsequently ODEs with Preisach hysteresis have been developed, such as a hysteretic version of Darcy's law and a hysteretic version of the linear reservoir known as the Preisach reservoir.

In this paper we combine the above Hysteretic Differential Equations (HDEs) with three linear reservoirs so as to develop a simple rainfall runoff model. The model can be represented by a block diagram: Rainfall $q(t)$ enters the soil component and either infiltrates and/or runs off when it exceeds the maximum rate of infiltration. The runoff part is fed into two linear reservoirs in series. Next, the drainage from the soil to groundwater is represented by a single linear reservoir, where the output from the soil becomes the input to the ground reservoir and vice-versa for capillary rise. Finally the groundwater and surface runoff are combined at some point and contribute to the total outflow from the catchment.
Finally we investigate the effects of hysteresis in this system and compare it to the non-hysteretic case.