Hydrology and Earth System Sciences Discussions

Hydrol. Earth Syst. Sci. Discuss., referee comment RC3
https://doi.org/10.5194/hess-2021-79-RC3, 2021

Comment on hess-2021-79

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Referee comment on "Hortonian Overland Flow, Hillslope Morphology and Stream Power I: Spatial Energy Distributions and Steady-state Power Maxima" by Samuel Schroers et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-79-RC3, 2021

Review of hess-2021-79 by Schroers et al.

This is a very interesting paper, investigating a new perspective on the very traditional hydrological process of surface runoff. Horton being maybe the first hydrologist to produce a realistic surface runoff equation, his theory has become so well known that it is considered by most hydrologists as a "physical" fact. Of course, Horton's theory is essentially empirical, as are other steady state equations by e.g. Manning, Chézy and the like. They are all based on a parametrization of energy dissipation. If there exists a physical basis for these empirical equations -- and this is what we can safely assume -- then surely the theory of Entropy production or Maximum Power is a strong candidate for this. So I welcome this paper in this quest, even though the issue is not entirely "solved".

I have a few observations and questions.

- In an open hydrological system, dissipation and conversion of free energy cannot be limited to a single subsystem. The hydrological system of rainfall-runoff consists of a number of interacting pathways, including surface runoff, open channel flow, subsurface flow, and groundwater flow, each with its own dissipative character. It would be my assumption that these processes are interacting components of the same dissipative structure and cannot be considered in isolation in a thermodynamic framework. In this article, the interaction between the surface runoff system and the other subsurface processes is represented by the exchange term $J^{pe}_{inf,out}$. It is a strong assumption that this variable is either constant or independent of other system components, such as subsurface flow and groundwater flow. Maybe the authors can give their view on this aspect.

- The authors try out different hillslope forms (linear, sinusoidal, exponential, negative exponential). From what I have seen in nature, exponential is the dominant form, with linear being a first order approximation. Is there any thermodynamic justification for either one of these shapes?

- I would be curious to know whether or how this theory agrees with field or laboratory experiments, of which many have been documented in the literature. Maybe a thorough empirical analysis is too much for this paper, but some considerations would be welcome.

- I think it is Bagnold and not Bangold (occurring at six times in the text and also in the parameters)