EGU21-14440
https://doi.org/10.5194/egusphere-egu21-14440
EGU General Assembly 2021

Hortonian Surface Runoff, Hillslope Form and Energy Dynamics, can we read the fingerprints?

Samuel Schroers and Erwin Zehe
Karlruhe Institute of Technology, IWG, Germany (samuel.schroers@kit.edu)

Since Horton's famous reinterpretation of Playfair's law hydrologists have marvelled over the organization of drainage networks in catchments and on hillslopes. We start at the cross junction of hillslope hydraulics and geomorphology, trying to interpret the formation of hydraulic networks and erosion alike and wondering why movement of fluid creates structure at all.

In its most basic form structure and form has been explained as the result of optimization, either of certain types of energy such as free energy or its thermodynamic counterpart entropy. Research has shown that river networks and river junctions tend to minimize dissipation of kinetic energy and it has been suggested that simultaneously other forms of free energy, such as sediment transport tend to increase along the flow path. Studies have focused on hydraulic networks on the hillslope scale as well as on the catchment scale. Surprisingly little attention has been given to the question why these networks exists in the first place and why discharge confluences towards the catchment outlet.

In the first part of our study we put Hortonian surface runoff into a thermodynamic framework and derive the energy balance for steady state runoff. We derive the equations on the hillslope scale, where we observe the transition from evenly distributed potential energy (the rainfall) to spatially organized discharge in micro rills to larger rills and gullies. In hydraulic terms we distinguish between sheet- and rill flow. We then apply Manning-Strickler's equation to estimate the distribution of hydraulic variables and compare energy conversion rates on typical 1D hillslope profiles for sheet- and rill flow. Interestingly, we find that only certain hillslope forms lead to spatial maxima of stream power.

In the second part of the study we extend the energy balance to transient flow and analyse power maxima during typical rainfall-runoff events. Finally, we relate our findings to observable, measurable hydraulic structures such as rill systems and estimate past work on sediments. We believe that current energy dynamics of surface runoff reflects past optimization and therefore holds potential for the understanding of landscape evolution and surface runoff contributions alike.