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Reply on RC1

Samuel Schroers et al.

Author 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-AC1>, 2021

We thank the reviewer for his comments on our manuscript.

We agree with the reviewer, that we primarily quantify dissipation during overland flow based on the residual of the free energy balance, and not by comparing different flow laws (e.g. Manning to Darcy Weißbach).

This is appropriate, as free energy is additive. We claim by no means that the usual momentum centered approach to characterize overland flow is not very helpful. We suggest a complementary avenue to explore the role of macroscale controls such as different hillslope width and hillslope forms on the steady state pattern of potential energy and power in overland flow. This reveals the existence of distinct maxima, implying a maximum available force in overland flow e.g. to initial erosion or rill formation. This maximum results from the tradeoff of the downslope increasing mass in overland flow (due to a rising water table) and the decline in geo potential and is sensitive to form and width functions of the hillslopes.

Here, we have tried to separate physical from structural hydraulic losses of energy and focus only on the latter to limit the degrees of freedom. Needless to say, physical roughness may adjust as well but our focus in this study was on macroscale (hillslope form) and microscale (microtopography) structural elements and their influence on runoff power and dissipation.

We also show that the role of rills is not so straightforward as proposed e.g. in Kleidon et al. (2013), who suggest that the related increase in the hydraulic radius implies a reduction in frictional loss per volume stream flow in rivers, which led to the conclusion that rill- or stream flow is generally less dissipative than sheet flow. We showed that this might only be the case if the transition from sheet to rill flow stays within certain limits. Here again formation of structure probably goes hand in hand with adaptation of physical roughness and we agree that this interplay should be investigated in a future study in more detail.

We also agree with the reviewer, that we do not account for the kinetic energy transfer from rainfall splash to the overland flow/sediments. This is certainly a highly interesting topic but beyond the scope of this study as it depends on the drop size distribution, which controls a) mass and velocity of the raindrops and b) the Bond number and thus whether

drops can be treated as being elastic or deforming. We do, however, account for the potential energy input due to different effective rainfall rates (or infiltration excess rates), the related tradeoff in potential energy mentioned above. This implies that we also do not account for the role of infiltration explicitly. We leave both for future research.

We thank the reviewer.