HESS point-by-point responses to referees

1st referee K. Beven:

K. Beven elaborated a detailed assessment of our study and presented a valuable critique, which we incorporated into the revised version of our manuscript.

We addressed his main comment regarding the limited evidence to our conclusions in two ways. First, we strengthened sect. 3 with an established theory, which links equilibrium hillslope forms and the dominant erosion process. This resulted in hillslope profiles which directly relate to the relative contribution of surface runoff and therefore allows a much more realistic analysis of the distribution of potential energy along the flow path. Second, we extended the analysis of rainfall simulation experiments in sect. 4 from 2 to 31 calibrated simulations and included a classification of steady state conditions, which are, as K. Beven commented as well, necessary for application of the presented steady state framework.

Related to these extensions is a restructuration of the theoretical section of the study (sect. 2), to which we added, as proposed by K. Beven a sub-section on the energy residual D_f. To this end, we elaborated on established friction laws and why constant parameters, such as Manning's *n*, are deemed to under- or overestimate friction losses and derived mean flow velocities of shallow surface runoff, especially in the case of high sediment loads. To avoid, as K. Beven mentioned, circularity of reasoning, we included an empirical friction law which implicitly incorporates heterogeneous friction losses and directly relates to equilibrium states of surface runoff on hillslopes. Finally, to draw focus on the accumulation and depletion of surface runoff potential energy as well as to streamline the narrative of the study, we excluded the comparison between surface runoff on hillslopes and in rivers.

Minor comments as addressed in K. Beven's commented manuscript are further addressed in the revised manuscript.

Referee #2:

Referee 2 made helpful comments regarding the structure and coherence of the study. We took advantage of the suggestions and focused the study on the accumulation and depletion of surface runoff potential energy exclusively on the hillslope-scale. Therefore, we excluded the comparison between surface runoff on hillslopes and in rivers and instead generally highlight the antagonistic effect of mass accumulation and geopotential loss.

To further streamline the manuscript, we restructured the introduction and highlighted the connection between the applications in sect. 3 and 4. In essence, sect. 3 relates geomorphological adaptations to surface runoff over long timescales, resulting in typical near equilibrium hillslope profiles, while in sect. 4 we analyze short-term morphological adaptations to surface runoff in the form of rills. In this second application we included in the revised manuscript the whole set of 31 evaluated experiments from Scherer (2008).

For both sections (sect. 3 and 4) we are able to show that adaptations of form, relative contribution of advective and diffusive processes, as well as the magnitude and location of the potential energy maximum are interrelated. In the revised manuscript we evaluated this finding by introducing a thermodynamic descriptor D_f^{acc}/J_{in}^{acc} which normalizes the energy residual of a spatially integrated system for given influxes of energy.

Interestingly, a potential energy maximum farther upstream relates to hillslope profiles (sect. 3) as well as hillslope surfaces (sect. 4) which maximize this relative dissipation along the flow path, while at the same time maximizing relative export of kinetic energy.

Minor comments of referee 2 were also addressed in the revised manuscript, e.g., we followed the suggestion to exclude the wording "Hortonian", as we indeed do not focus on the runoff generation mechanism itself, but on overland flow in general.