Reply to Referee #1 Hongkai Gao:

Hongkai Gao (HG): Summary and Recommendation: "*Loritz and his colleagues attempted to propose a new topographic index, named dissipation per unit length (DUNE). Generally, this is an interesting paper. The authors wanted to increase our understanding between topography and hydrology, which I think is still a big treasure to be further exploited. The paper has potential to be an important paper. But when I read the content, I found there are still several places need to be clarified before being considered for publication."*

Ralf Loritz (RL): We would like to thank Hongkai Gao for his comments and the time he invested to review our Manuscript (MS). The revised MS will follow the reviewer's recommendations and include among other things a passage where we more extensively link DUNE with our system understanding. Furthermore will we carefully check the two references of the reviewer and see whether they help to improve the argumentation in our MS.

Comments:

1. HG: *Please plot precipitation data in Figure 2, otherwise we cannot see how runoff responses to rainfall events.*

RL: Good idea. We will add precipitation to Figure 2 in a revised MS.

2. HG: *The hydrographs in six catchments present two interesting regimes: 3 marl catchments have sharp peak flow and fast recession, while 3 schist catchments have dampened peak flow and slow recession. If my understanding is correct, the authors wanted to conclude that topography controls the shape of hydrograph, rather than runoff generation (water balance), right? You probably intended to say runoff transfer or response or transition, right? What I want to say is that Figure 2 clearly shows that topography greatly impacts the shape of hydrography (runoff transfer/transition) rather than the amount of runoff (runoff generation). The authors should clarify these two terms, which are very important to communicate your results.*

RL: Exactly, the total amount of runoff over a longer time period is rather similar in the two geologies while the runoff generating processes and hence also the runoff reaction are not (e.g. Loritz et al. 2017). This is what we intended to say when we used the term runoff generation. In a revised MS we will rephrase the according section and explain in more detail what we mean by runoff generation following your advice.

3. HG: *Figure 3 showed that, comparing with TWI and HAND, DUNE has the best ability to distinguish different regimes of hydrograph response. The six DUNE curves show clearly two classes, which are well correlated with different hydrography regimes (Figure 2). This is an important conclusion, which is also the highlight of this research! From my understanding, the catchments with less DUNE values (Platen ,Colpach, Weierbach) have steeper topography and larger dissipation per unit length (kind of gradient divided by length), and subsequently resulting in sharp peak flow and fast recession process, right? But the observed hydrograph in Figure 2 shows an opposite regime. How can you explain this contradiction? Are there other factors influencing the shape of different hydrographs? If topography cannot be used to interpret different shapes of hydrography, why shall we use DUNE to analysis the relation between topography and hydrological processes? Please correct me, if my understanding is wrong.*

So I think it is really necessary to clarify the physical connection between DUNE and hydrographs.

RL: Thank you, this is a very valuable comment. Indeed our chosen index name "dissipation per unit length (DUNE)" is misleading. For instance, a relative high dissipation per unit length value could be interpreted in a way that we would assume that the dissipation of potential energy is rather high given a unit flow length in a corresponding landscape. However, exactly the opposite is true and a landscape characterized by on average high DUNE values indicates low friction and hence a reduced dissipation per flow length (e.g. macorpores, high hydraulic conductivities etc) if compared to a landscape characterized by on average lower DUNE values.

Again thank you for this comment. In a revised MS we will explain in detail how a high or low index could be physically interpreted and also connect our results, the absolute values of DUNE, better to our two geological regimes. Furthermore will we change the name to of the index to "reduced dissipation per unit length (rDUNE)" to make the interpretation more straightforward.

4. HG: *The authors also mentioned the similar index from Hjerdt et al. (2014) and Harman and Sivapalan (2009). But I did not see the comparison between DUNE and these two indices. If you want to propose a new index, you should also compare it with its ancestors and show your advantage. Right?*

RL: The similarity index from Hjerdt et al. (2014) is the ratio of HAND and an arbitrary drop in elevation. This means that it would reveal the same overall patterns as we have found using HAND (please see page 7 line 12).

The index developed by Harman and Sivapalan (2009) needs information that is not stored in a DEM, for instance the porosity and hydraulic conductivity. These can be neglected as long as we work in the same geological setting, however, this is not the case in our study.

We would also like to stress that DUNE is an energy centered re-interpretation and enhancement of HAND. This means that one of the major goals is to show that DUNE improves the ability of HAND to discriminate different landscapes exclusively based on the information stored within a DEM. We will stress this in a revised MS.

5. HG: *I found several very important relevant publications are missing in the reference list. I list some for your reference.*

Reference: Gao, H., Birkel, C., Hrachowitz, M., Tetzlaff, D., Soulsby, C. & H.H.G. Savenije (2019). A simple topography-driven and calibration-free runoff generation model. Hydrology and Earth System Sciences. DOI: 10.5194/hess-23-787-2019.

Gao, H., Hrachowitz, M., Fenicia, F., Gharari, S., and Savenije, H. H. G.: Testing the realism of a topography-driven model (flex-topo) in the nested catchments of the upper Heihe, china, Hydrology and Earth System Sciences, 18, 1895-1915, 10.5194/hess18-1895-2014, 2014.

RL: Thank you very much for pointing us to your studies. We will examine them in detail and consider adding these publications as references for our argumentation in our MS.

References:

Harman, C., & Sivapalan, M. (2009). A similarity framework to assess controls on shallow subsurface flow dynamics in hillslopes. Water Resources Research, 45(1), 1–12. https://doi.org/10.1029/2008WR007067

Hjerdt, K. N., McDonnell, J. J., Seibert, J., & Rodhe, A. (2004). A new topographic index to quantify downslope controls on local drainage. Water Resources Research, 40(5), 1–6. https://doi.org/10.1029/2004WR003130