1 Characteristic Length of Gabilan Mesa

We thank David Litwin for his review, in which he raises an important point about the difference between the characteristic length of 62 m on Gabilan Mesa, derived from a slope-area analysis, and the much shorter characteristic length scale presented in Perron et al. (2009). In Perron et al. (2009), the authors perform a regression of $\frac{|\nabla z|}{\nabla^2 z - C_{ht}}$ against drainage area to estimate $\frac{D}{K}$ and m, assuming a stream-power formulation with $n = 1$ (Equation 1 in our work). This analysis does not account for grid resolution, which appears to be 5 meters.

In our work, we demonstrate that the drainage area on hillslopes is not independent of grid resolution. Therefore, the regression for $\frac{D}{K}$ and m presented in Perron et al. (2009) is dependent on grid resolution and is not a valid method for extracting these parameters.

An improvement could involve using specific drainage area, $\frac{A}{\delta}$ for hillslopes and $\frac{A}{w}$ for channels. However, to validate this method for extracting $\frac{D}{K}$ and m, multiple tests should be conducted across a range of resolutions to ensure that there is no grid-resolution dependence. This is challenging, as grid resolution also affects slope and curvature calculations (Grieve et al., 2016b). Regressions based on slope and curvature often introduce substantial variability, even when the topography is smoothed, which reduces the reliability of these regressions.

While r is indeed the characteristic length for linear diffusive topography with $n = 1$, as shown in our simulations, real-world conditions—such as non-uniform runoff and weakly nonlinear diffusion—often violate these assumptions. For slopes approaching the critical gradient in the Andrews-Bucknam/Roering model, the characteristic length to the inflection point will exceed r, as observed in a one-dimensional analysis. In this case, an additional dimensionless group, $\frac{U}{\sqrt{DK}S_c}$, modulates the extent to which the horizontal length scale is influenced by nonlinear diffusion. Although Gabilan Mesa serves as a useful case study for stream-power plus linear diffusion, it still shows some effects of nonlinear diffusion, even if they are minor, as shown by Grieve et al. (2016a). Given the consistency between our numerical simulations and Gabilan Mesa, we consider it likely that $r \approx 62m$ for Gabilan Mesa. However, as we have emphasized, extracting K to validate this assumption is difficult, and we can only assume that our assumptions are reasonably met by referring to this value as r. We thank David Litwin once again for this comment and plan to discuss this issue in greater detail in the revised version.

2 Contour Curvature

Comment on line 93: Hillslopes do not just have parallel flowpaths, right?

We reference the concept of parallel flow paths on hillslopes as the intuition presented in previous research. On line 207, we address flow divergence ($0 < Df < 1$) and convergence ($1 < Df < 2$). This relationship is based on intuition, as we currently lack a rigorous proof connecting D_f and contour curvature.

References

Grieve, S. W. D., Mudd, S. M., Hurst, M. D., and Milodowski, D. T.: A nondimensional framework for exploring the relief structure of landscapes, Earth Surface Dynamics, 4, 309–325, https://doi.org/10.5194/esurf-4-309-2016, 2016a.

Grieve, S. W. D., Mudd, S. M., Milodowski, D. T., Clubb, F. J., and Furbish, D. J.: How does grid-resolution modulate the topographic expression of geomorphic processes?, Earth Surface Dynamics, 4, 627–653, https://doi.org/10.5194/esurf-4-627-2016, 2016b.

Perron, J., Kirchner, J., and Dietrich, W.: Formation of evenly spaced ridges and valleys, Nature, 460, 502–505, https://doi.org/10.1038/nature08174, 2009.