Earth Surface Dynamics Discussions

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Comment on esurf-2021-40

Anonymous Referee #2

Referee comment on "Hilltop curvature as a proxy for erosion rate: wavelets enable rapid computation and reveal systematic underestimation" by William T. Struble and Joshua J. Roering, Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-40-RC2, 2021

This ms by Struble and Roering explores various approaches for the calculation of landscape curvature, in particular along ridglines. Quantitative analysis of hillslope morphology has been a major advance in geomorphology, and is based on the theoretical framework proposed by Roering et al. (2007) as well as on the increasing availability of high resolution topographic data.

Such analysis of hillslope properties have allowed to extract high density information on the relative distribution of erosion rates, and to discuss their significance in terms of landscape transience (e.g. Hurst et al. 2012, 2013). One key attribute of hillslope, required in such analysis is hilltop curvature (CHT), which is theoretically linearly related with erosion rate in the vicinity of hilltops when slopes are sufficiently shallow. Computing curvature across landscapes has often been a tricky business, which is usually done by fitting a second order polynomial surface over a defined neighborhood. The procedure requires careful consideration of the size of this neighborhood and can become very resource intensive for high resolution Digital Elevation Models when this size increases.

In this contribution Struble and Roering provide a systematic exploration of an alternative approach based on continuous wavelet transforms, which they demonstrate to be much more efficient from a computational point of view. They compare CHT estimates obtained with both methods for the hillslopes of the Oregon Coast Range. They also test the accuracy of CHT calculation using synthetic hillslope topographies with various degrees of prescribed noise, and highlight the systematic shortcomings of all types of calculation when dealing with sharp ridges. As a follow up they discuss the recent results of Gabet et al. (2021), showing a deviation of the relationship between CHT and erosion rate from theoretical prediction (linear), suggesting that the underlying systematic bias in the calculation of CHT they identified might be involved here.

This manuscript presents important results of high significance for the growing community of geomorphologist interested in extracting and interpreting hillslope properties from high resolution topographic data. It is clear and convincing, and will make a great contribution to Esurf once some relatively minor issues have been addressed.

A necessary addition is one or two figures presenting a closer view of the DEMs in the vicinity of hilltops (with corresponding topographic profiles), in order to give the readers a better sense on hillslope morphology, hilltop structure and the roughness of the surfaces. You could for example focus on the representative hilltops for each basins.

The method used for the identification of hilltops, prior to CHT computation, and the associated cutoff parameters should be presented explicitly.

At some point in the discussion you should develop how the CWT methods could (or not) be used for the calculation of other types of curvature, which relevant for quantitative geomorphology studies. For example planar curvature used in some approaches for the delineation of channel heads (Clubb et al. …).

The quality of some figures could be substantially improved. I've noticed a lot of rasterization effects, see for example the non-existent X-axis line on figure 2i. Same remark for figures 5 and 9.

A great addition at the end of the paper would be a few guidelines and rules of thumb allowing to quickly identify situations where there is a substantial risk of bias in CHT calculation for a given field setting. This could be supported by a concluding figure allowing to visually make this assessment. For example what about generalizing Fig 10b with a measured/actual CHT surface as a function of estimated E (for which we can have some prior knowledge for a given setting) and Lambda (or D).

Specific comments

73 : PFT : acronym not clear

82 : how important are the specifics of the fitting procedure ?

- Circular vs rectangular window?

- z forced at central pixel elevation?

88 : yes PFT calculation are computationally expensive, however in many situations curvature calculation only occurs at hilltops, which makes it manageable in most cases.

144: you could add a bit more background information on these LiDAR DEMs (date, data source, point density ….).

164-165 : unclear this sentence sounds like the Laplacian and CHT are different things, as you need some extraction procedure to get the latter.

166 : I find this formulation a bit ambiguous (estimating erosion rate). By itself CHT will provide relative variations in erosion rates, and you will need an estimation of the sediment transport efficiency to derive absolute values. It might lead to confusion for some readers, so you should make that explicit here.

192 : CPU characteristics?

194 : be more explicit : float32?

199 : recall explicitly the procedure used to extract hilltops. Would the divide order metrics introduced by Scherler and Schwanghart be of interest here?

205 : how do you measure this asymmetry?

210 : more information needed to characterize this single representative hilltop, for each catchment (nb of pixels, summary statistics , etc …)

3.4.1 : See comment above on terminology (erosion rate estimation)

The title of this section is actually confusing as most of it deals with the scaling breaks

220 : in order to rule out any risk of circularity with what is presented below, recall the data used to infer this value of D, and explain to what extent they are independent from the newly acquired dataset.

265 : so what does the +/- 1 m mentioned above (262) refers to?

320 : is the slope of this relationship consistent with independently constrained transport coefficients?

406 Note that most well designed studies will limit the computation of CHT to the vicinity of identified hilltops and not the whole DEM, which implies a substantial reduction of computation times for all methods

412 high resolution topographic data are usually not pertinent and rarely used in such long-wavelength analysis of river profiles.

421: for PFT this effect is easy to visualize and correspond to the inability of the quadratic surface to provide an appropriate fit to the narrow and sharp hilltop in terms of mathematical form. It would be interesting to have a similar explanation for CWT? Ok seen below, but maybe add a simple scheme to give a better visual representation of this bias.

436 : could we think of a dedicated filtering procedure that could be applied before calculating CHT? Could you just make a simple test of applying a low-pass filter to the topography before CHT calculation and see under what condition does it improve the comparison?

Figure 9 : this figure us quite difficult to read due to the changes in Y-axis

Overall quality of the figure could be improved : lots of rasterization effects on this one

Table 3 : even if it just one new sample there is a lot of missing information. Use standard approaches for presenting CRN data (isotopic ratios, standardization ...)