Earth Surface Dynamics Discussions

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Comment on esurf-2020-110

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Referee comment on "A hybrid data–model approach to map soil thickness in mountain hillslopes" by Qina Yan et al., Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2020-110-RC2, 2021

The study site appears to be the bottom and adjacent toe slopes of a valley that was glaciated in late Quaternary time. I write "appears to be" because I do not know the glacial geology of this region but merely note that large moraines are present elsewhere in the valley in Google Earth imagery. The equations of this paper are applicable to hillslopes dominated by soil production and colluvial and overland flow sediment transport processes and where an approximate balance between the erosion caused by those processes and rock uplift has been achieved. Glacial erosion and/or deposition is not considered, yet these are possibly the dominant processes in this study site.

Indirect measurements of soil thickness can be useful in augmenting measurement of soil thickness in excavated soil pits, but it is inadvisable to use such methods in isolation. Augering and penetration methods are generally considered to be minimum values in rocky soils because the auger or penetrometer can be stopped by gravel. The study would be strengthened by reporting observations from soil pits at representative locations so that the nature of the soil-saprolite contact and the presence/absence of any glacial tills in the study site can be ascertained.

The authors state that the study site is in a soil-thickness steady state condition but Fig. S2 shows that this not to be the case. That figure shows the average soil thickness in a simulation increasingly steadily at the time (20 ky) when a steady state condition has purportedly been achieved. In stating that this figure demonstrates soil thickness steady state, I presume that the authors are referring to the fact that the rate of soil production is in decline. However, the rate of soil production is still far from zero and the rate of soil production for the simple case of a horizontal surface will result in a similar decline even as the soil thickness approaches infinity given sufficient time. Moreover, the average soil thickness should not be used to infer steady state because decreasing soil thickness in one area may be balanced out by increasing soil thickness elsewhere.

The authors state (line 35) that the mass conservation method can return no finite soil

thickness but this has not been demonstrated. Without such a demonstration application of the Patton method seems premature. If the model is applicable to the study site and correctly parameterized it should return a finite soil thickness value. Perhaps the model was unable to achieve such a steady state because the actual study site is not in steady state (e.g. recently glaciated) or because the authors used an inappropriate method for computing discharge by overland flow (d8 or steepest descent, as shown in Fig 1.)). In any case the paper would be strengthened by applying the model to the study site with appropriate assumptions first (see Pelletier et al., JGR, 2011 for examples of soil production and transport modeling without a steady state assumption) and then using the Patton method if and only if the model can be demonstrated to produce no adequate solution for any reasonable set of parameter values.

Some examples of unclear or incorrect methodology, incorrect units, parameter values that are very different from the literature, etc.: 1) please state how eqn. (7) was solved to determine h; this is the heart of the modeling and it is difficult to evaluate the paper without any mention of the solution method, 2) the drainage map in Fig. S1 suggests that D8 or steepest descent is used to determine sediment flux by overland flow; this method is incapable of modeling discharge by overland flow; D-infinity or another multiple flow direction routing algorithm must be used, 3) the h_0 value of 0.1-0.125 m is much smaller than other studies; h_0 typically ranges from 0.2-0.5 m, see papers by Heimsath et al.; 4) what is the relation of Bp to P_0? only P_0 appears in the equations yet only Bp appears in Fig. 3; if these are related by the bulk density ratio, as I would have thought, why is one larger on the n-facing side while the other is larger on the s-facing side? 5) values of alpha and beta are not reported, 6) the parameter a has incorrect units (must be L^2 since the product of a and curvature (units of 1/L) results in units of L). 7) In Fig. 7, what is the meaning of negative soil transport rate?