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-RC1, 2021

Review of Yan et al.

I have read the manuscript, "Hybrid data-model-based mapping of soil thickness in a mountainous watershed" by Yan and colleagues. The authors present a new approach to predicting soil thickness that utilizes the strengths of both numerical and empirical relationships within a portion of the East River, CO watershed. The new data presented here are 78 auger and 54 CPT measurements for 78 locations across two aspects. Their work produces a high-resolution (0.5 m) map of soil thickness, production rates, and transport rates for the two dominate aspects. I found this paper a pleasure to read. I thought it was interesting and provided a creative approach for predicting soil thickness where other approaches have limitations. This document is well written and has a logical flow that is easy to follow; however there are sections that could use more clarification to strengthen the approach and conclusions. Overall, the work was of good quality and falls within the scope of Earth Surface Dynamics target audience. Below I have provided a brief list of major and minor comments to the manuscript. In addition I have submitted a PDF with a more complete and thorough in-text comments.

Major Comments:

Methods clarity- Though I generally understood how your models work, it was difficult to follow the step-by-step methods (i.e., when each variable/equation is used). Could you more explicitly describe what equations (EQ1-10) and all the necessary variables (7) that the reader would need to use in your approach? At the present, I cannot tell if you calculate your 7 variables using OAT or your model, or if they already have been determine in a past study. Please clarify. Lastly, I would recommend making a diagram in the supplementary information that highlights the workflow and points to the exact equations and variables that are mentioned within the text.

Smoothing and resampling grid size- The different methods for smoothing the landscape is interesting but it's still unclear if it's extremely important for your study and possibly removes the focus away from the main findings. Curvature can be calculated at any resolution but what I am gathering from Sections 2.3 and 4.1 is that the authors want the highest resolution with the lowest RMSD, hence why they selected there smoothing over time approach. To my knowledge, I have not seen any studies which smooth elevation data using diffusion equations and since the authors did not mention any

previous studies, I am assuming this is new. If it is not, please provide some references. I do have some concerns with this smoothing approach:

- The smoothing of the DEM uses a linear sediment transport equation when in your hybrid model you utilize non-linear sediment transport (EQ2). If the East River watershed is govern by non-linear sediment transport than your current smoothing equation is inappropriate. Could you provide your reasoning for selecting this equation?
- What values of soil diffusion coefficient (K) and time-steps are you using? I see that your model calculated K value but this happens after the original smoothing occurred. Could you clarify?
- Though this approach is interesting, I believe it would introduce more uncertainty and unnecessary complexity into your elevation data. For instance, if you were to propagate the error with every time-step (error in original DEM and K) the uncertainty would be much larger than if you were to resample or use a smoothing window. If you were to propagate the error in all your smoothing methods and provide that uncertainty with your Figure 2, it may highlight a more appropriate smoothing method and resolution.

Sensitivity analysis- I have read through Section 2.4 and Results 4.2 several times, but I am still having a difficult time wrapping my head around the 7 variables, associated uncertainties, and subsequent sensitivity. Below are my two major questions. More clarification would be greatly appreciated. Lastly, it would benefit the general audience who may not have much expertise in the OAT method (such as myself) to provide a brief explanation on how to interpret Figure 3.

- Did you personally calculate values, acquire from prior studies, or did your model generate them?
- When you apply the OAT method to determine sensitivity, was this just for the 0.5 DEM smoothed with time?

Minor Comments:

Model comparison- You predict soil thickness through your hybrid approach and the random forest approach but why not compare it with the components of your model (i.e., just predicting soil thickness using the conservation of mass models and the Patton et al. method)? In the methods you nicely lay out their limitations but you could also demonstrate it. I am particularly interested in how your model will compare with the Patton et al. method because, like your model, it can determine soil thickness across the full topography. By adding a direct comparison you might be able to see additional pros and cons of the models. At the moment there are some clear benefits of your model and worth highlighting such as: you can account for the full landscape where the conservation of mass equations cannot, the Patton et al method is limited to a 5 m resolution, and your model can determine soil production and transport rates.

Model validation- I have no doubt that your hybrid approach is appropriate for other locations, given your reasonable results, but this has not been actually tested. A cross site comparison would be beneficial, specifically in sites that the Patton et al. approach is limited (watersheds with broad distributions of curvatures and avaible data) (i.e., Gordon Gulch, CO; Coos Bay, OR; Marshal Gulch, AZ). This would validate your models versatility and provide an additional comparison between the models.

Defining- Many of your symbols (i.e., E_{thre}) and specialized vocabulary (i.e., curvature) are missing definitions. Geomorphology is becoming increasingly interdisciplinary. Please insure you have clearly defined the words and the equations used. See PDF for in-text examples.

Figures- Overall, the figures are helpful to understand and progress the reader through the manuscript; however, minor edits will greatly benefit their readability. Please see comments in PDF for figure comments.

Please also note the supplement to this comment:
https://esurf.copernicus.org/preprints/esurf-2020-110/esurf-2020-110-RC1-supplement.pdf