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Interactive comment on "eSCAPE: Regional to Global Scale Landscape Evolution Model v2.0" *by* Tristan Salles

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First I would like to thank the reviewer for his useful comments. Below is my response to these comments.

General comments

GC1: I would like to hear how the author defends criticism that this model is not novel. eSCAPE v1 was published in the Journal of Open Source Software, how does v2 differ? What makes it require a whole new publication?

Response: The main differences between v1 and v2 of eSCAPE are in the way v2 handles the marine deposition and in the implementation of the depression filling algorithm. In v2, a priority-flood + epsilon variant of the algorithm proposed by Barnes

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et al. (2014) is implemented. It prevents the formation of flat surfaces and allows for the determination of flow directions on all regions of the simulated landscape. The depression-less surface is then used to estimate depositional regions and to force marine deposition. An analyse of the differences between v1 and v2 on GitHub shows that there have been 36 commits over 12 files with 2,241 additions and 1,212 deletions. In addition, the first version published in JOSS (https://doi.org/10.21105/joss.00964) was a one-page summary that did not explain the details of the algorithms. This new publication describes in details the physics and numerical approaches from eSCAPE, it also provides a series of hands-on examples that illustrate the code usage in different settings.

GC2: Furthermore, and I ask this out of naivety, how does eSCAPE differ from Badlands? Is the difference significant? Overall this is my only major concern, and it is one that is potentially wrong.

Response: There are many differences between Badlands and eSCAPE. First, the number of processes that can be simulated with eSCAPE is quite limited compared to Badlands. When considering the processes that both models simulate, the numerical approaches are completely different. Badlands is an explicit serial model able to simulate single flow direction river erosion/deposition. eSCAPE relies on an implicit iterative parallel approach able to evaluate multiple flow direction river processes. The approach in eSCAPE consists in solving a series of sparse matrix systems using the parallel library PETSc. In addition, eSCAPE can be used at global scale on a spherical mesh and relies on a different strategy to simulate depression filling (Planchon and Darboux 2001 for Badlands – Barnes 2014 for eSCAPE). In terms of outputs, one might find these two models similar, but they are really distinct when looking at the underlying algorithms and implementation strategies.

Minor comments

MC1: The introduction way oversells the model. Yes, it can model global erosion and deposition using a set of rules, however, the model cannot capture lateral movement of the surface due to faulting. In fact, there is no faulting, which is arguably the major process that connects mantle convection to surface processes. This is a very challenging problem, and not one the author seeks to solve. However, much text is wasted on describing a vision of a global coupled model. This should be saved for a research proposal and not used here.

Response: Following reviewer's comment, I have modified the introduction and removed the paragraph related to the coupling with geodynamic/lithospheric models as this is not essential to the paper and I definitely do not want to oversell the model, as pointed out in the introduction: "The model presented in this paper is a first step toward the development of a parallel global scale landscape evolution model."

MC2: Explain what the advance is in this model, how it advances on v1 and Badlands. What is eSCAPE v2 for?

Response: See response to the general comments from the reviewer above (GC1 & GC2).

MC3: Line 15: What was the reason for cherry-picking these citations, none of which date from the '80s?

Response: Following the reviewer's comment, I have modified the text from the '80s to '90s. The choice of citations illustrates some of the LEM models that have been created over the years: Caesar (Coulthard), Cascade (Braun), Apero (Davy), Badlands (Salles) or Landlab (Hobley). In addition, these models represent different numerical approaches based on cellular automata, stream power law, or more standard flow hydrodynamics. They have also been developed to look at different spatial domains from river to catchment scale up to regional and continental extent.

MC4: Line 28: What is the purpose of this paragraph? As it is, it is far too short to encompass how global mantle flow is expressed at the earth's surface.

Response: Following the reviewer's comment, I have removed this paragraph from the introduction.

MC5: Line 70: I thought the approach of Jean Braun was O(N) efficient, always? Is the author saying otherwise?

Response: The approach from Braun is O(N) efficient but its parallel implementation relies on the number of outlets present in the simulation and therefore can become inefficient and scale poorly when the number of processors increases.

MC6: Equation 2: The first line does not make sense. q_1 = b_1, not q_i = b_i

Response: I have made the correction in the manuscript

MC7: Line 127: "calibration" is out of place here.

Response: I have deleted "calibration"

MC8: Line 128: "evidence" should not get an "s", likewise "behaviour". There are other minor grammatical errors which I am sure will be corrected when copy edited.

Response: I have removed the "s" from evidence and behaviour in the text.

MC9: Equations 7 and 8: Here it is hard coded that n=1 and m=0.5. This is stated later in the manuscript, but this is potentially a major limitation of the model, as the recent study by Kwang & Parker (2017) suggests that "the choice m/n=0.5 yields a curiously unrealistic result: the predicted landscape is invariant to horizontal stretching".

Response: From Kwang & Parker (2017), this unrealistic behaviour is found when hillslope diffusion is neglected. In eSCAPE, hillslope diffusion could be turned on and thus should help to limit this behaviour. In addition, it is worth mentioning that the effect observed by Kwang & Parker is made when accounting only for a single flow direction (D8) when computing flow and drainage area. eSCAPE allows to simulate multiple flow direction (MDF) and the curious observations from Kwang & Parker have not been reported in such case.

MC10: Line 159: In this equation, the non-suspended sediment gets left behind, right? But the stream power law assumes instantaneous sediment transport. Therefore the two are incompatible? I am missing something here. Perhaps some additional explanation of how the model goes from erosion to deposition would help.

Response: At line 160, I define Ff as the fraction of fine sediment that remains in suspension. Ff represents the volumetric fraction of bedrock that breaks into sediment small enough to be considered permanently in suspension and for which no further treatment of bed–water column interactions is needed. For bedrock that breaks only into sand and gravel fractions, Ff would be zero. Therefore, simulated bed deposits and transported sediment flux only include sediment coarse enough that it does not permanently stay in suspension. I have added the explanation above in the manuscript.

MC11: Section 2.3: The “priority-flood” algorithm is non-physical, right? I wonder if it should not be done after the hillslope processes (diffusion), as this would smooth depressions and potentially fill them. Then the subsequent filling by fluvial deposition should occur?

Response: The reviewer is right, the “priority-flood” algorithm is a non-physical process and can be done prior to fluvial deposition. It could potentially help in cases where depressions are made of only a single point (local pit) or really small in size because induced filling from hillslope processes only occurs over much longer temporal scale than river ones. I believe over time, as the model iterates over the main loop the order proposed by the reviewer and the implemented one will produce equivalent results.

MC12: Section 2.5: Does marine deposition use a constant diffusion coefficient? Some marine deposition models vary this diffusion coefficient with water depth, to simulate wave and tide effects. I assume that this is not the case within eSCAPE?

Response: The reviewer is right I only use a constant diffusion coefficient for marine deposition in eSCAPE and do not account for water depth dependent (non-linear) diffusion. This could potentially be a new feature for the next model version.

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MC13: Table 3: I think the marine parameters are missing from the table.

Response: The only user-defined parameter required to simulate marine processes is the diffusion parameter sedimentK defined in table 3 and at line 288 page 13.

Reproducibility:

RC1: The code is available, and I have successfully installed it. I have come across minor issues in running the code, due to my install of python and petsc, but this will be fixed before publication I am sure.

Response: I have made some changes in the code to fix some of the issues encountered by the reviewer (https://github.com/Geodels/eSCAPE/issues/9). I have also added some documentation about the petsc installation (https://github.com/Geodels/eSCAPE/wiki/Dependency)

The supplement file shows the differences between the submitted version and the one accounting for the reviewer's comments.

Please also note the supplement to this comment:
https://www.geosci-model-dev-discuss.net/gmd-2019-126/gmd-2019-126-AC1-supplement.pdf

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