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Editor of ESurfD

Dear Editor,

We submit a revised version of our paper entitled "*Modelling sediment clasts transport during landscape evolution*".

The main changes we did, in agreement with reviewers comments, are :

- we added text and references in the Introduction as recommended by reviewer 2, to explain better the motivations for such an approach (reviewer 2),
- we added text to better explain how clasts are moved in section 3.2 (reviewers 1 and 2),
- we added section 3.3 to describe the initial LEM setup (reviewer 1),
- we slightly modified Figures 2,3,4,5,6 (reviewer 2),
- we added an electronic supplement with 3 additional Figures showing the slope-area and width-discharge scalings of the experiment shown in Figure 6 (reviewer 2).

We took all the reviewers comments into account concerning editing and new references.

The new text is in red in the revised manuscript. English was verified by a professional translater.

We thank you for handling our manuscript.

Best Regards

Sebastien Carretier and co-authors

Referee 1

`(...) However the description of the clast dynamics and its coupling to the landscape evolution, which is the central point of the paper, needs to be more detailed.`

We added significant text in section 3.2 in order to be more specific on the procedure used to move clasts.

`(...) 1. What is the initial setup of the 3d landscape? 2. Does the initial condition consist of a "geologic 3d map" composed of materials of different erodible materials at different location and depths?`

We added section 3.3 in the revised manuscript in order to provide this information.

`(...) 3. How is the calst initially distributed in this 3d landscape`

We added a line in section 3.3 to specify this. The initial number, size, location and depth of clasts is set by the user. A list of initial clasts is used as input, file. There is no limitation except the one imposed by computational times. For example, 1000 clasts can be spread randomly on the grid with depths between 0 and 100 m, and sizes between 1 mm and 5 cm. In the example of Figures 3, 4 and 5, 1000 identical clasts are initially set at the surface of one cell. In the more general example of Figure 6, clasts are initially grouped in two populations at two different cells and depth ranges.

`(...) 4. How has the initial grain size R of the clast material been chosen.`

In the experiments presented in this manuscript, the clast size has been chosen to obtain mean transport rates on the order of 1 to 5 km / 50 kyr. Smaller clasts would go faster, larger clasts would go slower. The important point here is that their mean transport rates are consistent with the transport fluxes calculated from the deterministic rules of Cidre, which is illustrated by Figures 3B and 5B. It is also important to note that any distribution of initial clast size can be imposed, what we specify now in section 3.2.

`(...) It is also not completely clear how the stochastic moment of clast is coupled with the deterministic rules of sediment transport. The authors have to explain more clearly how clast and sediment are coupled spatially and temporally. One could imagine an awkward situations (with low probability) where all the sediment is removed, while the clast stays in place.`

We added text in section 3.2 of the revised manuscript, in particular explaining the possibility of this apparent awkward situation.

We thanks Referee 1 for its comments.

Referee 2

`(...)The introduction is perhaps a little too short. Tackling both landscape evolution models and particle transport in about a page of text is by no means an easy task and sells some of the novelty of the paper short. I suggest to focus the introduction a bit more on why it is challenging to couple both particles and landscape evolution models, and why each approach separately has not been able to rectify this gap (...).`

Thanks. We developed this point by adding a paragraph in the Introduction.

`The initial model set up in sections 3 to 3.2 is well laid out and easy to follow, however more information is needed to understand how the authors treat the addition of clasts to the system. In that it is not clear how the clasts are actually moved, in line 6 on page 14 there is a mention of a numerical random function to used to move the clasts. It is not clear to me where in the model framework that fits in, nor is it present in any of the given equations.`

Indeed. We added significant text in secion 3.2 and a new section 3.3 to better explain how clasts are moved.

`It is worrying (or perhaps just perplexing) that the variance and the mean are not equally susceptible` to the choice of dt and dx. In particular the authors should explore and rigorously comment on why the smallest spatial step (dx) results in the poorest agreement between the expected and the model results for all model runs. In the con- clusion the author?s state that decreasing the cell size decreases the over estimation, but the smallest cell size has the greatest mismatch with the expected trends, unless I am really misreading the graphs.

Concerning the dependence of variance on dx, this is a direct consequence of the simplified method adopted here. You can imagine an extreme case where we impose that all clasts initially seeded at one pixel of an inclined plane, descent at the same rate. This means that the probability to move downstream is identical for all the clasts. They will step all from line to line, but they will increasingly spread along each line because they can choose one of the three downstream direction. In that case, the mean transport rate does not depend on dx, but the variance necessarily does. Note that the probability to go to these downstream directions is calculated by the multiple flux algorithm. One may think that this algorithm should be adapted for large pixels. The comparison of observed and modelled clast movements in specific cases may actually help to improve the multiple flux algorithm. One simple way to do this could be to reproduce the downstream spreading of gravels of a particular color (visible on satellite images) sourced from a localised rocks (dyke, hydrothermally altered rock, etc...) for different pixel sizes. Such cases exist for example in the Andes. Note that the variance decreases always with dx. Figures 3,4,5 B may be ambiguous because the sqrt(t) trend fitted to the reference model is not the predicted variance. It indicates that the scaling is respected, although the expansion factor is overestimated. We state this more clearly in the revised Figures 3,4 and 5 and their captions.

It is interesting to see the modeled topography evolve with the addition of sediment clasts in figure 6 and section 4.4, but it would be useful and a great contribution for the authors to analyze the resulting clast and topography statistics to show that the model results are capable of producing realistic topography. Such as whether the slopes of the catchment satisfy well known slope area scaling relationships, or how the hydraulic geometry of the channels grows with area (...).

Thanks. In order to illustrate these points, we added 3 Figures that we propose to put in an Electronic Supplement, joined to the revised manuscript. Basically, we show that Cidre predicts consistent S-A scaling when lateral erosion is turned off. When lateral erosion is taken into account, the observed scaling between the valley width and the total river discharge seems to be consistent with the relationship $w \propto Q^{0.5}$ observed worldwide, although this consistency requires further works to be confirmed (parametrical study varying pixel size in particular).

Did the clasts stop moving because they reached a low enough slope or because they became buried (i.e. why has the trailing edge not transported itself further or why has the leading edge transported itself so far).

They stop because they are buried under sediment. Clasts are exhumed before steady-state so that the foreland is still filling. We added this information.

I understand that it is not the authors intentions to analyze the final modeled topogra- phy or clast statistics in figure 6, but in that it represents the strongest case for their approach it would represent a substantial contribution to their ideas. Currently the gap between figure 6 and figures 3, 4, and 5 is rather vast (adding a channel to the run in figure 5 would help in reducing this gap). In that I am left wondering if the model actually produces statistically realistic topography and therefore has potential to realize the perspectives in section 5. Figure 6 is in many ways the realization of the manuscripts title, while figures 3, 4, and 5 represent more proofs of concept that clasts can be tracked using the rules developed for hillslopes and river networks.

We hope that the supplement Figures are useful to fill this gap. It is true that this paper is mainly oriented to a proofs of concept represented by Figures 3, 4 and 5 and that Figure 6 is more an illustration than a case study.

pg.3 ln 26 - It might be best to reword this sentence as neither Hassan et al., (1991) or Haschenburger (2011) use magnetic minerals as tracers, they have implanted magnets into natural cobbles. As an example the work of Houbrechts et al., (2011) uses magnetic iron slag as a tracer (their work may be relevant considering the longer timescales of the study). It may also be useful to consider the recent work using RFID tracers (there are numerous studies over the last decade), the work of Bradley and Tucker (2012) comes to mind as they develop the transport distance distribution for a large population of tagged clasts.

Thanks. we modified the text to be more rigorous and added these pertinent references.

`pg.4 ln 11 - reduced-complexity rather than complexity-reduced.`
Thanks. Done.

`pg. 9 ln 19 - In this line are "Eqs. (1) and (2).`
Sorry, we do understand.

`pg. 10 ln 1 - "a brutal", is this supposed to be abrupt?`
Yes, thanks.

`pg. 10 equation 9 - in the case of setting the river width to Q?.5 is the width then allowed to change due to the bank/lateral erosion in section 3.1.4 or are the banks only allowed to erode when the river width is set to the cell size? If width is set to the cell size and it is allowed to evolve does it reproduce the` $Q^{0.5}$ `scaling?`
Banks can erode in both cases. If width is set to the cell size, the new FigureES3 in the electronic supplement suggests that the model might reproduce the $Q^{0.5}$ scaling, but this has be studied in more details.

`pg. 11 eq 10 - Qs is not defined in this paragraph or previously.`
Thanks, we added it.

`pg. 12 ln 8 - suggest shallower or smaller rather then lower. Lower as used here connotes below which does not seem to be what the paragraph is saying.`
Thanks, we changed for shallower.

`Figure 2 A and B - It is very difficult to see the black dots under the red. Most readers will completely miss that they are even present.`
OK, we increased the size of black circles.

`Figure 5 A - final panel has "ans" instead of yr.`
Thanks, done.

`Figure 5 B - "analitical" should be analytical.`
Thanks, done.

`Figure 6 - Northern and southern boundaries are referenced in the text, however there is no indication within the figure where these directions are.`
Done.

`pg. 18 ln 18 - The debate on decreasing grain size as one travels down river has mostly concluded at this point. Size selective deposition is responsible for the majority of the downstream fining process in all but the steepest catchments where steep slopes and large particles allow for energetic collisions. See Fedele and Paola (2007), Paola and Seal (1995) and more recently Miller et al. (2014) for a catchment specific view.`
Thanks, we modified the text and added these references.

Thanks a lot for providing the references of the cited papers and for these constructive comments.