

## ***Interactive comment on “Detection of seasonal erosion processes at the scale of an elementary black marl gully from time series of Hi-Resolution DEMs” by J. Bechet et al.***

**J. Bechet et al.**

michel.jaboyedoff@unil.ch

Received and published: 27 May 2016

Interactive comment on “Detection of seasonal erosion processes at the scale of an elementary black marl gully from time series of Hi-Resolution DEMs” by J. Bechet et al.

Anonymous Referee #2

Comments from Referees : I was saddened when reading in the acknowledgements that the first author had deceased in an avalanche accident. I wish the team of co-authors much strength in dealing with this loss. It is to be commended that they decided

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to finish this work and dedicate it to Dr. Bechet.

The ms deals with a multi-temporal dataset of highly accurate DEMs, which are subtracted from each-other to yield Dems of Difference (although this term is not mentioned). The objective is to create seasonal maps of erosion (confusingly called ablation) and sedimentation, and to extract a conceptual model from this. The data presented are interesting and worth my time.

Author’s response: We will change the terms and use erosion, but in some case if the difference is linked to something else we need to keep a word similar to ablation.

The main conclusions about seasonality appear to be warranted, although they should be defended rather than posited, and some extra calculations are required to put them further into context. I am not well placed to comment on the quality of embedding the discussion in the context of (international) gully erosion research, but this appears to be going well. Figures are well made up (but see comments) and support the storyline. My main points for improvement of the ms follow here - a detailed list of suggestions is given below.

First, I find that the seasonality of processes is the most interesting point of the document. It deserves a clear presentation - first as a hypothesis, which has led to your data gathering scheme (i.e. multiple times per year). Then the data should be examined, and you can conclude (a bit later in the ms than you do now) that there are strong seasonal differences in what you observe. From that, the conceptual model can follow.

Author’s response: We will change the sequence of arguments and distinguish in a better way both data and model.

Second, one main possible uncertainty that you have not been able to resolve is the effect of weathering on bulk density and hence on slope swelling. I think that you should get at some preliminary estimates of this effect, and that this can strengthen your interpretation. I make suggestions below.

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Author's response: We will try to give more explanations, but quantification is very difficult (see below).

Third, there is a long list of small language issues in the ms. I make detailed suggestions for improvement below. The main point would be that in my perception 'erosion' is a more common term for what you call 'ablation'.

Author's response: see first comment.

Most of my comments will be easily considered and if needed, corrected. However, because some restructuring of the arguments is needed along with new calculations that could lead to some changes in the argumentation, I recommended major revisions to the editor. I expect however that these will not take up too much of your time.

Comments from Referees : Abstract l 22 temporal : temporary?

Author's response: temporal sequence of. ...

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Comments from Referees : l 20 : It is unclear to me what SOERE RBV is. Is it a reference? Then it lacks a year.

Author's response: we will add: SOERE (SYSTÈMES D'OBSERVATION ET D'EXPÉRIMENTATION POUR LA RECHERCHE EN ENVIRONNEMENT) RBV (Réseau de Bassins Versants = network of catchments for the study of the critical zone, see [portailrbv.sedoo.fr](http://portailrbv.sedoo.fr))

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Comments from Referees : l 15 - move the explanation of SOERE BV to earlier in the ms

Author's response: we will add: ok!

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Comments from Referees : l19 what is IRSTEA?

Author's response: sorry we completely forgot to add the meaning of IRSTEA which is: Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture

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Comments from Referees : l23 A limestone ridge overlies the marls - this is confusing to me. A ridge is a landform, 'the marls' is a sedimentary formation. Please clarify.

Author's response: we will change. In fact the limestone overlies the marls, which is expressed in the landscape by a large limestone cliff. Remember that this description concerns the regional scale, we will clarify that point.

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Comments from Referees : l17 it would be useful here to present the mean annual air temp and the average temperature in the three winter months instead of daily average.

Author's response: we can add this, but we do not see the goal!

Comments from Referees : l25 But... this sentence is not understandable (use 'but' only once, for instance).

Author's response: we will change like this: Because considering only the freezing and thaw cycles the south-facing slopes suffer more cycles than the north-facing ones, but the gullies located in the south-facing slope are equivalent to north facing slope (Rovera and Robert, 2005).

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Comments from Referees : l 11 A popcorn structure? This requires a photograph and/or some extra explanation. I have no idea what this means.

Author's response: we will add: we will add a reference, see for instance picture in:

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<https://books.google.ch/books?id=adz8z21Ysv0C&pg=PA336&lpg=PA336&dq=popcorn+struDMAhUImBoKHUJcDygQ6AEIHjAA#v=onepage&q=popcorn%20structure%20geomorpholc>

Comments from Referees : l 13 erosion rates of the b. m. is 8 mm yr-1 (no 'of').

Author's response: ok!

Comments from Referees : l14 8 mm / yr , calculated over which period? Same for next sentences

Author's response: over one year!

Comments from Referees : l17 upper part of the slopes

Author's response: ok!

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Comments from Referees : l 8 Yes, indeed, give wavelength.

Author's response: it is a mistake which occurred during our internal review, we will only give what the manufacturer indicates: green laser.

Comments from Referees : l10 from May 2007 to November 2010 (no 'the' )

Author's response: ok!

Comments from Referees : l18 are less than (no of)

Author's response: ok!

l19 ranges from 0.3 to 3 pts cm-2

Author's response: ok!

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Comments from Referees : l8 As an example : this sentence is too long, has at least one error and is not clear to me. Please check and cut up into two new sentences.

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Author's response: This will be reformulated. But the main goal is to show that the high density of points increase the accuracy assuming that the point cloud is well georeferenced.

Comments from Referees : l21 to l24 this is not understandable to me. What are you doing in addition to simply taking the difference between each HRDEM and the subsequent HRDEM? Are you matching a HRDEM with one from the same season a year back? Why? If that is true, change in

Author's response: we will clarify this sentence, as well as the next one. We compared the changes and match the HRDEM for each season.

Comments from Referees : l17 : "from AN earlier HRDEM".

Author's response: ok!

l26 "these maps ....including the interpretation ... of .. process"? How can a map include an interpretation of a process - it should be a result of your work that can not be contested - not an interpretation that we can have different opinions about.

Author's response: we will clarify that point. This was not well formulated. It is the legend of the map that shows the results of our interpretation. We will check in the text to be coherent and modify accordingly other parts of the text.

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Comments from Referees : l5 subtracted from

Author's response: ok!

Comments from Referees : l10 why do these volumes need to be corrected? Do you mean convert? And what does this have to do with vegetated areas?

Author's response: we will change this sentence, it means that the small areas that were not imaged by the Lidar, have to be taken into account in the sediment budget,

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which implies a correction!

Comments from Referees : I12 and if the density changes throughout the year, then why always use 1500 kg m<sup>-3</sup> ?

Author's response: this sentence is confusing and is not related to the same density, it was an apparent one. . . . It has been removed from the table.

Comments from Referees : I16 results were compared

Author's response: ok!

Comments from Referees : I23 that were quantified

Author's response: ok!

Comments from Referees : I25 due to atmospheric conditions in the last section of the methods, you talk a lot about what CAN be done to quantify the errors. Has this also been done in your case? 4 results

Author's response: the solution is explained later in the text, we will change to be more precise in that section!

Comments from Referees : I22 ablation should be erosion, also in captions and elsewhere. It is not an international term, I believe.

Author's response: ok!

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Comments from Referees : Two main comments about the 5 'seasons'. I believe that your recognition of possible seasonality is a main attraction of this work. I think you should therefore not posit that seasons make a difference, but you should formulate it such that we see how you came to believe this, and to what extent you are sure about it. One weakness that you could highlight in this respect is that the winter season is characterized by only one observation / pattern. Second, does your method account

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for the fact that in some cases there may be a difference in altitude (or distance to the scanner) that is caused by expansion of the slope as it undergoes weathering but not erosion? You did discuss the large differences in bulk density between bedrock and regolith/soil, so this effect may be significant. This may be particularly important in the winter season. Please comment.

Author's response: We will discuss this point, but we did not have enough data to solve fully the problem. This study underlines the necessity to take into account micro processes, because the Lidar accuracy is high enough to catch some of them. We will try to clarify improve this point as far as we can with our data. But mainly, we suspect swelling process and we demonstrated it experimentally in the paper of Bechet et al., (2015 HESS). But remember that the sediment transfer is supported by the sediment trap data.

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Comments from Referees : I7 . This is probably etc. : please save interpretation for the discussion section.

Author's response: ok, you are right!

Comments from Referees : I8 This sentence is superfluous: for gullies with any flow accumulation, if there is not enough rainfall or rain intensity, there will be no transport.

Author's response: ok!

Comments from Referees : I19 very often: often

Author's response: ok!

Comments from Referees : I21 characterized by relative drought

Author's response: ok!

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Comments from Referees : l 8 The difference is in an - this is a new sentence

Author's response: ok!

Comments from Referees : l12 I would prefer the dimensions of 8m<sup>3</sup> to be changed into volume per time. This is going to be important because not all your seasons are equally long. 14 rainfall was

Author's response: we will give both data type!

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Comments from Referees : At l6 you conclude that you are underestimating - and then you give the reasons, before hypothesizing that you are underestimating, Better turn this around: first hypothesize, then give your reasons for it, and then conclude that you have a lot of confidence in your hypothesis.

Author's response: we will modify accordingly!

Comments from Referees : l16 I am glad to see your attention for the swelling due to weathering. But before you discount this, why don't you provide a back-of-the-envelope calculation of the difference this would make? Roughly speaking, most of the year's weathering happens in winter, right? So, assuming equilibrium between weathering and erosion (which you implied before when you said that slopes do not change shape), why not take the annual volume of material captured in your sediment trap, divide that over the slope area (perpendicular to the slope, not aerial area). That should give you a first order estimate of the swelling? In imaginary numbers: if you have 10 kg leaving your catchment in a year, and you have 1000 m<sup>2</sup> of slope area, then on average you have 0.01 kg/m<sup>2</sup> slope area that has been eroded, and hence been weathered first. Weathering 0.01 kg/m<sup>2</sup> from a bulk density of bedrock (2500 kg/m<sup>3</sup>) into a bulk density of sediment (1350 kg/m<sup>3</sup>) , would correspond to a swelling of the slope by  $(0.01/1350)-(0.01/2500)$  m / m<sup>2</sup>. My numbers are surely wrong, but perhaps the approach is valuable. Alternatively and more locally, you have the local erosion for

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your pixels over a whole year - assuming again that this is of an order with the local weathering, you could maybe do local erosion [m] \* local slope gradient [m/m] \* (density regolith / density bedrock) [-] .

Author's response: your proposal will probably not be able to capture the order of magnitude of the swelling, because it affects the regolith in several ways as we observed in experiment in Bechet, J., Duc, J., Jaboyedo , M., Loye, A., and Mathys, N.: Erosion processes in black marl soils at the millimetre scale: preliminary insights from an analogous model, Hydrol. Earth Syst. Sci., 19, 1849–1855, doi:10.5194/hess-19-1849-2015, 2015.

But, it is clear that it opens a full topic of research for both field and experimental contexts.

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Comments from Referees :

11 rainfall event

Author's response: ok!

l12 from a transportlimited pattern (at ....spring) to a supply-limited one (in summer).

Author's response: ok!

Comments from Referees : l22 sentence may be wrong

Author's response: we propose: ... (Mathys et al., 2000). That threshold is lower if the dry period is smaller than 5 days.

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Comments from Referees : l19 inter-rill erosion

Author's response: ok!

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23 moving a few m through solifluction in one winter? That is very surprising to me. I am not aware of so rapid solifluction. Please illustrate this statement with literature or process knowledge. Are you thinking about mudfl

Author's response: you are right we will use micro-mudflow for the large movements!

Figure

Comments from Referees : Figures F1 - no comment

Comments from Referees : F2 - I love this figure. Very crucial to the paper, and it illustrates the richness of your data. However, individual maps are rather small. Could you please rearrange the titles of each so that you can zoom in a bit more to the maps? They deserve as much space as you can give them.

Author's response: We will rearrange and provide a supplementary material large in addition to the video.

Comments from Referees : F3 ablation=erosion. In legend: deposit - deposition. Also here, I think you can blow up the maps a bit larger.

Author's response: ok!

Comments from Referees : F4 do not show the zero values for cumulative [recipitation or intensity. You have used a threshold so this is not fair. In the caption, are you talking intensities per minute over a 1 minute period? Or five? or ten?

Author's response: yes we used threshold, in the hurry we forget to fully give them. In any case we will explain and add the full data in two additional graphs. The intensity are calculated by time laps of emptying of calibrated bucket (Bucket rain gauge).

Comments from Referees : F5 perfect.

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Interactive comment on Earth Surf. Dynam. Discuss., 3, 1555, 2015.