Review 2

This manuscript presents field and modeling data to explore the impact of bioturbation on erosion and sedimentation on hillslopes. I think this is a worthwhile study to publish. However, I did not understand some of the modeling methods, which made the results mostly uninterpretable for me. I think differences in nomenclature may have also made it difficult for me to follow.

My main challenges were that I didn't understand how the model worked, so it was difficult for me to interpret the results. Even if I understood the basics of the model, I did not understand how the sensitivity analysis was carried out, which I think, but I am not sure, led to the results presented in Table 3, which I also did not understand. Without understanding the model experiments, it was difficult for me to take away much about how the processes impacted erosion and deposition.

It seems like the authors did a very thorough experiment, so hopefully my questions and comments can illustrate where I got lost. With a bit more clarity, I think this paper would be a lot more impactful. For now I'm left with "bioturbation increases erosion and sediment accumulation", and especially in temperate climate zones. But if I understood Table 3, I would have a lot better chance of using what they found to understand how bioturbation might be impacting another landscape.

Regarding this paragraph, we addressed the underlined points as follows:

"**I didn't understand how the model worked"**

We added paragraphs describing the model (Lines 338 – 362):

The model is a semi-empirical raster-based Morgan-Morgan Finney soil erosion model. During the model simulation, water and sediment are transferred from pixels located at higher elevations to pixels situated at lower elevations. This occurs in two stages: The first stage is the hydrological phase where the model calculates surface runoff which happens when the amount of surface water input exceeds the water-holding capacity. The amount of surface runoff is computed by taking the infiltration capacity of the surface, the volume of surface water input, and the fraction of the impervious area of a pixel into account. Infiltration capacity represents the maximum amount of surface water that can penetrate the subsurface layer. It is determined by the percentage of the impervious area and the available pore space.

The second stage is the sediment phase, where the model estimates the sediment budget for each particle size class, based on the surface conditions. The model calculates the detachment and deposition of sediments in a step-by-step process. The sources of sediments are detached particles from the pixel itself due to rainfall and surface runoff, and delivered soil particles from higher elevation pixels. The detachment of soil particles by rainfall occurs when raindrops hit the ground with enough energy to detach soil particles from the surface. Rainfall has different impacts on areas with and without canopy cover, as canopy cover changes the kinetic energy of raindrops.

The amount of soil particles detached by raindrops is calculated based on the soil particle detachability, the percentage of each particle size class, the bare soil surface area, and the kinetic energy of effective rainfall. The amount of detached soil particles by surface runoff is calculated based on the soil particle detachability, the amount of runoff, the slope angle of the pixel, and the proportion of the bare surface area. The third source of sediment is from higher elevation pixels and is averaged by the surface area of the pixel.

Once sediments are delivered to the surface runoff, a portion of the suspended sediments settles to the bottom due to gravitational force. To calculate this settling, the model requires the flow velocity of the runoff and the settling velocity of each particle size class, which are influenced by the flow depth, slope angle of the pixel, and Manning's roughness coefficient (Choi et ail. 2019).

“I did not understand how the sensitivity analysis was carried out”

We rephrased the section regarding the sensitivity analysis (Lines 435 – 441):

We conducted a sensitivity study to identify the input parameters, which significantly influence the model output. For this, we first estimated the mean value of each spatial parameter listed in table 1. Then, we created an artificial hillslope catchment of 100 m * 100 m. To start the test, each pixel received the mean value of each parameter. We ran the model for one rainfall event. Then, we stepwise changed the single input parameter values from their minimum to their maximum values while we did not adjust any other parameters. To quantify the significance of the input variations, we conducted a t-test (Table A2). For this, we compared the amount of redistributed sediment of each model run to the first model run.

“Table 3, which I also did not understand.” “I needed someone to walk me through it.”

We apologize that the presentation of our results shown in table 3 seems to be confusing. We therefore decided to combine table 3 with figure 8 from the previous version of the manuscript and created a new figure (now figure 10) which describes and summarizes our results in a more direct way. Please note, that this figure is a conceptual figure summarizing results showed in figures A3 – A8.

In this figure we show the magnitude of bioturbation impact on sediment redistribution in dependancy to surrounding environment. The impact was estimated using a general additive model as described in section 3.6. The x-axis in this figure describes the impact magnitude of bioturbation on sediment redistribution. The y-axis the relative value of the single environmental parameters. The values are normalized over all climate zones.

Elevation describes the upper, middle and lower part of the hillslope catchment. At high and low parts of the hillslope catchment, bioturbation strongly increases erosion. At middle parts of the hillslope catchment, bioturbation mildly enhance accumulation. Slope is the inclination of the hillslope catchment. Within steeper parts of the hillslope catchment, bioturbation strongly enhances erosion. Otherwise, bioturbation mildly impacts redistribution. At high vegetation cover, bioturbation mildly enhances accumulation. With decreasing vegetation cover, bioturbation strongly enhances erosion. At high surface roughness, bioturbation enhances strongly sediment accumulation. At middle and low roughness, bioturbation mildly impacts redistribution. With increasing connectivity, bioturbation enhances erosion. At low connectivity, bioturbation has no impact on redistribution. Bioturbation enhances accumulation with increasing soil moisture. At low ruggedness, bioturbation had no impact on redistribution. Increasing from middle to high ruggedness, bioturbation enhances erosion. The results are discussed in section 5.2.

Lines 611-620

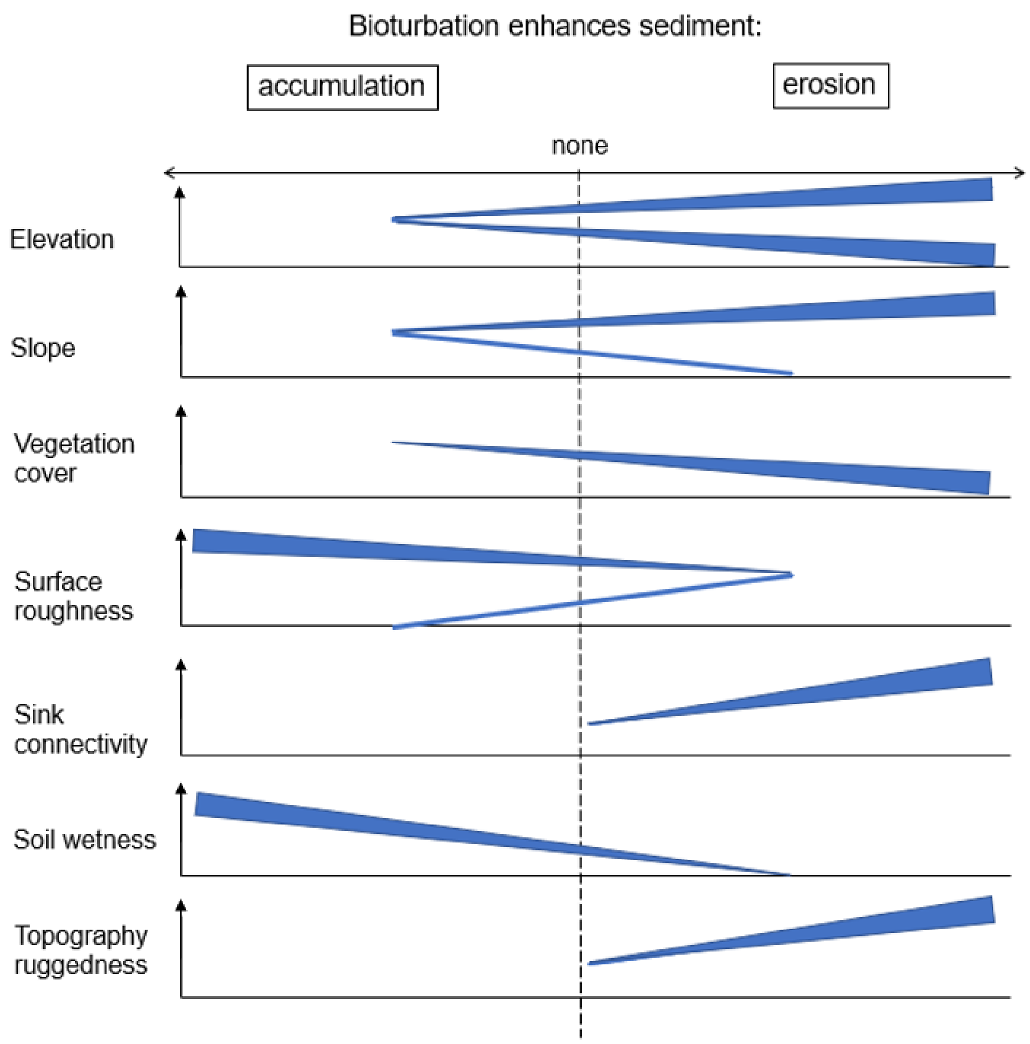


Figure 10. This figure is a conceptual summary of the detailed results from figures A3 – A8. Bioturbation increases erosion or accumulation depending on the values of environmental parameters. The dependencies are the same for all climate zones. The figure is the conceptual summary for all climate zones, therefore, there are no values stated on the x- and y-axes. The x-axis shows if bioturbation increases erosion or accumulation. The y-axis are environmental parameters. Line thicknesses indicate the magnitude of impact. Please note that bioturbation has no impact on sediment redistribution in regions with low sink connectivity and topographic ruggedness. The relationship between the values of environmental parameters and the impact of bioturbation is not linear: Bioturbation can have the same impact on sediment redistribution at high or low values of an environmental parameter, but a contrasting impact at middle values of this parameter (as in this case for elevation, slope or surface roughness).

“For now, I'm left with "bioturbation increases erosion and sediment accumulation":

Here is the list of new findings provided by our study:

a) We compare the impact of bioturbation on redistribution along the climate gradient.

Lines 507-511: The impact of burrows on sediment redistribution was significant in arid PdA, semi-arid SG and Mediterranean LC. Burrows increased sediment redistribution by 137.8 % ±16.4 % in arid PdA (3.53 kg ha^{-1} $year^{-1}$ vs. 48.79 kg ha^{-1} $year^{-1}$), by 6.5 % ±0.7 % in semi-arid SG (129.16 kg ha^{-1} $year^{-1}$ vs. 122.05 kg ha^{-1} $year^{-1}$) and by 15.6 % ±0.3 % in Mediterranean LC (4602.69 kg ha^{-1} $year^{-1}$ vs. 3980.96 kg ha^{-1} $year^{-1}$).

b) We differentiate between sediment erosion and sediment accumulation:

Lines 511-515: Overall, bioturbation increased sediment accumulation in the arid zone (as the magnitude of the sediment excavation by the animal exceeded sediment erosion which occurs during rainfall events), but increased sediment erosion in semi-arid and Mediterranean climate (where animal burrowing activity and rainfall is present). The largest impact was found under Mediterranean conditions. We found no significant effect on redistribution in the humid zone (Figure 7).

c) We compare results at a resolution of a whole hillslope catchment as well at a resolution of a single burrow:

Lines 515-517: However, impact of bioturbation varied throughout the hillslope catchment (Figure 7, 8 and 9) – it depended on a specific context if bioturbation supports sediment erosion or accumulation.

d) Additionally, we provide sufficient information on the sediment redistribution by the animals during the sediment excavation (burrow creation, maintenance, movement of sediment to the surface).

Lines 561-570: The density of burrows was the highest in arid PdA, then Mediterranean LC, semi-arid SG and the lowest in humid NA. Burrows were mostly distributed within groups of several burrows in Mediterranean LC and semi-arid SG, while they were more evenly distributed in arid PdA and humid NA. The burrows were of largest size in Mediterranean LC, followed by arid PdA, semi-arid SG and humid NA. Similarly, the highest volume of excavated sediment at the beginning of the modelling period was in Mediterranean LC and arid PdA. The volume of excavated sediment during the burrow reconstruction after rainfall events was the highest in humid NA, followed by Mediterranean LC, semi-arid SG and arid PdA. The fraction of sediment excavated by the animal to the amount of sediment redistributed during rainfall events was 128 % in PdA, 24 % in SG, 33.5 % in LC and 5.6 % in NA.

e) Instead, we could show that there is a complex interaction of bioturbation, climate and spatial ecosystem complexity. This is illustrated in Fig. 10 and discussed in section 4.4. and 5.2.

Specifically, bioturbation increases erosion with increasing slope, but also bioturbation enhances erosion with decreasing vegetation cover, increasing sink connectivity and topography ruggedness as well as with decreasing soil wetness. Bioturbation enhances sediment accumulation with increasing surface roughness and soil wetness, as well as with increasing vegetation cover.

Detailed comments:

L 110-111: Don't process-based models need to be parameterized for each location? I'm confused by the statement "once calibrated, they can be applied to almost any site"

We rephrased the sentences describing different kinds of models and included section about the parametrization of process-based models:

Lines 122-138: Process-based models are based on a mechanistic understanding of the underlying physical, chemical, and biological processes that govern the behaviour of the system being studied. They must be parametrised for each site; however, these models explicitly represent the governing processes by respective differential equations and simulate the system's behaviour by numerically solving them. Process-based models are generally considered to be more realistic and accurate than empirical models because they capture the fundamental processes that drive the system's behaviour. However, process-based models can be computationally expensive, require more data and knowledge of system properties, and may require complex numerical algorithms for solution process-based (Morgan et al., 1998; ROO et al., 1996; Nearing et al., 1989; Beasley et al., 1980).
Within empirical models, on the other hand, the physical equations are completely replaced by empirically determined equations which only hold for the specific area they are derived for. These models are generally simpler, less computationally expensive, and require more data and knowledge of system properties than process-based models. However, empirical models also tend to be less accurate than process-based models, particularly when applying beyond the range of data used to fit the model. In contrast to physical-based models, empirical models may not be applicable to new or different conditions, as they are based on observed relationships and do not capture the underlying processes that govern system behaviour. (Wischmeier and Smith, 1978; Williams, 1975; Renard et al., 1991).

L 140: What does high spatial and temporal resolution mean? Can you quantify? Do you need to model variability with depth? Later in the paragraph you mention 0.5 meter resolution and daily time step - are those minimums? Maximums? One person's high resolution can be another person's low resolution. In other words, the definition of high resolution can vary among readers. In Figure 1, is the scale bar in the lower right the same for b - d?

We answered all the stated questions as follows:

"What does high spatial and temporal resolution mean? One person's high resolution can be another person's low resolution. In other words, the definition of high resolution can vary among readers."

We removed the misleading wording from the introduction.
Lines 160 - 162: For this, bioturbation has to be included into erosion models at a spatial resolution which allows to imitate the surface processes occurring within and near the burrow, and at a temporal resolution which captures the animal daily burrowing behaviour.

"Can you quantify? 0.5-meter resolution and daily time step - are those minimums? Maximums?"
0.5 m spatial resolution and daily time step was the minimum resolution for us.

"In Figure 1, is the scale bar in the lower right the same for b - d?"
We included the description regarding the scale bar into the figure captions:
Line 211: The scale bar is the same for (b), (c), (d) and (e).

L 246 What is "above-ground skeleton."

Rocks are located on the surface. We included this definition into the manuscript and adjusted the wording.
Line 266: We estimated the rock coverage on the surface.

L 261: How is dm different from Sd? If they are the same, I think you should probably use the same symbol. Isn't equation 4 the ratio of non-organic matter, because Sc has the organic matter burned out?

We used Sd to calculate bulk density and dm to calculate soil particle density. Bulk density describes the density of a soil volume including pores, whereas to calculate soil particle density, we estimated the density of soil volume excluding the pores. Sd is thus soil volume including pores, dm is soil volume excluding pores. We included this explanation to the manuscript:

Line 281: dm [g] is the dry mass of soil particles excluding pores.

We also corrected equation 4, to calculate the percentage of organic matter instead of non-organic matter (Line 281):

$$OM = 1 - \frac{Sc}{Sd} \quad , \qquad (4)$$

L 292, 293 : I don't know what the equations for TPI and TRI are, or what they represent. It might be good to at least describe them.

We explained the meaning and calculation of TPI and TRI:

Lines 313 - 317: The TPI subtracts the mean elevation of pixels in a specified range from the elevation of the central pixel. Positive values represent hills while negative values represent valleys. The TRI adds together the elevation differences between a grid cell and its eight neighbours. It measures the relative level of topography irregularity, the higher the value, the more irregular the topography.

L 364 : I'm a bit confused about the depth aspect of the model. Is this a 2-D or 3-D model? When you write that you include vertical movement of sediment particles, does that mean you are keeping track of the density of the subsurface? Or are you just piling loose material on the surface of the hillslope?

Yes, we did include vertical movement of sediment particles and we adapted the density of soil accordingly. This included subsurface soil density and density of soil excavated to the surface. We added an explaining sentence to the manuscript:

Lines 410 - 413: For this, we adapted the density of soil, the topography and vegetation cover accordingly. We created a 3D-model of the burrow structure, adjusted subsurface soil properties and properties of soil excavated to the surface; the removed vegetation within the pixel with a predicted burrow and decreased adjacent vegetation cover.

We do not keep track density of the subsurface.

Section 3.5 I don't understand how parameters were chosen for each of the individual cites. You describe a sensitivity test in the first paragraph of Section 3.5. In the second paragraph on validation, there is nothing about what parameters were chosen, besides the different bioturbation experiments.

For the sensitivity tests, you "stepwise changed the input parameter values" (L 382). Table A2 shows the results of the sensitivity analysis. But isn't there co-variance among the parameters? And are all the relationships between parameter change and erosion change linear? It's impossible to tell that from this table. Also note in Table A2, I think some of the parameter values need units. Erosion also needs units.

You then refer to Fig. A2, ("To quantify the significance of the input variations, we conducted a t-test (Fig A2).") but this seems to me like a spread of variables for each site. I guess I didn't understand Fig. A2, and maybe that was critical for understanding the sensitivity analysis?

We rewrote the paragraph regarding sensitivity test (Lines 435 - 441):

We conducted a sensitivity test to identify the input parameters, which significantly influence the model output. For this, we first estimated the mean value of each input parameter. Then, we created an artificial hillslope catchment of 100 m * 100 m. To start the test, each pixel received the mean value of each parameter. We ran the model for one rainfall event. Then, we stepwise changed the single input parameter values from their minimum to their maximum values while we did not adjust any other parameters. To quantify the significance of the input variations, we conducted a t-test (Table A2). For this, we compared the amount of redistributed sediment of each model run to the first model run.

We addressed points made in this paragraph as follows:

"<u>How parameters were chosen for each of the individual cites</u>."
The parameter set used within the model is the same for each site. The spatial parameter values were estimated hillslope catchment – wide by applying machine learning (see section 3.4.2). No selection of input parameters used later within the model was done during the sensitivity analysis or elsewhere. The spatial parameters required by the model were all used.

"In <u>the second paragraph on validation, there is nothing about what parameters were chosen."</u>
During validation, we did not choose any parameters. We always ran the model including all parameters listed in table 1. For validation, we compared the sediment redistribution estimated by the model with the amount of sediment collected in the field within the fences.

"<u>Isn't there co-variance among the parameters?"</u>
Yes, there is some co-variance between the parameters (see Fig. A10), especially between the initial and saturated water content; between water content and vegetation cover; and between clay content and field capacity.

We included following into the manuscript (Lines 410-474):
There was correlation between some of the spatial model parameters (Fig. A10), especially between the initial and saturated water content; between water content and vegetation cover; and between clay content and field capacity. However, a high correlation between spatial parameters does not mean that these parameters impact the sediment redistribution in a similar way.

Line 842:

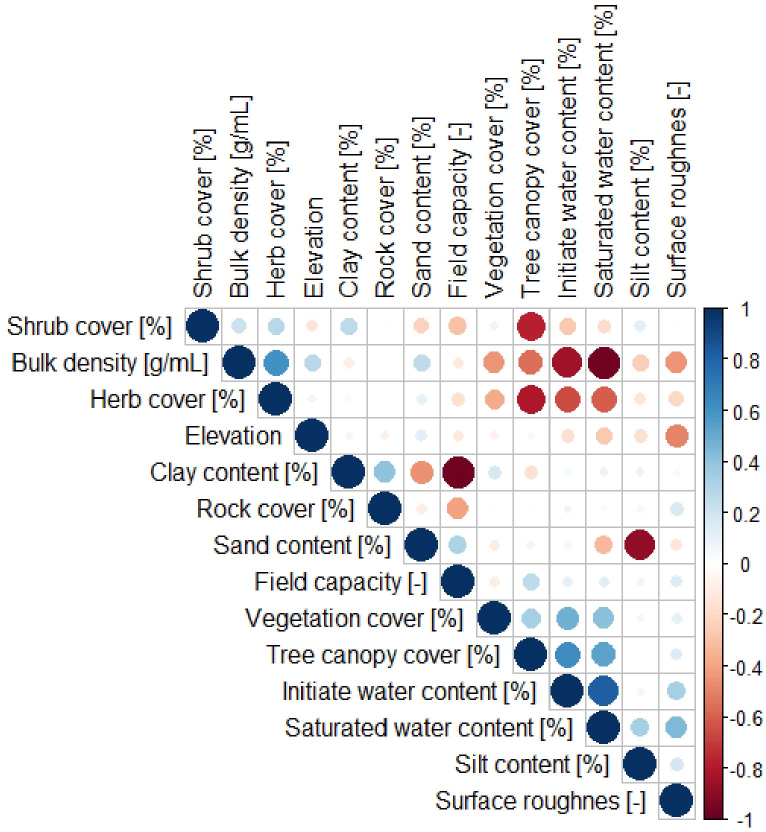


Figure A10. Correlation matrix between the model input parameters.

<u>"And are all the relationships between parameter change and erosion change linear?"</u>

No, the relationship is not linear, but rather exponential. However, it depends on the parameter (Fig 1). We created a figure (see below) but did not included it into the manuscript for now.

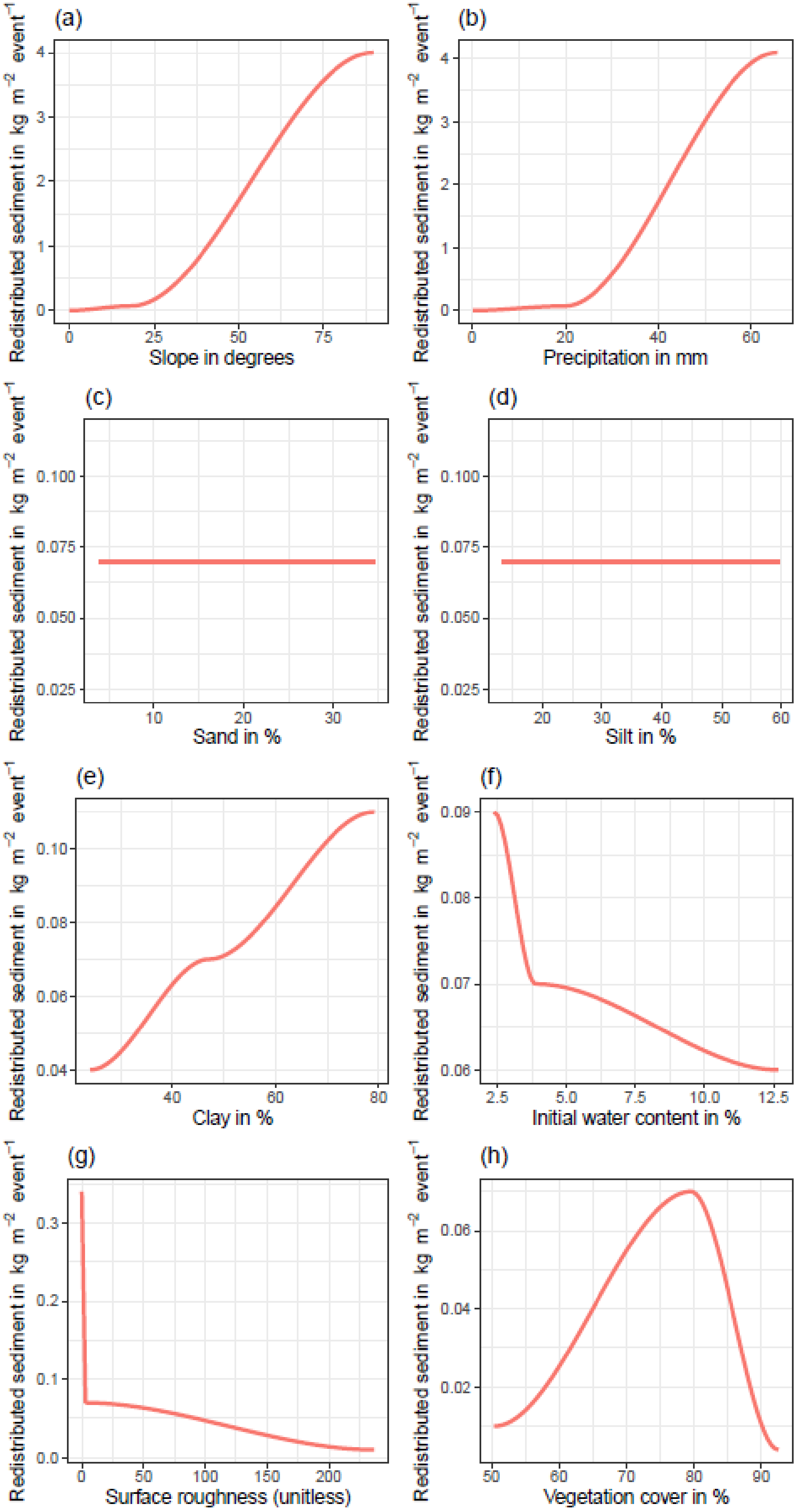
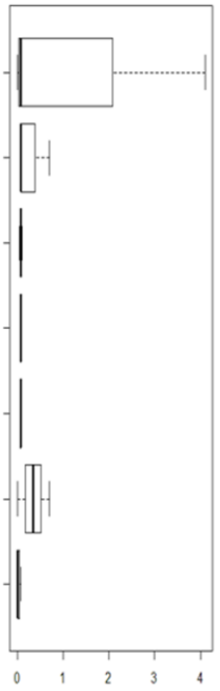


Figure 1. Impact of input parameters on modelled sediment redistribution. Only significant parameters are shown. The test was done by running one rainfall event.

“In <u>Table A2, I think some of the parameter values need units</u>.”

We updated Table A2 (Lines 756 - 762):

Parameter	mean value	min value	max value	mean erosion [kg m^{-1}]	Min erosion [kg m^{-1}]	Max erosion [kg m^{-1}]	Erosion [kg m^{-1}]
Precipitation [mm rainfall event^{-1}]	19.9	0.2	65.6	0.07	0	4.1	
clay content [%]	10.61	3.87	34.64	0.07	0.07	0.07	
silt content [%]	38.49	13.32	59.59	0.07	0.04	0.11	
sand content [%]	47.04	24.13	79.17	0.07	0.07	0.07	
water content [%]	3.87	2.38	12.68	0.07	0.09	0.06	
roughness [-]	0.97	0	236.8	0.07	0.34	0.01	
vegetation [%]	79.54	50.38	92.48	0.07	0.01	0.004	
Slope of DEM [°]	18.2	0	89.78	0.07	0	inf.	



“<u>You then refer to Fig. A2…</u>”

We apologize, we meant Table A2.

Line 407, 408 - Couldn't a positive value also mean that bioturbation reduced erosion in comparison with no bioturbation? Is that possible?

No, this is not possible, as it would still mean that overall, the accumulation was increased more by bioturbation than erosion was reduced. We enhanced the paragraph in the manuscript as follows

Lines 457 – 461: Within each pixel, two processes are happening simultaneously: a certain amount of sediment erodes, and a certain amount of sediment accumulates. To estimate the sediment redistribution for each pixel of each model run, we estimate which of these processes dominated. Positive pixel values thus mean, bioturbation enhanced sediment accumulation, negative pixel values mean, bioturbation enhanced sediment erosion.

Line 417 "We quantified the model performance ..." this implies to me that your sensitivity test is your calibration. Is that correct? And if you are only varying one parameter at a time, how do you find the optimal value for all parameters?

No, that is not correct. The optimal value for all parameters for each pixel within the hillslope catchment was predicted by applying machine learning, see section 3.4.2.
Lines 365 - 366: For spatial parameterization of the DMMF model, we upscaled land cover, soil properties and burrow distribution onto the hillslope catchments using machine learning techniques.
The sensitivity test was done afterwards, to test the impact of single input parameters on model output:
Lines 435 - 436: We conducted a sensitivity test to identify the input parameters, which significantly influence the model output.

L 444 - How can you accumulate more sediment than you erode? Where does the sediment come from?

The line you're referring to, states: "In NA, LC and SG, the erosion processes dominated, while in PdA, more sediment accumulated than eroded."
We included the sediment excavation onto the surface by the animal into the model. The excavation was rainfall- and season dependant. In the arid PdA, more sediment was excavated throughout the year than eroded during the rainfall events, due to high sediment excavation rate by the animals, low frequency of rainfall events and low precipitation rate.

L 445 - 447: These numbers need some context for me. I don't know (i) how significant a 15.6% rise in erosion rate is? (ii) What does this mean for the landscape? (iii) And aren't there error bounds in these numbers, because isn't there a whole suite of parameter values that can be tested with and without burrows?

We added following paragraph:

For (i), how significant is a 15.6% increase:
Lines 666-678: Our study found an increase of erosion in the semi-arid and Mediterranean climate zone to be between 6.5 % and 15.6 % due to bioturbation. Previous studies found that already a small increase of erosion has significant impacts on the whole hillslope catchment.

For (ii), what does this mean for the landscape:
Lines 678-680: A 10% increase in erosion rates over a 10-year period can lead to significant changes in the landscape, including e.g. a 20-30% reduction in soil thickness and an increase in sediment transport in nearby rivers (Kuhn 2016).

For (iii), we added the error bounds:

Lines 507-511: The impact of burrows on sediment redistribution was significant in arid PdA, semi-arid SG and Mediterranean LC. Burrows increased sediment redistribution by 137.8 % ±16.4 % in arid PdA (3.53 kg ha^{-1} $year^{-1}$ vs. 48.79 kg ha^{-1} $year^{-1}$), by 6.5 % ±0.7 % in semi-arid SG (129.16 kg ha^{-1} $year^{-1}$ vs. 122.05 kg ha^{-1} $year^{-1}$) and by 15.6 % ±0.3 % in Mediterranean LC (4602.69 kg ha^{-1} $year^{-1}$ vs. 3980.96 kg ha^{-1} $year^{-1}$).

From Figure 5a, it looks to me like there is a lot of overlap in sediment redistribution rates between the with and without bioturbation. I'm not sure I understood figure 5a though. Is each dot from a pixel on the landscape? How do we know how the dots align with each other? That is, what are the comparative values at a point with and without bioturbation?

Thank you for this interesting suggestion. We created a new figure in which we compare the model output values pixel-wise. Lines 540-553:

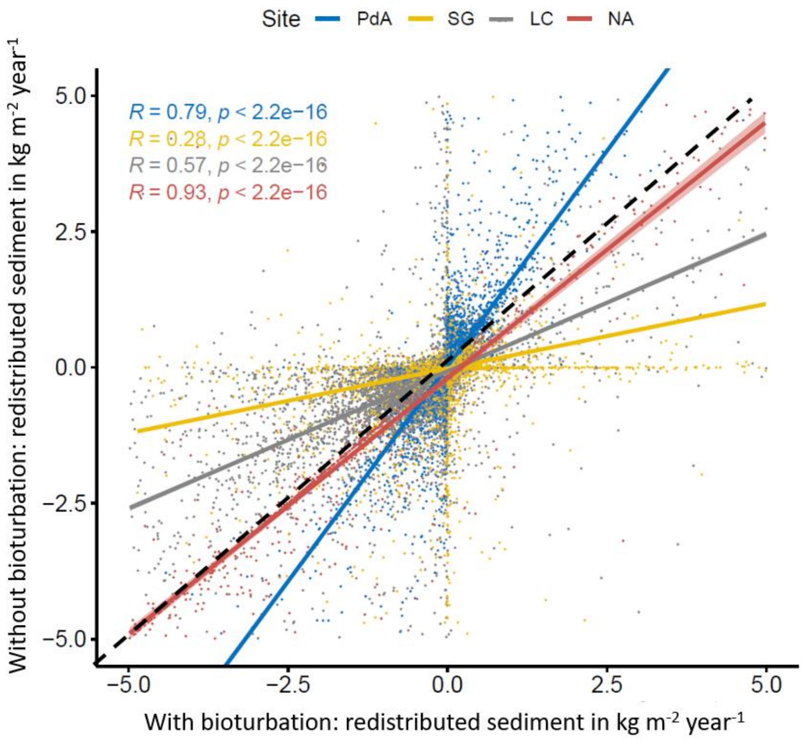


Figure 7. Comparison of the model outputs with and without bioturbation of each pixel (0.5 m) in all study sites. The x-axis shows the output of the model with bioturbation, the y-axis the model output without bioturbation. PdA is arid Pan de Azúcar, SG is semi-arid Santa Gracia, LC is Mediterranean La Campana, NA is humid Nahuelbuta. Points represent single pixel values; lines show linear regressions for the sites. The lower R, the higher the impact of burrows on sediment redistribution at the resolution of 0.5 m. The black dashed line symbolizes a perfect correlation – along this line the bioturbation would have no effect on sediment redistribution. Bioturbation lead to more accumulation if the regression line representing results from a particular climate zone is steeper than the perfect correlation line. Bioturbation lead to more erosion if the regression line representing results from a particular climate zone is flatter than the perfect correlation line. Bioturbation increases sediment accumulation in arid

PdA (through the high burrowing rate, more sediment is accumulated on the surface than eroded during rainfall events). Bioturbation increases sediment erosion in semi-arid SG and Mediterranean LC. Absolutely, the highest impact on sediment redistribution is in the Mediterranean climate zone. The lowest impact is in the humid zone.

We expanded the manuscript by one paragraph to describe this figure:
Lines 515-518: We found no significant effect on redistribution in the humid zone (Figure 7). However, impact of bioturbation varied throughout the hillslope catchment (Figure 7, 8 and 9) – it depended on a specific context if bioturbation supports sediment erosion or accumulation.

Figure 6 - In general I think plots like this one are better with binned rather than gradational color schemes. In other words, distinct colors for erosion in contrast to accumulation. Same could be said for Fig. 7.

We changed the color scheme in the figures from gradational to binned. Erosion and accumulation, do, however, have distinct colors – erosion from yellow to red, accumulation from yellow to blue. We would not want to use only one color for erosion and one color for accumulation, as such presentation would not allow to see the magnitude of erosion and accumulation. We also did not use two separate bars in figure 7, as this figure shows the difference between the modelled erosion and accumulation and must thus include negative and positive numbers.

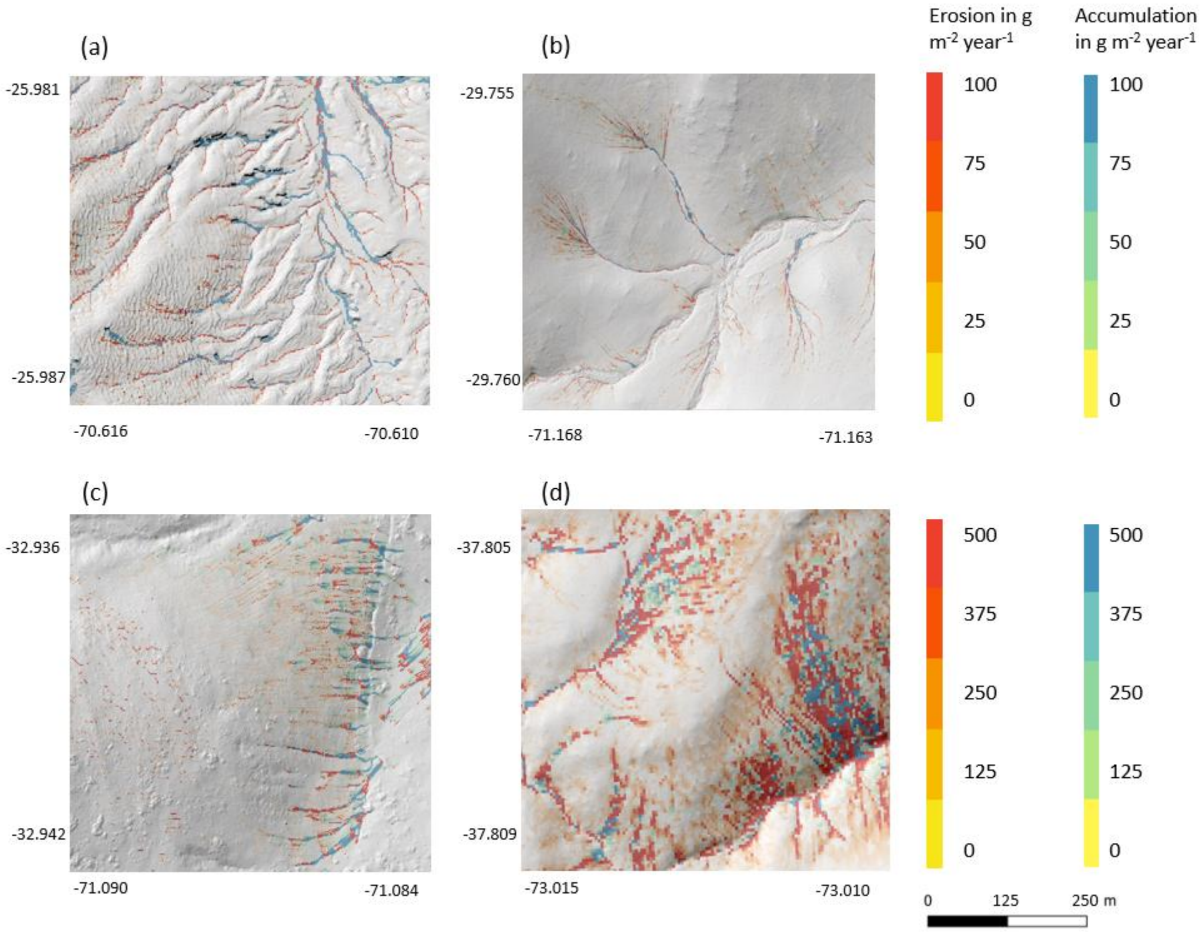


Figure 8. Hillslope catchment-wide predicted sediment redistribution. Colours indicate sediment redistribution. Grey shadows indicate the hill shading calculated from LiDAR data. (a) Pan de Azúcar, (b) Santa Gracia, (c) La Campana, (d) Nahuelbuta.

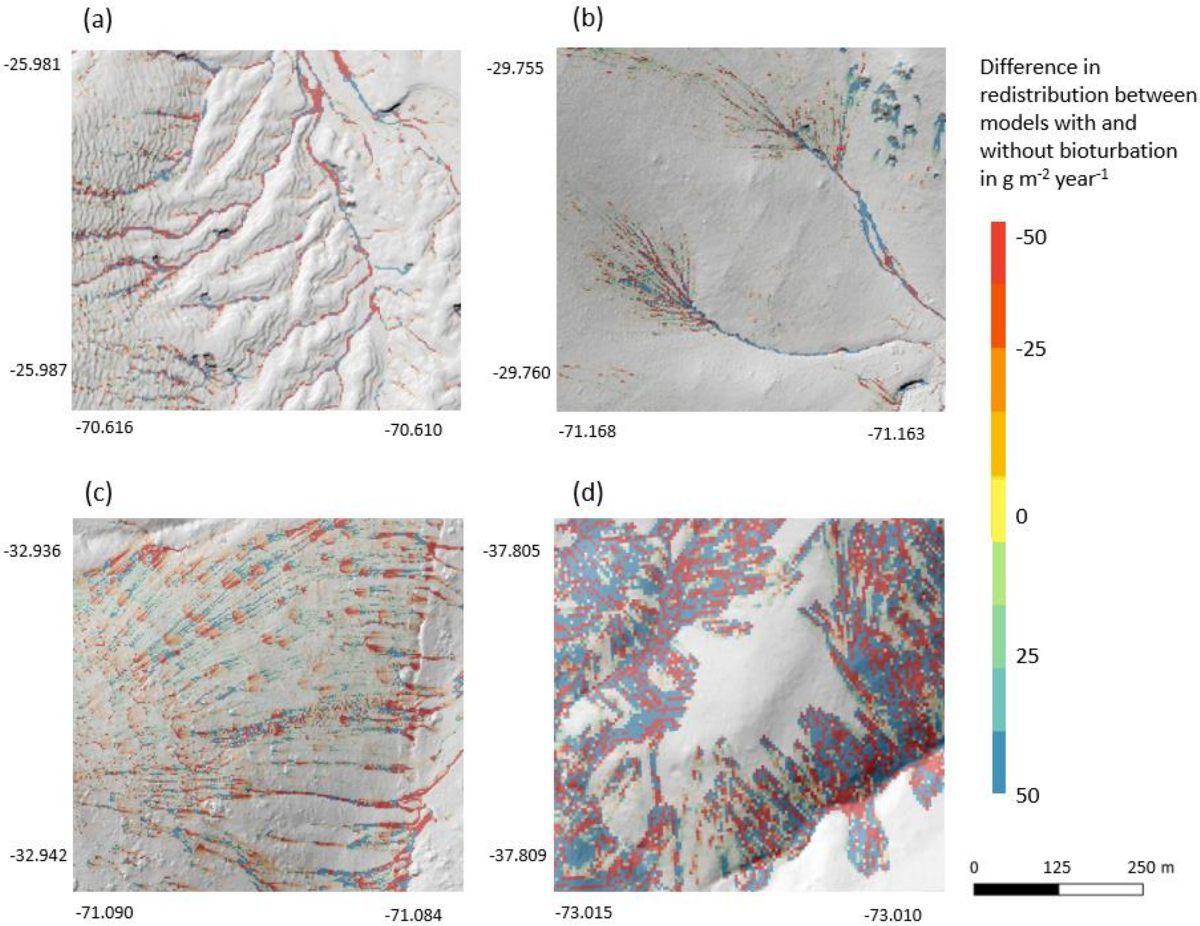


Figure 9. Hillslope catchment-wide impact of bioturbation on sediment redistribution. The colours indicate the direction and strength of the impact. Positive values indicate bioturbation enhanced sediment accumulation, negative values indicate bioturbation enhanced sediment erosion. Grey shadows indicate the hill shading calculated from LiDAR data. (a) Pan de Azúcar, (b) Santa Gracia, (c) La Campana, (d) Nahuelbuta.

L 556 It might be helpful to explain a bit more about what the settings of these other studies. I don't know anything about those studies so I don't know if their methods were similar to yours. L 563: I would be very cautious about comparing bioturbation results with other studies. I would guess that bioturbation impacts erosion almost everywhere, but the degree that it impacts erosion probably varies a lot based on local variables and parameters. So comparing between different settings should probably be done with more context.

Lines 637-647: We compared the modelled impact of bioturbation on sediment redistribution with the impact of bioturbation estimated in previous studies conducted in location with similar climates. In the humid zone, our model predicted an erosion up to 3.5 kg m^{-2} year^{-1}. This estimation is in line with erosion rates due to bioturbation established by in-situ measurements in other studies conducted in temperate climate zone (between 1.5 kg m^{-2} year^{-1} and 3.7 kg m^{-2} year^{-1}) (Black and Montgomery, 1991; Yoo and Mudd, 2008; Yoo et al., 2005; Rutin, 1996). This also confirms the reliability of our approach. Previous authors estimated the impacts using rainfall simulators, erosion pins or splash boards. The measurements were conducted for a time period between 3 months and 3 years and the sites were revisited for each estimation. We do not compare our results with studies which previously applied models to estimate impacts of bioturbation, as, to our knowledge, none of the previous studies integrated vertebrate burrow structures into a soil erosion model and ran the model on a daily basis.

In the last part of your review you commented on Table 3. As we agree that this table is confusing, we decided to combine table 3 with figure 8, and created a new figure which describes and summarizes our results in a more direct way. It is this figure which we described in the beginning of our rebuttal letter.