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Earth Surface Dynamics Discussions

Interactive comment on "Controls on slope-wash erosion rates in the Mojave Desert" *by* O. Crouvi et al.

Anonymous Referee #2

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General comments This paper uses a classical approach of 137Cs as tracer to identify soil erosion rates. The paper is overall well-written, although it could overall be much more concise.

The principal added value of this paper is that it provides hillslope erosion rates for relatively understudied arid lands at decadal timescales. The results confirm previous findings from semiarid regions regarding the role of rock fragment cover on soil erosion rates and the interaction with slope gradient. Scientific progress obtained through this is limited to confirmation of well-known processes for slightly different climate conditions.

The paper can potentially have a much higher impact if the authors put their results in perspective by comparing and combining them with those findings under other climate

and land cover conditions to be able to make further reaching conclusions about the driving forces behind soil erosion processes. Moreover, it would be interesting to add further discussion on the relevance of temporal scale of assessments and the interaction between soil erosion and soil formation processes (including soil disturbances). Also, the fact that higher rock fragment cover on steeper slopes is potentially an artefact of previous higher soil erosion rates on those steep slopes is not sufficiently elaborated by the authors (see for example Govers et al 2006; Poesen et al., 1998).

The authors argue that they evaluate the factors determining soil erosion rates, but given the rather homogeneous land cover, lithology and climate between their study sites, in fact the paper only evaluates the relative role of rock fragment cover versus slope characteristics. The impact of these two factors may be completely over-ruled by other factors such as lithology, vegetation or climate, but we can't say that based on your results.

The author's justification of this study builds strongly on the argument that there are few data on erosion rates from arid regions around the world. While arid lands may be understudied for assessments of hillslope soil erosion rates, the paper would benefit from a more critical and in-depth discussion of those data that are available for arid lands around the world (see specific comments below) and contrasting them with data under more humid conditions. That may help to highlight the role of climate and provide an added value to your paper.

It may also be interesting to include reference from the introduction and discussion section to the recently published pan-European database of soil erodibility that specifically accounts for stoniness, and highlights its strong reducing effect on soil erodibility (http://eusoils.jrc.ec.europa.eu/library/themes/erosion/Erodibility/).

There are several concerns about the methodology. Several of the replicate profiles taken at few meters distance show very different Cesium inventories (Figure 2), also for example for reference profile GM2. The author's explanation for this is that erosion

rates are spatially very variable. However, there could be other explanations as well. It is not clear how you dealt with this and it potentially puts some serious doubts on the interpretation of your results. In relation to that, it would be interesting if you could discuss the assumptions made for Cesium as a tracer to assess soil erosion rates (see Parsons and Foster, 2011), and how these may affect your results.

Further, it is not clear from the methodology how rock fragment cover was determined. It somewhere mentions that rocks larger than 0.5m were counted, somewhere else it is mentioned that fractions > 2mm were considered as rocks?

I am not convinced by the added value of paragraph 3.4. What exactly do these results tell us and how are they complementary to the Cesium results? It is not clear to me why greater heterogeneity in the degree of calcic soil development, higher soluble salt contents and less weathered C horizons in more gently sloping sites should be related to higher observed soil erosion rates. The authors suggest that these are indicators for higher runoff and therefore higher soil erosion rates, but convincing arguments or data to support this are not provided.

The discussion section is very chaotic and difficult to follow. Splitting up the discussion paragraph in 2-3 sub-paragraphs would make it a lot easier to read and extract the main messages. The whole discussion section can be reduced by about 50% by being more concise and bringing in more structure. You now bring the same message several times.

Specific comments

The abstract can be written more concise.

L16-18: how do you explain the higher rock fragment cover for the semiarid sites as compared to arid sites?

P537L4: what about erosion plots? Probably the most widely used method.

P537L9: you may want to add reference and discussion of results presented in Van-

maercke et al (2012; 2014) and Cerdan et al (2010).

P537L9-12: This is not only the case in (semi-)arid regions, but generally valid for erosion processes.

P537L18-20: Indeed that is also why the USLE and most other models use the C and K factor to describe soil erodibility and protection by land cover.

P538L17-19: The paper would benefit from better discussion and reference to the results of work done by previous authors in arid lands like, Yair, Lavee, Sarah, and others (see reference list for some suggestions).

P538L21-23: Where does this characterization of arid regions come from? Is soil thickness and rock cover more variable than in semiarid areas? Is rainfall of higher intensity than in any other area?

P538L26-28: So you mean to say that studies based on cosmogenic nuclides represent average rates of large drainage areas and are therefore not suited to obtain information on slope and soil surface characteristics, which justifies your study based on Cesium 137? Please explain this.

P539L1: moreover, I assume we would like to know which factors determine these soil erosion rates.

P539L14: please explain where this dust comes from. You refer to higher wind erosion rates? If these are so high, how does this affect your water erosion assessments? Maybe part of your estimated water erosion is actually wind driven? This might explain that steep slopes exposed opposite to the dominant wind direction result in lower erosion rates than flat terrain exposed to any wind direction?

P539L12-14: Can you explain how hypothesis 1 relates to the classical Langbein and Schumm (1958) curve suggesting a maximum erosion rate around about 300mm of effective annual rainfall, with decreasing erosion rates below that threshold due to a lack of rainfall to provoke high erosion rates?

P539L15-16: I am not sure if we can say that erosion rates are 'mainly' controlled by rock coverage in semarid regions. Indeed rock coverage plays an important role, but so do vegetation cover, lithology, rainfall intensity and duration characteristics. So maybe trim down the statement somewhat or simply refer to the relative role of rock coverage as compared to slope gradient.

P539L18-20: What about vegetation cover, generally considered one of the most important factors controlling erosion rates? Or is your study limited to controlling factors under equal vegetation cover? Your objectives suggest you will also include the role of vegetation cover, but apart from the numbers is Table 1, no analysis are performed with vegetation cover.

P539L21-23: What exactly is 'floral bioturbation'? In fact, the cited paper by Kaste et al (2007) seems to suggest that physical soil mixing (bioturbation) was found to be an important process in some of their study sites (grasslands in California). So, how does this support your assumption that floral bioturbation is not expected to be of relevance for the evaluated timescales?

P539L24-25: what about wind erosion here?

P539L25: what is meant by 'erosion by colluvial processes'? You mean deposition processes and interpret that as a negative erosion process? Please clarify.

P540L15: what is meant with residuum?

P540L27: what does the 50-100% stand for? The % of sediments with Aeolian origin? The same for the 11-33% later on? What does this mean?

P541L14: It is interesting that you included a less weathering resistant lithology in case soil formation rates might affect trends in your soil erosion rates. However, this aspect is not dealt with in your paper so it remains unclear why you included this less weathering resistant lithology and what is the added value.

P542L2: so what about wind erosion deposits?

P542L15-20: method used to assess rock fragment cover is unclear. Why were only rocks larger than 0.5 meters (diameter?) included? How was rock fragment cover determined 'visually' in the other two sites with less rocks? Both methods seem to be 'visual'?

P542L20: what characteristics of vegetation cover were determined? The type of vegetation, surface cover, how was this done? What did you do with the information?

P543L5: So everything larger than 2mm is considered to be a rock fragment? That is a very low threshold! How does this compare with rocks larger than 0.5 meter above?

P544L23: what kind of LiDAR? Airborn, groundbased?

P544L25: can we expect these animal burrows to affect our bioturbation and Cs profiles?

P545L9: gird=grid

P545L20: why is it that we see higher values in Figure 2 (over 800 Bqm-2)?

P546L5: the large variation between replicates at the summit position is especially worrying as this is your reference profile.

P546L10-25: This description of results is a bit chaotic, some information is documented twice (e.g. fact that only in 4 profiles Cs was detected between 3–6 cm), and results could be described more systematic and more concise.

P547L3: it makes sense that if you don't find Cesium, high erosion rates are to be expected, assuming the assumptions of the Cesium methodology are valid.

P547L4: What exactly is the value or information we obtain from an average soil erosion rate per site if variation is so large?

P548LL8 what do you mean by 'high and only minimal erosion rates'? Are they high or minimal?

P548L21: Please rephrase ‘mean value of volume fraction of rocks’. Not clear what is meant now.

P549-P550: Did you also find an A horizon in the profiles with no detectable Cesium? I suppose that the presence of an A horizon would not agree with a high erosion rate (>50t ha-1 yr-1), where I would expect truncated profiles and shallow soils and no A horizon.

P549L23-24: how are cobbles and stones defined?

P551L13-14: Didn’t you just show in your previous paragraph that soil thickness was rather constant?

P551L17-18: Indeed, selection of reference sites is the most crucial step. But how do you explain that only 2 out of 8 summit positions showed useful reference profiles? What happened in the others? What does this tell us about the reliability of reference profiles?

P552L25: simply quantify this by the correlation between rock fragment cover and slope gradient.

P553L4-7: please rephrase this sentence, very difficult to follow. For example what do you mean by ‘slope-velocity equilibrium the develops on slopes’?

P554L4 & L13: slats= salts

P554L13: I am not so convinced by the direct relationship between the absence of a weathered C horizon and high erosion rates.

P554L27: what is colluvial erosion? You mean creep? Also, previously you that wind erosion in these sites may be important.

P555L1: what about concentrated flow erosion? This is often mentioned to be responsible for large parts of total erosion, especially in areas with high intensity rainfall, in areas with high runoff rates etc..

P555L4: bioturbation is likely to act on a shorter timescale than 50 years.

P555L23: what do you mean with ‘diffusion like erosion’?

P555L28-29: Please refer also to these studies in your intro where you stress the absence of studies in these environments. At least mention and discuss all studies available.

P556L4: again, this contrasts your previous statement that wind erosion is not relevant here due to crusts. So, do we have wind erosion and Aeolian sediments or not?

P557L10-12: what is the size of the source area of this study (km2)?

Figure 2: the yellow triangles and numbers stand for Cs inventories (totals over 9 cm depth?)?

Figure 6: what does the +/- values after the erosion rates stand for? Standard deviation based on only 2 numbers?? The EC profiles are unclear/too small to interpret.

Figure 7: why are profiles with no detectable Cs not included, and why would these refer to minimal erosion rates? Wouldn’t this be the other way around (extremely high erosion rates left no Cs in the profile?)?

Table 2: which profiles are included here? All replicate profiles? On figure 2 some profiles show inventory 0, which is not included in this Table.

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