

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

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Received and published: 12 September 2014

We thank Prof. Parsons for the comprehensive review and detailed comments and suggestions that will improve the manuscript. Below we reply and discuss the comments and suggest changes and additions to the manuscript.

Q1: This paper seeks to estimate erosion rates for rocky hillslopes in the Mojave desert. The fundamental problem with the paper is the assumption that all differences between measured Cs137 inventories and the reference sites (2 points) must be due to erosion by water.

A1: We addressed this issue in the discussion.

Q2: 537/1 Given the discussion by Boardman, Pimental's rates may not be the most  
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reliable benchmark.

A2: We agree that the estimations given by Pimental et al. (1995) are not the most accurate ones. We deleted the relevant sentences from the text.

Q3: 537/29 Something of an oversimplification of the finding of Abrahams & parsons, who argued for a peak in erosion rate at c. 12°N as a result of the combined impact of gradient and stone cover.

A3: In the introduction we want to stress the fact that soil erosion rates are not only related to slope gradient but are also related to stone cover. Generally, all the cited papers agree with this argument. Nevertheless, we added the threshold of slope gradient to the text.

Q4: 538/15-25. The distinction between arid and semi-arid is not normally based upon just precipitation but on the ratio of precip to evapotranspiration. The assertions that all arid climates have the same precipitation regime and rates of dust accumulation are demonstrably incorrect.

A4: We did not write that all arid climates have the same rainfall regime and rate of dust accumulation. We stress that generally, arid regions are characterized by certain climatic and surficial properties that differ from semi-arid regions. Anyway, we re-phrased these statements in the text and added citations.

Q5: 539/15 and 24. The addition of dust by aeolian activity is likely also to affect 137Cs inventories at the local scale.

A5: We certainly believe, as we discussed in the original paper and again in the revision, that aeolian accumulation is important in our study site, as demonstrated by Crouvi et al (2013). If such accumulation is assumed to be uniform over spatial scales of 10-100 m at our study site, then relative 137Cs abundances can be used as proxies for slope-wash erosion rates over those spatial scales. However, except for unusual cases in which hillslopes are located very close to a localized aeolian source, the ac-

cumulation rate of dust transported in suspension can be and usually is assumed to be uniform unless the hillslope has a strong gradient in vegetation cover. The slopes we studied have had uniformly sparse vegetation cover since the time <sup>137</sup>Cs was deposited, and significant aeolian sources are ~1-10 km from the hillslopes we studied, i.e. much larger than the 10-100 m scales separating our measurements within each hillslope. As such, we know of no reason why aeolian accumulation rates could have been highly spatially variable at these scales. In the revision we have stated as clearly as possible that we have assumed relatively uniform aeolian accumulation at scales of ~10-100 m. All tracers/proxies require similar assumptions of uniformity in space or stationarity in time. Our study is no different.

Q6: 540/10 Indeed, which conflicts with the notion of the importance of high-intensity rainfall. Some climatic data would be useful here (return periods of varying intensities for example).

A6: We don't see the conflict stated by the reviewer. In any case, we added information regarding average days of high-intensity rainfall.

Q7: 542/3. Accepting 2 of the reference sites simply because they conform to some expectation seems somewhat arbitrary. Surely, the issue is whether or not they could have experienced erosion/deposition or not is the key criterion. Topographically, they exhibit no better qualities than the rejected sites (from the profiles shown). Given the estimates of erosion rates hinge on the validity of these sites, this approach would seem to undermine any faith one might put in the results.

A7: Choosing the reference sites is always a major challenge in Cesium-137 research. We disagree with the reviewer and think that topographic summit no or limited erosion/deposition is the first condition for choosing reference sites. Yet, after sampling and analyzing the potential 8 reference sites we came to a conclusion that we cannot use 6 out of the 8 sites due to their depth profile. Thus, it seems that topographic condition cannot be used as a sole condition for choosing reference site. We also disagree

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with the reviewer and think that the fact that the average reference inventory is similar to a model calculation (based on the coordinates of the study site) strongly strengthen the usage of the chosen reference sites and is not arbitrary, but rather based on the depth profiles as discussed. Finally, we argue in the text that even if our reference sites are not accurate we can expect a constant shift in the absolute values of erosion - this does not affect the validity of the results in terms of the regressions between erosion rates and controlling factors (i.e., slope, rock fragments).

Q8: Tables 1 and 2. It would be more useful to have data for individual sampling sites than just statistics for the transects.

A8: We think that these tables are important as they show the average differences between the sites. Information on the individual sampling sites is provided in the supplementary data.

Q9: 543/22 Is a uniform bulk density justified?

A9: Yes. The standard deviation of the average of 7 samples used is 0.16 g cm<sup>-3</sup>, and thus the coefficient of variation is only 13%. This error has a limited effect on the calculated soil erosion rates. We added the standard deviation to the text.

Q10: 545/1-3 Although you do not say, I presume your soil profiles were of the order of a few 10s of cm across so it is the gradient at this scale that is important, not the hillslope scale, if you are trying to relate erosion rate to gradient. Why could you not have measured the gradient at the same time as digging the soil profiles?

A10: We do write in detail the distance between soil profiles (541/22-24): 20-40 m between topographic positions, and 1-5 m between two profiles within the same topographic position. These scales correspond to the hillslope scale, and thus we used the 1 m pixel Lidar data (after smoothing) to calculate topographic properties.

Q11: 545/13-15 Although sheet erosion is due to raindrop detachment and not flow detachment.

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A11: Sheet erosion requires both raindrop detachment and the transport of the detached particles down the slope by sheetflow. For all but the finest particles (i.e., wash load), erosion is limited by the shear stress /velocity of the sheetflow, not rainsplash detachment. If this were not the case, all particles detached by raindrops (which disturb a soil depth comparable to the mean rainsplash diameter during every storm) would be completely transported off the slope, resulting in erosion rates orders of magnitude higher than what we measure.

Q12: 545/21 You can't calculate a coefficient of variation with 2 points.

A12: We deleted the CV for the reference sites.

Q13: 546/25 et seq Throughout, the assumptions are that a) deposition of <sup>137</sup>Cs is spatially uniform, and b) differences from the reference value are due to water erosion (551/6). Neither seems particularly sound. Deposition on rocky slopes, where rock cover may exceed 50% implies that more than half the initial deposition is onto this rocky surface. Where does this <sup>137</sup>Cs end up? Your own data suggest that wind-blown material can account for up to 100% of soil fines. No consideration is given to these issues. Likewise, no discussion is given to the significance of spatial variation in vegetation.

A13: We added discussion regarding these assumptions in the discussion (see also A5). We assume that the initial Cesium-137 that deposit on the rocky surfaces ends up in the adjacent cracks and/or soil (see also A16). We do not see how this can change the overall trend along the hillslope. Regarding spatial variability in vegetation within individual sites – During our field trips to the study area we didn't identify any clear spatial variation of vegetation along the hillslopes (beside higher vegetation density along the rills at the lower parts of the slope). Moreover, to re-examine this assumption we calculated the Normalized Difference Vegetation Index (NDVI) of ASTER data (15 m pixel) and found no evident spatial variability in vegetation along the specific studied hillslopes.

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Q14: 549 What processes do you attribute these differences in soil thickness to?

A14: A combination of colluvial erosion and slope-wash (see also Crouvi et al., 2013).

Q15: 551/25-27. Yes, but they will affect your claim to have estimates of absolute erosion rates and any subsequent comparisons with other rates.

A15: We agree – the main aim of the paper is to learn on the controlling factors on soil erosion rates. We treat the absolute erosion rates as general values when we compare them to other rates.

Q16: 552/3 Might that not be a result of wash-off from the rock fragments – see comment on 546/25

A16: We do not think that the variability in Cesium -137 can be a result of a local wash-off from rock fragments as we sampled the Cesium-137 from a pit that is 10\*10 cm in size, and we avoided sampling near large rocks (>10 cm). We assume that under these circumstances, the addition of wash off from small rocks (<10 cm) is negligible to a 10\*10 cm size sampling area.

Q17: 557/29-30 The study would be more convincing if there had been data from <sup>137</sup>Cs on deposition in these areas, rather than simply asserting this must be the explanation.

A17: We agree that adding samples from downslope depositional areas would have added more information to this study. Yet, as the main aim of the study focused on estimating soil erosion rates on the hillslope scale, we think that this is beyond the scope of this paper. We use the results of other studies that estimated basin-scale erosion rates to learn on the fate of the sediments further downslope.

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Interactive comment on *Earth Surf. Dynam. Discuss.*, 2, 535, 2014.