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Hydrology and Earth System Sciences Discussions

Interactive comment on "Pertinent spatio-temporal scale of observation to understand sediment yield control factors in the Andean Region: the case of the Santa River (Peru)" *by* S. B. Morera et al.

Anonymous Referee #2

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Land use is well-known to influence catchment sediment yields, with heavily forested areas usually producing smaller volumes of sediment than cleared or poorly vegetated areas. At the same time, reported sediment yields from forested areas vary widely as a function of underlying lithologies and tectonic setting (even for similar rainfall totals). Sediment production in high mountain ranges subject to monsoonal rainfall and seismicity (e.g. the Himalayas *sensu lato*, Taiwan, Philippines) ranks amongst the highest and has been attributed primarily to large-scale mass wasting during extreme rainfall (sometimes in conjunction with seismic activity) rather than adverse land use practices (although quantitative information on mining is scarce). It is equally well-known that the bulk of annual sediment yield is often generated during a limited number of extreme events. The paper by Morera et al. sets out on a valiant attempt to disentangle the complex relationships between various factors known to influence erosion rates and catchment sediment yield (such as rainfall dynamics, slope steepness, geology and land use) for two large catchment areas in the sub-humid to very dry western Andes of northern Peru, an area known to be subject to major fluctuations in rainfall due to the ENSO phenomenon and for which reasonably long-term streamflow, rainfall and sediment yield data are presented. In view of the prevalent mining in the study area (and having seen the adverse consequences of mining in various parts of the Andes) and considering the distinct lack of sound published information on the influence of mining on tropical catchment sediment yields in general, this reviewer had high expectations.

Unfortunately, the authors start on a wrong footing by stating that 'there is almost no published data on specific sediment yield for the Central Andes along the Pacific Coast of Peru' (p. 630, lines 22-23) whereas they further claim that 'the relationships between ENSO, precipitation, runoff, and the sediment transport dynamics of the central Andes are poorly understood' (p.631, lines 6-8). Whilst this may have been true at the time their study (which is based on a PhD thesis defended in 2010) was initiated, there are several examples of long-term streamflow and sediment yield studies in relation to the occurrence of ENSO events for the very same region that should/could have been referred to, if only for comparative purposes. A key example of the latter is the thorough analysis of the role of ENSO events in long-term sediment dynamics in the equally large (17 000 km^2) Catamoya Chira Basin near the border between Ecuador and Peru by Tote et al. (2011) (*Earth Surface Processes and Landforms* 36(13): 1776-1788). In addition, there are reasonably long-term (1987+) streamflow and sedimentation data of high quality (twice daily sampling for suspended sediment) available for the Gallito Ciego Reservoir in northern Peru (draining the 3470 km^2 Jequetepeque Basin). Whilst the latter data may not have been published in the regular scientific literature they must be comparatively easy to come by judged by the fact that various international NGOs are using them (a.o. WWF-CARE International). At any rate, both these examples illustrate the overwhelming influence exerted by (strong) ENSO events on annual sediment yield in the area under consideration. Thus, taking these recent relevant findings into account may help the authors to narrow the scope of their study somewhat and to focus more on disentangling the relative importance of the various factors influencing erosion rates and sediment production, notably ENSO occurrence and such key catchment attributes as lithology and land use (presumably most slopes are steep anyway). The Introductory section of the paper wanders all over the place (including repeated emphasis on chemical aspects that is not followed up later on in the paper) and could be shortened by having such a clearer focus (and line of thought). In addition – and this holds for most of the paper – it could do with some serious editing for language. Indeed, much of the paper reads rather like it was simply assembled from the PhD thesis on which it is based.

On a related note, analysis of the paper by Morera et al. is not made any easier by the often convoluted and frequently imprecise style of writing (what to think of the 'Bolivian front size of the Andes' (p. 630, lines 6); 'non-exhaustiveness of. . . data' (idem, line 14); 'plate areas' in the river's longitudinal profile (p.633, line 3); 'annual mass balance of water discharge' instead of 'annual water yield' (p.668, caption to Fig. 6); mixing up stream discharge Q and specific SY in the caption of Figure 8 (p. 670); solid line in Fig. 8 referred to as 'dashed' line and broken line as 'dotted' line; poorly explained summary graphs in Figs. 10 and 11, etc.). Examples of the former include giving ample detail where this is not needed and *vice versa*: e.g. section 2.2 on lithology which contains a number of incomprehensible sentences even to a trained geologist (as a result, the connection to the subject at hand tends to be lost); or section 2.4 on 'slope degree' which does not give any information on slope steepness in the study watersheds (sic!); or section 2.5 on the climatological context which fails to give any information on the variation in annual or wet-season rainfall with altitude or even for the (undefined) 'second climate zone' as a whole, etc., etc.

To this should be added the lack of a clear structure for the paper. Information that belongs in the Introductory or Methods sections (or even Study Area at times) crops up in the Results section (e.g. the classification of ENSO events on p. 640 lines 1-2 and 5-10) and *vice versa* (e.g. Figure 5 showing historic rainfall, streamflow and sediment concentrations series but placed in the Methods section). More seriously, the Methods section lacks an introductory paragraph detailing how the various types of information are combined in a single robust analysis. Instead, there are scattered (and somewhat vague if not confusing) methodological hints in separate sub-sections (e.g. section 3.1, lines 23-25 on linking slope steepness and lithology; section 3.2, lines 6-11 on linking stream SSY to the lithology map and (lines 11-12) once again, slope distribution per lithology. Limitations in the basic data are sometimes discussed (e.g. p. 638 lines 26-28 on gaps in streamflow data) but not quantified (i.e. what fraction of the data is missing, etc.) and sometimes not addressed at all (e.g. reference is made to the use of two rainfall stations at 2500-3300 m elevation whilst the discharge gauging stations are located around 500 m, thereby leaving an altitudinal range of as much as 2000–2800 m uncovered in terms of rainfall inputs! Likewise, contributions by bedload to the overall SSY remain entirely undiscussed although the river beds must be filled with stones of various sizes that are known to be transported during major ENSO events (e.g. blocks of 50 cm diameter crossed the several km Gallito Ciego reservoir in 1997/98 destroying the turbines at the downstream end of the reservoir!). Such issues need to be discussed more fully if the reader is to assess the overall quality of the data-set and thus the robustness of the conclusions.

Despite these criticisms and despite the absence of clear-cut relationships between specific factors and catchment SSY derived in the study the authors seem to be on the right track when indicating the heavily mined Chimu formation as the most likely culprit of the much higher SSY observed for the Tablachaca catchment given the contrast in relative areas between catchments for this formation. This finding might point the way forward for further useful work in the area. A thorough rewriting of the present paper remains a necessity, however, before these results can find their way into the mainstream hydro-geomorphological literature.

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Interactive Comment

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