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Interactive Comment

Interactive comment on "On the potential for regolith control of fluvial terrace formation in semi-arid escarpments" *by* K. P. Norton et al.

Anonymous Referee #1

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In the paper by Norton et al, a sediment routing model coupled with a cosmogenic dating framework provide some important and interesting insights on the role of climate in moderating cycles of channel change over the long term (roughly 50 kyr, in this case). This paper considers regional gradients in precipitation, temperature and denudation, and their influence on soil thickness, and thus the supply of weathered material to the fluvial channel over the course of millennia. As soil production increases during warm and wet climatic phases, there is enhanced delivery of sediment to the channel, prompting episodes of aggradation and thus terrace development during subsequent downcutting of the deposit.

The presentation is clear, and the content is engaging. The dating framework and characterization of the terrace stratigraphy have been presented in previous works

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(e.g. Steffen et al., 2009; Abbuhl et al., 2010, 2011; Bekaddour et al., 2014), and the soil production model has been introduced in Norton et al., 2014. Thus, the key contribution of this paper is a real-world application of the soil thickness model, and a 1-D coupled hillslope-river routing model that assesses the balance of sediment supply and transport capacity along the length of the channel, from the Peruvian Altiplano to the coast.

Specific Comments

The key finding that emerges from this is that there is a region, upstream of the valley terrace deposits, wherein the balance between supply and capacity would tip toward incision, during phases where the hillslope supply was exhausted, or toward deposition, during pluvial phases where the abundant supply exceeds transporting capacity. This would appear to be a reasonable supposition, and is in good agreement with field observations.

The routing model uses a raster accumulation algorithm, summing hillslope inputs to the channel at each 1-km node along the trunk river corridor. A transient hillslope model is proposed, that captures alternating phases of stripping of the hillslope regolith during wet phases, followed by incision once the hillslopes have shed most of their weathered regolith, and supply is reduced.

I propose that this paper needs to take more explicit consideration of parameter variability within the 1-D model. It would be appropriate to include a section (or expand existing sections) that more rigorously considers the potential range of input variables, which can then be used to produce an ‘envelope’ of plausible model outputs. The finely detailed ‘transport capacity’ line, for instance, in Figure 7 surely possesses some important uncertainties.

Given the long timescales of climate cycles (∼10ˆ4 years), many aspects of channel response may justifiably be ignored, however, the sediment transport capacity model is vitally dependent on specification of channel slope, width, flow depth and grain size. It

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would be of interest, then, to comment on the effects of dynamic adjustments of channel slope, planform morphology, sediment storage, grain size and hydraulic resistance that would surely accompany large-scale (many 10s of vertical meters) aggradation or degradation of a valley fill. For instance, if the deposit were building up over time, channel slopes would be reduced, the width/depth ratio would increase, and the overall resulting transport rate is likely to be reduced. It may also be worth noting potential interactions and feedbacks between the channel, landslides, and hillslope undercutting (see, for instance, recent papers by Roering et al., 2015 and Bilderback et al., 2015). I don't expect this changes the principal findings, but it is important to indicate these factors.

Finally, the authors employ mean annual rainfall to drive the simplified channel hydraulics. Given the non-linear relationship between sediment transport and channel flow, it would be desirable to compile the statistics of extreme events, assume some intermittency of these events (presumably changing with climate cycle), and use this to drive the model. One could then assess the impact of this modified frequency-magnitude assumption on model results.

In sum, I found this to be an illuminating modelling study of climate's role in moderating the bedrock/alluvial transition across a steepland landscape with notably spatially varying rates of regolith production. Some further consideration of the modelling assumptions and the range of parameter variability would provide important bounds on the estimates of the location of the bedrock/alluvial transition.

Technical Corrections:

P.717 L.19: "Altiplano"

P.717 L.26: Willett et al, 2014 are not in the references.

P.717 L.27: Simply: "The sediment transport regime in the Rio Pisco is currently under capacity.." or slightly clearer phrasing here?

P.718 L.6: Bekaddour et al., 2014 is not in the references. Also, Bekaddour has two 'k's and one 'd' in Figure 8 caption.

P.718 L.9: Litty et al., 2015 are not in the references.

P.722: Equation 2 should indicate the value used for the 'a' constant. Equation 3 uses a Manning-type equation to evaluate shear stress ('n'), while Equation 4 for the critical threshold shear stress uses a Strickler-type equation ('D50'). Given that skin friction is effectively incorporated as one composite element within the 'n' term, it would be best to use either one framework or the other, for consistency.

P.725 L.11: "striping" should be "stripping"

P.725 L.12: "drop of" should be "drop off (in the rate) of"

P.727 L.27: "knickpiont"

Figure 1 and 2: It would be enlightening to see the primary data points for the contours (Fig 1) and the trend line (2c). "Downstream distance" should be "Upstream distance"? (Also in Figs 3,5).

Figure 3: The points overlaid on the long profile in 3a are indistinguishable; perhaps a finer line weight and greater vertical exaggeration might bring them out.

Figure 7: Provide some explicit indication of the significance of the colours in the graphs (pink, brown, green).

Roering, J. J., Mackey, B. H., Handwerger, A. L., Booth, A. M., Schmidt, D. A., Bennett, G. L., & Cerovski-Darriau, C. (2015). Beyond the angle of repose: A review and synthesis of landslide processes in response to rapid uplift, Eel River, Northern California. Geomorphology, 236, 109-131.

Bilderback, E. L., Pettinga, J. R., Litchfield, N. J., Quigley, M., Marden, M., Roering, J. J., & Palmer, A. S. (2015). Hillslope response to climate-modulated river incision in the Waipaoa catchment, East Coast North Island, New Zealand. Geological Society of

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America Bulletin, 127(1-2), 131-148.

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