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Interactive comment on “Short Communication: Earth is (mostly) flat, but mountains dominate global denudation: apportionment of the continental mass flux over millennial time scales, revisited” by J. K. Willenbring et al.

Anonymous Referee #3

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This Willenbring et al. 2014a paper addresses two fundamental errors in their Willenbring et al. 2013 paper published in GEOLOGY. The original paper generated much press as its hypothesis flew in the face of 50 years of scientific literature, based on field evidence, laboratory experiments, numerical models, and theory. The original paper concluded that the flat areas of the Earth contributed ~90% of the sediment delivered to the sea. That assertion did elicit a Comment (Warrick et al., 2013) that outlined five broad categories of problems with the original paper: 1) Mixing two related but different concepts: “gross” basin denudation and river sediment discharge; 2) global gross

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denudation likely an order-of-magnitude greater than the 4.4 Gt/yr stated; 3) important data gaps in both flat and steep landscapes; 4) ignoring decades of previous research and the basic principles of physics; and 5) conceptual and technical problems including misrepresenting watershed sizes, no assessment of uncertainty, no corrections for floodplain storage, and elimination of data based on a basin size threshold rather than a morphologic threshold. The Comment elicited a Reply (Willenbring 2014a) that acknowledged that they had misrepresented results, calculation errors, and faulty conclusions.

This new submission, Willenbring et al. 2014b, repeats the points raised by Willenbring 2014a and provides a clearer view of some of the original errors discovered in their first paper. However the authors still do not address the main points outlined in the Warrick et al 2014 Comment. Changing grid scales and using log transformations may allow the authors to arrive at a result that is closer to sediment load values reported in the literature, but that in and of itself is problematic. If the authors had chosen an even finer DEM would they have doubled their estimates? Is the entire scaling approach suspect?

The Willenbring et al. 2014b revised rates of global denudation (~23 Gt/yr) match the rates of sediment flux to the sea (~20 Mt/yr). This is a problem, as it is a sign that the model is vastly underestimating denudation. There is much in the literature on topics of chemical weathering and sediment storage in watersheds over the time scales in question that when combined suggests that denudation should be much greater than fluvial sediment loads. Denudation rates should be at least double if not more than the flux of sediment that reaches the world's coastal oceans. There still appears to be problems with the Willenbring et al model.

Willenbring et al. 2014b, acknowledge that their global data set is biased on the basis of location and denudation rate. They note that the high denudation regions have been "avoided" and are thus grossly underrepresented in their "global" database and model. Roughly half of the Earth's surface, representing the flattest of all landscapes, has no

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denudation data to contribute to this model, even though these “flat” landscapes occur in diverse geological settings. Thus the model relies upon extrapolation beyond the range of measured data.

A paper should add to the science literature by providing new insights, data, or models to push the field forward. In this case, the authors are simply expanding on a Reply to a Commentary on their original paper. That is insufficient reason to publish these new results. I would encourage the authors to reflect more carefully on the original Comment to their first paper, now that they better understand some of the issues related to scaling disparate data into a global model. The authors should be congratulated for beginning to put together a global database on denudation. Issues raised in the first Commentary mostly remain. They are surmountable and surely could point the way forward in reconciling gross basin denudation and fluvial sediment fluxes.

References Willenbring, J. K., Codilean, A. T., and McElroy, B.: Earth is (mostly) flat: apportionment of the flux of continental sediment over millennial time scales, *Geology*, 41, 343–346, 2013. Willenbring, J. K., Codilean, A. T., and McElroy, B.: Short Communication: Earth is (mostly) flat, but mountains dominate global denudation: apportionment of the continental mass flux over millennial time scales, revisited, *Earth Surf. Dynam. Discuss.*, 2, 1–17, 2014a. Willenbring, J. K., Codilean, A. T., and McElroy, B., 2014b, Reply: Earth is (mostly) flat: Apportionment of the flux of continental sediment over millennial time scales, *Geology* doi: 10.1130/G35326Y.1 Warrick, JA, JD Milliman, DE Walling, RJ Wasson, JPM Syvitski, RE Aalto, 2014, Comment: Earth is (mostly) flat: Apportionment of the flux of continental sediment over millennial time scales, *Geology* doi:10.1130/G34846C.1

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