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Interactive comment on "Short Communication: Increasing vertical attenuation length of cosmogenic nuclide production on steep slopes negates topographic shielding corrections for catchment erosion rates" *by* R. A. DiBiase

Anonymous Referee #1

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In this manuscript, DiBiase presents a thorough representation of cosmic ray shielding in eroding complex topography. By necessity, the manuscript covers much of the same ground as Dunne et al., 1999 and Gosse and Phillips, 2001 but extends those works by looking at the implications of geometry on the effective attenuation path length across an idealised landscape. This is a fascinating and provocative manuscript. The results suggest that the topographic shielding corrections that are often applied for cosmogenic nuclide derived erosion rates are not necessary. Taken at face value, this implies that previously reported denudation rates could be underestimated by up to 20%.

The manuscript is well written and, for the most part, clear. There are a few main points (all related) that I think require clarification: 1) the effect of foreshortening, 2) the role of changing surface production rates due to changing attenuation path length, and 3) the implications of defining attenuation path length as a vertical vector instead of its traditional definition as perpendicular to the surface.

1) Gosse and Phillips (2001) noted on pg 1521 that increasing effective attenuation length due to increasing surface slope is exactly offset by foreshortening. Is that not also the case here?

2) It is counterintuitive that the effective shielding factor can be greater than 1. In this model, this is due to the large increase in vertical attenuation length. Previous authors have noted that attenuation path length decreases on sloped surfaces due to increasingly oblique incidence angles reducing the intensity. This discrepancy should be addressed. On a similar topic, it is not clear is how production rates were dealt with here. For a give incoming flux, increasing the attenuation path length must decrease the near surface production rate as it implies fewer collisions per mass length. The implication is that as normalized effective attenuation length increases, the normalized effective surface production rate must decrease. This would offset the effect of increasing attenuation length (requiring a topographic shielding correction again). This could be treated as equivalent to foreshortening.

3) There is an important potential talking point here on how erosion/denudation is defined in cosmogenic nuclide studies. Both lowering rates (i.e. m My-1) and mass loss rates (i.e. t km-2 yr-1) tend to be based on 2D areas. This is in line with the definition of attenuation length presented here. However, it is not clear that this is the appropriate definition (of either erosion or attenuation) for the real world. A broader discussion around the implications of setting the attenuation path length to the vertical could be quite useful since previous authors rotate the coordinate system to determine attenuation path length perpendicular to the surface. The vertical definition makes sense since we tend to perform shielding calculations on a DEM and often define erosion

as a lowering rate. However, it seems unlikely that an 80° slope would be eroding vertically. In this case, using a vertical attenuation path length would result in an artificial increase in production rate (i.e. it would appear as less shielding, as found here). The ‘true’ surface area in this case is also probably the 3D surface area and erosion would be spread across a larger area (essentially the foreshortening argument applied to erosion). I recognise that this is a bit circular, but it highlights the need for a clearer explanation around coordinate definitions.

In summary, while there are some important ideas to clarify, this manuscript raises the very enticing idea that topographic shielding corrections are not needed for denudation studies. If this is indeed the case, then DiBiase will surely receive a whole-hearted ‘thank you’ from the cosmogenic nuclide community.

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