Earth Surf. Dynam. Discuss., author comment AC2
https://doi.org/10.5194/esurf-2021-27-AC2, 2021

Response to Reviewer Greg Balco

Yanyan Wang and Sean D. Willett

Author comment on "Escarpment retreat rates derived from detrital cosmogenic nuclide concentrations" by Yanyan Wang and Sean D. Willett, Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-27-AC2, 2021

Response to Greg Balco (Referee)

Greg Balco:

This paper is quite simple in principle: it points out that a cosmogenic-nuclide measurement in fluvial sediment leaving a basin, which is usually interpreted as a mean erosion rate in the basin, could also be interpreted as a horizontal retreat rate of an basin fronting a retreating escarpment. The cosmogenic-nuclide measurement is telling you is the mass flux out of the basin, and the mass flux could equivalently be the result of either vertical "erosion" or horizontal "retreat." Of course this is correct, and retreat makes more sense than erosion if you are trying to figure out what is happening to an escarpment. The main complication is only that relating a mass flux out of a basin to a horizontal "retreat" of the basin is geometrically fairly complicated, and much of the paper is devoted to unscrambling this issue.

Overall, I think this paper is good and I'm supportive of publishing it. I only found one major issue in review, as follows. Basically, relating a cosmogenic-nuclide concentration to an erosion or retreat rate has two halves: (i) figuring out the cosmogenic-nuclide production rate in the basin, and (ii) parameterizing the mass flux out of the basin. This paper is all about (ii), and simply adopts (i) from previous literature. However, there is a sizeable section of the paper (section 2.3.1, starting line 240) devoted to explaining (i). This is a bit of a problem in the paper, because it contains some vague and confusing elements that make this explanation more confusing than it is in the standard literature describing basin-scale production rate calculations. Specifically, these elements are confusing:

RESPONSE to the general comments:

We agree with the comments that several statements were confusing and inaccurate. We have simplified Section 2.3.1. In the simplified Section 2.3.1, we removed the detailed production calculation for non-vertical exhumation pathways. We agree that it is ultimately not needed. We keep the equations of cosmogenic nuclide concentration as expressed with catchment-integrated production and erosion rate by citing published literatures.

Greg Balco:

-- Line 249, 'generally taken to be exponential.' In fact this isn't true, because the fact that muon energy increases with increasing depth means that the exponential attenuation length continually increases with depth. You can't approximate this accurately with a finite sum of exponentials. What you can do in integrating production for this application is assume that there is a single exponential function that, when integrated, gives the right answer...but the parameters of that exponential function vary with the erosion rate, so this approach is implicit. I don't think it's necessary to get into this level of detail, but the point is that this statement is oversimplified and confusing.

RESPONSE:

We agree that the expression "generally taken to be exponential" was overly simplified and causes more confusion than clarification. We removed this expression in the revision.

Greg Balco:

-- Line 250. I don't understand the sentence " The penetration distance is in a general direction...." What does this mean?

RESPONSE:

The particle rays attenuate into a bedrock surface propagate in any direction, each direction has its own attenuation length (Lal 1991). In practice, this attenuation process can be modeled as a collimated ray penetrating the target rock and the variable attenuation length is scaled into one effectively representative value to account for the overall production of cosmogenic nuclides (Lal 1991; Dunne et al., 1999). The penetration is scaled to be vertical in the many papers. What we meant was the if one considers a rock parcel exhumed from underground to the surface, the accumulation of nuclides in the rock parcel has to be integrated along that exhumation path, which is not necessarily vertical. After the simplification of Section 2.3.1, catchment-wide accumulation of nuclides for non-vertical exhumation path is beyond our goal of this study so we have removed this expression in the revision.

Greg Balco:

-- Line 288-89. "...most shielding is local...and therefore sums to zero during integration.' This statement implies that a shielding factor less than one at some location within the watershed will be balanced by other locations where the shielding factor is greater than one. Shielding factors greater than one are impossible by definition, so this statement makes no sense. This may have something to do with the fallacy that the total cosmic-ray flux impinging on a basin is the same as the flux passing through a horizontal plane at the top of the basin. This isn't true.

RESPONSE:

We are not sure what the final statement is referring to as we didn't make any reference to a horizontal surface. The principle that we were trying to convey is that once a particle enters the convex-hull of a drainage basin as define by its perimeter, it either impacts air or the rock, and any local topography within the convex hull will not change this quantity, apart from the change in air/rock ratio. In any case, if the reviewers are satisfied with our assumption that a shielding correction is not needed, we will omit controversial justifications and simply state our assumption.

Greg Balco:

-- Line 291-92. It's fine to simplify the math by ignoring radioactive decay, but if you do this you need to be specific about when this assumption is inaccurate. Specifically, this assumption is OK when the quantity E/L (erosion rate in g/cm2/yr divided by attenuation constant in g/cm2) is a lot bigger than the nuclide decay constant lambda (1/yr). I would choose a typical nuclide (Be-10) and specifically indicate for what range of erosion rates this is true. Note this also needs to be dealt with later at line 369.

RESPONSE:

We agree that we simplified this expression by removing the decay constant without carefully pointed out the proper conditions. In the revision, we add the decay factor to Equation (2) and pointed out threshold erosion rate that radioactive decay can be ignored for detrital ^{10}Be. We also have dealt with Line 369 accordingly. We note however, that this is not so simple for the case of spatially variable erosion rate as we have with escarpment retreat, as even with an average erosion rate above the validity threshold, some parts of the basin may have an erosion rate much lower. We specify this point on Line 410-414.

Greg Balco:

The point of all this is that section 2.3.1 doesn't add anything to previous literature -- it's not intended to, that isn't what this paper is about -- but it contains several confusing sections that make the reader more confused than if they had just referred to existing literature. I strongly recommend greatly simplifying this section to use a simple form of the integral production equation and refer everything to existing literature rather than getting into the details here. Sure, the question of whether or not to consider muon production is important in understanding the accuracy of an erosion or retreat rate inferred from a Be-10 concentration, but it has nothing to do with what this paper is about, which is representing mass flux as retreat instead of erosion. Summary: greatly simplify this section.

Other than that, I found this paper interesting to read and I'm supportive of publishing it.

RESPONSE:

We have simplified Section 2.3.1 accordingly.

Greg Balco:

Line 384 -- in this section you don't derive expressions for cosmogenic-nuclide production. Rethink this sentence.

RESPONSE:

We have modified this sentence accordingly.

Greg Balco:

Figures 9 and 10. It would be helpful to label the methods used for each polar plot (basin projection, local scalar product) on the figure itself, so that the reader doesn't have to refer back and forth between the caption and the figure.

RESPONSE:

We have labeled the methods for the two figures.