

Supporting Information for

Stochastic in Space and Time: Part 2, Effects of Simulating Orographic Gradients in Daily Runoff Variability on Bedrock River Incision

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Introduction

This supplemental file contains seven supplemental figures that contain additional details on model results. It also contains two tables. Table S1 are the invariant STIM parameters common to all models, whereas Table S2 highlights the values or properties that change between model runs.

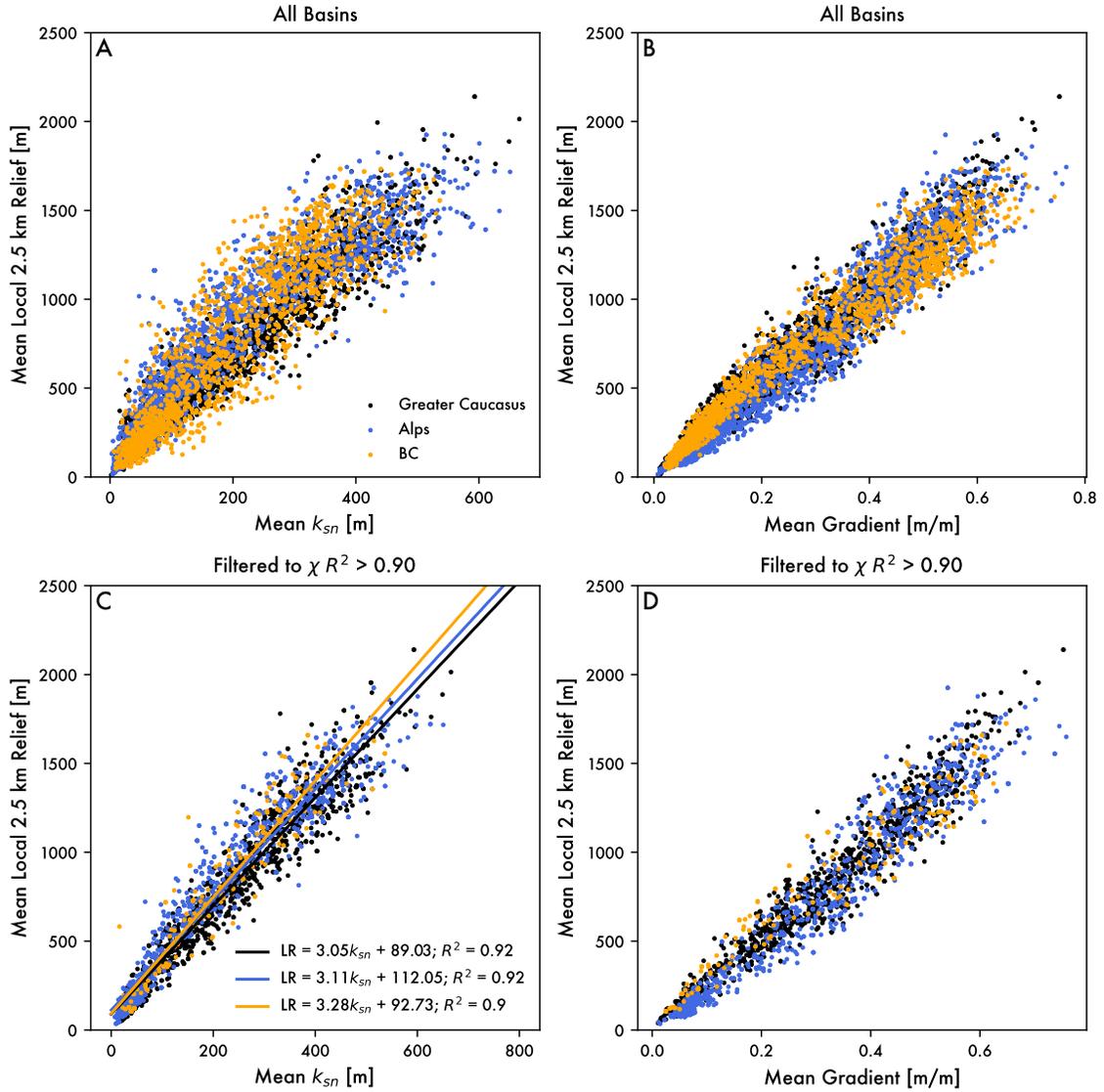


Figure S1. A) Mean basin k_{sn} compared to mean local 2500 m relief for randomly selected basins for the three example locations. B) Mean hillslope gradient compared to mean local 2500m relief for the same basins. C) Filtered mean basin k_{sn} compared to mean local 2500 m relief, using a cutoff of 0.9 for the R^2 of the χ -elevation relationship as

a proxy for basins without major knickpoints. Also shown are linear fits between k_{sn} and relief which are used in the models. D) Same as B but for the filtered basins shown in C.

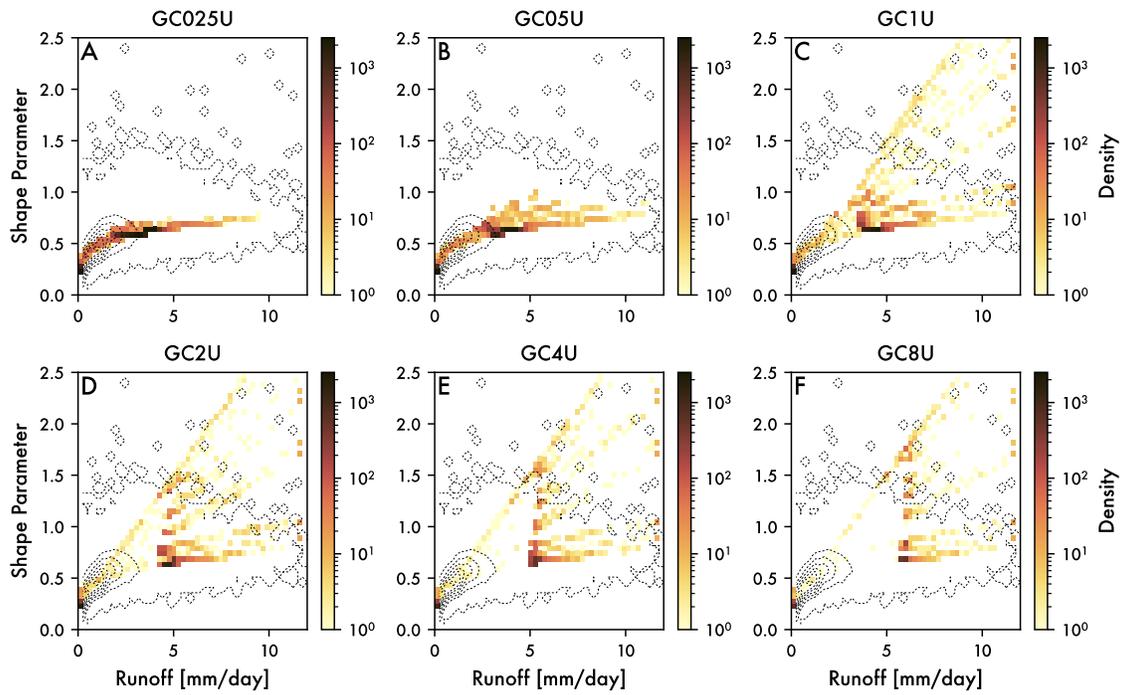


Figure S2. 2D density plots of individual pairs of runoff and variability within all bins across all timesteps between model initiation and achievement of steady state for the base Greater Caucasus unlinked runs. Generally, the majority of the time in the models are spent in portions of parameter space well represented in the WaterGAP3 data (e.g., Figure 2A), which are shown with the contours.

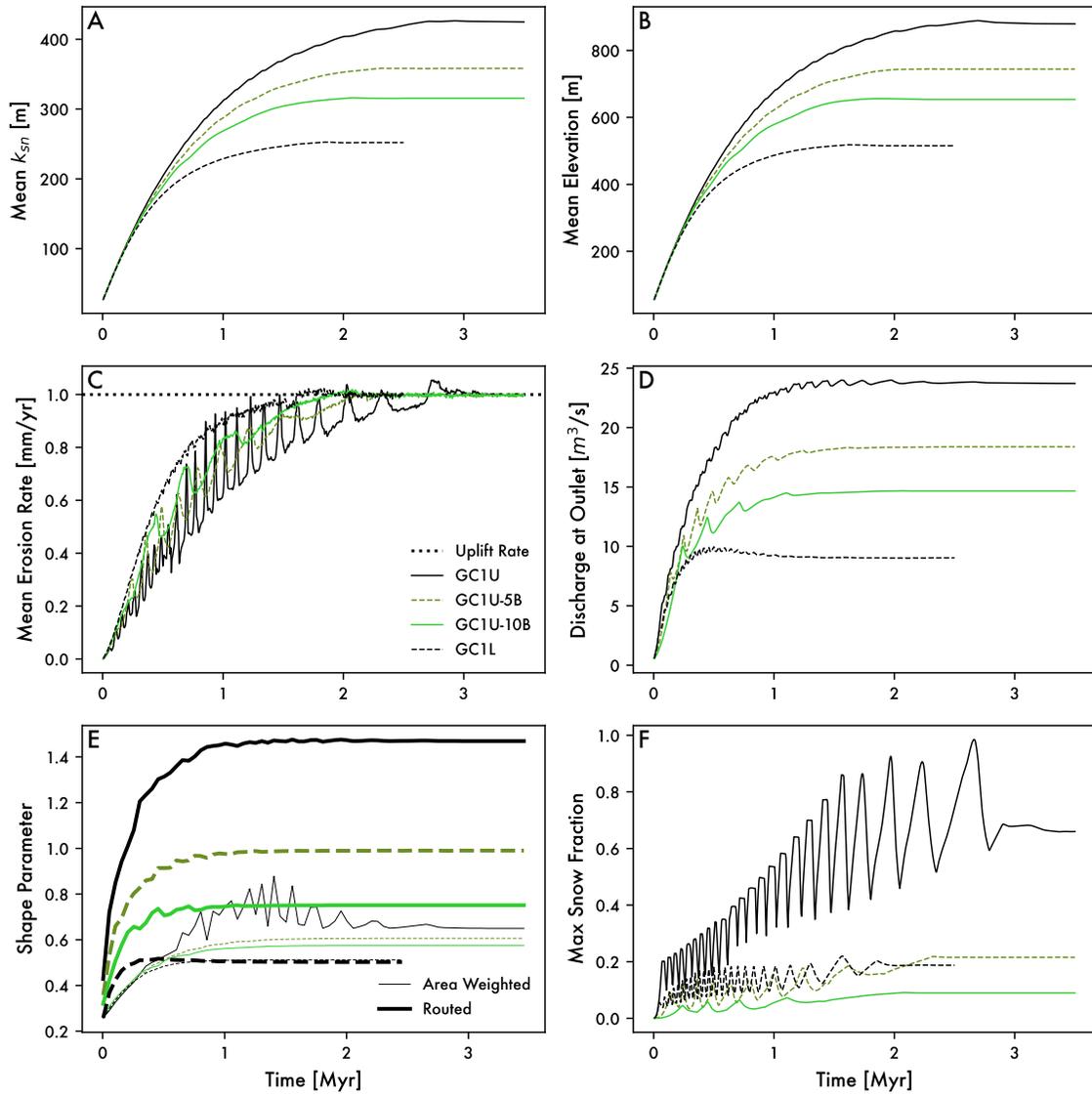


Figure S3. Comparison of evolution of model GC1U to similar models with different size runoff bins, specifically 5000 m (GC1U-5B) and 10000 m (GC1U-10B). Model GC1L is also included for reference. Setup of figure is identical to that of main text Figure 4.

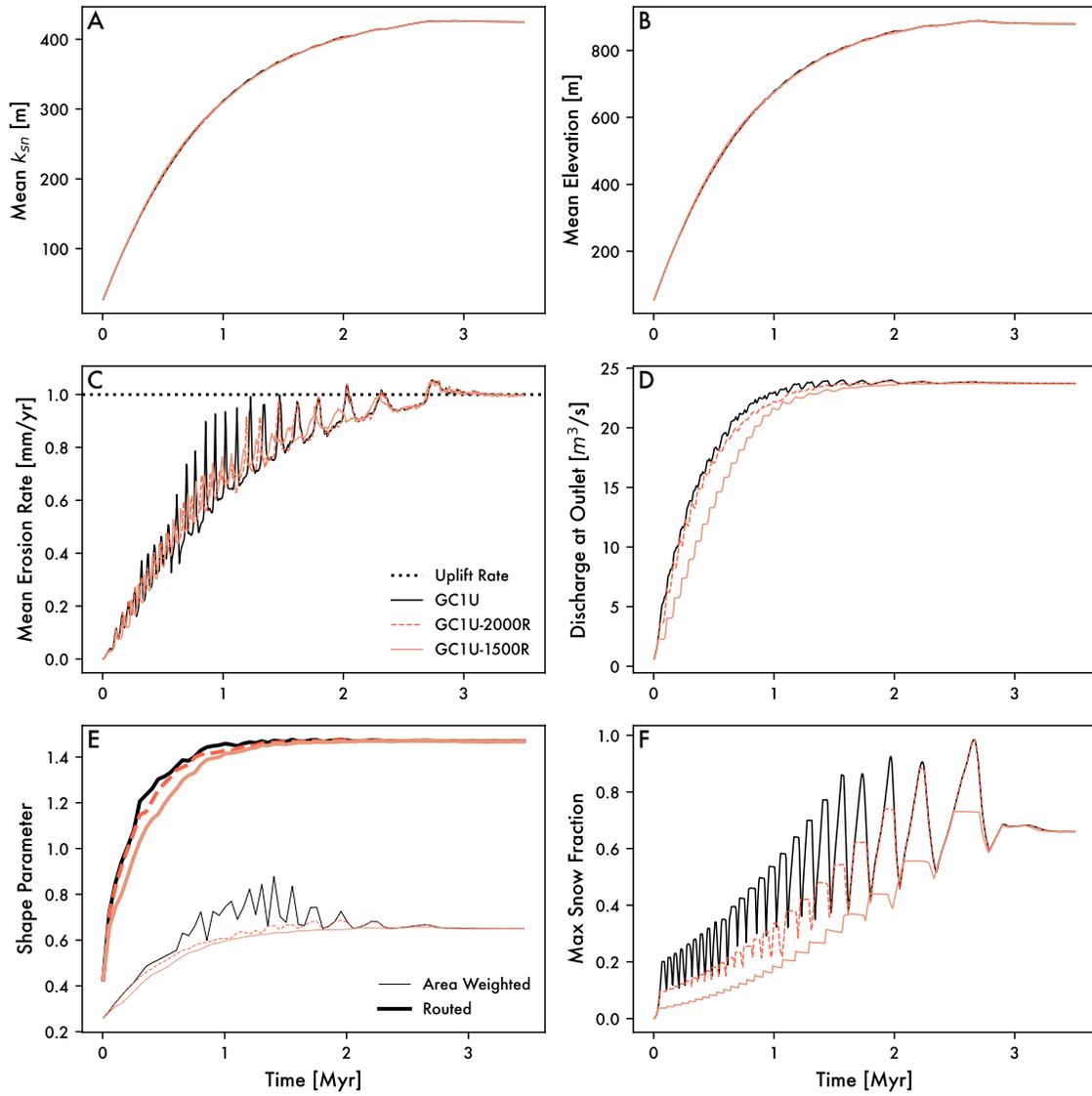


Figure S4. Comparison of evolution of model GC1U to similar models with different imposed maximum reliefs, specifically 2000 m (GC1U-2000R) and 1500 m (GC1U-1500R). Setup of figure is identical to that of main text Figure 4.

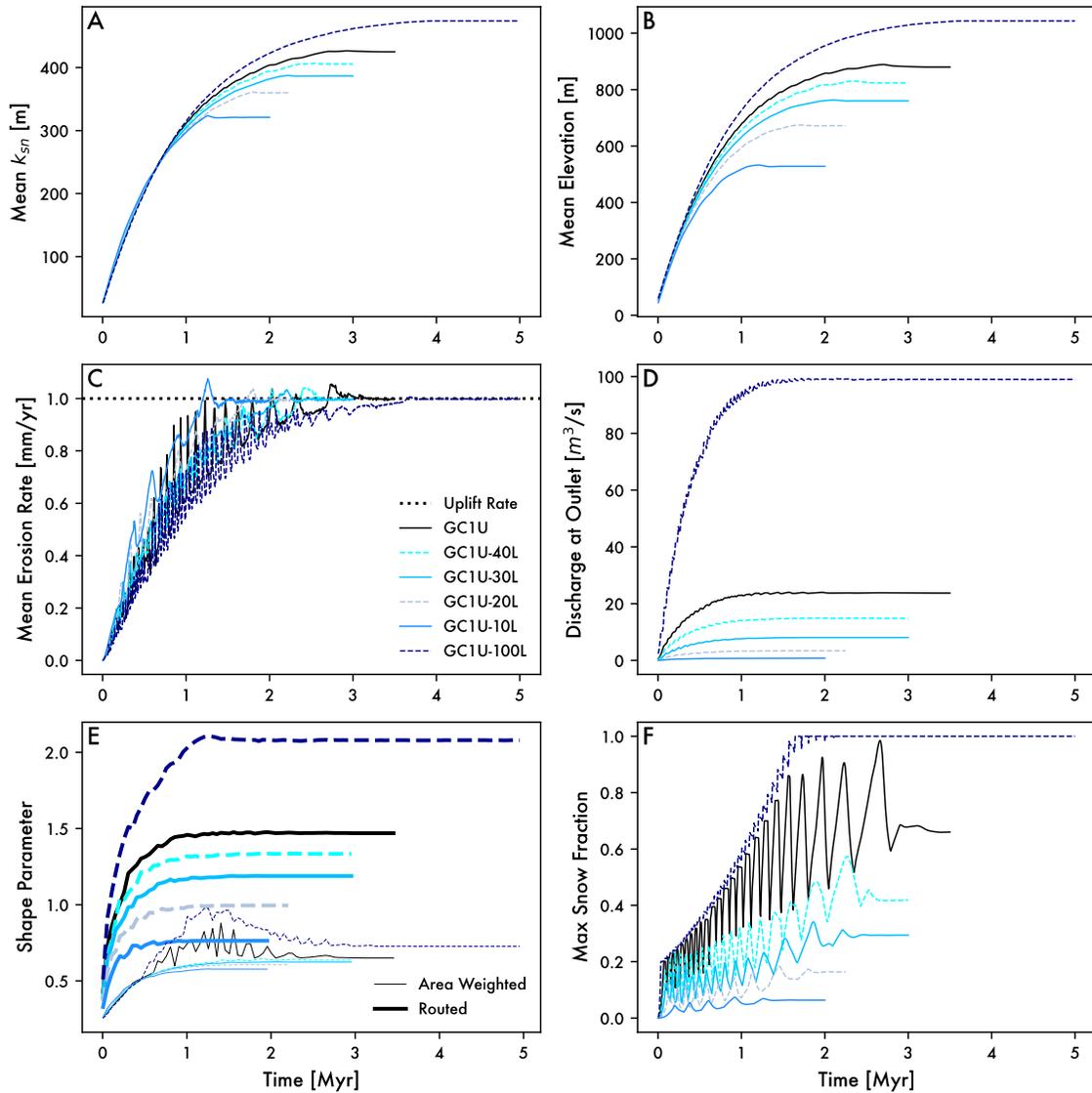


Figure S5. Comparison of evolution of model GC1U to similar models with different stream lengths, specifically 40 km (GC1U-40L), 30 km (GC1U-30L), 20 km (GC1U-20L), 10 km (GC1U-10L), and 100 km (GC1U-100L). Setup of figure is identical to that of main text Figure 4.

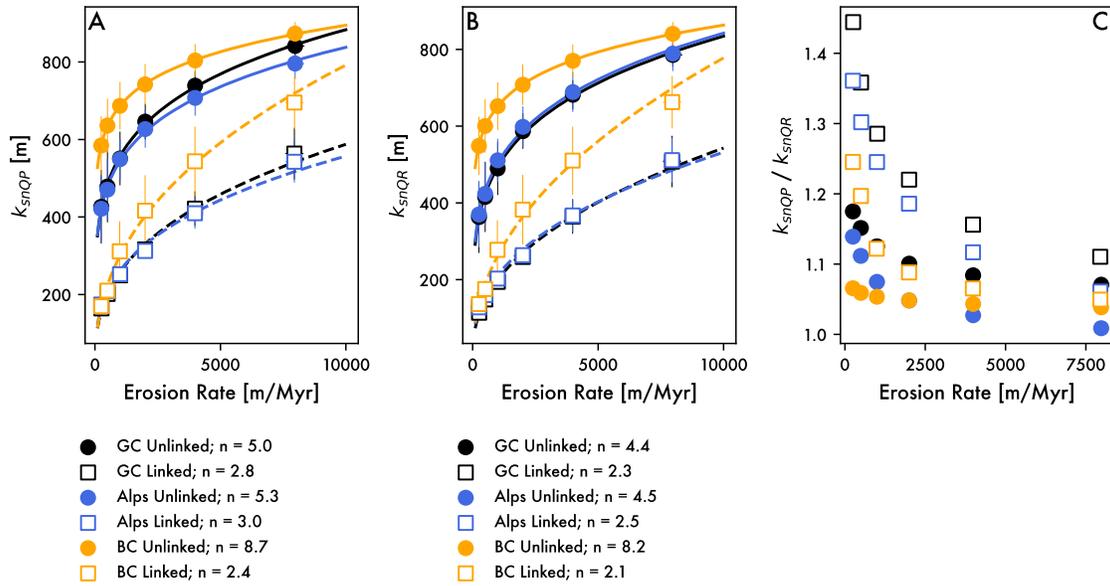


Figure S6. Comparison of predictions of different versions of k_{snQ} . A) B) Relationship between erosion rate and mean k_{snQR} along with power law fits. k_{snQR} is calculating k_{snQ} sensu Adams et al. (2020) but using runoff as opposed to precipitation. B) Relationship between erosion rate and mean k_{snQP} along with power law fits. k_{snQP} is calculating k_{snQ} identical to Adams et al. (2020). For this, runoff is converted to precipitation using the local linear relation between runoff and precipitation from the WaterGap3 data for each area and then this precipitation value is routed along the profile as if it was runoff. This is what is displayed in Figure 8B. C) Ratio of k_{snQP} to k_{snQR} as a function of erosion rate.

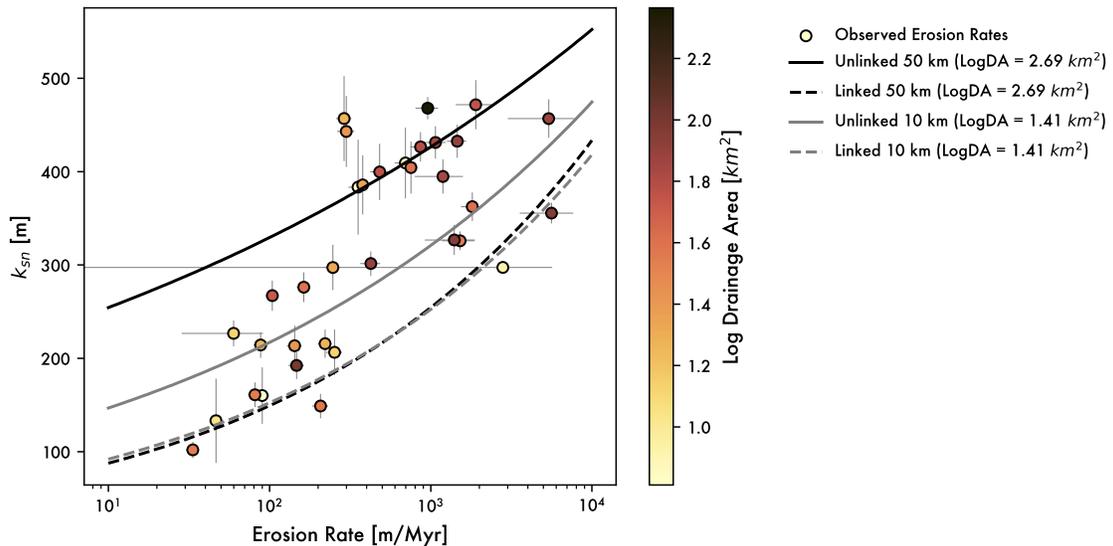


Figure S7. Power law fit to model results for unlinked and linked cases for 50 km (black) and 10 km (gray) profiles using the Greater Caucasus scenario, compared to observed cosmogenic ^{10}Be erosion rates in the Greater Caucasus from Forte et al., (2022). Notice

loose correlation between basin drainage area and the degree to which the linked vs unlinked relationship explains the dataset.

Parameter	Value	Units
k_p	1e-11	$m^{2.5}s^2ka^{-1.5}$
τ_c	45	Pa
k_w	15	$m^{-0.5}s^{0.5}$
k_t	1000	$m^{-7/3}s^{-4/3}ka$
ω_n	0.5	Dimensionless
ω_s	0.25	Dimensionless
a	3/2	Dimensionless
α	2/3	Dimensionless
β	2/3	Dimensionless
dx	100	m
dt	1	days

Table S1. STIM and other model parameters fixed for all runs. STIM parameters are similar to those used by Forte et al., (2022) for the Greater Caucasus.

Model Name	Site	Length [km]	Bin Size [km]	Bin Relation	Uplift Rate [mm/yr]	Maximum Relief [m]
GC025U	GC	50	2	Unlinked	0.25	2500
GC025L	GC	50	2	Linked	0.25	2500
GC05U	GC	50	2	Unlinked	0.5	2500
GC05L	GC	50	2	Linked	0.5	2500
GC1U	GC	50	2	Unlinked	1.0	2500
GC1L	GC	50	2	Linked	1.0	2500
GC2U	GC	50	2	Unlinked	2.0	2500
GC2L	GC	50	2	Linked	2.0	2500

Model Name	Site	Length [km]	Bin Size [km]	Bin Relation	Uplift Rate [mm/yr]	Maximum Relief [m]
<i>GC4U</i>	<i>GC</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>4.0</i>	<i>2500</i>
<i>GC4L</i>	<i>GC</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>4.0</i>	<i>2500</i>
<i>GC8U</i>	<i>GC</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>8.0</i>	<i>2500</i>
<i>GC8L</i>	<i>GC</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>8.0</i>	<i>2500</i>
<i>GC1U-</i>	<i>GC</i>	<i>50</i>	<i>5</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2500</i>
<i>GC1U-</i>	<i>GC</i>	<i>50</i>	<i>10</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2500</i>
<i>GC1U-</i>	<i>GC</i>	<i>40</i>	<i>2</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2500</i>
<i>GC1U-</i>	<i>GC</i>	<i>30</i>	<i>2</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2500</i>
<i>GC1U-</i>	<i>GC</i>	<i>20</i>	<i>2</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2500</i>
<i>GC1U-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2500</i>
<i>GC1U-</i>	<i>GC</i>	<i>100</i>	<i>2</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2500</i>
<i>GC1U-</i>	<i>GC</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2000</i>
<i>GC1U-</i>	<i>GC</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>1.0</i>	<i>1500</i>
<i>GC025U-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Unlinked</i>	<i>0.25</i>	<i>2500</i>
<i>GC025L-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Linked</i>	<i>0.25</i>	<i>2500</i>
<i>GC05U-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Unlinked</i>	<i>0.5</i>	<i>2500</i>
<i>GC05L-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Linked</i>	<i>0.5</i>	<i>2500</i>
<i>GC1L-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Linked</i>	<i>1.0</i>	<i>2500</i>
<i>GC2U-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Unlinked</i>	<i>2.0</i>	<i>2500</i>
<i>GC2L-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Linked</i>	<i>2.0</i>	<i>2500</i>
<i>GC4U-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Unlinked</i>	<i>4.0</i>	<i>2500</i>
<i>GC4L-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Linked</i>	<i>4.0</i>	<i>2500</i>
<i>GC8U-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Unlinked</i>	<i>8.0</i>	<i>2500</i>
<i>GC8L-</i>	<i>GC</i>	<i>10</i>	<i>2</i>	<i>Linked</i>	<i>8.0</i>	<i>2500</i>
<i>GC1U-</i>	<i>GC</i>	<i>10</i>	<i>1</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2500</i>

Model Name	Site	Length [km]	Bin Size [km]	Bin Relation	Uplift Rate [mm/yr]	Maximum Relief [m]
<i>A025U</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>0.25</i>	<i>2500</i>
<i>A025L</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>0.25</i>	<i>2500</i>
<i>A05U</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>0.5</i>	<i>2500</i>
<i>A05L</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>0.5</i>	<i>2500</i>
<i>A1U</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2500</i>
<i>A1L</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>1.0</i>	<i>2500</i>
<i>A2U</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>2.0</i>	<i>2500</i>
<i>A2L</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>2.0</i>	<i>2500</i>
<i>A4U</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>4.0</i>	<i>2500</i>
<i>A4L</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>4.0</i>	<i>2500</i>
<i>A8U</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>8.0</i>	<i>2500</i>
<i>A8L</i>	<i>Alps</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>8.0</i>	<i>2500</i>
<i>BC025U</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>0.25</i>	<i>2500</i>
<i>BC025L</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>0.25</i>	<i>2500</i>
<i>BC05U</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>0.5</i>	<i>2500</i>
<i>BC05L</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>0.5</i>	<i>2500</i>
<i>BC1U</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>1.0</i>	<i>2500</i>
<i>BC1L</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>1.0</i>	<i>2500</i>
<i>BC2U</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>2.0</i>	<i>2500</i>
<i>BC2L</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>2.0</i>	<i>2500</i>
<i>BC4U</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>4.0</i>	<i>2500</i>
<i>BC4L</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>4.0</i>	<i>2500</i>
<i>BC8U</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Unlinked</i>	<i>8.0</i>	<i>2500</i>
<i>BC8L</i>	<i>BC</i>	<i>50</i>	<i>2</i>	<i>Linked</i>	<i>8.0</i>	<i>2500</i>

Table S2. Model runs and key parameters or properties that are varied between individual model runs

References

Adams, B. A., Whipple, K. X., Forte, A. M., Heimsath, A. M., & Hodges, K. V. (2020). Climate controls on erosion in tectonically active landscapes. *Science Advances*, 6(42).

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