



Supplement of

Meteoric beryllium-10 fluxes from soil inventory measurements in the East River watershed, Colorado, USA

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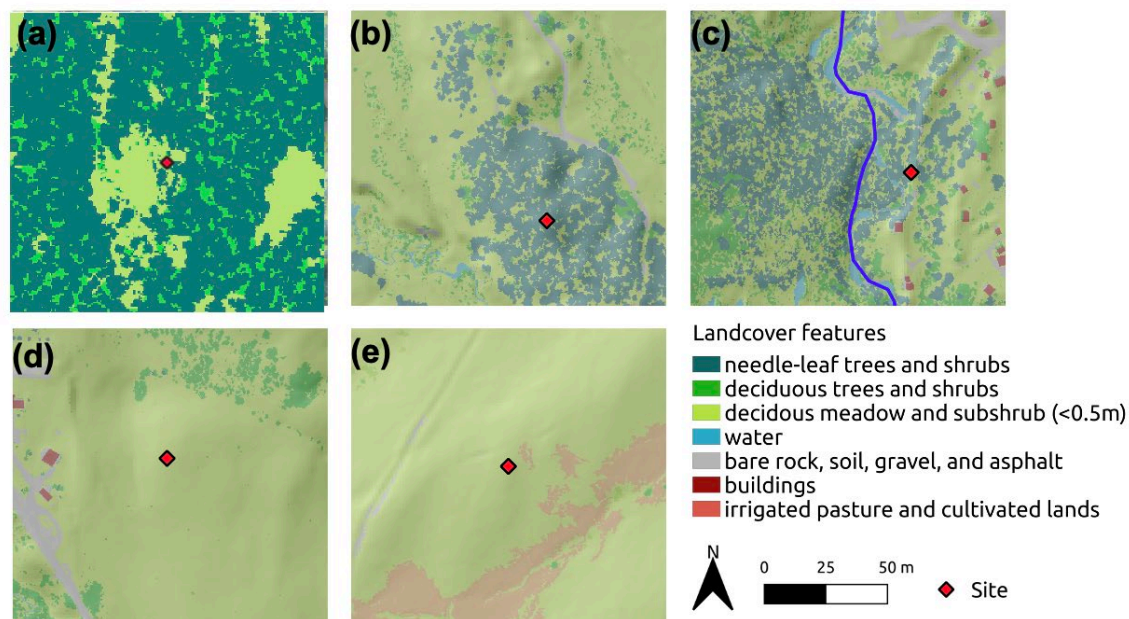


Figure S1. Land cover classifications for calibration sites. a) Copper Creek; b) Washington Gulch North; c) Gothic; d) Washington Gulch South; e) East River terminal.

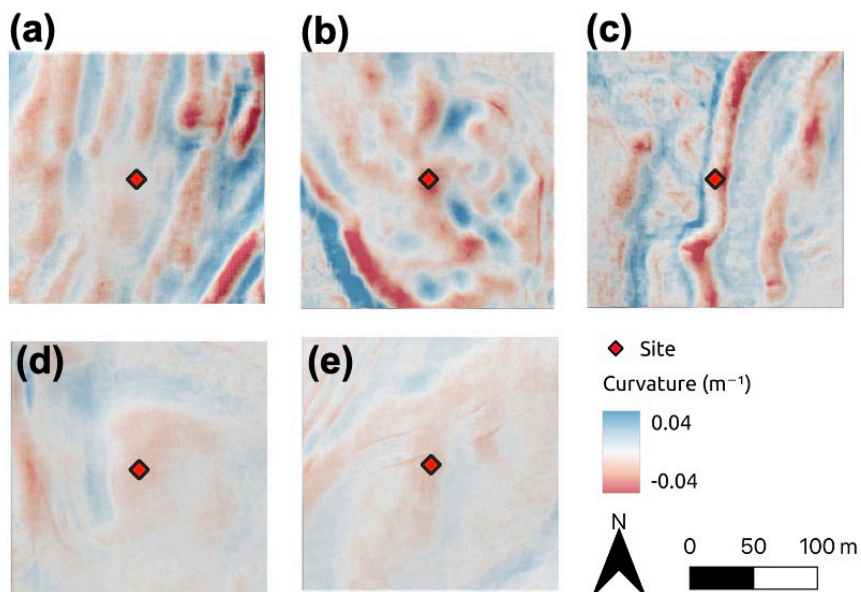


Figure S2. Topographic curvature for (a) Copper Creek, (b) Washington Gulch North, (c) Gothic, (d) Washington Gulch South, and (e) East River Terminal moraines.

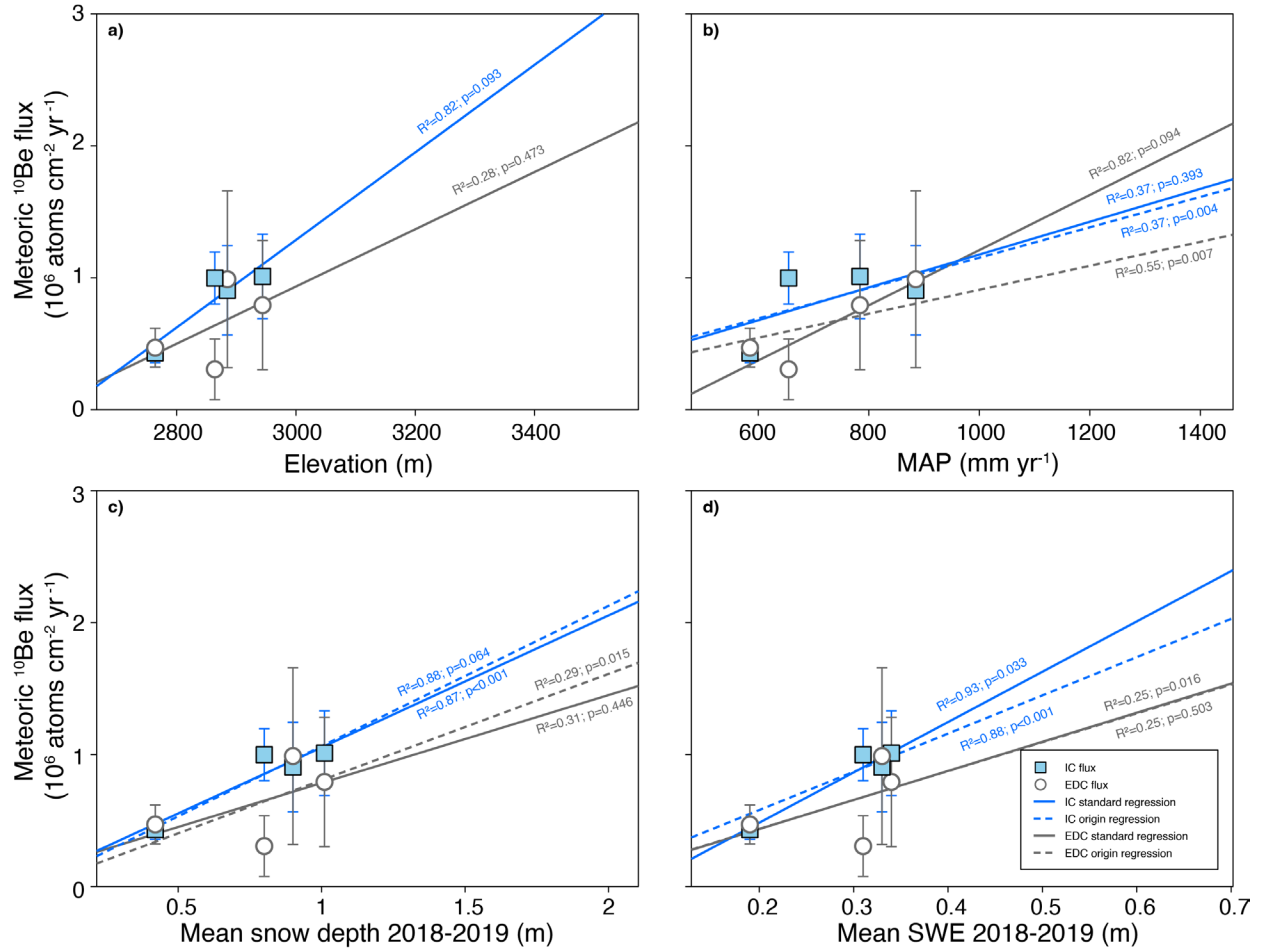


Figure S3. Linear regression models of $^{10}\text{Be}_{\text{met}}$ flux versus (a) elevation, (b) mean annual precipitation (MAP), (c) mean snow depth (2018-2019), and (d) mean snow water equivalent (SWE) (2018-2019) with the Copper Creek site omitted. Blue squares show inheritance-corrected fluxes and open gray circles show erosion- and desorption-corrected fluxes. The erosion- and desorption-corrected fluxes use the profile-average desorption model. For the inheritance-corrected (IC) data, solid blue lines show results from standard regression models and the dashed blue lines show regression through the origin models. For the corrected (EDC) data, solid grey lines show standard regression model results and grey dashed lines show regression through the origin models where the y-intercept is zero. Regression through the origin models are shown only for MAP, mean snow depth, and mean SWE.

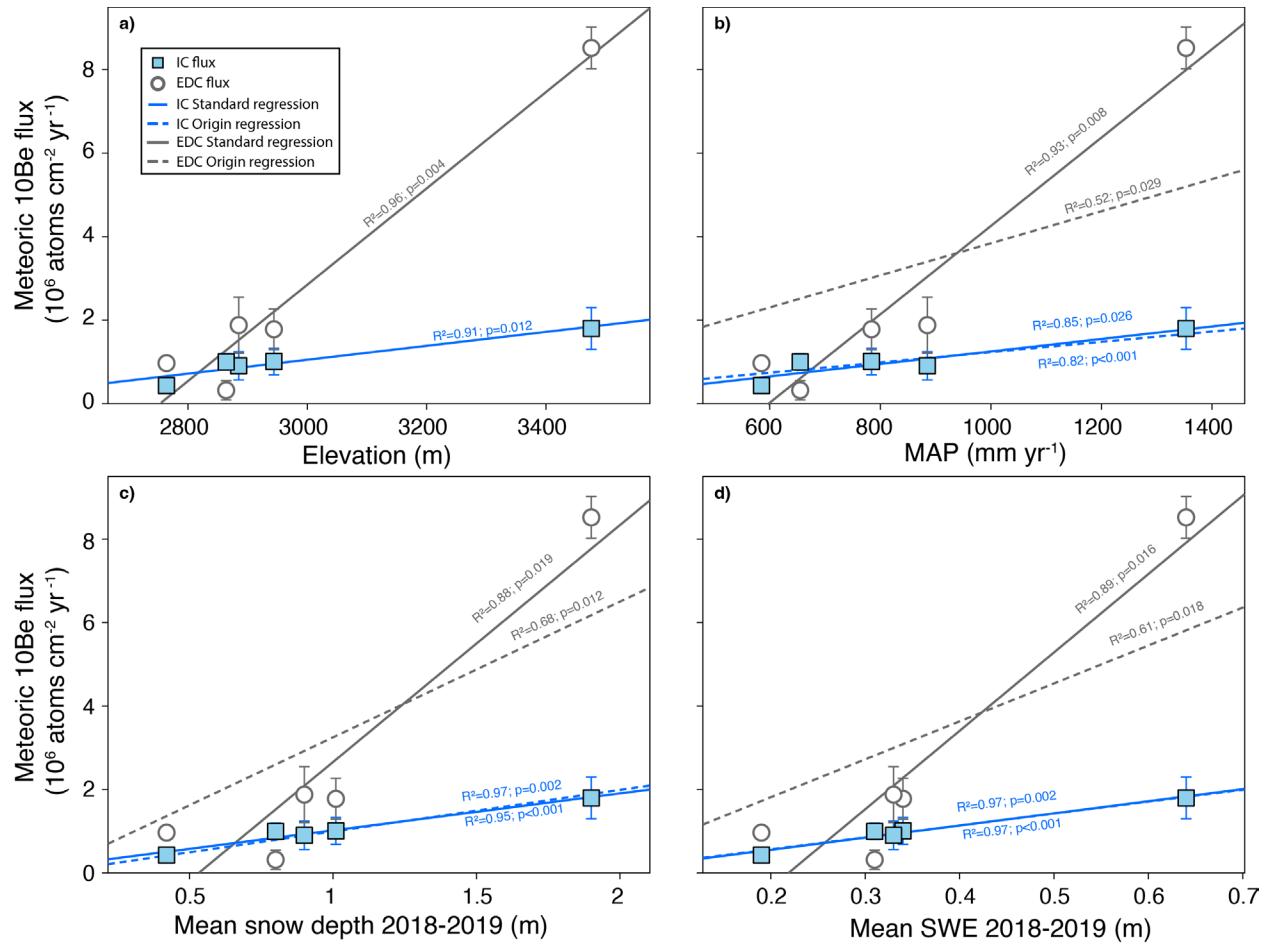


Figure S4. Linear regression models of $^{10}\text{Be}_{\text{met}}$ flux versus (a) elevation, (b) mean annual precipitation (MAP), (c) mean snow depth (2018–2019), and (d) mean snow water equivalent (SWE) (2018–2019), with erosion- and desorption-corrected fluxes calculated using the upper-sample desorption model.

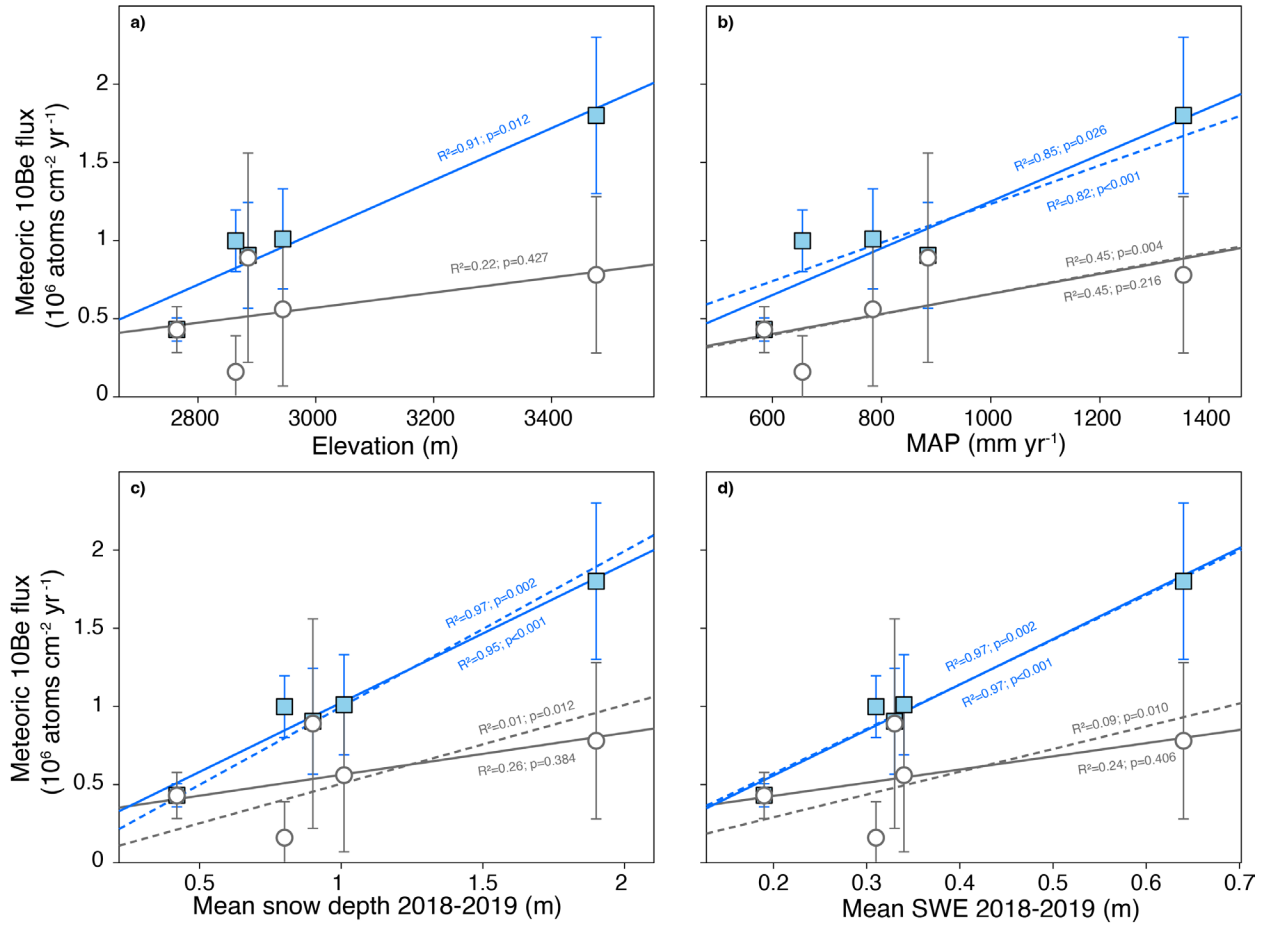


Figure S5. Linear regression models of $^{10}\text{Be}_{\text{met}}$ flux versus (a) elevation, (b) mean annual precipitation (MAP), (c) mean snow depth (2018–2019), and (d) mean snow water equivalent (SWE) (2018–2019), with erosion- and desorption-corrected fluxes calculated using the lowermost-sample desorption model. Blue squares show inheritance-corrected fluxes and open gray circles show corrected fluxes. Solid blue and gray lines show ordinary least-squares regressions with freely fitted intercepts. Dashed blue and gray lines show regression-through-origin models, which are shown only for MAP, mean snow depth, and mean SWE.

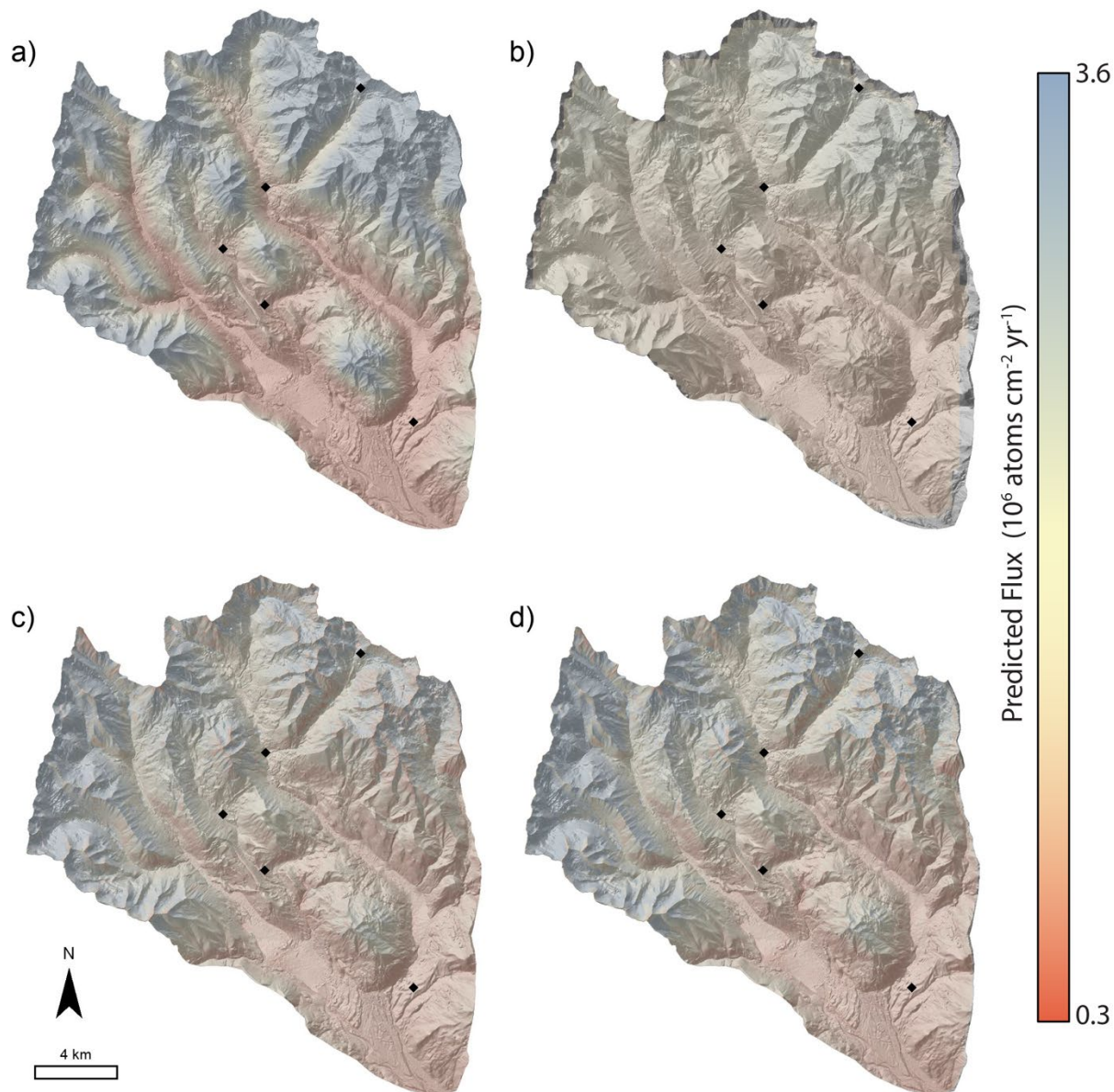


Figure S6. Spatial predictions of $^{10}\text{Be}_{\text{met}}$ flux based on erosion- and desorption-corrected fluxes calculated using the thickness-weighted profile-average desorption model and regression models using: (a) elevation with the regular regression; (b) mean annual precipitation with the origin regression; (c) mean snow depth from 2018–2019 with the origin regression; and (d) mean snow water equivalent from 2018–2019 with the origin regression.

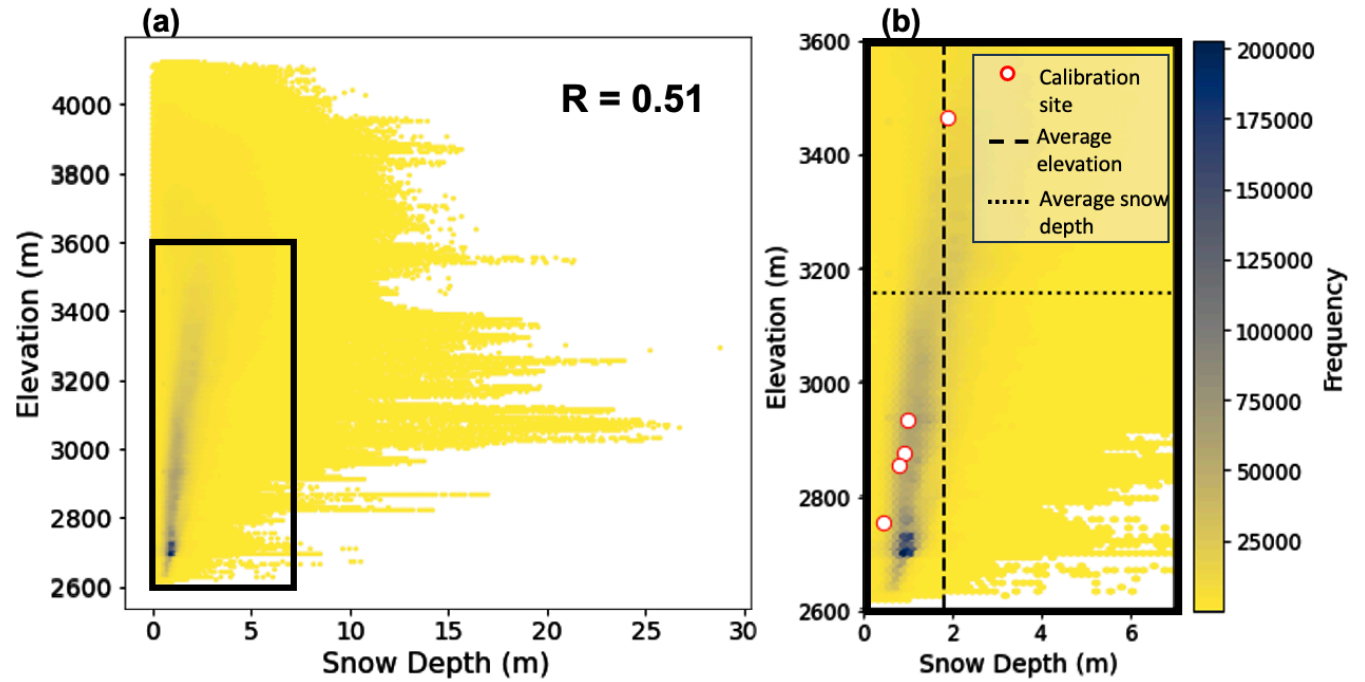


Figure S7. Hexbin frequency distribution plots of elevation versus snow depths versus elevation. (b) Close-up view focusing on the region captured by the calibration point (2600 m and 3600 m). This inset highlights specific data points, marked with black markers and dashed and dotted lines representing the mean snow depth and elevation, respectively.

Table S1. Soil bulk density measurements.

Site	Sample	Depth (cm)	Dry Density (g cm ⁻³)	Horizon
Copper Creek	ER_CCT_Pit_1	10	1.0	Bw
	ER_CCT_Pit_1	20	0.9	Bs
	ER_CCT_Pit_1	30	1.1	Bs
	ER_CCT_Pit_1	40	1.0	Bs
Washington Gulch North	ER_AM_Pit_1	10	1.0	A
	ER_AM_Pit_1	30	1.2	A
	ER_AM_Pit_1	50	0.8	Bk
	ER_AM_Pit_1	75	1.6	Bk
	ER_AM_Pit_1	87.5	1.6	Bk
Gothic	ER_GM_Pit_1	8	0.2	A
	ER_GM_Pit_1	40	1.4	Bw
	ER_GM_Pit_1	70	1.4	Bt
Washington Gulch South	ER_S2_Pit_1	5	0.8	A
	ER_S2_Pit_1	32	1.2	Bw
	ER_S2_Pit_1	60	1.5	Bt
	ER_S2_Pit_1	100	1.5	Bt
East River Terminal	ER_BCTM_Pit_1	6	0.9	A
	ER_BCTM_Pit_1	40	1.2	Bw
	ER_BCTM_Pit_1	70	1.1	Bw

Table S2. Soil pH measurements.

Site	SAMPLE ID	Depth	H ₂ O pH no. 1	H ₂ O pH no. 2	Average pH in H ₂ O	1σ sd	CaCl ₂ pH	K _a (L Kg ⁻¹)
Copper Creek	ER_CCT_pit_1_0-10	0-10	4.35	4.32	4.34	0.02	3.66	5171
	ER_CCT_pit_1_10-20	10-20	4.41	4.39	4.40	0.01	3.62	5724
	ER_CCT_pit_1_20-30	20-30	4.67	4.64	4.66	0.02	3.72	8789
	ER_CCT_pit_1_30-40	30-40	4.66	4.69	4.68	0.02	3.70	9076
	ER_CCT_pit_1_40-50	40-50	4.73	4.72	4.73	0.01	3.69	9830
	ER_CCT_pit_1_50-60	50-60	5.39	5.38	5.39	0.01	4.12	25972
	Depth average pH = 4.70 ± 0.37							
Washington Gulch North	ER_S2_pit_1_0-10	0-10	5.18	5.18	5.18	0	4.47	19396
	ER_S2_pit_1_10-20	10-20	5.23	5.22	5.23	0.01	4.37	20824
	ER_S2_pit_1_20-30	20-30	5.61	5.63	5.62	0.01	4.59	35069
	ER_S2_pit_1_30-40	30-40	5.69	5.7	5.7	0.01	4.79	38743
	ER_S2_pit_1_40-55	40-55	5.63	5.65	5.64	0.01	4.50	35962
	ER_S2_pit_1_55-75	55-75	5.85	5.83	5.84	0.01	4.7	45846
	ER_S2_pit_1_75-95	75-95	6.07	6.1	6.09	0.02	4.97	60765
	ER_S2_pit_1_130-140	130-140	5.50	n/a	5.50	n/a	4.47	30060
	Depth average pH = 5.60 ± 0.30							
Gothic	ER_GM_pit_1_0-15	0-15	5.08	5.07	5.08	0.01	4.65	16782
	ER_GM_pit_1_15-30	15-30	5.05	5.04	5.05	0.01	4.52	16057
	ER_GM_pit_1_30-45	30-45	5.01	5.01	5.01	0	4.49	15131
	ER_GM_pit_1_45-65	45-65	5.81	5.82	5.82	0.01	5.20	44778
	ER_GM_pit_1_65-85	65-85	5.81	5.82	5.82	0.01	5.43	44778
	ER_GM_pit_1_85-105	85-105	6.61	6.64	6.63	0.02	5.96	103044
	ER_GM_pit_1_105-125	105-125	6.42	6.47	6.45	0.04	5.72	87441
	ER_GM_pit_1_125-145	125-145	6.35	6.36	6.36	0.01	5.52	80198

Depth average pH = 5.77 ± 0.67								
Washington Gulch South	ER_AM_pit_1_0-10	0-10	6.15	6.2	6.18	0.04	5.39	66857
	ER_AM_pit_1_10-20	10-20	6.05	6.1	6.08	0.04	5.28	60112
	ER_AM_pit_1_20-30	20-30	6.02	5.99	6.01	0.02	5.11	55672
	ER_AM_pit_1_30-40	30-40	5.65	5.66	5.66	0.01	5.15	36871
	ER_AM_pit_1_40-55	40-55	5.64	5.61	5.63	0.02	5.12	35513
	ER_AM_pit_1_55-65	55-65	5.82	5.83	5.83	0.01	5.26	45310
	ER_AM_pit_1_65-85	65-85	5.86	5.86	5.86	0	5.31	46933
Depth average pH = 5.89 ± 0.21								
East River Terminal	ER_BCTM_pit_1_0-10	0-10	5.36	5.40	5.38	0.03	4.93	25623
	ER_BCTM_pit_1_10-20	10-20	6.23	6.27	6.25	0.03	5.63	71862
	ER_BCTM_pit_1_20-30	20-30	6.33	6.34	6.34	0.01	5.65	78640
	ER_BCTM_pit_1_30-50	30-50	6.51	6.54	6.53	0.02	5.80	94195
	ER_BCTM_pit_1_50-80	50-80	7.05	7.09	7.07	0.03	6.72	146898
Depth average pH = 6.31 ± 0.61								

Note: H₂O pH was measured on approximately 5 g of powdered <2 mm material mixed with 12 mL ultrapure water. CaCl₂ pH was measured on the same samples using approximately 5 g of powdered <2 mm material mixed with 25 mL of 0.01 M CaCl₂, maintaining the 1:5 soil:solution ratio used by You et al. (1989). Samples were stirred and left overnight prior to pH measurements in water and were shaken for 1 h prior to measurement in CaCl₂. K_d values were calculated from H₂O pH using the pH-dependent relation of Campforts et al. (2016) as reported by Deng et al. (2021). Quality-control measurements of a pH 6 standard treated as an unknown yielded 6.02, 6.00, 6.03, 6.02, and 6.02 (mean = 6.02 ± 0.01, 1σ, n = 5). The Washington Gulch North 130-140 cm sample was measured once in H₂O and is therefore reported without duplicate pH or 1σ.

Table S3. Soil bulk density and fraction of < 2 mm clast values assigned to each composite sample interval.

Site	Sample ID	Bulk density (g cm ⁻³)	Fine (< 2 mm, V _f) fraction	Coarse (> 2 mm, V _{cl} +V _{c2}) fraction
Copper Creek	ER_CCT_pit_1_0-10	1.0	0.89	0.11
	ER_CCT_pit_1_10-20	0.9	0.94	0.06
	R_ER_CCT_Pit_1_20_30	1.1	0.83	0.17
	ER_CCT_pit_1_30-40	1.0	0.87	0.13
	ER_CCT_pit_1_40-50	1.0	0.86	0.14
	ER_CCT_pit_1_50-60	1.0	0.74	0.26
Washington Gulch North	ER_S2_pit_1_0-10	0.8	0.87	0.13
	ER_S2_pit_1_10-20	1.2	0.73	0.27
	ER_S2_pit_1_20-30	1.2	0.77	0.23
	ER_S2_pit_1_30-40	1.2	0.78	0.22
	ER_S2_pit_1_40-55	1.5	0.77	0.23
	ER_S2_pit_1_55-75	1.5	0.74	0.26
	ER_S2_pit_1_75-95	1.5	0.75	0.25
	ER24_S2_Pit_2_130-140_A	1.5	0.39	0.61
Gothic	ER_GM_pit_1_0-15	1	0.93	0.07
	ER_GM_pit_1_15-30	1.4	0.73	0.27
	ER_GM_pit_1_30-45	1.4	0.63	0.37
	ER_GM_pit_1_45-65	1.4	0.61	0.39
	ER_GM_pit_1_65-85	1.4	0.74	0.26
	ER_GM_pit_1_85-105	1.4	0.63	0.37
	ER_GM_pit_1_105-125	1.4	0.57	0.43

	ER_GM_pit_1_125-145	1.4	0.74	0.26
Washington Gulch South	ER_AM_Pit_1_0-10	1	0.90	0.1
	ER_AM_pit_1_10-20	1.2	0.88	0.12
	ER_AM_pit_1_20-30	1.2	0.86	0.14
	ER_AM_pit_1_30-40	1.4	0.84	0.16
	ER_AM_pit_1_40-55	1.4	0.83	0.17
	ER_AM_pit_1_55-65	1.6	0.65	0.35
	ER_AM_pit_1_65-85	1.6	0.62	0.38
East River Terminal	ER_BCTM_pit_1_0-10	0.9	0.87	0.13
	ER_BCTM_pit_1_10-20	1.2	0.47	0.53
	ER_BCTM_pit_1_20-30	1.2	0.72	0.28
	ER_BCTM_pit_1_30-50	1.2	0.74	0.26
	ER_BCTM_pit_1_50-80	1.2	0.79	0.21

Note: Copper Creek: Bulk density values for each depth interval were based on the values measured for each 10 cm increment to 40 cm depth. The 40-50 and 50-60 cm increments were assigned the bulk density value measured at 40 cm depth. Washington Gulch South: The 0-10 cm depth increment is assigned the measured bulk density at 10 cm. The 10-20 and 20-30 cm increments are assigned the measured bulk density at 30 cm. We consider the bulk density measured at 50 cm to be anomalously low and assign the 30-40 and 40-55 cm depth increments the mean value of the measurements above and below this sample (1.4 g cm^{-3}). The 55-65 and 65-85 cm depth increments are assigned the bulk density measurements at 75 and 87.5 cm. Gothic: The 0-15 cm increment is assigned a bulk density value (1.0 g cm^{-3}) that reflects the organic-rich and mineral horizons encompassed by that depth interval. All other depth increments are assigned the bulk density values measured at 40 and 70 cm depth (1.4 g cm^{-3}). Washington Gulch North: The 0-10 cm increment is assigned the bulk density measured at 5 cm depth. The 10-20, 20-30, and 30-40 cm depth increments are assigned the bulk density value measured at 32 cm depth. The deeper sample intervals were assigned the bulk density values measured at 60 and 100 cm depth (1.5 g cm^{-3}). East River Terminal: The 0-10 cm increment was assigned the bulk density measured at 6 cm depth. The deeper sample intervals were assigned the bulk density measured at 40 cm depth (1.2 g cm^{-3}).

Table S4. Evapotranspiration, water flux (Q), profile-average K_d , and modeled desorption loss values used for the profile-average pH scenario.

Site	Elevation (m)	MAP PRISM (mm yr ⁻¹)	CLM ET station	CLM ET station elevation (m)	CLM ET land cover	CLM ET 2014-2015 (mm yr ⁻¹)	Q (L cm ⁻² yr ⁻¹)	K_d (L kg ⁻¹)	F_{des} (10 ⁶ atoms cm ⁻² yr ⁻¹)
Copper Creek	3476	1353	Mexican_Cut	3412	Evergreen Forest	476.9	0.0876	10760	3.69
Washington Gulch North	2944	784	Kettle_Ponds	2860	Grassland/Herbaceous	276.2	0.0508	38753	0.23
Gothic	2885	885	Kettle_Ponds	2860	Grassland/Herbaceous	276.2	0.0609	54650	0.10
Washington Gulch South	2864	655	Kettle_Ponds	2860	Grassland/Herbaceous	276.2	0.0379	48466	0.14
East River Terminal	2764	585	wu_KCOCREST4	2711	Shrub/Scrub	280.3	0.0305	100651	0.04

Table S5. Natural ⁹Be contribution relative to the ⁹Be carrier added for meteoric ¹⁰Be measurements.

Site	Sample ID	Be concentration in aliquot (ug g ⁻¹)	Fusion sample mass (g)	Native ⁹ Be in fusion sample (ug)	⁹ Be carrier added (ug)	Native ⁹ Be / carrier × 100 (%)
Copper Creek	ER_CCT_pit_1_0-10	1.2	0.5227	0.6272	353.3	0.178
Copper Creek	ER_CCT_pit_1_10-20	0.6	0.5396	0.3238	352.9	0.092
Copper Creek	R_ER_CCT_Pit_1_20_30	0.6	0.5174	0.3104	351.7	0.088
Copper Creek	ER_CCT_pit_1_30-40	1	0.4994	0.4994	352.9	0.142
Copper Creek	ER_CCT_pit_1_40-50	1.1	0.4998	0.5498	352.9	0.156
Copper Creek	ER_CCT_pit_1_50-60	0.9	0.5004	0.4504	352.2	0.128

Washington Gulch North	ER_S2_pit_1_0-10	1.1	0.5456	0.6002	353.8	0.17
Washington Gulch North	ER_S2_pit_1_10-20	0.9	0.5366	0.4829	353.3	0.137
Washington Gulch North	ER_S2_pit_1_20-30	1	0.5165	0.5165	352.2	0.147
Washington Gulch North	ER_S2_pit_1_30-40	1.4	0.4948	0.6927	353.5	0.196
Washington Gulch North	ER_S2_pit_1_40-55	1.1	0.4992	0.5491	353.4	0.155
Washington Gulch North	ER_S2_pit_1_55-75	1.4	0.5032	0.7045	352.4	0.2
Washington Gulch North	ER_S2_pit_1_75-95	1.4	0.4959	0.6943	353.1	0.197
Washington Gulch North	ER24_S2_Pit_2_130-140_A	2	0.5249	1.0498	351.1	0.299
Gothic	ER_GM_pit_1_0-15	0.6	0.4996	0.2998	352.3	0.085
Gothic	ER_GM_pit_1_15-30	1.4	0.4975	0.6965	350.6	0.199
Gothic	ER_GM_pit_1_30-45	1.4	0.4983	0.6976	351.9	0.198
Gothic	ER_GM_pit_1_45-65	1.5	0.5025	0.7537	352.1	0.214
Gothic	ER_GM_pit_1_65-85	1.6	0.5308	0.8493	354.6	0.24
Gothic	ER_GM_pit_1_85-105	1.4	0.5149	0.7209	351.3	0.205
Gothic	ER_GM_pit_1_105-125	1	0.5073	0.5073	352.1	0.144
Gothic	ER_GM_pit_1_125-145	1.4	0.5174	0.7244	351.7	0.206
Washington Gulch South	ER_AM_Pit_1_0_10	1	0.4927	0.4927	353	0.14
Washington Gulch South	ER_AM_pit_1_10-20	1.1	0.4863	0.5349	352.6	0.152
Washington Gulch South	ER_AM_pit_1_20-30	1.4	0.5008	0.7011	352	0.199
Washington Gulch South	ER_AM_pit_1_30-40	1.4	0.521	0.7294	351.8	0.207
Washington Gulch South	ER_AM_pit_1_40-55	1.6	0.5648	0.9037	351.7	0.257
Washington Gulch South	ER_AM_pit_1_55-65	1.5	0.5088	0.7632	352	0.217
Washington Gulch South	ER_AM_pit_1_65-85	1.4	0.5308	0.7431	354.6	0.21
East River Terminal	ER_BCTM_pit_1_0-10	1.1	0.4968	0.5465	351.1	0.156
East River Terminal	ER_BCTM_pit_1_10-20	0.9	0.498	0.4482	352.2	0.127
East River Terminal	ER_BCTM_pit_1_20-30	1.4	0.5889	0.8245	353	0.234
East River Terminal	ER_BCTM_pit_1_30-50	1	0.4999	0.4999	353	0.142
East River Terminal	ER_BCTM_pit_1_50-80	1.1	0.4902	0.5392	352.9	0.153

Table S6. Regression coefficients and statistics for the models shown in Figure 4.

Variable	Dataset	Regression type	Slope	y-intercept	R ² (centered)	p-value
Elevation (m)	Inheritance-corrected	Regular	1669	-3.95e+06	0.91	0.012
Elevation (m)	Erosion- and desorption-corrected	Regular	4858	-1.33e+07	0.96	0.004
MAP (mm yr ⁻¹)	Inheritance-corrected	Regular	1497	-247540	0.85	0.026
MAP (mm yr ⁻¹)	Inheritance-corrected	Origin	1234	0.000	0.82	<0.001
MAP (mm yr ⁻¹)	Erosion- and desorption-corrected	Regular	4488	-2.57e+06	0.95	0.005
MAP (mm yr ⁻¹)	Erosion- and desorption-corrected	Origin	1746	0	0.56	0.020

Mean snow depth (m) 2018-2019	Inheritance-corrected	Regular	885345	138143	0.97	0.002
Mean snow depth (m) 2018-2019	Inheritance-corrected	Origin	996407	0.000	0.95	<0.001
Mean snow depth (m) 2018-2019	Erosion- and desorption-corrected	Regular	2.40e+06	-1.16e+06	0.88	0.017
Mean snow depth (m) 2018-2019	Erosion- and desorption-corrected	Origin	1.47e+06	0	0.72	0.008
Mean SWE (m) 2018-2019	Inheritance-corrected	Regular	2.91e+06	-24454	0.97	0.002
Mean SWE (m) 2018-2019	Inheritance-corrected	Origin	2.85e+06	0.000	0.97	<0.001
Mean SWE (m) 2018-2019	Erosion- and desorption-corrected	Regular	7.96e+06	-1.63e+06	0.90	0.013
Mean SWE (m) 2018-2019	Erosion- and desorption-corrected	Origin	4.11e+06	0	0.66	0.012

Table S7. Regression coefficients and statistics for the Figure 4 regression models fitted after omitting the Copper Creek data point.

Variable	Dataset	Regression type	Slope	y-intercept	R ² (centered)	p-value
Elevation (m)	Inheritance-corrected	Regular	3317	-8.67e+06	0.82	0.093
Elevation (m)	Erosion- and desorption-corrected	Regular	2169	-5.57e+06	0.28	0.473
MAP (mm yr ⁻¹)	Inheritance-corrected	Regular	1245	-69194	0.37	0.393
MAP (mm yr ⁻¹)	Inheritance-corrected	Origin	1152	0.000	0.37	0.004
MAP (mm yr ⁻¹)	Erosion- and desorption-corrected	Regular	2090	-881067	0.82	0.094
MAP (mm yr ⁻¹)	Erosion- and desorption-corrected	Origin	909	0.000	0.55	0.007
Mean snow depth (m) 2018-2019	Inheritance-corrected	Regular	1.00e+06	53242	0.88	0.064
Mean snow depth (m) 2018-2019	Inheritance-corrected	Origin	1.06e+06	0.000	0.87	<0.001
Mean snow depth (m) 2018-2019	Erosion- and desorption-corrected	Regular	666408	117629	0.31	0.446
Mean snow depth (m) 2018-2019	Erosion- and desorption-corrected	Origin	805527	0.000	0.29	0.015
Mean SWE (m) 2018-2019	Inheritance-corrected	Regular	3.81e+06	-279440	0.93	0.033
Mean SWE (m) 2018-2019	Inheritance-corrected	Origin	2.90e+06	0.000	0.88	<0.001
Mean SWE (m) 2018-2019	Erosion- and desorption-corrected	Regular	2.20e+06	-5718	0.25	0.503
Mean SWE (m) 2018-2019	Erosion- and desorption-corrected	Origin	2.19e+06	0.000	0.25	0.016