



*Supplement of*

**Stream water sourcing from high-elevation snowpack inferred from stable isotopes of water: a novel application of d-excess values**

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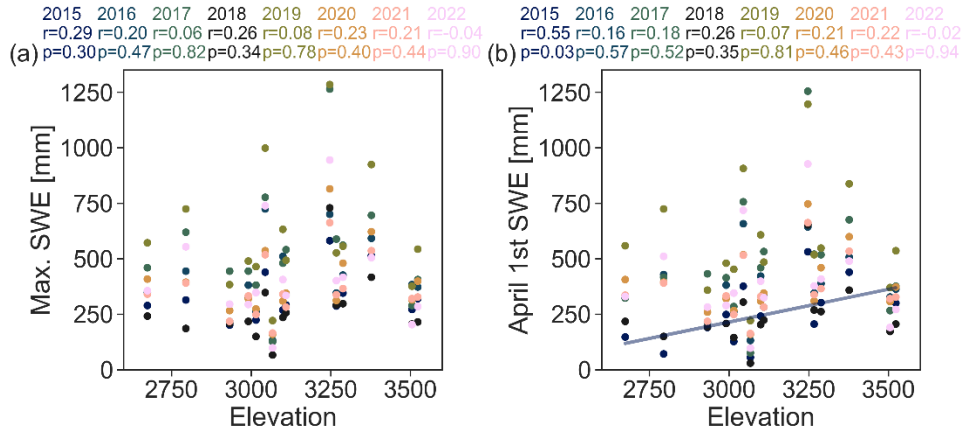


Figure S1 (a) Relation between maximum snow water equivalent (SWE) at the 15 SNOTEL sites in the Gunnison River basin and the elevation of the SNOTEL sites for the years 2015 to 2022. (b) same as in (a), but with SWE on April 1<sup>st</sup>. Given are the Pearson correlation coefficients for each year and the years are color coded (data from NWCC, 2023).

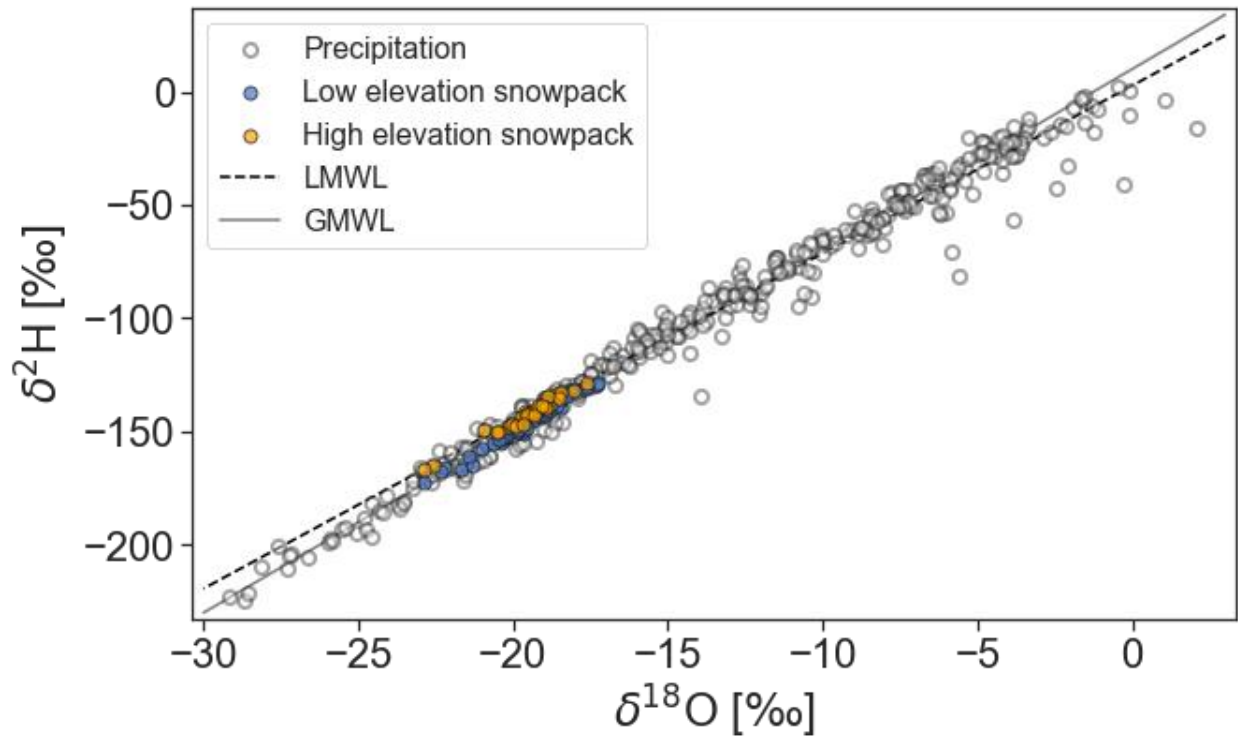


Figure S2 Precipitation samples from 2015 to 2022 (white points) and snowpack sampled at sites <3200 m a.s.l. (“Low elevation”, blue) and sites above >3200 m a.s.l. (“High elevation”, orange). Also shown are the Global Meteoric Water Line (GMWL:  $\delta^2\text{H} = 8.2 \delta^{18}\text{O} + 11.27$ , Rozanski et al. (1993)) and the Local Meteoric Water Line (LMWL:  $\delta^2\text{H} = 7.4 \delta^{18}\text{O} + 2.4$ , Carroll et al. (2022)).

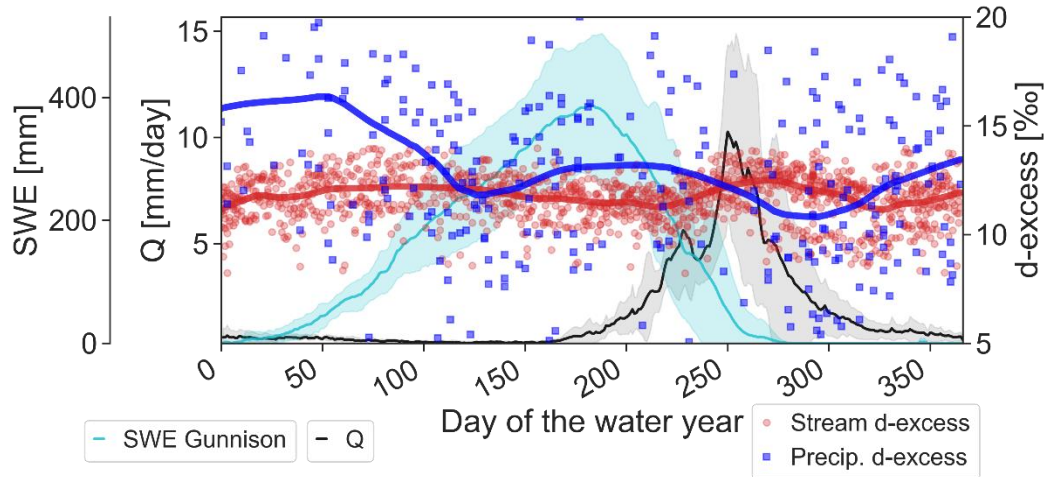


Figure S3 Median annual dynamics of snow water equivalent (SWE) at the Gunnison SNOTEL stations (cyan) and East River streamflow (Q, black) from water year 2015 to 2022 with semitransparent area representing the range. The d-excess of all stream water at East River (red) and precipitation (blue) samples collected between water year 2015 and 2022. The red and blue lines represent a lowess filter to show any trends in the data.

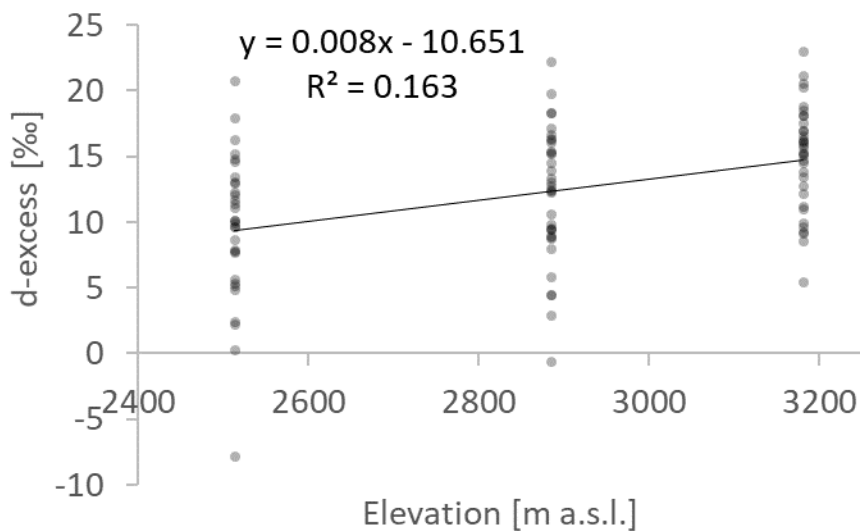
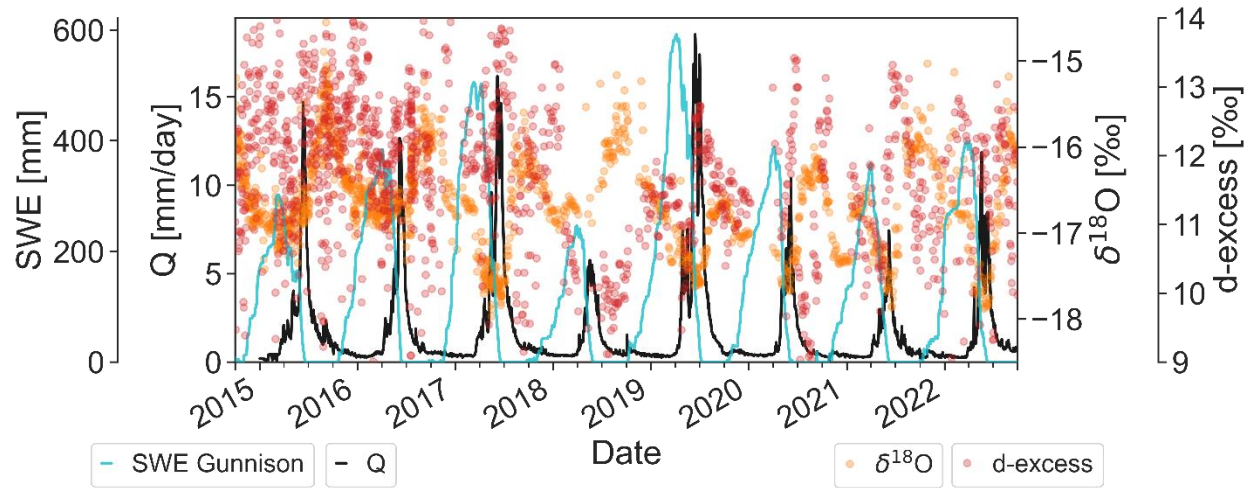
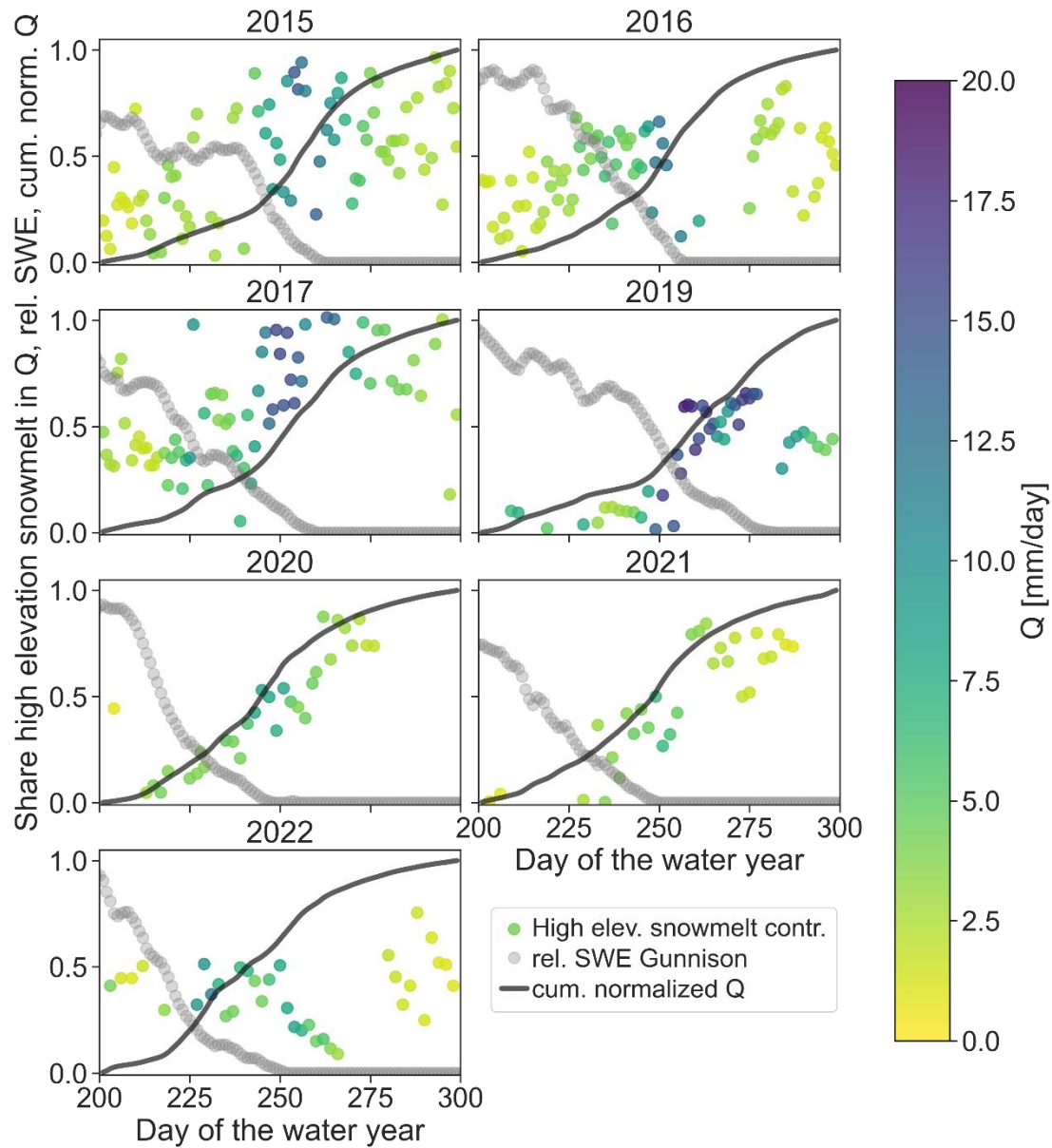


Figure S4 The d-excess of winter precipitation from samples collected between November and April during the water years 2021 and 2022 at the locations Estess (2513 m), Mount Crested Butte (2885 m) and Irwin Barn (3181 m). The black diamonds show the mean values and half-transparent dots are individual samples. The regression line shows the d-excess lapse rate of 0.7 ‰/100 m.



**Figure S5** Snow water equivalent (SWE) at the Gunnison SNOTEL stations (cyan line), streamflow (Q, black line) at the East River, as well as the  $\delta^{18}\text{O}$  (orange points) and *d-excess* (red points) of the stream water sampled at Pumphouse for the water years 2015 to 2022.



**Figure S6** Total streamflow (Q, black line) as well as the snow water equivalent (SWE, cyan) for the SNOTEL sites in the Gunnison catchment. (right) Share of high elevation snowmelt in the streamflow (points, color coded by Q), relative observed SWE in Gunnison (1= maximum SWE), and cumulative streamflow between day 200 and 300 of the water year. Note that the y-axis for the graphs on the right is plotted on the right-hand side.

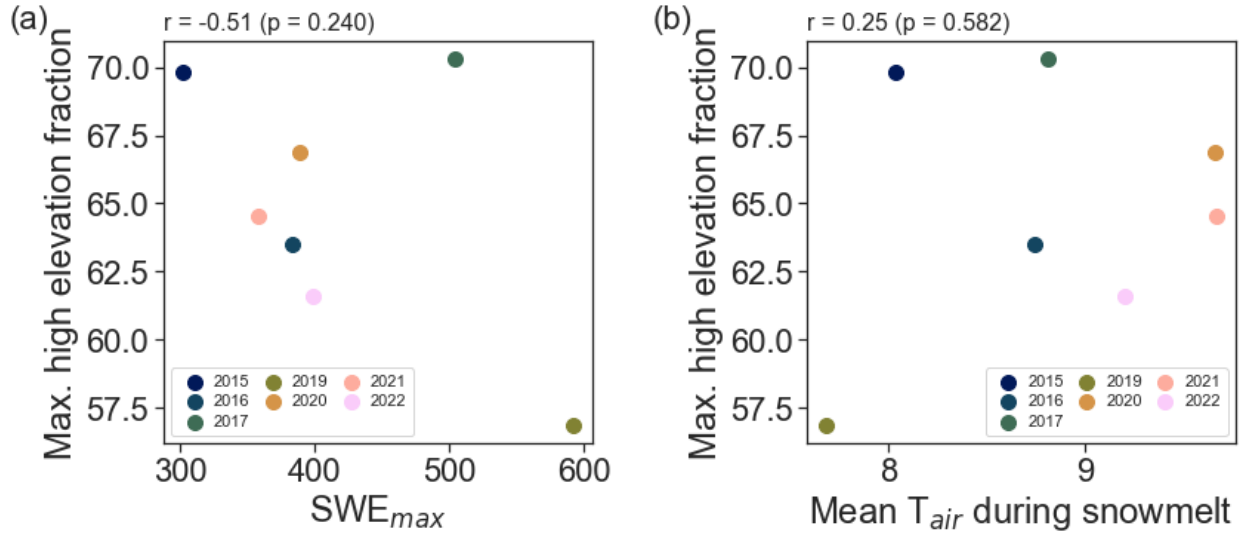


Figure S7 Relation between maximum fraction of high elevation snowpack contributions to the snowmelt runoff and the maximum snow water equivalent (in a) and mean air temperature during the snowmelt period (in b).

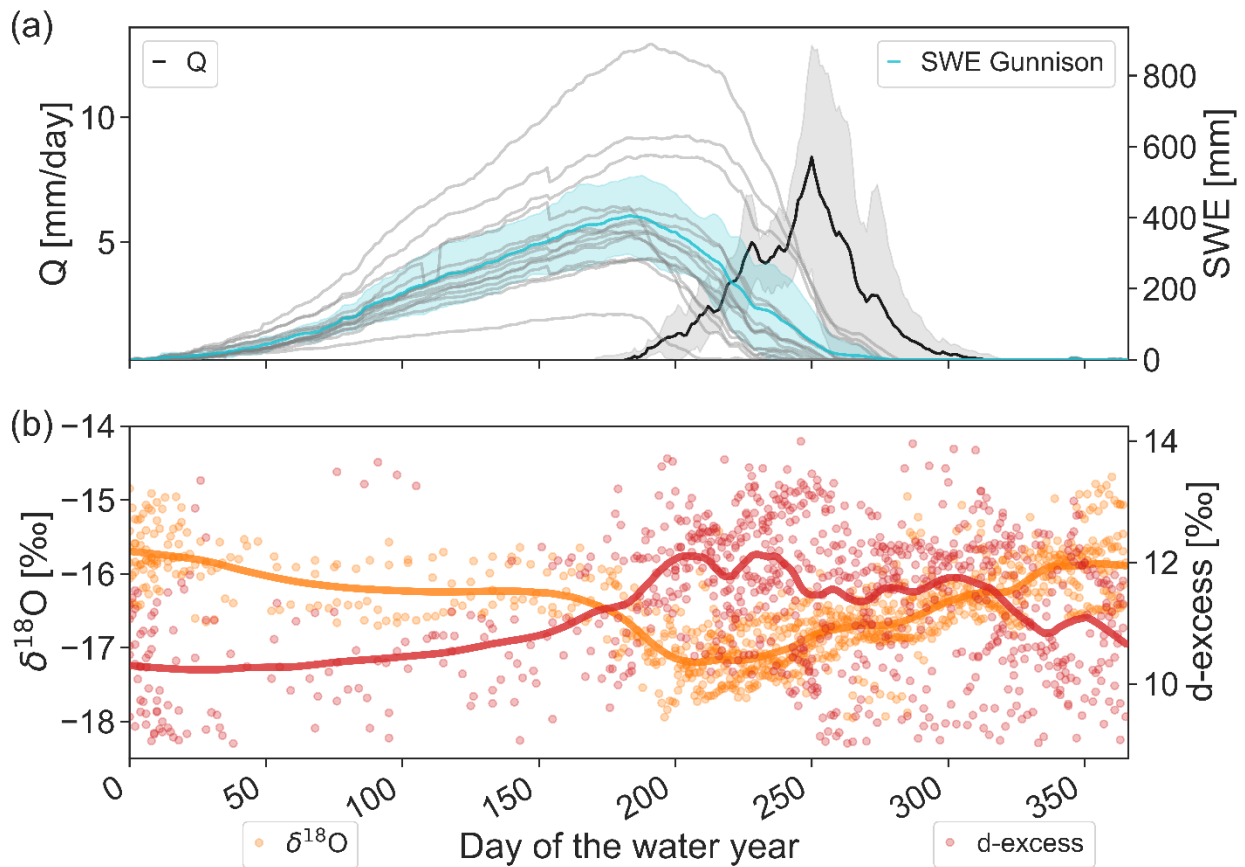
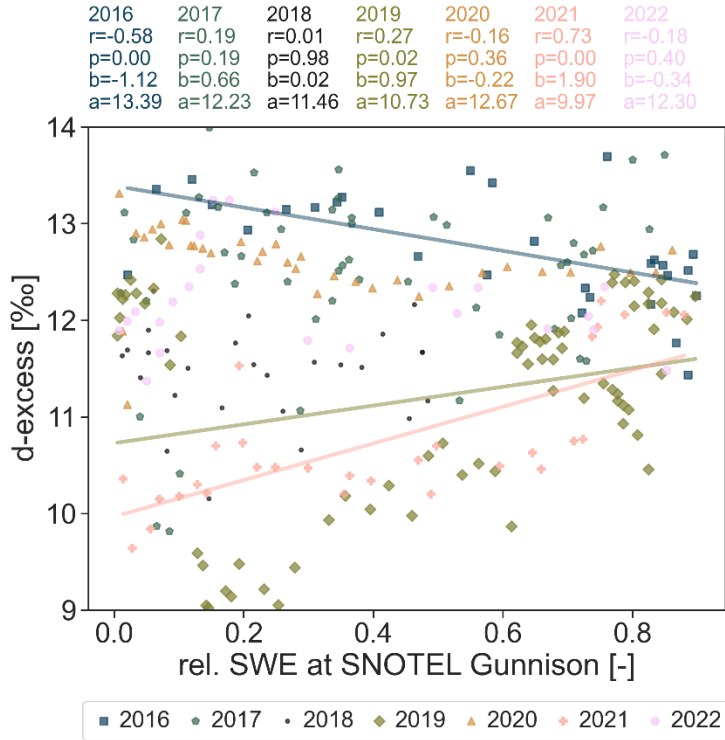
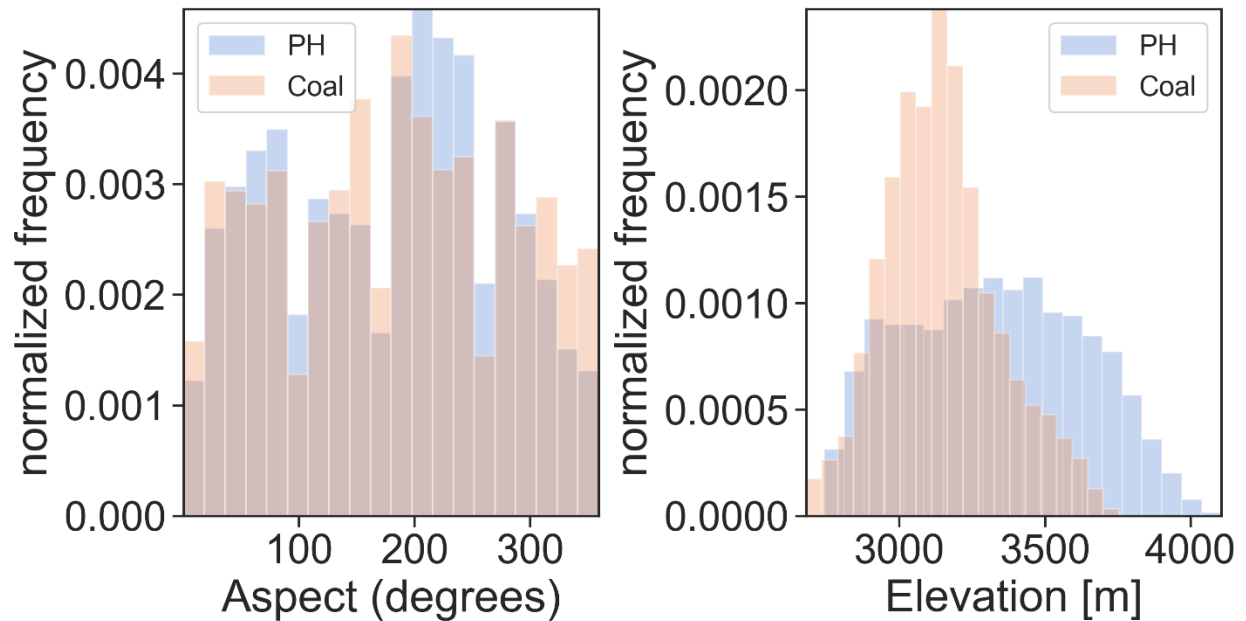


Figure S8 (a) Median annual dynamics of Coal Creek streamflow ( $Q$ , black) and snow water equivalent (SWE) at the individual SNOTEL sites within the Gunnison River catchment (grey) and the average of all sites (cyan) from water year 2016 to 2022 with semitransparent grey and cyan area representing the standard deviation of  $Q$  and SWE, respectively. (b) The  $\delta^{18}O$  (orange) and  $d$ -excess (red) of all stream water samples collected between water year 2016 and 2022 from the East River at the Pumphouse location. The orange and red lines are a LOWESS fit to the data points.



**Figure S9** The *d-excess* of Coal Creek stream water during snowmelt for seven individual years, shown as a function of relative SWE measured at the SNOTEL stations across the Gunnison River catchment at the time of sampling. For each year, the Pearson correlation ( $r$ ) and the associated significance level ( $p$ ) are given as well as the intercept ( $a$ ) and slope ( $b$ ) of the regression.



**Figure S10** Distribution of aspect (left) and elevation (right) across the East River catchment defined at Pumphouse (PH, blue) and Coal Creek (Coal, orange).

**Table S1 SNOTEL sites located in the Gunnison River Basin ((data from NWCC, 2023)).**

| <b>Station Id</b> | <b>Station Name</b> | <b>Elevation (m)</b> | <b>Latitude</b> | <b>Longitude</b> | <b>County Name</b> |
|-------------------|---------------------|----------------------|-----------------|------------------|--------------------|
| 380               | Butte               | 3108.96              | 38.8944         | -106.95          | Gunnison           |
| 1059              | Cochetopa Pass      | 3066.59              | 38.1627         | -106.6           | Saguache           |
| 409               | Columbine Pass      | 2795.32              | 38.4182         | -108.38          | Montrose           |
| 538               | Idarado             | 2990.7               | 37.9339         | -107.68          | Ouray              |
| 618               | Mc Clure Pass       | 2674.32              | 39.129          | -107.29          | Gunnison           |
| 622               | Mesa Lakes          | 3099.21              | 39.0574         | -108.06          | Mesa               |
| 675               | Overland Res.       | 3015.39              | 39.0904         | -107.64          | Delta              |
| 680               | Park Cone           | 2932.48              | 38.8198         | -106.59          | Gunnison           |
| 682               | Park Reservoir      | 3044.04              | 39.0443         | -107.88          | Delta              |
| 701               | Porphyry Creek      | 3288.18              | 38.4886         | -106.34          | Gunnison           |
| 713               | Red Mountain Pass   | 3377.18              | 37.8917         | -107.71          | San Juan           |
| 1128              | Sargents Mesa       | 3504.9               | 38.2856         | -106.37          | Saguache           |
| 737               | Schofield Pass      | 3247.03              | 39.0147         | -107.05          | Gunnison           |
| 762               | Slumgullion         | 3523.49              | 37.9908         | -107.2           | Hinsdale           |
| 1141              | Upper Taylor        | 3266.54              | 38.9907         | -106.75          | Gunnison           |



| <b>Station Id</b> | <b>Station Name</b> | <b>Elevation (m)</b> | <b>Latitude</b> | <b>Longitude</b> | <b>County Name</b> |
|-------------------|---------------------|----------------------|-----------------|------------------|--------------------|
| 1030              | Arapaho Ridge       | 3345.48              | 40.351          | -106.38          | Grand              |
| 1061              | Bear River          | 2777.34              | 40.0615         | -107.01          | Routt              |
| 1041              | Beaver Ck Village   | 2610.61              | 39.5987         | -106.51          | Eagle              |
| 335               | Berthoud Summit     | 3448.51              | 39.8036         | -105.78          | Grand              |
| 345               | Bison Lake          | 3341.83              | 39.7646         | -107.36          | Garfield           |
| 913               | Buffalo Park        | 2819.1               | 40.2284         | -106.6           | Grand              |
| 1101              | Chapman Tunnel      | 3078.48              | 39.2621         | -106.63          | Pitkin             |
| 408               | Columbine           | 2794.1               | 40.3959         | -106.6           | Jackson            |
| 415               | Copper Mountain     | 3207.41              | 39.4892         | -106.17          | Summit             |
| 1120              | Elliot Ridge        | 3215.34              | 39.8638         | -106.42          | Summit             |
| 485               | Fremont Pass        | 3452.16              | 39.3801         | -106.2           | Summit             |
| 505               | Grizzly Peak        | 3395.17              | 39.6465         | -105.87          | Summit             |
| 542               | Independence Pass   | 3230.27              | 39.0754         | -106.61          | Pitkin             |
| 547               | Ivanhoe             | 3212.9               | 39.2923         | -106.55          | Pitkin             |
| 970               | Jones Pass          | 3177.84              | 39.7645         | -105.91          | Grand              |
| 556               | Kiln                | 2933.4               | 39.3172         | -106.62          | Pitkin             |
| 565               | Lake Irene          | 3255.87              | 40.4145         | -105.82          | Grand              |
| 607               | Lynx Pass           | 2718.51              | 40.0783         | -106.67          | Routt              |
| 618               | Mc Clure Pass       | 2674.32              | 39.129          | -107.29          | Gunnison           |

|      |                   |         |         |         |          |
|------|-------------------|---------|---------|---------|----------|
| 1040 | Mccoey Park       | 2900.48 | 39.6023 | -106.54 | Eagle    |
| 622  | Mesa Lakes        | 3099.21 | 39.0574 | -108.06 | Mesa     |
| 1014 | Middle Fork Camp  | 2733.75 | 39.7957 | -106.03 | Grand    |
| 658  | Nast Lake         | 2661.21 | 39.297  | -106.61 | Pitkin   |
| 669  | North Lost Trail  | 2809.95 | 39.0782 | -107.14 | Gunnison |
| 675  | Overland Res.     | 3015.39 | 39.0904 | -107.64 | Delta    |
| 682  | Park Reservoir    | 3044.04 | 39.0443 | -107.88 | Delta    |
| 688  | Phantom Valley    | 2756.92 | 40.398  | -105.85 | Grand    |
| 737  | Schofield Pass    | 3247.03 | 39.0147 | -107.05 | Gunnison |
| 802  | Summit Ranch      | 2856.28 | 39.718  | -106.16 | Summit   |
| 842  | Vail Mountain     | 3142.49 | 39.6177 | -106.38 | Eagle    |
| 869  | Willow Creek Pass | 2902.61 | 40.3473 | -106.1  | Grand    |

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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