

Supplement to: Data-driven inference of snowmelt from streamflow in 110 catchment across three continents

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S1 Streamflow availability in snow-influenced catchments

Data sources

Daily streamflow records and catchment attributes were taken from the Caravan large-sample hydrological dataset and its GRDC extension (Kratzert et al., 2025; Färber et al., 2025). We analysed four Caravan subsets for which daily discharge time series and HydroATLAS-derived catchment attributes are available locally: the GRDC extension (`grdc`), CAMELS–United States (`camels`), CAMELS–Chile (`camelscl`), and CAMELS–Great Britain (`camelsgb`). For each gauge, HydroATLAS attributes, Caravan climate attributes, and other station metadata (including gauge coordinates, country, and catchment area) were merged on `gauge_id`. Daily discharge was read from the Caravan NetCDF or CSV time series (`streamflow`).

Where the same United States Geological Survey (USGS) gauging site appears in both CAMELS–US and the GRDC extension, the GRDC record was retained and the CAMELS–US duplicate was discarded, so that the typically longer GRDC series is not double-counted.

Definition of snow-influenced and mountainous catchments

Catchments were screened using HydroATLAS attributes distributed with Caravan (Linke et al., 2019):

- snow-influenced: long-term mean annual snow-cover extent `snw_pc_syr` > 25% and glacier cover `gla_pc_sse` < 10%;
- no additional drainage-area filter was imposed beyond discarding gauges with missing area or coordinates (operational bounds $0\text{--}2 \times 10^6 \text{ km}^2$).

This snow-and-glacier filter defines the set of *snow-influenced* catchments reported in Appendix A of the main text.

A second, more restrictive set of *mountainous snow-influenced* catchments additionally required that at least 20% of raster cells within the Caravan basin polygon belong to mountain classes of the global K3 mountain inventory raster (`k3classes`;

class codes 26, 27, 31 and 32) (Körner et al., 2017). Mountain fraction was computed by masking the K3 raster with each catchment polygon and taking the ratio of mountain-classified cells to all cells in the mask.

Only gauges that passed the static filters and for which a daily discharge time series could be located were retained.

Water years and streamflow completeness

25 Catchment-years were counted on a water-year basis using the water-year *end* year Y as the label:

- Northern Hemisphere (gauge latitude ≥ 0): 1 October of calendar year $Y - 1$ through 30 September of year Y ;
- Southern Hemisphere (gauge latitude < 0): 1 April of calendar year $Y - 1$ through 31 March of year Y (six-month shift relative to the October–September convention).

A water year was counted only if (i) the full water-year interval lies within the observed discharge record, (ii) daily dates are
30 complete over that interval (one value per day), and (iii) the fraction of missing (NaN) discharge values does not exceed 10%.
Catchments with no such complete water year were excluded from the reported catchment totals.

Assignment to satellite eras

Valid catchment-years were grouped by the water-year end label Y relative to the operational start of Landsat-era and MODIS-era snow observations:

- 35
- pre-Landsat: $Y < 1985$;
 - Landsat / pre-MODIS: $1985 \leq Y \leq 2000$;
 - post-MODIS: $Y > 2000$.

The pre-MODIS totals quoted in Appendix A of the main text (years that precede the onset of MODIS observations in 2000) are the sum of the first two classes, i.e. all valid water years with end label $Y \leq 2000$. Pre-Landsat totals correspond to $Y < 1985$
40 only. While earlier Landsat missions exist before 1985, those are not deemed suitable for SWE reanalysis (Margulis et al., 2015).

Reported totals

Applying the snow-influenced filters and water-year completeness criteria above yields **101,732** valid catchment-years across **2,495** catchments. Of these, **69,648** have water-year end label $Y \leq 2000$ (pre-MODIS) and **41,335** have $Y < 1985$ (pre-
45 Landsat). Restricting further to the mountainous snow-influenced subset ($\geq 20\%$ K3 mountain cells) yields **1,371** catchments contributing **40,480** pre-MODIS and **23,833** pre-Landsat catchment-years. Spatial patterns of the number of valid water years per gauge are shown in Fig. A1 of the main text.

These figures are a lower bound on historically available streamflow in snow-influenced regions: Caravan does not yet include several national mountain networks (e.g. parts of Eastern Europe, Asia, the Middle East, France and Italy), which would further enlarge the sample.

S2 Results across all configurations and catchments

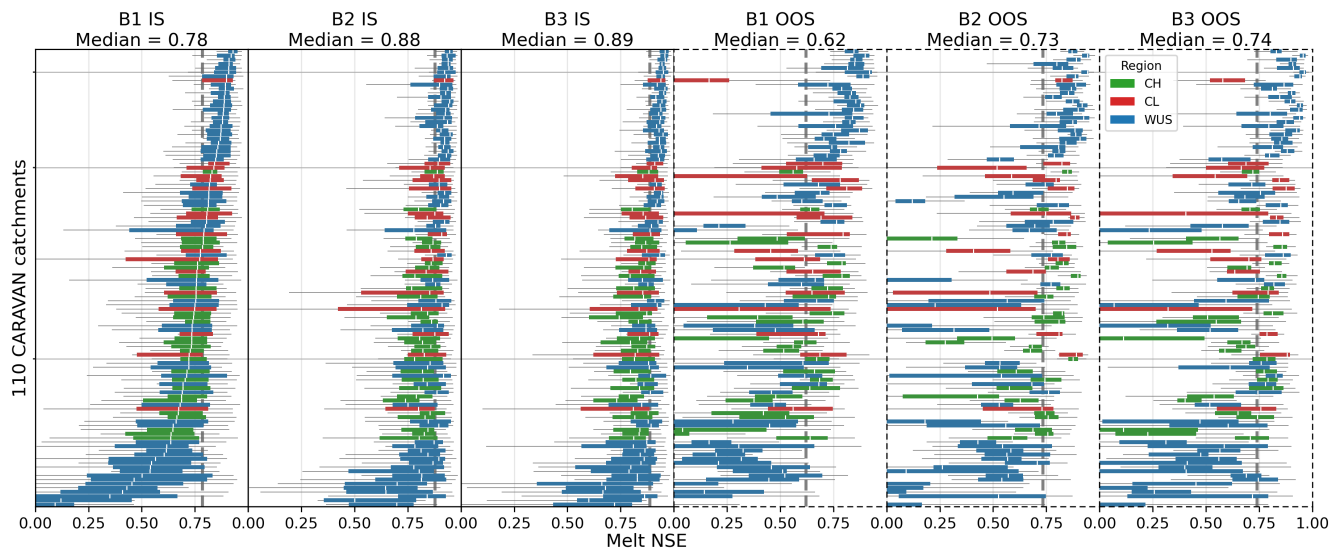


Figure S1. Boxplots showing annual median melt NSE values (x-axis) for each of the 110 test catchments (y-axis), in both IS (a-c) and OOS (d-f) experiments. Color-coding reflects whether the catchment is located in the Western US (WUS), Switzerland (CH), or Chile (CL). Overall median melt NSE is reported in the respective titles and through the grey dashed lines. Catchments in all figures are sorted based on B1 IS catchment ranks. Boxes show the interquartile (IRQ) range, white lines show the median, and whiskers extend to the most extreme values within 1.5×IQR of the quartiles.

S3 Catchment overview table

An overview of the catchments used in this study is given in Table S1.

Table S1: Overview of the 163 catchments used in this study, including gauge identifiers, names, drainage area, location, elevation and snow fraction.

Gauge ID	Name	Area (km ²)	Lat (°)	Lon (°)	Elev. (m)	Snow fraction
camels_06278300	SHELL CREEK ABOVE SHELL CREEK RESERVOIR, WY	59.13	44.51	-107.40	2266.16	0.49
camels_06280300	SOUTH FORK SHOSHONE RIVER NEAR VALLEY, WY	792.61	44.21	-109.55	2097.57	0.61
camels_06289000	Little Bighorn River at State Line nr Wyola MT	471.10	45.01	-107.62	1583.32	0.42
camels_06311000	NORTH FORK POWDER RIVER NEAR HAZELTON, WY	62.97	44.03	-107.08	1899.07	0.39
camels_06332515	BEAR DEN CREEK NR MANDAREE, ND	191.17	47.79	-102.77	617.51	0.22
camels_06339100	KNIFE RIVER AT MANNING, ND	528.28	47.24	-102.77	689.36	0.22
camels_06344600	GREEN RIVER NR NEW HRADEC, ND	407.89	47.03	-103.05	768.90	0.22
camels_06350000	CANNONBALL RIVER AT REGENT, ND	1502.92	46.43	-102.55	777.21	0.22
camels_06352000	CEDAR CREEK NR HAYNES, ND	1439.34	46.15	-102.47	806.26	0.22
camels_06431500	SPEARFISH CR AT SPEARFISH SD	427.13	44.48	-103.86	1449.24	0.25
camels_06614800	MICHIGAN RIVER NEAR CAMERON PASS, CO.	4.20	40.50	-105.87	2697.56	0.60
camels_06622700	NORTH BRUSH CREEK NEAR SARATOGA, WY	101.49	41.37	-106.52	2417.00	0.51
camels_06623800	ENCAMPMENT RIVER AB HOG PARK CR, NR ENCAMPMENT, WY	188.67	41.02	-106.82	2550.00	0.53
camels_06632400	ROCK CREEK AB KING CANYON CANAL, NR ARLINGTON, WY	164.87	41.59	-106.22	2119.00	0.43
camels_07208500	RAYADO CREEK NEAR CIMARRON, NM	159.58	36.37	-104.97	2095.27	0.24
camels_08267500	RIO HONDO NEAR VALDEZ, NM	96.56	36.54	-105.56	2036.80	0.29
camels_08269000	RIO PUEBLO DE TAOS NEAR TAOS, NM	163.21	36.44	-105.50	2310.88	0.29
camels_08271000	RIO LUCERO NEAR ARROYO SECO, NM	46.40	36.51	-105.53	2063.62	0.30
camels_08324000	JEMEZ RIVER NEAR JEMEZ, NM	1221.90	35.66	-106.74	2157.78	0.18
camels_08377900	RIO MORA NEAR TERRERO, NM	138.91	35.78	-105.66	2472.00	0.22
camels_08378500	PECOS RIVER NEAR PECOS, NM	444.88	35.71	-105.68	2408.52	0.23
camels_08380500	GALLINAS CREEK NEAR MONTEZUMA, NM	199.54	35.65	-105.32	2146.13	0.12
camels_09034900	BOBTAIL CREEK NEAR JONES PASS, CO.	21.28	39.76	-105.91	2723.90	0.54
camels_09035900	SOUTH FORK OF WILLIAMS FORK NEAR LEAL, CO.	71.54	39.80	-106.03	2719.51	0.56
camels_09065500	GORE CREEK AT UPPER STATION, NEAR MINTURN, CO.	37.70	39.63	-106.28	2543.17	0.50
camels_09066000	BLACK GORE CREEK NEAR MINTURN, CO.	32.51	39.60	-106.27	2548.27	0.49
camels_09066200	BOOTH CREEK NEAR MINTURN, CO.	16.02	39.65	-106.32	2539.22	0.60
camels_09066300	MIDDLE CREEK NEAR MINTURN, CO.	15.87	39.65	-106.38	2393.87	0.62
camels_09081600	CRYSTAL RIVER AB AVALANCHE C, NEAR REDSTONE, CO.	436.43	39.23	-107.23	2278.60	0.55
camels_09210500	FONTENELLE C NR HERSCHLER RANCH, NR FONTENELLE, WY	397.45	42.10	-110.42	2183.19	0.53
camels_09223000	HAMS FORK BELOW POLE CREEK, NEAR FRONTIER, WY	333.77	42.11	-110.71	2325.84	0.58
camels_09312600	WHITE RIVER BL TABBYYUNE C NEAR SOL-DIER SUMMIT, UT	198.38	39.88	-111.04	2228.69	0.42

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Table S1: Continued.

Gauge ID	Name	Area (km ²)	Lat (°)	Lon (°)	Elev. (m)	Snow fraction
camels_09378170	SOUTH CREEK ABOVE RESERVOIR NEAR MONTICELLO, UT	21.75	37.85	-109.37	1752.39	0.23
camels_09378630	RECAPTURE CREEK NEAR BLANDING, UT	11.62	37.76	-109.48	1856.57	0.21
camels_09386900	RIO NUTRIA NEAR RAMAH, NM	186.25	35.28	-108.55	2244.81	0.21
camels_09430600	MOGOLLON CREEK NEAR CLIFF, NM	190.86	33.17	-108.65	1706.00	0.15
camels_09492400	EAST FORK WHITE RIVER NEAR FORT APACHE, AZ.	120.37	33.82	-109.81	1838.00	0.24
camels_09494000	WHITE RIVER NEAR FORT APACHE, AZ.	1628.52	33.74	-110.17	1769.15	0.17
camels_10173450	MAMMOTH CREEK ABV WEST HATCH DITCH, NEAR HATCH, UT	281.46	37.62	-112.52	2244.48	0.44
camels_10205030	SALINA CREEK NEAR EMERY, UT	150.61	38.91	-111.53	2087.00	0.38
camels_10234500	BEAVER RIVER NEAR BEAVER, UT	238.52	38.28	-112.57	2133.57	0.44
camels_10242000	COAL CREEK NEAR CEDAR CITY, UT	1902.18	37.67	-113.03	1674.66	0.31
camels_10244950	STEPTOE C NR ELY, NV	29.10	39.20	-114.69	1992.95	0.46
camels_10249300	S TWIN R NR ROUND MOUNTAIN, NV	608.21	38.89	-117.25	1684.47	0.30
camels_10316500	LAMOILLE C NR LAMOILLE, NV	90.84	40.69	-115.48	1721.56	0.48
camels_10329500	MARTIN C NR PARADISE VALLEY, NV	513.33	41.53	-117.42	1546.86	0.30
camels_10396000	DONNER UND BLITZEN RIVER NR FRENCH-GLEN OR	967.30	42.79	-118.87	1421.77	0.31
camels_11264500	MERCED R A HAPPY ISLES BRIDGE NR YOSEMITE CA	471.73	37.73	-119.56	1717.99	0.79
camels_11266500	MERCED R A POHONO BRIDGE NR YOSEMITE CA	835.62	37.72	-119.67	1475.81	0.71
camels_11522500	SALMON R A SOMES BAR CA	1944.06	41.38	-123.48	557.48	0.18
camels_11523200	TRINITY R AB COFFEE C NR TRINITY CTR CA	384.56	41.11	-122.71	938.69	0.47
camels_12048000	DUNGENESS RIVER NEAR SEQUIM, WA	407.22	48.01	-123.13	287.64	0.43
camels_12054000	DUCKABUSH RIVER NEAR BRINNON, WA	178.43	47.68	-123.01	0.00	0.38
camels_12056500	NF SKOKOMISH R BL STAIRCASE RPDS NR HOODSPORT, WA	146.87	47.51	-123.33	266.00	0.15
camels_12082500	NISQUALLY RIVER NEAR NATIONAL, WA	358.73	46.75	-122.08	548.05	0.63
camels_12092000	PUYALLUP RIVER NEAR ELECTRON, WA	240.57	46.90	-122.04	554.78	0.62
camels_12143600	SF SNOQUALMIE RIVER AT EDGEWICK, WA	164.67	47.45	-121.72	130.00	0.37
camels_12144000	SF SNOQUALMIE RIVER AT NORTH BEND, WA	212.34	47.49	-121.79	133.27	0.37
camels_12167000	NF STILLAGUAMISH RIVER NEAR ARLINGTON, WA	689.75	48.26	-122.05	89.19	0.36
camels_12186000	SAUK RIVER AB WHITECHUCK RIVER NEAR DARRINGTON, WA	397.58	48.17	-121.47	380.94	0.63
camels_12189500	SAUK RIVER NEAR SAUK, WA	1852.65	48.42	-121.57	350.25	0.63
camels_12374250	Mill Cr ab Bassoo Cr nr Niarada MT	53.19	47.83	-114.70	842.03	0.47
camels_12375900	South Crow Creek near Ronan MT	19.75	47.49	-114.03	880.48	0.48
camels_12381400	South Fork Jocko River near Arlee MT	148.28	47.20	-113.85	1308.41	0.45
camels_12390700	Prospect Creek at Thompson Falls MT	468.45	47.59	-115.36	823.92	0.57
camels_12411000	NF COEUR D ALENE R AB SHOSHONE CK NR PRICHARD ID	863.55	47.71	-115.98	871.34	0.59
camels_12447390	ANDREWS CREEK NEAR MAZAMA, WA	58.29	48.82	-120.15	862.37	0.60

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Table S1: Continued.

Gauge ID	Name	Area (km ²)	Lat (°)	Lon (°)	Elev. (m)	Snow fraction
camels_12451000	STEHEKIN RIVER AT STEHEKIN, WA	827.69	48.33	-120.69	554.64	0.65
camels_12488500	AMERICAN RIVER NEAR NILE, WA	205.75	46.98	-121.17	858.00	0.65
camels_13011900	BUFFALO FORK AB LAVA CREEK NR MORAN WY	846.53	43.84	-110.44	2190.89	0.68
camels_13018300	CACHE CREEK NEAR JACKSON, WY	29.61	43.45	-110.70	1817.23	0.60
camels_13023000	GREYS RIVER AB RESERVOIR NR ALPINE WY	1161.75	43.14	-110.98	2009.22	0.59
camels_13161500	BRUNEAU RIVER AT ROWLAND NV	988.82	41.93	-115.67	1731.02	0.47
camels_13235000	SF PAYETTE RIVER AT LOWMAN ID	1156.35	44.09	-115.62	1385.41	0.69
camels_13240000	LAKE FORK PAYETTE RIVER AB JUMBO CR NR MCCALL ID	125.92	44.91	-116.00	1598.00	0.58
camels_13313000	JOHNSON CREEK AT YELLOW PINE ID	564.05	44.96	-115.50	1677.94	0.66
camels_13331500	MINAM RIVER NEAR MINAM, OR	617.60	45.62	-117.73	1083.20	0.56
camels_14020000	UMATILLA RIVER ABOVE MEACHAM CREEK, NR GIBBON, OR	342.26	45.72	-118.32	673.18	0.36
camels_14092750	SHITIKE CR, AT PETERS PASTURE, NR WARM SPRINGS, OR	64.93	44.75	-121.63	733.53	0.43
camels_14096850	BEAVER CREEK, BLW QUARTZ CR, NR SIM-NASHO, OR.	383.58	44.96	-121.39	709.52	0.32
camels_14137000	SANDY RIVER NEAR MARMOT, OR	674.82	45.40	-122.14	454.78	0.40
camels_14158790	SMITH R AB SMITH R RES NR BELKNAP SPRGS, OREG.	40.66	44.33	-122.05	584.71	0.41
camels_14185000	SOUTH SANTIAM RIVER BELOW CASCA-DIA, OR	448.58	44.39	-122.50	339.16	0.15
camels_14216500	MUDDY CREEK BELOW CLEAR CREEK NEAR COUGAR, WA	349.19	46.08	-122.00	381.33	0.39
camelsch_2033	Ilanz	771.99	46.78	9.21	909.78	0.40
camelsch_2044	Andelfingen	1696.73	47.60	8.68	508.02	0.19
camelsch_2067	Martina	1932.34	46.89	10.47	1504.68	0.41
camelsch_2070	Emmenmatt	441.84	46.95	7.75	650.48	0.20
camelsch_2087	Andermatt	189.68	46.64	8.59	1429.00	0.42
camelsch_2106	Münchenstein-Hofmatt	884.79	47.52	7.62	395.43	0.06
camelsch_2112	Appenzell	74.23	47.33	9.41	640.00	0.19
camelsch_2122	Moutier-La_Charrue	185.28	47.28	7.38	525.00	0.06
camelsch_2126	Wängi	79.91	47.50	8.95	386.00	0.13
camelsch_2132	Neftenbach	342.34	47.52	8.65	462.71	0.07
camelsch_2139	St_Margrethen	174.45	47.45	9.66	424.09	0.20
camelsch_2141	Tiefencastel	527.64	46.66	9.57	1145.47	0.40
camelsch_2150	Felsenbach	612.10	46.97	9.61	807.77	0.34
camelsch_2151	Oberwil	342.79	46.66	7.44	892.90	0.38
camelsch_2159	Belp-Mülimatt	115.84	46.89	7.50	511.00	0.21
camelsch_2160	Broc-Château_d'en_bas	634.56	46.60	7.09	875.43	0.38
camelsch_2179	Thörishaus-Sensematt	350.24	46.89	7.35	600.50	0.21
camelsch_2181	Halden	1081.93	47.51	9.21	578.26	0.19
camelsch_2185	Chur	263.65	46.86	9.51	834.97	0.33
camelsch_2187	Salez	182.11	47.24	9.51	437.71	0.19
camelsch_2203	Aigle	131.24	46.32	6.97	382.00	0.37

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Table S1: Continued.

Gauge ID	Name	Area (km ²)	Lat (°)	Lon (°)	Elev. (m)	Snow fraction
camelsch_2219	Oberried/_Lenk	34.65	46.43	7.47	1018.00	0.39
camelsch_2232	Adelboden	28.71	46.49	7.55	780.00	0.46
camelsch_2244	Klusmatten	19.39	46.22	8.02	1030.00	0.43
camelsch_2251	Plaffeien-Schwyberg	1.69	46.69	7.28	592.04	0.22
camelsch_2252	Plaffeien-Schwyberg	1.37	46.69	7.29	603.92	0.22
camelsch_2263	La_Punt-Chamues-ch	73.16	46.57	9.94	1683.00	0.50
camelsch_2283	Wasen-Riedbad	0.60	47.02	7.89	568.14	0.21
camelsch_2290	St-Sulpice	103.78	46.91	6.56	969.89	0.15
camelsch_2299	Erstfeld-Bodenberg	20.63	46.81	8.60	451.00	0.41
camelsch_2303	Jonschwil-Mühlau	491.54	47.41	9.08	617.98	0.19
camelsch_2304	ZerneZ-Punt_la_Drossa	55.11	46.66	10.19	1473.00	0.42
camelsch_2305	Herisau-Zellersmühle	16.67	47.40	9.26	467.00	0.19
camelsch_2307	Sonceboz	126.90	47.20	7.17	434.00	0.14
camelsch_2319	ZerneZ	26.87	46.69	10.12	1473.00	0.41
camelsch_2327	Davos-Kriegsmatte	42.75	46.78	9.88	1512.00	0.40
camelsch_2342	Brig	76.31	46.32	7.99	647.81	0.35
camelsch_2343	Huttwil-Häberenbad	59.76	47.12	7.83	416.00	0.07
camelsch_2347	Roveredo-Bacino_di_compenso	8.10	46.20	9.17	241.00	0.15
camelsch_2355	Davos-Frauenkirch	183.19	46.76	9.79	1481.11	0.40
camelsch_2368	Locarno-Solduno	926.35	46.17	8.77	377.80	0.30
camelsch_2372	Mollis-Linthbrücke	598.59	47.10	9.07	555.53	0.33
camelsch_2374	Mogelsberg-Aachsäge	87.85	47.36	9.12	585.00	0.18
camelsch_2386	Frauenfeld	212.67	47.57	8.89	386.00	0.07
camelsch_2409	Eggiwil-Heidbüel	124.03	46.87	7.80	650.00	0.26
camelsch_2414	Mosnang-Rietholz	3.18	47.38	9.01	489.42	0.13
camelsch_2426	Mels	105.78	47.05	9.42	447.00	0.32
camelsch_2430	Somvitg-Encardens	21.70	46.65	8.99	888.00	0.40
camelsch_2437	Ecublens-Eschens	6.90	46.60	6.81	530.00	0.08
camelsch_2450	Zofingen	365.19	47.28	7.94	474.76	0.07
camelsch_2468	St._Gallen-Bruggen/_Au	260.33	47.41	9.33	636.14	0.19
camelsch_2469	Hondrich	489.37	46.67	7.67	726.92	0.47
camelsch_2474	Buseno	120.21	46.28	9.12	325.00	0.31
camelsch_2478	Soyhières-Bois_du_Treuil	567.88	47.39	7.40	444.06	0.06
camelsch_2487	Werthenstein-Chappelboden	310.64	47.03	8.07	639.59	0.20
camelsch_2491	Bürglen-Galgenwäldli	107.61	46.87	8.65	455.00	0.34
camelsch_2494	Pollegio-Campagna	442.59	46.36	8.95	669.89	0.41
camelsch_2497	Nebikon	104.40	47.19	7.97	476.92	0.07
camelsch_2634	Emmen	476.99	47.07	8.28	569.38	0.20
camelscl_4511002	Rio Grande En Las Ramadas	569.38	-31.01	-70.58	1962.48	0.70
camelscl_4512001	Rio Tascadero En Desembocadura	241.19	-31.02	-70.67	1314.00	0.51
camelscl_4513001	Rio Grande En Cuyano	1288.22	-30.93	-70.77	1512.98	0.47
camelscl_4530001	Rio Cogoti En Fraguita	491.22	-31.12	-70.89	1531.49	0.18
camelscl_4532001	Rio Combarbala En Ramadillas	189.35	-31.23	-70.91	1407.12	0.18
camelscl_4703002	Rio Choapa En Cuncumen	1133.12	-31.96	-70.60	2009.70	0.55
camelscl_4721001	Rio Illapel En Las Burras	557.48	-31.51	-70.81	1781.09	0.52
camelscl_4723001	Rio Illapel En Huintil	1023.84	-31.57	-70.96	1347.74	0.31
camelscl_5401003	Rio Juncal En Juncal	343.24	-32.86	-70.17	2390.35	0.84

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Table S1: Continued.

Gauge ID	Name	Area (km ²)	Lat (°)	Lon (°)	Elev. (m)	Snow fraction
camelscl_5402001	Rio Blanco En Rio Blanco	387.40	-32.91	-70.30	1863.76	0.73
camelscl_5406001	Rio Colorado En Colorado	1141.73	-32.86	-70.42	1840.61	0.74
camelscl_5414001	Rio Putaendo En Resguardo Los Patos	885.74	-32.50	-70.58	1791.57	0.49
camelscl_5706001	Rio Olivares Antes Junta Rio Colorado	542.31	-33.49	-70.14	2311.71	0.82
camelscl_5707002	Rio Colorado Antes Junta Rio Maipo	1665.00	-33.59	-70.37	2054.81	0.79
camelscl_5721001	Estero Yerba Loca Antes Junta San Francisco	110.17	-33.34	-70.36	1370.00	0.61
camelscl_5722001	Estero Arrayan En La Montosa	216.50	-33.33	-70.46	900.00	0.40
camelscl_5722002	Rio Mapocho En Los Almendros	638.44	-33.37	-70.45	1320.79	0.51
camelscl_6013001	Rio Claro En Hacienda Las Nieves	244.92	-34.50	-70.70	762.87	0.52
camelscl_7103001	Rio Claro En Los QueÑEs	354.37	-35.00	-70.81	917.27	0.37
camelscl_7115001	Rio Palos En Junta Con Colorado	490.42	-35.28	-71.02	1058.72	0.16

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