

Supplementary data

Water sources	Places	Sites	Samples
Rivers	Vacas, Cuevas, Tupungato and Mendoza rivers in Punta de Vacas. Cuevas River in Puente del Inca. Horcones Superior and Horcones rivers at Mt. Aconcagua Confluencia Camp.	7	42
Ice bodies	Horcones Inferior Glacier and Mt. Tolosa rock glaciers conglomerate.	2	34
Groundwaters	Vertiente del Inca, La Salada Stream, Confluencia Nueva Spring, Confluencia Vieja Spring and geothermal waters of "Copa de Champagne" and "Viejo Túnel", both in "Puente del Inca".	6	41
Precipitations	Collectors at Laguna de Horcones and Confluencia Camp, both in the Mt. Aconcagua Park	2	4
Snow basins	Valle Azul, Los Puquios and Santa María	3	33

Table S1: Sampling along the melting period 2013-2014 in Cordillera Principal geological province. Ice body type classification corresponds to the official inventory of glaciers (IANIGLA-ING, 2018a). Sites refers to quantity of sampling sites for each water source.

Weather Station 2 and HI Glacier streamflow	MDS HI m3/s	Soil MDT °C	Air MDT °C	DMaxT °C	DMinT °C	max-min °C
Mean	2.09	7.17	4.90	3.55	0.77	2.72
SD	0.95	3.15	3.35	4.35	3.30	3.02
VC%	45.34	43.90	68.31	122.56	430.53	111.07
Max	4.88	11.60	10.68	11.27	6.41	11.27
Min	0.52	1.35	-3.65	-5.95	-7.28	-5.95

Rock glaciers streamflow	MDS Tolosa m3/s
Mean	0.02
SD	0.01
VC%	70.80
Max	0.05
Min	0.00

Weather Station 1	Atm Press hPa	Air MDT °C	DMaxT °C	DMinT °C	RH%
Mean	706.44	11.12	17.82	4.74	37.27
SD	1.55	2.88	3.41	2.66	17.39
VC%	0.22	25.89	19.15	56.17	46.67
Max	710.04	16.57	24.84	11.20	97.60
Min	703.11	2.89	6.25	-0.53	13.60

Weather Station 1	Soil DMT °C	Wind Dir.°	W mean vel.	W max vel.	SWE (mm)	Incid. Rad.
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Mean	12.58	173.07	1.87	15.83	0.00	274.66
SD	2.71	55.19	1.16	3.09	0.00	54.84
VC%	21.57	31.89	62.08	19.53		19.97
Max	17.25	349.05	6.04	22.80	0.00	330.99
Min	6.39	16.36	0.14	7.94	0.00	64.56

Table S2: Mean values (Mean), standard deviation (SD), % variation coefficient (VC %) and maximum (Max) and minimum values (Min) for weather stations 2 and 1. Mean daily streamflow (MDS) of Horcones Inferior Glacier (HI) and Tolosa rock glaciers conglomerate (Rock glaciers streamflow). Atmospheric pressure in hPa (Atm Press hPa), mean daily air temperature in °C (Air MDT), daily maximum and minimum temperature in °C (DMaxT and DMinT, respectively), maximum and minimum mean daily temperature (max-min), relative humidity in % (RH%), mean daily soil temperature in °C (Soil MDT), wind direction in degrees (Wind Dir °), mean and maximum wind velocity in m/s (W mean/max vel.), snow water equivalent in mm (SWE) and incident solar radiation in W/m² (Incid. Rad.).

Site-water source / (mean/range)	$\delta^{18}\text{O}$ ‰ (mean/min-max)	$\delta^2\text{H}$ ‰	d‰
Cuevas River Pte. del Inca	-17.5/-18.2- to -16.9	-134.3/-136.5 to -132.2	3.9/0.0-8.9
Cuevas River PV	-18.2/-18.8 to -17.9	-136.8/-141.3 to -134.0	6.8/0.0-9.4
Tupungato River PV	-19.3/-19.6 to -18.9	-144.9/-147.5 to -142.5	6.3/0.0-9.9
Vacas River PV	-19.3/-19.5 to -19.1	-145.5/-147.5 to -143.8	7.1/0.0-9.0
Horcones Inferior Glacier	-20.2/-21.0 to -18.8	-151.1/-157.3 to -139.4	10.7/8.2-12.8
Tolosa rock glaciers conglomerate	-17.0/-17.5 to -15.6	-129.7/-131.6 to -127.6	4.2/-3.1 a 8.9
Valle Azul stream	-17.2/-17.6 to -16.1	-131.8/-133.4 to -129.6	2.3/-4.7 a 7.6
Los Puquios snow basin	-17.0/-17.5 to -16.0	-129.9/-131.6 to -123.4	4.9/0.0-8.4
Santa María stream	-18.1/-18.5 to -17.35	-138.3/-141.3 to -134.8	5.12/4.3-8.1
Groundwater	-18.4/-20.2 to -17.4	-139.8/-154.3 to -132.8	6.3/-1.8 a 10.3
Puente del Inca geothermal	-18.3/-18.4 to -18.2	-141.3/-141.8 to -140.8	4.3/4.4-6.26
Summer precipitation	-9.8/-10.9 to -8.7	-57.3/-66.2 to -48.5	20.9/20.7-21.1

Table S3: Mean and range of the water stable isotopes and deuterium excess (d) values for different water sources. PV refers to the samples taken in “Punta de Vacas” site. Pte. del Inca refers to the samples in “Puente del Inca” location.

Site-water source / (mean/range)	(me/L) Na ⁺	(me/L) K ⁺	(me/L) Ca ⁺²	(me/L) Mg ⁺²
Cuevas River Pte del Inca	8.67/5.00-11.00	0.03/0.00-0.10	10.30/8.40-13.80	3.67/2.80-5.30
Cuevas River PV	6.08/2.20-15.00	0.05/0.00-0.10	9.80/5.70-12.50	3.26/1.30-7.40
Tupungato River PV	3.85/1.30-13.00	0.00/0.00-0.00	6.33/4.00-15.20	2.77/1.90-3.30
Vacas River PV	0.83/0.70-1.10	0.00/0.00-0.00	3.64/2.40-4.70	1.57/1.20-2.00
Horcones Inferior Glacier	1.44/0.80-3.00	0.05/0.00-1.00	4.52/2.30-10.30	1.67/0.80-5.30
Tolosa rock glaciers	0.27/0.10-0.40	0.00/0.00-0.00	5.86/4.00-8.10	2.82/0.60-4.50
Valle Azul stream	0.36/0.30-0.40	0.00/0.00-0.00	2.46/1.40-3.60	1.35/0.60-2.10
Los Puquios snow basin	0.80/0.50-1.10	0.00/0.00-0.00	1.05/0.40-3.00	0.26/0.20-1.20
Santa María stream	0.55/0.20-1.10	0.00/0.00-0.00	1.41/0.80-2.30	0.56/0.30-0.80
Groundwater	1.29/0.20-10.00	0.01/0.00-0.30	21.29/3.30-29.60	6.29/1.00-10.50
Puente del Inca geothermal	275.20/110.00-550.00	3.50/1.00-5.00	47.65/40.50-57.90	8.67/2.60-15.60

Table S4: Mean and range cation concentrations for the different water sources.

Site-water source / (mean/range)	(me/L) HCO ₃ ⁻	(me/L) SO ₄ ⁻²	(me/L) Cl ⁻
Cuevas River Pte del Inca	2.51/1.97-2.78	10.90/9.60-12.10	8.20/6.10-11.00
Cuevas River PV	1.99/1.73-2.44	9.51/7.70-14.20	5.51/3.10-12.30
Tupungato River PV	1.87/1.73-2.03	6.88/4.40-14.20	3.28/1.10-12.10
Vacas River PV	1.63/1.42-1.84	3.63/2.50-5.00	0.54/0.30-1.30
Horcones Inferior Glacier	1.42/0.96-3.55	5.33/2.50-11.70	0.70/0.10-1.30
Tolosa rock glaciers	1.74/1.09-2.40	6.80/4.40-9.20	0.34/0.00-1.70
Valle Azul stream	1.48/1.13-1.80	2.30/1.00-3.30	0.27/0.00-1.20
Los Puquios snow basin	1.42/1.09-2.33	0.44/0.10-1.90	0.15/0.00-0.70
Santa María stream	1.47/1.22-1.80	0.74/0.10-1.30	0.24/0.10-0.70
Groundwater	3.16/1.84-4.62	23.10/1.00-31.30	1.13/0.00-7.30
Puente del Inca geothermal	27.09/23.80-28.11	83.70/26.00-343.80	213.80/77.20-311.30

Table S5: Mean and range anion concentrations for the different water sources.

Site-water source / (mean/range)	pH	EC ($\mu\text{S/cm}$)
Cuevas River Pte del Inca	7.72/7.68-7.75	1839/1473-2205
Cuevas River PV	8.0/7.80-8.15	1461/544-2094
Tupungato River PV	7.60/6.87-8.03	834/626-1031
Vacas River PV	7.82/7.13-8.10	566/391-665
Horcones Inferior Glacier	7.41/7.41-7.41	674/424-1033
Tolosa rock glaciers	7.74/6.84-8.19	809/640-1093
Valle Azul stream	8.05/7.28-8.90	431/286-515
Los Puquios snow basin	8.12/7.72-8.64	144/98-176
Santa María stream	7.87/6.59-8.41	238/121-324
Groundwater	7.63/6.72-8.60	2187/1340-2950
Puente del Inca geothermal	6.24/6.19-6.29	22682/20500-23440

Table S6: Mean and range pH and electric conductivity (EC) for the different water sources.

Event	Date	MODIS	Ranger s	Cache.	Polv.	PV
Light snowfall in Tolosa rock glaciers conglomerate (and something in Horcones Inferior Glacier) areas	November 14 th & 19 th to 21 st 2013	X	X			
Light snowfall	November 25 th 2013	X	X	X		
Rain	December 25 th 2013		X	10.5 mm		
Light snowfall	January 16 th to 18 th 2014	X	X	X	X	X
Light snowfall	January 26 th to 27 th 2014	X	X			
Light snowfall	February 14 th to 18 th 2014	X	X	X	X	
Light snowfall	February 24 th & 25 th 2014	X	X	X	X	
Light snowfall	March 1 st & 2 nd 2014	X	X	X	X	

Table S7: Precipitation records from weather stations, MODIS satellite imagery (MODIS) and Mt. Aconcagua Park Rangers (Rangers) daily records. Cache. and Polv. refers to Cacheuta and Polvaredas National Hydric Resources Secretariat weather stations, respectively. PV refers to Punta de Vacas station, dependent on the National Meteorological Service (SMN).

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Mean
MMS 1957-2017	21	20	22	28	48	84	101	81	54	34	27	23	45
1968	15	15	14	13	19	23	46	56	39	18	15	13	24
2004	23	22	24	24	26	43	75	71	46	28	24	23	36
2010	20	19	17	19	20	30	44	54	41	27	20	18	27
2011	13	13	16	18	29	49	68	58	46	28	20	18	31
2013	17	16	16	20	36	73	79	54	36	25	21	18	34
2013%*	81	78	72	71	76	87	78	67	67	74	79	79	76
Monthly Hm³	56	55	57	76	123	224	270	195	144	88	72	59	1419
2013 Monthly Hm³	45	43	43	54	96	196	212	145	96	67	56	48	1101
Seasonal contribution	1957-2017	Year	%	2013	Year	%	2013**						
	Hm³			Hm³			%						
Jun-Aug	169	12	136	12	81								
Sep-Nov	256	18	193	18	75								
Dec-Feb	689	49	552	50	80								
Mar-May	304	21	220	20	72								
Total	1419	100	1101	100	78								

Table S8: Mendoza River mean monthly streamflow record (MMS) in m³s⁻¹ (DGI, 2018). Extreme dry years (1968, 2004, 2010-11) are also shown. 2013 %* refers to the 2013 percentage of the long term mean 1957-2017. Each year refers to July-June hydrological cycle (p.e.: 2013 year starts in July 2013 and ends in June 2014) retrieved from National Secretariat of Hydric Resources (SRH). Long term monthly and seasonal contribution (Hm³ and %) is showed. 2013** refers to the percentage of 2013 seasonal streamflow with respect to the 1957-2017 values.

	Long term mean (1987-2015)	Long term mean (1987-2016)	2004	2010	2011	2013
Winter SWE (mm)	616		451	320	432	310
SWE% regarding '87-'15 record			73	52	70	50
Mean (Dec- Mar) temperature in °C		14.5	14.7	13.7	15.1	14.6
Temperature% regarding '87-'16 record			101	94	104	101

Table S9: Portillo (3000 m a.s.l.; 32.84°S – 70.12°W) winter snow water equivalent (SWE) in mm and summer (December-March) temperature data from El Yeso Embalse Station (2475 m a.s.l.; 33.65°S – 70.07°W). The same dry years as Table S8 are showed. Source: Barrios (2018).

Site	Altitude m asl	Since	Until	$\delta^{18}\text{O}$ ‰	$\delta^2\text{H}$ ‰	d‰
Confluencia Camp	3433	February 5 th , 2014	March 15 th , 2014	-10.9	-66.2	20.7
Laguna de Horcones	3043	December 19 th , 2013	April 2 nd , 2014	-8.7	-48.5	21.1
Mean				-9.8	-57.3	20.9

Table S10: Stable water isotopes precipitation composition gathered from in-situ collectors.

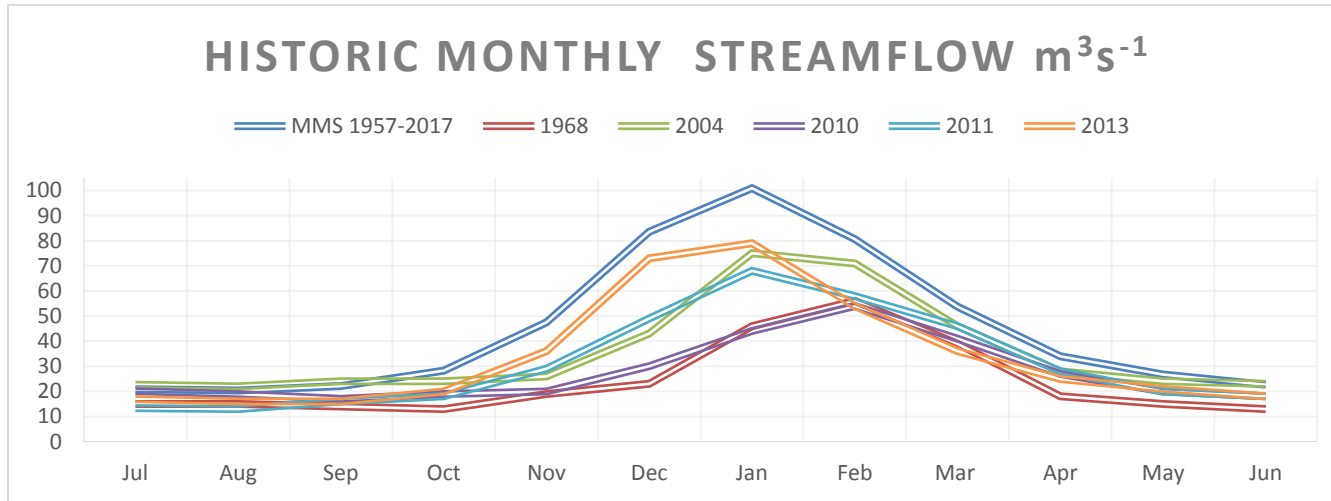


Figure S1: Mendoza River Long term mean monthly streamflow in m^3s^{-1} (MMS). MMS from 1957 to 2017 (DGI, 2018) presents a maximum in January, a 2nd maximum in December and a 3rd one in February, corresponding to a "mitigated glacial regime" according to the Parde genetic classification of solid feeding fluvial regimes (Bruniard, 1994). Many drought periods are plotted below this mean values line, including the year 2013 analyzed in this work. The more extreme dry years in the record (1968 and 2010, respectively), show the maximum discharge month displaced to February, which corresponds to an "ultra-glacial regime", according to the Parde classification.

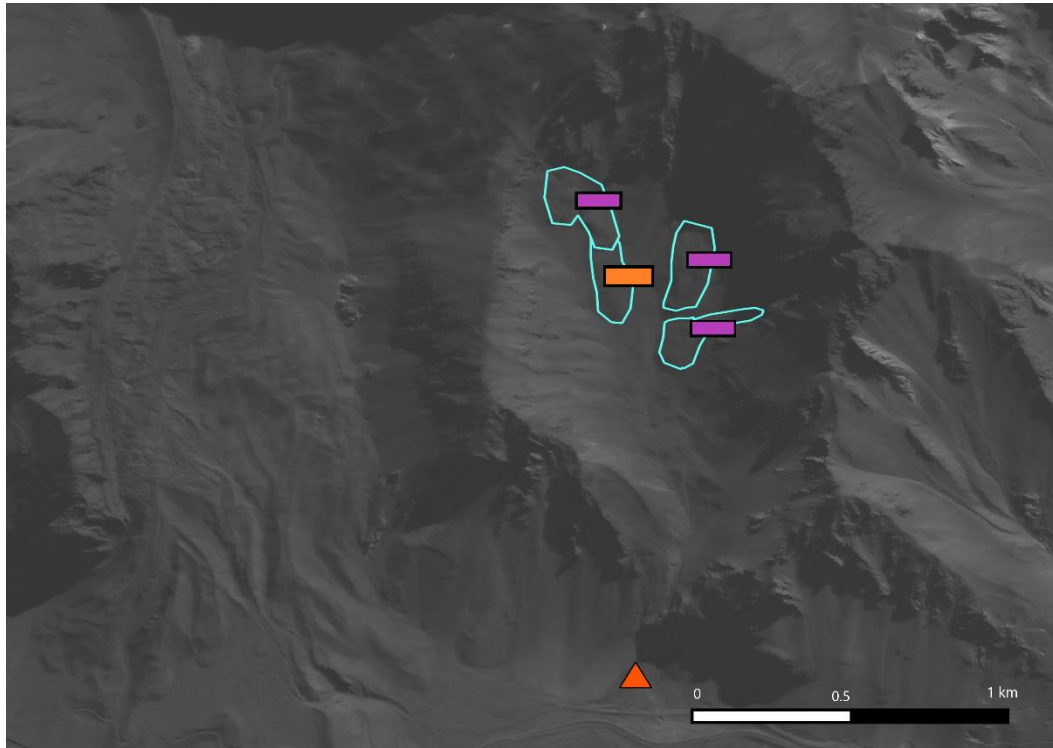


Figure S2: Tolosa Rock glaciers conglomerate ice bodies shape, according to the National Glacier Inventory (IANIGLA-ING, 2018a). The purple color indicates active rock glacier facie. The orange, refers to inactive rock glacier facie. Just one of the 3 rock glaciers shows an inactive facie (the left one). The red triangle indicates the streamflow measurement site. Image: Alos.

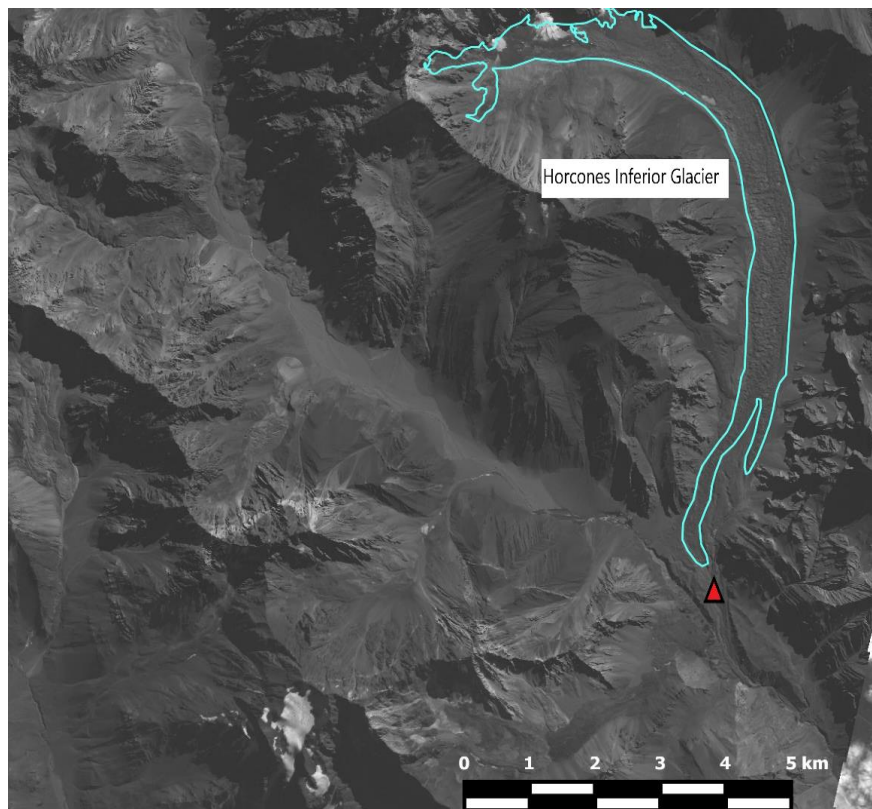


Figure S3: Horcones Inferior Glacier shape, according to the National Glacier Inventory (IANIGLA-ING, 2018a). The red triangle indicates the streamflow measurement site. Image: Alos.