Supplementary Material

Unseasonal atmospheric river drives anomalous glacier accumulation in the ablation season of the subtropical Andes

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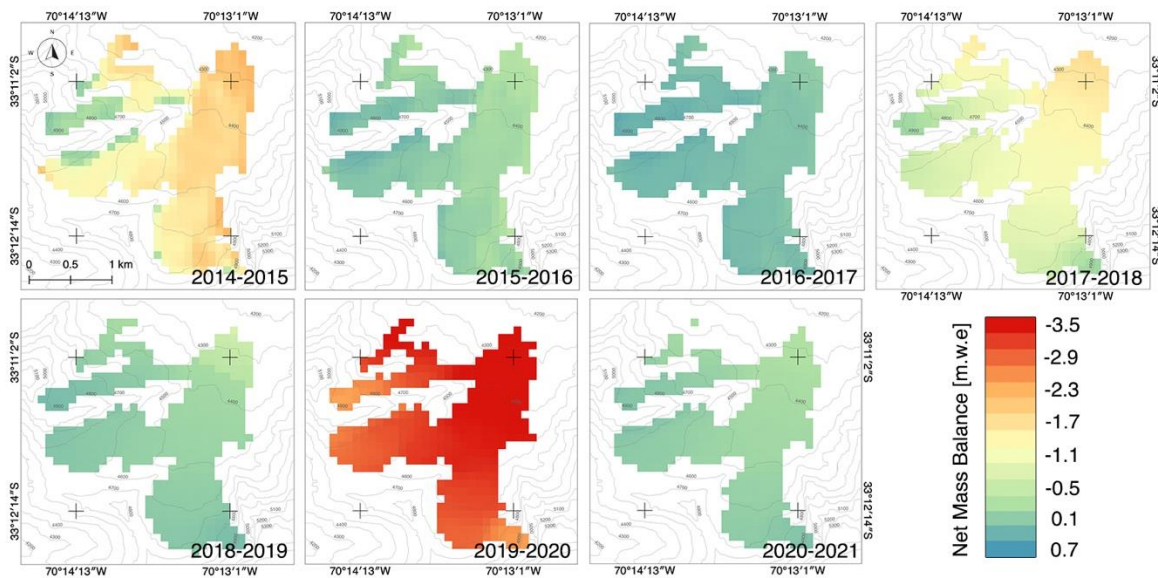
Figure S1. Accumulated distributed surface mass balance of the Olivares-Alfa glacier between 2014 and 2021.

Figure S2. Pre and post event pictures of the Paloma Norte Glacier, located in the Olivares sub-basin, nearby to Olivares Alfa Glacier (see Fig. 1).
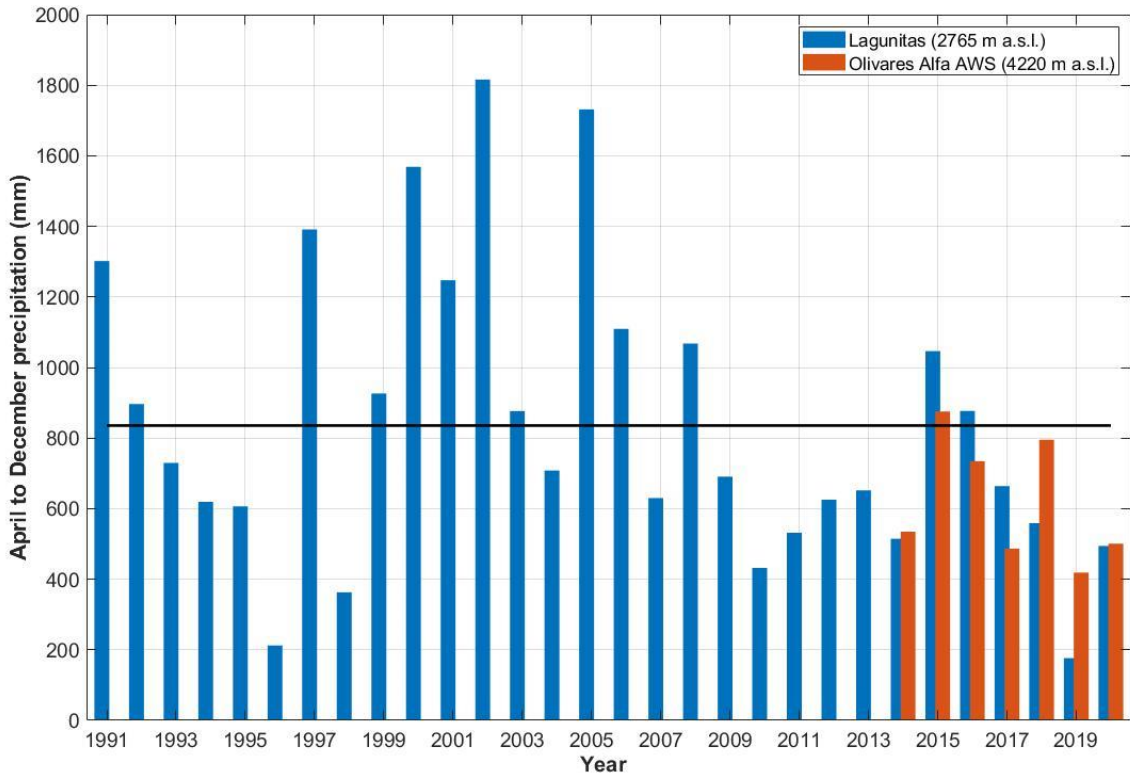
Figure S3. Accumulated precipitation between April and December for Lagunitas meteorological station and Olivares Alfa AWS. Black line is the climatological mean (1991-2020) of the Lagunitas meteorological station.
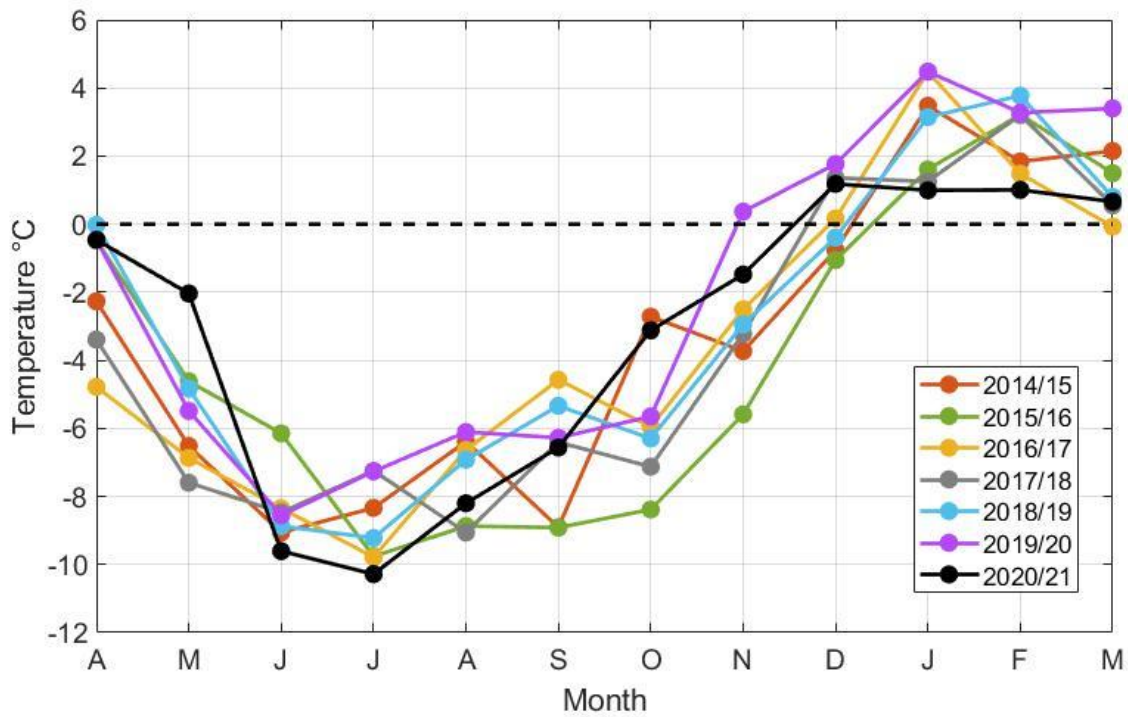
Figure S4. Monthly mean air temperature recorded at the Olivares Alfa AWS.

Table S1. Atmospheric rivers catalogue with ERA5 reanalyses for the period April 2013 to March 2021.

Number	Start		End		Duration (hours)	Latitude range		AR Cat_Max	Int max (kg m⁻¹s⁻¹)
	Day	Time	Day	Time					
1	02-may-13	9:00:00	03-may-13	13:00:00	28	-35	-31	2	673.2
2	17-may-13	16:00:00	19-may-13	0:00:00	32	-35	-30	1	555.6
3	27-may-13	2:00:00	28-may-13	21:00:00	43	-35	-30	2	695.7
4	30-may-13	22:00:00	31-may-13	12:00:00	14	-35	-34	1	662.3
5	26-jun-13	21:00:00	28-jun-13	12:00:00	39	-35	-31	2	685.3
6	02-jul-13	18:00:00	06-jul-13	1:00:00	55	-35	-30	2	613.7
7	08-jul-13	22:00:00	10-jul-13	8:00:00	34	-35	-32	2	521.8
8	13-jul-13	13:00:00	14-jul-13	15:00:00	26	-35	-31	0	292.6
9	26-jul-13	1:00:00	26-jul-13	23:00:00	22	-35	-30	1	682.3
10	06-Aug-2013	16:00:00	07-Aug-2013	22:00:00	30	-35	-30	1	565.5
11	11-Aug-2013	1:00:00	12-Aug-2013	0:00:00	23	-35	-32	0	460.3
12	06-sept-13	6:00:00	07-sept-13	12:00:00	25	-35	-30	0	391
13	09-sept-13	15:00:00	10-sept-13	22:00:00	31	-35	-35	1	402.9
14	29-mar-14	15:00:00	30-mar-14	2:00:00	11	-35	-35	1	630.7
TOTAL	2013/2014	=	14						
1	30-Apr-2014	20:00:00	03-may-14	11:00:00	56	-35	-32	1	484.2
2	28-may-14	23:00:00	29-may-14	18:00:00	19	-35	-33	1	576.9
3	03-jun-14	4:00:00	04-jun-14	6:00:00	26	-35	-31	1	650.4
4	10-jun-14	19:00:00	12-jun-14	4:00:00	33	-35	-30	1	640.8
5	13-jul-14	18:00:00	14-jul-14	20:00:00	26	-35	-31	1	610.6
6	27-jul-14	15:00:00	29-jul-14	10:00:00	43	-35	-34	2	509
7	30-jul-14	17:00:00	01-Aug-2014	8:00:00	39	-35	-34	2	502.6
8	05-Aug-2014	15:00:00	06-Aug-2014	10:00:00	19	-35	-34	0	474.7
9	22-Aug-2014	14:00:00	23-Aug-2014	22:00:00	18	-35	-32	0	345
10	29-Aug-2014	19:00:00	30-Aug-2014	16:00:00	21	-35	-30	1	553.2
11	31-Aug-2014	15:00:00	02-sept-14	0:00:00	33	-35	-30	2	556.4
12	02-sept-14	16:00:00	03-sept-14	20:00:00	28	-35	-32	1	449.3
13	13-sept-14	4:00:00	13-sept-14	17:00:00	13	-33	-30	0	392.8
14	26-Jan-2015	19:00:00	27-Jan-2015	10:00:00	15	-32	-30	0	296.6
15	20-feb-15	14:00:00	20-feb-15	23:00:00	9	-33	-32	0	295.2
16	23-mar-15	12:00:00	26-mar-15	3:00:00	63	-35	-30	2	459.7
TOTAL	2014/2015	=	16						
1	04-jun-15	13:00:00	09-jun-15	6:00:00	66	-35	-34	2	504.6
2	08-jul-15	6:00:00	09-jul-15	8:00:00	26	-35	-35	1	370
3	11-jul-15	8:00:00	12-jul-15	22:00:00	38	-35	-30	2	739.6
4	26-jul-15	2:00:00	27-jul-15	23:00:00	45	-35	-33	2	590.2
5	01-Aug-2015	5:00:00	02-Aug-2015	7:00:00	26	-35	-33	0	431.6
6	05-Aug-2015	0:00:00	09-Aug-2015	10:00:00	106	-35	-30	4	1056.6
7	21-Aug-2015	15:00:00	22-Aug-2015	0:00:00	9	-35	-34	0	411
8	25-Aug-2015	4:00:00	25-Aug-2015	23:00:00	19	-35	-34	0	438.8
9	28-Aug-2015	1:00:00	29-Aug-2015	12:00:00	35	-35	-34	2	633.3
10	06-sept-15	2:00:00	07-sept-15	16:00:00	38	-35	-31	2	523.6
11	27-sept-15	15:00:00	29-sept-15	5:00:00	38	-35	-30	0	358.6
12	30-sept-15	16:00:00	01-oct-15	15:00:00	23	-35	-30	0	434.6
13	04-oct-15	1:00:00	05-oct-15	6:00:00	29	-35	-31	0	392.7
14	13-oct-15	18:00:00	14-oct-15	13:00:00	19	-35	-30	0	463
15	19-oct-15	2:00:00	19-oct-15	18:00:00	16	-34	-30	0	397.6
16	07-Jan-2016	6:00:00	08-Jan-2016	5:00:00	23	-35	-30	0	360.1
17	23-Jan-2016	16:00:00	24-Jan-2016	2:00:00	10	-33	-32	0	341.8
TOTAL	2015/2016	=	17						

1	05-Apr-2016	16:00:00	07-Apr-2016	3:00:00	22	-35	-32	0	479.8
2	14-Apr-2016	2:00:00	18-Apr-2016	1:00:00	95	-35	-30	3	589.6
3	22-Apr-2016	22:00:00	23-Apr-2016	23:00:00	25	-35	-32	0	469.3
4	01-may-16	6:00:00	01-may-16	20:00:00	14	-35	-35	0	288.7
5	10-may-16	16:00:00	12-may-16	6:00:00	38	-35	-30	2	636.3
6	14-may-16	10:00:00	15-may-16	2:00:00	16	-35	-31	0	410.1
7	02-jun-16	19:00:00	04-jun-16	2:00:00	31	-32	-30	1	490.8
8	12-jun-16	6:00:00	13-jun-16	5:00:00	23	-35	-33	0	394.7
9	10-jul-16	9:00:00	11-jul-16	11:00:00	26	-35	-32	0	407.2
10	13-jul-16	0:00:00	14-jul-16	3:00:00	27	-35	-30	2	689.9
11	23-jul-16	18:00:00	25-jul-16	5:00:00	35	-35	-30	1	389.6
12	15-Aug-2016	23:00:00	16-Aug-2016	12:00:00	13	-35	-35	0	373.2
13	06-oct-16	5:00:00	07-oct-16	6:00:00	25	-35	-30	0	324
14	15-oct-16	3:00:00	16-oct-16	10:00:00	31	-35	-30	2	597.6
15	03-nov-16	12:00:00	04-nov-16	13:00:00	25	-35	-31	0	366.3
16	09-Dec-2016	0:00:00	09-Dec-2016	13:00:00	13	-33	-32	0	369
17	10-Dec-2016	11:00:00	11-Dec-2016	15:00:00	28	-35	-30	0	341
18	24-Jan-2017	2:00:00	25-Jan-2017	9:00:00	28	-35	-35	0	318.7
19	21-feb-17	20:00:00	23-feb-17	11:00:00	39	-35	-30	1	363.6
TOTAL	**2016/2017**	**=**	**19**						
1	19-Apr-2017	17:00:00	21-Apr-2017	2:00:00	33	-35	-30	1	495.3
2	06-may-17	12:00:00	07-may-17	14:00:00	26	-35	-30	2	656.7
3	10-may-17	7:00:00	14-may-17	12:00:00	101	-35	-30	3	727.1
4	15-jun-17	13:00:00	17-jun-17	3:00:00	38	-35	-30	3	764.5
5	21-jun-17	10:00:00	23-jun-17	7:00:00	45	-35	-31	3	755.1
6	23-jun-17	20:00:00	27-jun-17	0:00:00	76	-35	-30	4	918.4
7	23-jul-17	0:00:00	23-jul-17	18:00:00	18	-32	-31	0	376
8	08-Aug-2017	20:00:00	10-Aug-2017	9:00:00	37	-35	-31	2	569.6
9	18-Aug-2017	12:00:00	19-Aug-2017	1:00:00	13	-35	-34	0	448.3
10	22-Aug-2017	13:00:00	23-Aug-2017	2:00:00	13	-35	-34	1	515
11	29-sept-17	13:00:00	30-sept-17	17:00:00	28	-35	-32	2	664.6
12	04-oct-17	5:00:00	05-oct-17	7:00:00	26	-35	-32	1	529.9
13	31-oct-17	18:00:00	02-nov-17	4:00:00	34	-35	-33	0	332.5
14	08-Jan-2018	9:00:00	08-Jan-2018	16:00:00	7	-32	-32	0	304.4
15	17-mar-18	5:00:00	17-mar-18	22:00:00	17	-35	-34	1	570
TOTAL	**2017/2018**	**=**	**15**						
1	10-Apr-2018	11:00:00	11-Apr-2018	20:00:00	33	-35	-30	2	564.3
2	05-may-18	17:00:00	07-may-18	10:00:00	41	-35	-31	1	388.6
3	28-may-18	4:00:00	30-may-18	0:00:00	44	-35	-31	3	754.6
4	09-jun-18	2:00:00	11-jun-18	8:00:00	47	-35	-30	2	761.2
5	01-jul-18	10:00:00	02-jul-18	11:00:00	25	-35	-30	0	463.8
6	03-jul-18	8:00:00	06-jul-18	12:00:00	76	-35	-30	3	715.1
7	06-Aug-2018	13:00:00	07-Aug-2018	5:00:00	16	-35	-34	0	463.8
8	17-sept-18	4:00:00	18-sept-18	8:00:00	28	-35	-32	2	542
9	27-sept-18	2:00:00	29-sept-18	8:00:00	54	-35	-33	2	486.2
10	29-oct-18	3:00:00	30-oct-18	1:00:00	22	-35	-34	0	369.7
11	01-nov-18	14:00:00	02-nov-18	13:00:00	23	-35	-33	1	559
12	21-feb-19	11:00:00	21-feb-19	22:00:00	11	-35	-34	0	293.1
13	30-mar-19	15:00:00	31-mar-19	3:00:00	12	-33	-32	0	325.8
TOTAL	**2018/2019**	**=**	**13**						
1	24-Apr-2019	4:00:00	24-Apr-2019	22:00:00	18	-35	-30	0	423
2	02-may-19	2:00:00	04-may-19	20:00:00	64	-35	-34	3	646.7
3	29-may-19	2:00:00	31-may-19	23:00:00	60	-35	-30	2	574.3
4	12-jun-19	0:00:00	13-jun-19	2:00:00	26	-35	-32	1	498.9

5	24-jun-19	2:00:00	25-jun-19	1:00:00	23	-34	-30	0	358.8
6	27-jun-19	5:00:00	29-jun-19	13:00:00	56	-35	-30	1	499.7
7	06-jul-19	17:00:00	07-jul-19	12:00:00	19	-35	-31	0	353.1
8	20-jul-19	23:00:00	21-jul-19	8:00:00	9	-35	-35	1	573.8
9	28-Aug-2019	15:00:00	29-Aug-2019	3:00:00	12	-35	-35	1	500.3
10	09-sept-19	2:00:00	09-sept-19	22:00:00	20	-35	-33	0	372.7
11	07-oct-19	1:00:00	07-oct-19	10:00:00	9	-31	-31	0	270.9
12	14-oct-19	1:00:00	15-oct-19	6:00:00	29	-35	-30	1	510
13	15-nov-19	22:00:00	16-nov-19	9:00:00	11	-35	-31	0	309.5
14	21-mar-20	18:00:00	22-mar-20	3:00:00	9	-32	-31	0	282.8
TOTAL	**2019/2020**	**=**	**14**						
1	23-Apr-2020	16:00:00	25-Apr-2020	9:00:00	41	-35	-32	1	444.6
2	15-may-20	1:00:00	16-may-20	4:00:00	25	-35	-32	0	291.7
3	19-may-20	6:00:00	20-may-20	8:00:00	26	-35	-35	1	304.7
4	29-may-20	5:00:00	29-may-20	18:00:00	13	-32	-30	0	352.4
5	11-jun-20	10:00:00	12-jun-20	12:00:00	26	-35	-32	1	643.6
6	15-jun-20	11:00:00	17-jun-20	19:00:00	56	-35	-30	3	590.5
10	18-jun-20	3:00:00	19-jun-20	15:00:00	36	-35	-32	2	631.9
11	20-jun-20	11:00:00	21-jun-20	2:00:00	15	-35	-32	0	435
12	22-jun-20	3:00:00	23-jun-20	3:00:00	24	-35	-32	1	512.3
13	28-jun-20	3:00:00	29-jun-20	18:00:00	39	-35	-30	2	635.2
14	01-jul-20	2:00:00	01-jul-20	17:00:00	15	-35	-32	0	374.9
15	03-jul-20	6:00:00	04-jul-20	20:00:00	36	-35	-32	0	472.2
16	10-jul-20	2:00:00	10-jul-20	14:00:00	12	-35	-35	0	392.1
17	17-jul-20	1:00:00	19-jul-20	13:00:00	60	-35	-31	3	555.8
18	01-Aug-2020	13:00:00	01-Aug-2020	22:00:00	9	-35	-35	0	468.5
19	24-Aug-2020	8:00:00	26-Aug-2020	1:00:00	41	-35	-30	2	564.7
20	28-Jan-2021	19:00:00	30-Jan-2021	9:00:00	38	-35	-33	1	425.6
TOTAL	**2020/2021**	**=**	**20**						