

Article

Mapping Three Decades of Changes in the Tropical Andean Glaciers Using Landsat Data Processed in the Earth Engine

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Table S1. Number of images per sensor and year in the study area.

Year	All Available Images			Cloud Cover less than or equal to 70%		
	TM	ETM+	OLI	TM	ETM+	OLI
1985	95			90		
1986	454			420		
1987	335			313		
1988	510			496		
1989	417			402		
1990	549			510		
1991	753			689		
1992	454			446		
1993	521			496		
1994	377			362		
1995	436			425		
1996	667			631		
1997	490			456		
1998	691			633		
1999	664	346		607	296	
2000	612	739		555	650	
2001	608	829		576	751	
2002	109	778		98	679	
2003	328	578		313	508	
2004	661	796		613	717	
2005	607	820		573	739	
2006	588	734		551	655	
2007	518	635		499	572	
2008	536	786		502	732	
2009	596	814		576	736	

2010	421	735	409	664	
2011	376	749	355	659	
2012		848		741	
2013		747	656	667	548
2014		884	940	791	801
2015		890	994	800	828
2016		903	1003	829	880
2017		869	965	769	798
2018		906	963	800	811
2019		882	959	796	814
2020		932	974	857	843

Table S2. Access to multiannual classification products and glacier loss maps.

Collections	Asset ID in Google Earth Engine
Classification 1985–2020	<i>users/eturpo/Glacier-Mapping/COLECCION1/INTEGRACION/Glacier_collection1_integration_4</i>
Glacier Retreat 1990–2020	<i>users/eturpo/Glacier-Mapping/PRODUCTS/Glacier_Retreat-1990-2020-5</i>

Table S3. Results of glacier surface coverage in the TAGs by country.

Year	Peru	Bolivia	Ecuador	Colombia	Chile	Argentina	Venezuela	Total
1990	1743.45	499.58	86.10	77.21	20.77	1.15	1.12	2429.38
1991	1710.24	486.31	77.55	69.42	19.48	1.05	0.76	2364.80
1992	1676.98	478.88	77.55	69.42	18.82	1.00	0.76	2323.41
1993	1666.18	476.36	77.55	69.29	18.56	0.97	0.76	2309.67
1994	1646.19	471.23	77.55	69.16	17.46	0.90	0.76	2283.24
1995	1592.74	461.08	77.55	69.15	16.55	0.76	0.76	2218.58
1996	1575.81	457.24	76.93	67.73	16.30	0.75	0.75	2195.50
1997	1558.89	453.22	76.34	63.99	16.25	0.75	0.65	2170.08
1998	1529.94	445.85	75.04	62.49	16.03	0.74	0.48	2130.57
1999	1522.55	443.61	74.80	60.31	15.98	0.74	0.45	2118.44
2000	1503.67	434.75	73.70	60.18	15.73	0.73	0.44	2089.20
2001	1492.44	428.73	72.09	59.35	15.65	0.73	0.43	2069.41
2002	1487.04	427.45	71.63	55.98	15.47	0.72	0.35	2058.63
2003	1445.10	407.81	71.12	54.95	14.42	0.72	0.29	1994.41
2004	1419.82	398.14	70.23	53.86	14.10	0.71	0.26	1957.13
2005	1388.17	387.42	69.94	52.91	13.40	0.70	0.24	1912.78
2006	1378.18	383.84	69.35	52.22	13.33	0.69	0.21	1897.83
2007	1367.23	380.38	69.22	51.20	13.11	0.69	0.19	1882.01
2008	1352.38	375.00	69.06	50.59	12.63	0.69	0.19	1860.53
2009	1334.18	369.32	68.74	49.85	12.51	0.68	0.16	1835.43
2010	1320.85	364.02	68.52	49.21	12.15	0.68	0.14	1815.57
2011	1315.88	362.24	68.16	48.67	12.07	0.68	0.13	1807.83
2012	1305.61	359.58	67.83	46.57	12.06	0.68	0.12	1792.45
2013	1289.90	350.90	66.91	45.67	11.78	0.68	0.11	1765.94
2014	1279.49	347.18	66.41	42.15	11.55	0.68	0.11	1747.55
2015	1258.80	344.04	64.58	40.93	11.48	0.68	0.09	1720.59
2016	1210.19	329.60	62.79	38.41	11.24	0.68	0.07	1652.97
2017	1196.89	326.97	60.44	37.41	11.19	0.67	0.06	1633.64
2018	1178.61	323.56	59.95	36.82	11.16	0.67	0.06	1610.83
2019	1142.10	314.32	59.37	35.00	11.12	0.67	0.05	1562.63
2020	1025.29	286.69	54.78	30.73	10.96	0.63	0.03	1409.12

Table S4. Results of glacier surface coverage (km²) in the TAGs at different geographic latitudes.

Year	Latitudes					
	−24° to −20°	−19° to −15°	−14° to −10°	−09° to −00°	01° to 11°	
1990		6.24	438.11	1195.23	692.39	97.42
1991		5.40	423.92	1172.02	676.01	87.44
1992		5.05	415.22	1147.60	668.11	87.44
1993		4.87	412.48	1138.35	666.65	87.31
1994		4.20	407.26	1123.64	660.97	87.18
1995		3.70	399.67	1076.91	651.14	87.17
1996		3.52	396.38	1061.12	648.74	85.73
1997		3.47	393.45	1047.64	643.71	81.81
1998		3.34	388.07	1020.53	638.75	79.88
1999		3.32	386.29	1014.06	637.15	77.62
2000		3.27	379.84	995.77	632.87	77.45
2001		3.24	374.20	987.38	628.11	76.48
2002		3.22	371.71	983.22	627.53	72.96
2003		2.98	354.36	954.86	610.37	71.84
2004		2.92	346.69	931.26	605.60	70.65
2005		2.83	338.38	900.31	601.62	69.64
2006		2.81	335.67	891.18	599.39	68.78
2007		2.79	333.52	880.40	597.58	67.72
2008		2.73	328.57	865.28	596.86	67.08
2009		2.68	325.02	846.03	595.48	66.21
2010		2.63	320.64	834.17	592.65	65.49
2011		2.63	319.35	829.25	591.72	64.89
2012		2.62	317.40	822.49	587.18	62.75
2013		2.58	311.26	806.69	583.81	61.60
2014		2.56	307.96	797.49	581.56	57.99
2015		2.56	305.74	783.61	572.22	56.45
2016		2.54	291.48	747.86	557.37	53.71
2017		2.52	289.08	738.84	550.77	52.43
2018		2.51	285.14	729.56	542.06	51.56
2019		2.50	278.33	701.39	530.79	49.62
2020		2.34	258.07	630.64	473.51	44.55

Table S5. Results of glacier surface coverage (km²) in the TAGs at different geographic longitudes.

Year	Longitude					
	−78° to −77°	−76° to −75°	−74° to −73°	−72° to −71°	−70° to −69°	−68° to −67°
1990	715.14	284.70	54.74	531.51	505.27	338.02
1991	696.65	273.98	51.87	519.23	497.24	325.83
1992	688.65	268.63	51.06	510.34	484.36	320.37
1993	687.17	266.60	50.50	506.04	481.18	318.19
1994	681.39	262.57	49.28	500.24	476.08	313.69
1995	671.34	254.01	47.93	484.92	453.03	307.37
1996	668.90	249.22	46.86	479.91	446.17	304.45
1997	663.70	245.98	45.10	473.21	440.17	301.92
1998	658.42	241.85	43.69	460.92	428.44	297.27
1999	656.73	238.67	43.17	457.76	426.28	295.83
2000	652.37	236.33	42.37	451.59	416.49	290.05
2001	647.47	233.88	41.42	448.46	413.25	284.94
2002	646.78	228.98	41.30	445.09	412.83	283.65
2003	629.32	220.90	40.25	436.28	399.02	268.63
2004	624.39	216.50	39.30	426.38	388.49	262.07
2005	620.32	211.33	37.52	413.23	375.09	255.28
2006	617.93	209.61	36.93	408.87	371.46	253.01

2007	616.09	207.60	36.10	404.37	366.42	251.43
2008	615.32	206.09	35.85	398.23	356.59	248.45
2009	613.83	204.22	35.17	391.56	345.40	245.25
2010	610.89	201.89	34.20	387.31	339.00	242.28
2011	609.91	200.97	34.04	385.25	336.39	241.26
2012	605.26	198.08	33.22	382.66	333.45	239.78
2013	601.60	195.18	32.10	377.15	324.69	235.20
2014	599.23	191.41	31.10	372.46	320.27	233.08
2015	589.48	187.72	30.24	367.66	314.09	231.41
2016	574.28	180.74	28.06	349.12	299.75	221.02
2017	567.38	177.80	27.46	345.26	296.30	219.44
2018	558.30	174.85	26.58	340.60	293.57	216.93
2019	546.84	167.24	24.77	328.96	283.61	211.21
2020	488.61	140.47	21.93	305.24	258.98	193.89

Table S6. Results of glacier surface coverage (km²) in the TAGs by aspect.

Year	North	East	South	West	Sum
1990	480.27	511.76	754.99	682.31	2429.38
1991	466.99	496.17	735.37	666.22	2364.80
1992	457.89	487.08	723.64	654.75	2323.41
1993	454.97	484.15	719.64	650.87	2309.67
1994	450.51	479.51	711.28	641.90	2283.24
1995	435.28	464.94	693.76	624.57	2218.58
1996	430.85	459.72	686.63	618.27	2195.50
1997	425.50	454.63	679.12	610.81	2170.08
1998	416.38	445.75	667.76	600.66	2130.57
1999	413.94	443.32	664.25	596.90	2118.44
2000	407.56	436.23	655.66	589.73	2089.20
2001	403.63	432.50	649.22	584.05	2069.41
2002	402.23	430.45	644.89	581.04	2058.63
2003	388.45	415.93	626.38	563.63	1994.41
2004	381.35	407.39	613.99	554.40	1957.13
2005	370.80	397.45	601.92	542.60	1912.78
2006	367.52	394.36	597.78	538.17	1897.83
2007	363.73	391.18	593.36	533.73	1882.01
2008	358.75	386.95	587.09	527.74	1860.53
2009	353.74	382.47	578.95	520.27	1835.43
2010	349.21	378.41	573.21	514.74	1815.57
2011	347.60	376.80	570.89	512.54	1807.83
2012	344.02	373.68	566.84	507.91	1792.45
2013	338.27	368.60	558.68	500.39	1765.94
2014	334.56	364.73	553.09	495.18	1747.55
2015	328.48	359.81	545.52	486.77	1720.59
2016	314.44	345.31	525.26	467.95	1652.97
2017	310.58	341.38	519.54	462.13	1633.64
2018	306.57	337.62	511.51	455.12	1610.83
2019	298.91	329.48	494.39	439.85	1562.63
2020	274.42	303.83	441.01	389.85	1409.12

Table S7. Results of glacier surface coverage (km²) in the TAGs on different slopes.

Year	Slope (degrees)								
	0°–10°	11°–20°	21°–30°	31°–40°	41°–50°	51°–60°	61°–70°	71°–80°	81°–90°
1990	246.10	576.47	692.41	518.33	261.59	108.38	24.71	1.36	0.03
1991	241.50	562.41	672.51	503.77	254.23	105.19	23.87	1.29	0.03
1992	236.27	553.10	660.84	495.08	249.78	103.51	23.54	1.26	0.03

1993	234.81	549.78	656.96	492.21	248.33	102.86	23.44	1.25	0.03
1994	233.03	544.59	649.47	485.83	244.74	101.27	23.06	1.23	0.03
1995	227.12	529.75	630.19	471.68	237.60	98.50	22.52	1.20	0.02
1996	224.95	523.71	623.06	467.04	235.41	97.74	22.37	1.19	0.02
1997	222.80	517.29	615.33	461.59	232.85	96.83	22.19	1.18	0.02
1998	218.76	506.45	602.86	453.64	229.70	95.96	22.01	1.17	0.02
1999	217.52	503.30	599.07	451.20	228.65	95.58	21.94	1.16	0.02
2000	214.98	495.89	589.92	444.90	225.88	94.67	21.79	1.15	0.02
2001	213.32	490.86	583.97	440.71	223.80	93.95	21.64	1.14	0.02
2002	212.28	487.68	580.26	438.71	223.15	93.79	21.61	1.14	0.02
2003	207.57	472.15	560.09	423.83	216.59	91.76	21.28	1.12	0.02
2004	204.78	463.33	548.64	415.05	212.60	90.54	21.08	1.10	0.02
2005	201.56	453.09	535.24	404.57	207.51	88.90	20.80	1.08	0.02
2006	200.30	449.43	530.59	401.17	206.05	88.47	20.71	1.08	0.02
2007	199.09	445.85	525.66	397.32	204.38	88.00	20.62	1.07	0.02
2008	197.06	439.85	518.88	392.94	202.66	87.51	20.54	1.06	0.02
2009	194.46	432.99	511.32	387.78	200.50	86.88	20.42	1.06	0.02
2010	192.66	427.83	505.06	383.47	198.78	86.39	20.33	1.05	0.02
2011	191.92	425.91	502.73	381.82	197.99	86.12	20.29	1.05	0.02
2012	190.47	422.04	498.02	378.52	196.51	85.64	20.19	1.04	0.02
2013	187.79	415.16	490.18	372.92	193.97	84.81	20.04	1.03	0.02
2014	185.90	410.25	484.63	369.12	192.34	84.34	19.94	1.02	0.02
2015	183.83	404.61	476.78	362.43	189.11	83.15	19.65	1.01	0.02
2016	179.06	391.07	457.17	345.66	180.17	79.87	18.99	0.96	0.02
2017	177.26	386.76	451.84	341.35	177.84	78.86	18.75	0.95	0.02
2018	175.78	382.37	445.56	335.59	174.64	77.51	18.42	0.94	0.02
2019	172.57	373.69	433.86	324.22	166.94	73.11	17.29	0.92	0.02
2020	163.17	348.12	396.63	288.25	140.93	58.01	13.25	0.74	0.02

Table S8. Results of glacier surface coverage (km²) in the TAGs at different altitudes.

Year	Altitude (masl)								
	less than 4600	4601–4800	4801–5000	5001–5200	5201–5400	5401–5600	5601–5800	5801–6000	greater than 6000
1990	21.22	134.84	421.36	658.63	599.69	328.77	140.55	72.87	51.44
1991	15.49	121.97	404.13	644.44	591.42	325.50	138.92	71.84	51.09
1992	14.78	117.29	394.20	634.46	580.42	322.97	137.45	71.04	50.80
1993	14.29	114.88	390.16	630.97	578.44	322.36	137.12	70.76	50.70
1994	13.70	110.02	381.83	624.61	575.21	321.00	136.16	70.31	50.40
1995	13.09	103.14	363.52	605.22	561.49	317.20	134.89	69.81	50.22
1996	11.96	99.29	356.03	598.70	558.52	316.58	134.59	69.67	50.15
1997	10.66	94.00	347.61	591.76	555.76	316.09	134.45	69.64	50.12
1998	9.18	86.73	334.54	580.16	551.07	315.11	134.14	69.56	50.08
1999	8.52	84.21	331.20	576.69	549.39	314.80	134.04	69.52	50.07
2000	8.15	81.08	322.35	567.27	543.98	313.37	133.55	69.42	50.03
2001	7.67	77.84	315.99	561.19	541.33	312.76	133.22	69.38	50.02
2002	7.29	75.14	312.97	558.82	540.21	312.27	132.68	69.24	50.01
2003	6.98	69.23	291.42	537.09	530.12	309.70	131.23	68.72	49.92
2004	6.55	65.13	280.25	524.93	523.22	308.17	130.60	68.41	49.88
2005	6.33	60.70	267.61	511.38	514.39	305.44	129.35	67.91	49.68
2006	6.05	58.30	262.70	507.11	512.10	304.96	129.12	67.84	49.65
2007	5.80	56.15	257.38	502.19	509.80	304.38	128.94	67.77	49.60
2008	5.50	54.71	252.27	494.30	505.52	303.23	128.19	67.37	49.46
2009	5.33	52.51	245.49	485.16	500.09	302.19	127.93	67.29	49.43
2010	5.17	51.03	239.86	478.21	496.64	301.17	127.18	66.94	49.38
2011	4.97	49.98	237.90	475.83	495.16	300.79	127.00	66.87	49.34
2012	4.72	47.98	232.92	470.68	492.93	300.28	126.81	66.79	49.33
2013	4.32	46.68	226.34	460.62	487.37	298.76	126.04	66.51	49.31
2014	4.07	44.59	220.57	455.01	484.39	297.86	125.51	66.30	49.26
2015	3.72	42.76	213.85	445.45	478.43	296.23	124.90	66.06	49.20

2016	2.91	37.50	196.36	424.31	463.91	291.71	123.24	64.86	48.17
2017	2.48	34.69	191.39	419.07	460.24	290.64	122.57	64.55	47.98
2018	2.33	33.01	185.54	411.17	455.54	289.19	121.86	64.27	47.91
2019	2.21	30.14	174.94	394.75	442.91	285.50	120.66	63.71	47.81
2020	1.61	22.59	147.06	346.33	403.95	267.15	113.18	60.81	46.43

Table S9. Glacier surface coverage results in the TAGs by basin.

Year	Area (km ²)		Area Loss (km ²)		Area Loss (%)	
	Other Basins	Amazon Basin	Other Basins	Amazon Basin	Other Basins	Amazon Basin
1990	901.93	1527.45	0.00	0.00	0.00	0.00
1991	876.20	1488.60	−25.73	−38.85	−2.85	−2.54
1992	860.62	1462.79	−15.58	−25.81	−4.58	−4.23
1993	856.56	1453.11	−4.06	−9.68	−5.03	−4.87
1994	847.09	1436.15	−9.47	−16.96	−6.08	−5.98
1995	828.87	1389.72	−18.23	−46.43	−8.10	−9.02
1996	822.82	1372.68	−6.04	−17.04	−8.77	−10.13
1997	812.59	1357.49	−10.23	−15.19	−9.91	−11.13
1998	802.59	1327.98	−10.00	−29.51	−11.01	−13.06
1999	797.27	1321.17	−5.32	−6.81	−11.60	−13.50
2000	790.41	1298.79	−6.85	−22.38	−12.36	−14.97
2001	783.60	1285.81	−6.81	−12.98	−13.12	−15.82
2002	776.84	1281.79	−6.76	−4.02	−13.87	−16.08
2003	752.51	1241.90	−24.34	−39.89	−16.57	−18.69
2004	742.49	1214.64	−10.01	−27.26	−17.68	−20.48
2005	732.02	1180.76	−10.47	−33.88	−18.84	−22.70
2006	727.94	1169.89	−4.08	−10.87	−19.29	−23.41
2007	723.62	1158.39	−4.32	−11.50	−19.77	−24.16
2008	717.56	1142.96	−6.06	−15.42	−20.44	−25.17
2009	711.82	1123.60	−5.74	−19.36	−21.08	−26.44
2010	704.69	1110.88	−7.13	−12.72	−21.87	−27.27
2011	702.49	1105.35	−2.20	−5.54	−22.11	−27.63
2012	694.99	1097.46	−7.50	−7.89	−22.94	−28.15
2013	685.97	1079.97	−9.02	−17.49	−23.94	−29.30
2014	678.32	1069.24	−7.65	−10.73	−24.79	−30.00
2015	666.83	1053.77	−11.49	−15.47	−26.07	−31.01
2016	644.30	1008.66	−22.52	−45.10	−28.56	−33.96
2017	637.39	996.24	−6.91	−12.42	−29.33	−34.78
2018	625.80	985.03	−11.59	−11.22	−30.62	−35.51
2019	607.97	954.66	−17.83	−30.37	−32.59	−37.50
2020	539.53	869.59	−68.44	−85.07	−40.18	−43.07

Table S10. Validation results of the glacier cover classification without filters.

Year	F1score	Accuracy	Kappa	Precision	Recall
1985	91.13	94.04	86.64	93.69	88.70
1986	91.82	94.62	87.82	94.88	88.96
1987	92.11	95.05	88.51	95.47	88.97
1988	92.41	95.60	89.32	97.50	87.82
1989	93.24	95.89	90.29	95.23	91.34
1990	92.52	95.63	89.44	97.10	88.35
1991	91.79	95.38	88.59	96.50	87.52
1992	92.69	96.00	89.95	97.52	88.32
1993	93.24	96.15	90.55	95.63	90.97
1994	93.11	96.11	90.41	95.88	90.50
1995	91.68	95.57	88.68	98.40	85.82
1996	92.55	95.95	89.78	97.95	87.72
1997	92.86	96.08	90.17	96.59	89.41

1998	85.41	93.01	80.91	98.13	75.61
1999	92.29	95.74	89.35	94.42	90.26
2000	92.83	96.09	90.15	94.25	91.46
2001	92.12	95.67	89.13	93.57	90.71
2002	76.87	89.39	70.03	72.08	82.34
2003	91.58	95.69	88.70	97.03	86.71
2004	90.73	95.31	87.61	97.58	84.77
2005	88.19	94.26	84.42	94.86	82.39
2006	91.35	95.75	88.55	97.30	86.09
2007	92.46	96.26	89.98	96.67	88.60
2008	89.80	94.91	86.42	94.31	85.71
2009	89.71	95.16	86.56	96.63	83.71
2010	87.53	94.48	84.03	96.89	79.83
2011	90.96	95.68	88.12	93.55	88.50
2012	91.57	95.81	88.78	92.24	90.90
2013	91.19	95.90	88.52	95.31	87.41
2014	91.05	96.01	88.50	96.76	85.99
2015	91.66	96.20	89.21	96.72	87.11
2016	86.04	94.43	82.62	97.60	76.93
2017	90.24	95.79	87.57	97.19	84.22
2018	90.44	95.77	87.73	94.19	86.98
2019	90.72	96.14	88.30	96.92	85.27
2020	86.74	94.91	83.64	97.08	78.39

Table S11. Validation results of the glacier cover classification with filters.

Year	F1score	Accuracy	Kappa	Precision	Recall
1985	92.27	94.46	87.96	94.41	90.23
1986	93.62	95.72	90.41	96.00	91.37
1987	93.75	96.06	90.88	97.05	90.66
1988	93.91	96.37	91.33	96.31	91.64
1989	93.84	96.26	91.16	96.79	91.05
1990	93.63	96.23	90.95	97.26	90.26
1991	93.35	96.22	90.71	96.81	90.13
1992	94.25	96.79	92.03	97.45	91.26
1993	94.16	96.68	91.85	98.01	90.59
1994	94.24	96.76	91.99	97.97	90.79
1995	93.99	96.72	91.74	98.44	89.93
1996	93.44	96.40	90.97	98.28	89.05
1997	93.95	96.68	91.68	98.45	89.85
1998	93.51	96.61	91.22	97.32	89.99
1999	93.23	96.34	90.73	97.81	89.06
2000	93.36	96.46	90.95	97.66	89.41
2001	93.37	96.45	90.95	98.19	89.00
2002	93.05	96.31	90.55	97.98	88.60
2003	93.45	96.64	91.19	98.01	89.30
2004	92.68	96.24	90.16	97.80	88.07
2005	92.67	96.37	90.26	97.96	87.92
2006	93.04	96.55	90.76	98.20	88.39
2007	92.67	96.39	90.28	98.02	87.86
2008	92.49	96.29	90.05	98.19	87.42
2009	92.51	96.41	90.16	97.93	87.66
2010	92.24	96.40	89.90	97.23	87.74
2011	92.76	96.59	90.53	97.35	88.58
2012	92.08	96.24	89.62	97.07	87.58
2013	92.49	96.52	90.24	97.59	87.90
2014	92.33	96.58	90.13	98.03	87.26

2015	91.94	96.36	89.60	97.57	86.93
2016	91.30	96.35	89.00	97.18	86.09
2017	91.57	96.34	89.25	97.70	86.17
2018	91.41	96.29	89.06	97.60	85.97
2019	91.44	96.49	89.25	97.72	85.92
2020	87.06	95.08	84.08	98.65	77.91

Table S12. Validation metrics disregarding and considering area proportions.

Year	Without Area Proportions				With Area Proportions			
	F1score	Accuracy	Precision	Recall	F1score	Accuracy	Precision	Recall
1985	92.27	94.46	94.41	90.23	91.10	94.41	92.13	90.10
1986	93.62	95.72	96.00	91.37	91.50	95.38	92.84	90.21
1987	93.75	96.06	97.05	90.66	91.91	95.77	94.42	89.53
1988	93.91	96.37	96.31	91.64	92.18	96.13	94.73	89.76
1989	93.84	96.26	96.79	91.05	91.87	95.83	95.30	88.68
1990	93.63	96.23	97.26	90.26	91.85	95.83	95.85	88.16
1991	93.35	96.22	96.81	90.13	91.66	95.94	95.30	88.29
1992	94.25	96.79	97.45	91.26	92.83	96.56	96.05	89.83
1993	94.16	96.68	98.01	90.59	92.43	96.22	96.61	88.60
1994	94.24	96.76	97.97	90.79	92.56	96.36	96.28	89.12
1995	93.99	96.72	98.44	89.93	92.10	96.15	96.81	87.82
1996	93.44	96.40	98.28	89.05	91.51	95.80	97.00	86.61
1997	93.95	96.68	98.45	89.85	92.08	96.08	97.23	87.44
1998	93.51	96.61	97.32	89.99	91.42	96.06	96.22	87.07
1999	93.23	96.34	97.81	89.06	91.11	95.73	96.55	86.25
2000	93.36	96.46	97.66	89.41	91.29	95.95	96.02	87.00
2001	93.37	96.45	98.19	89.00	91.19	95.80	96.58	86.38
2002	93.05	96.31	97.98	88.60	90.77	95.64	96.39	85.78
2003	93.45	96.64	98.01	89.30	91.45	96.10	96.54	86.86
2004	92.68	96.24	97.80	88.07	90.50	95.69	96.07	85.54
2005	92.67	96.37	97.96	87.92	90.51	95.79	96.56	85.17
2006	93.04	96.55	98.20	88.39	91.00	96.00	96.82	85.85
2007	92.67	96.39	98.02	87.86	90.53	95.84	96.39	85.35
2008	92.49	96.29	98.19	87.42	90.69	95.84	96.89	85.24
2009	92.51	96.41	97.93	87.66	90.60	95.97	96.41	85.45
2010	92.24	96.40	97.23	87.74	90.18	96.01	95.42	85.48
2011	92.76	96.59	97.35	88.58	90.47	96.07	95.75	85.74
2012	92.08	96.24	97.07	87.58	89.95	95.83	95.42	85.06
2013	92.49	96.52	97.59	87.90	90.61	96.16	95.99	85.79
2014	92.33	96.58	98.03	87.26	90.50	96.18	96.53	85.18
2015	91.94	96.36	97.57	86.93	89.97	96.02	95.37	85.15
2016	91.30	96.35	97.18	86.09	89.35	96.09	94.66	84.60
2017	91.57	96.34	97.70	86.17	89.61	96.03	95.32	84.53
2018	91.41	96.29	97.60	85.97	89.24	95.91	95.19	83.98
2019	91.44	96.49	97.72	85.92	89.34	96.14	95.16	84.20
2020	87.06	95.08	98.65	77.91	86.12	95.01	96.91	77.49
Mean	92.81	96.32	97.56	88.54	90.89	95.90	95.83	86.48

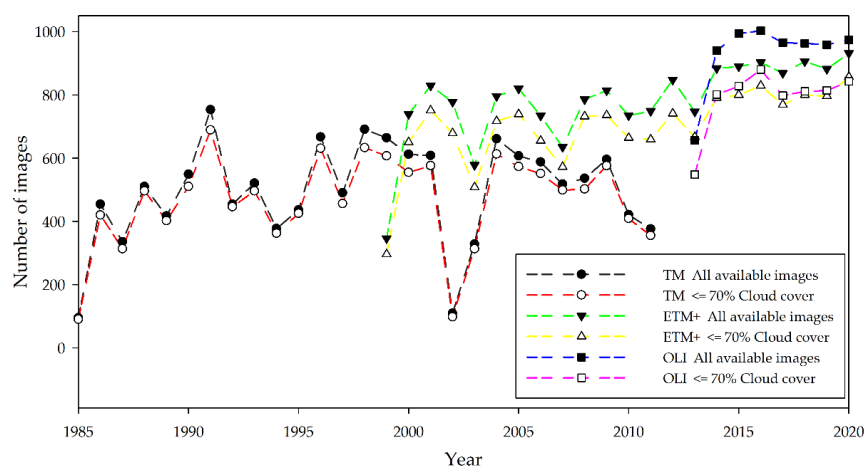


Figure S1. Number of images per sensor and year in the study area.

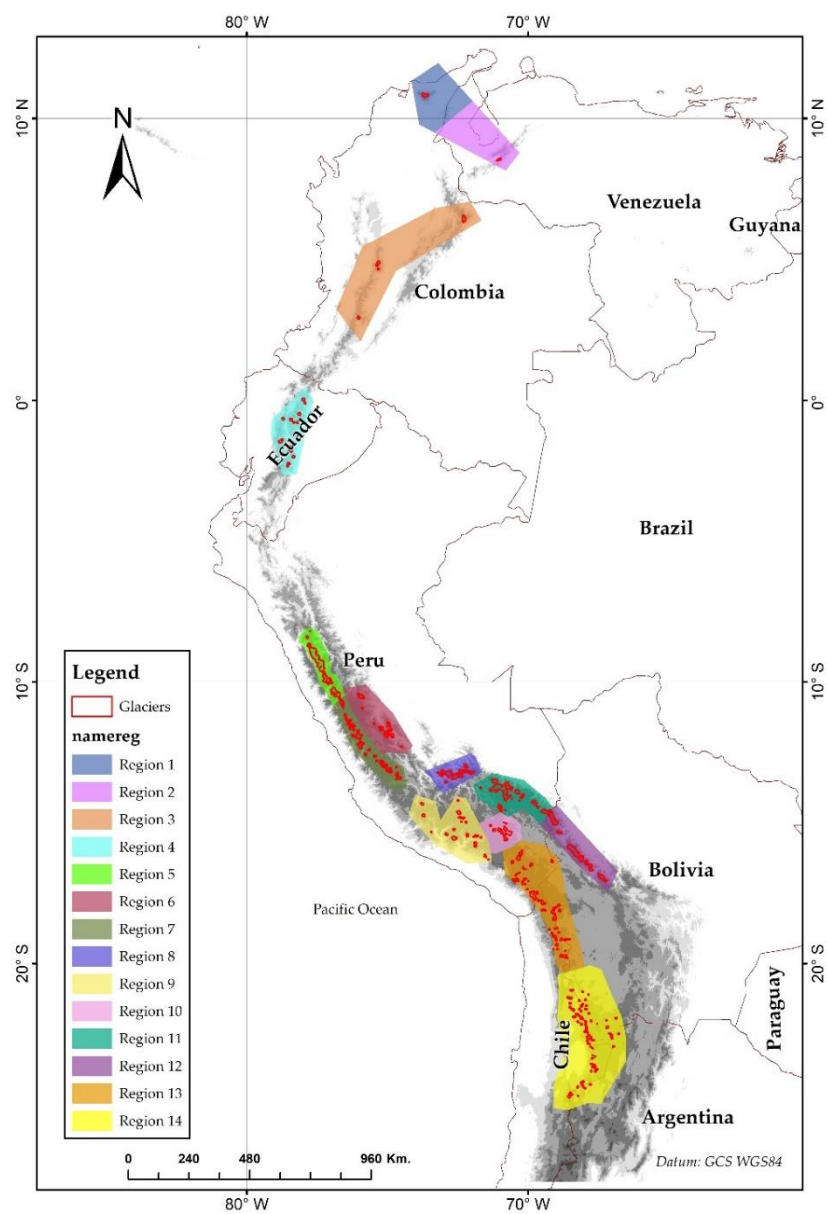


Figure S2. Benchmark glaciers and classification regions. The division of regions is based on the criteria of similar geoclimatic conditions.

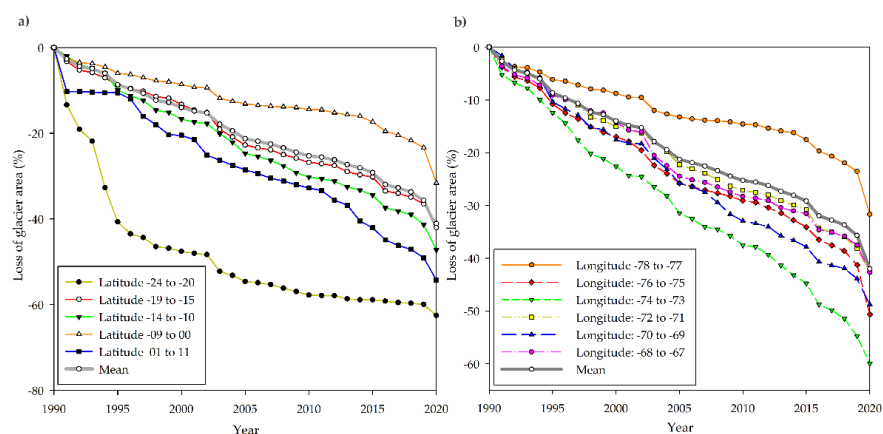


Figure S3. Evolution of annual glacier area coverage loss in the TAGs from 1987 to 2019: (a) loss at different latitudes and (b) loss at different longitudes.

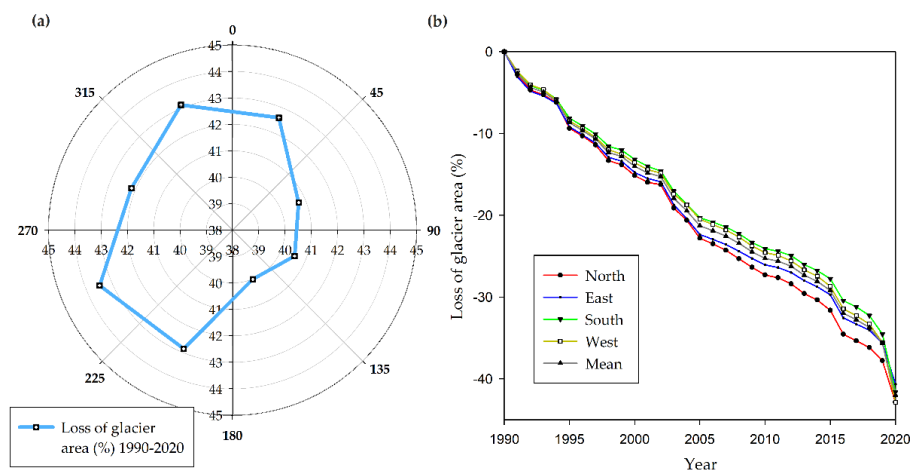


Figure S4. Evolution of annual glacier area coverage loss in the TAGs from 1990 to 2020 at different glacier slope orientations: (a) polar plot of glacier loss, and (b) change in annual glacier area loss.

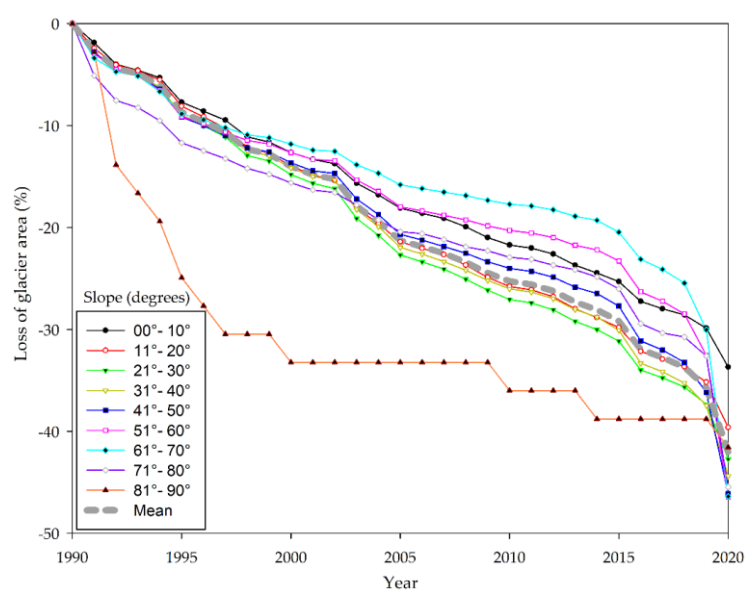


Figure S5. Loss of the annual glacier area coverage in the TAGs from 1990 to 2020 in different slope ranges.

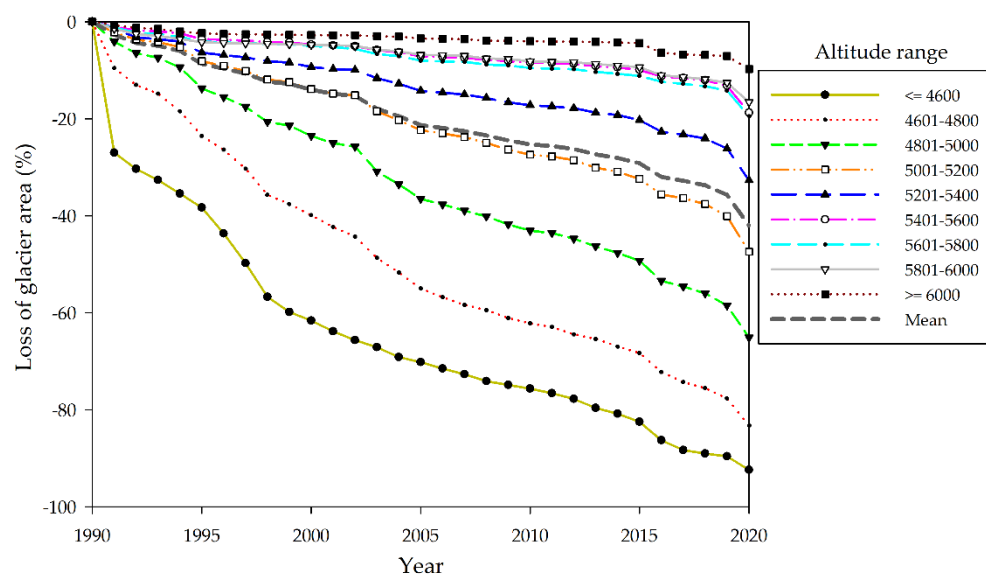


Figure S6. Annual glacier loss in the TAGs from 1990 to 2020 in different altitude ranges.

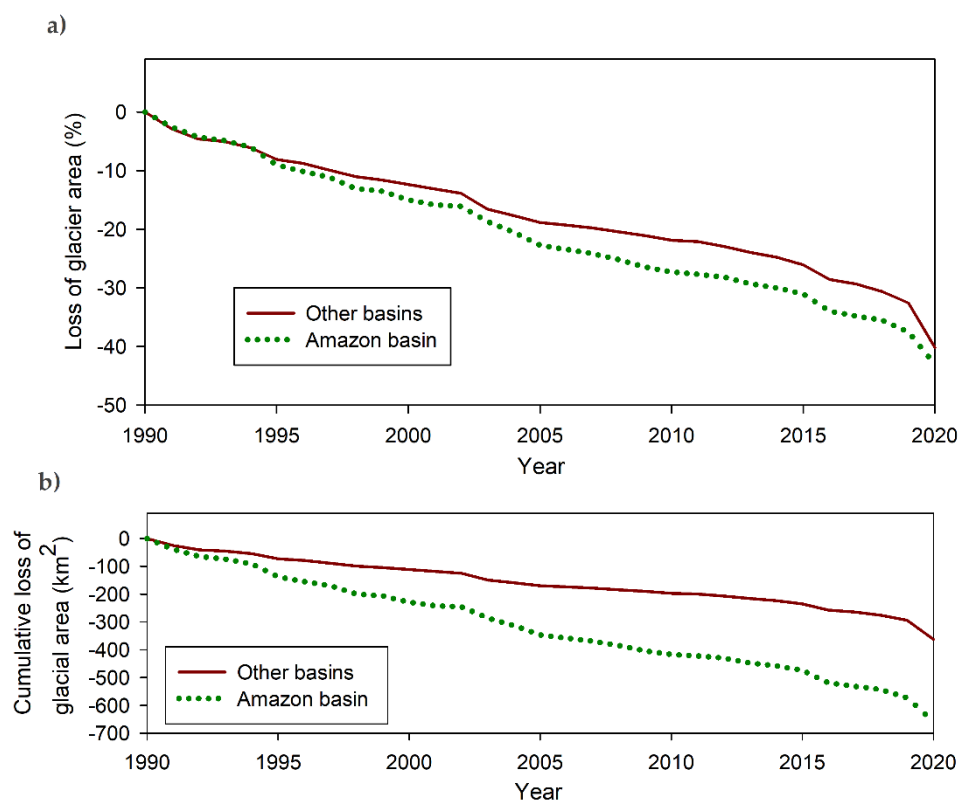


Figure S7. Evolution of the annual loss of glacier area in the TAGs from 1990 to 2020 by basins (a) percentage loss of glacier area and (b) cumulative loss of glacier area in km².

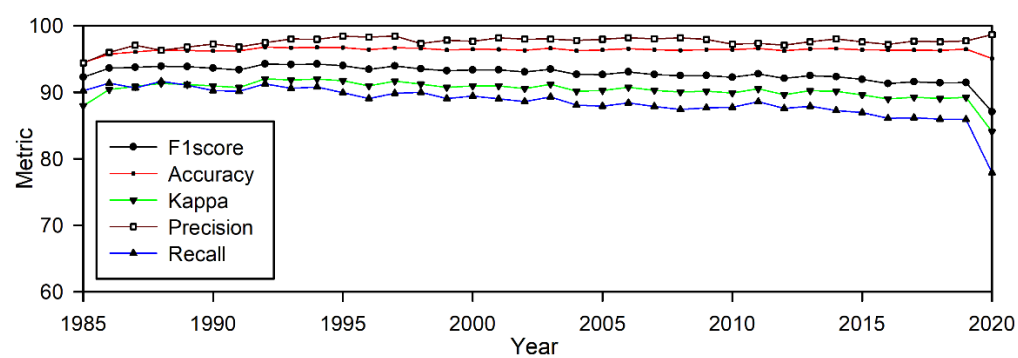


Figure S8. Multitemporal validation metrics for the final multiyear glacier cover maps.