Supplementary material for

Global clustering of recent glacier surges from radar backscatter data, 2017–2022

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Table S1: Surge-type events 2017–22 from Sentinel-1 backscatter changes. The columns of our event file are GLIMS ID and RGI ID of the glacier, rough longitudes and latitudes of the glacier surge (not necessary coinciding with GLIMS or RGI lat/lon), name of the glacier (if available) and comment, and the current RGI (version 6) surge indication (RGI surge categories 3 = observed surge, 2 = probable surge, 1 = possible surge; 0 = no evidence, 9 = no information). We also include the start and end year in which we observe increasing or decreasing backscatter, respectively, or indication if the start happened before 2017 (= 1000), or the end is not yet observed in 2022 (=3000), respectively. x in the last column indicates that the glacier is not identified as surge-type in RGI (flags 0 and 9) but in the other studies used as additional reference (in particular Farnsworth and others, 2016; Guillet and others, 2022). Note that this agreement refers to RGI IDs, i.e. glacier systems, and not necessary to the same glacier part or tributary. Two surges of different branches of Sortebræ are treated as different events in the table (# 15 and 16).

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	GLIMS ID	RGI ID	Lon.	Lat.	Start	End	Name/comment	RGI surge flag x: other studies
1	G220204E60098N	RGI60-01.14391	-139,667	60,040	2020	2021	Turner	9
2	G220740E60158N	RGI60-01.14443	-138,960	60,131	2021	2022	small tributary to Hubbard gl.	9
3	G216046E62056N	RGI60-01.15772	-143,877	62,143	2018	2019	-	9
4	G220578E60873N	RGI60-01.16198	-139,463	60,914	2017	2019	Kluane	x
5	G219819E61242N	RGI60-01.16377	-140,188	61,207	1000	2017	Steele	9
6	G218909E61392N	RGI60-01.17183	-140,649	61,457	1000	2020	Klutlan	x
7	G218909E61392N	RGI60-01.17183	-140,765	61,297	1000	2018	Klutlan tributary	9
8	G218909E61392N	RGI60-01.17183	-140,936	61,389	2018	3000	Klutlan tributary	9
9	G209330E63184N	RGI60-01.22169	-150,363	63,307	2020	3000	Muldrow	3
10	G219611E60880N	RGI60-01.26738	-140,447	60,855	1000	2018	Walsh	x
11	G219611E60880N	RGI60-01.26738	-140,578	60,925	1000	2018	Walsh tributary	9
12	G280187E81438N	RGI60-03.03342	-79,910	81,280	1000	3000	Chapman, different glacier branches	2
13	G305818E70120N	RGI60-05.01879	-54,182	70,120	1000	2017	-	9
14	G330976E68786N	RGI60-05.13667	-29,390	68,716	2018	2020	tributary to Rosenborg Gl.	9
15	G332896E69162N	RGI60-05.13429	-27,040	68,790	2015	2018	Sortebræ (East branch)	1
16	G332574E68832N	RGI60-05.13429	-27,253	68,740	1000	2017	Sortebræ West	1
17	G024396E79406N	RGI60-07.00026	24,476	79,363	1000	2018	Austfonna basin 2	0
18	G024340E79634N	RGI60-07.00027	25,183	79,479	1000	2020	Austfonna basin 3	2
19	G021502E79897N	RGI60-07.00042	21,518	79,854	2018	2020	Bodleybreen (outlet)	3
20	G015037E77377N	RGI60-07.00228	14,796	77,450	2018	2020	Recherchebreen	3
21	G015616E77394N	RGI60-07.00241	15,625	77,472	1000	2019	Penckbreen	1
22	G017096E77164N	RGI60-07.00250	17,239	77,148	1000	2019	Markhambreen	3
23	G017158E77876N	RGI60-07.00266	17,114	77,865	2021	3000	Vallakrabreen	1
24	G018098E77802N	RGI60-07.00276	18,213	77,843	2017	2021	Arnesenbreen (two surge phases)	1
25	G016964E77694N	RGI60-07.00283	16,974	77,728	2020	3000	Scheelebreen	1
26	G018031E77579N	RGI60-07.00293	17,961	77,562	2020	3000	Kvalbreen	1
27	G017697E77678N	RGI60-07.00296	17,531	77,603	1000	2020	Morsjnevbreen / Strongbreen	2
28	G016742E76846N	RGI60-07.00299	16,761	76,861	2017	2020	Vasilievbreen	3
29	G016633E77290N	RGI60-07.00322	16,194	77,420	1000	2017	Nathorst	3
30	G016777E76955N	RGI60-07.00440	16,778	76,963	2017	2020	Svalisbreen	x
31	G013901E78579N	RGI60-07.00465	14,063	78,504	1000	2020	Wahlenbergbreen	2
32	G013139E78668N	RGI60-07.00482	13,204	78,614	2019	2021	Osbornebreen	3
33	G016346E79525N	RGI60-07.00849	16,100	79,540	2021	3000	Midtbreen	0
34	G020098E78757N	RGI60-07.00892	20,117	78,690	2019	2021	Sonklarbreen	3
35	G020757E78746N	RGI60-07.00897	20,721	78,743	2017	2019	Ganskijbreen	3
36	G017497E78572N	RGI60-07.01458	17,433	78,498	1000	2019	Tunabreen	3
37	G016915E77433N	RGI60-07.01472	16,700	77,430	2022	3000	Listoelbreen	1
38	G012363E79148N	RGI60-07.01492	12,363	79,148	2021	3000	Fjortende Julibreen	3
39	G012697E79319N	RGI60-07.01494	12,553	79,474	2018	2021	Monacobreen	3
40	G018042E78675N	RGI60-07.01506	18,921	78,591	1000	2020	Negribreen	3
41	G023608E77828N	RGI60-07.01554	24,084	77,737	2019	2021	Stonebreen	3
42	G017399E77693N	RGI60-07.01470	17,400	77,693	2022	3000	Paulabreen	2

43	G067156E76738N	RGI60-09.00149	66,750	76,800	2018	3000	Novaja Semlia, slow start at lower part	9
44	G095377E79354N	RGI60-09.00971	94,372	79,314	1000	2020	Vavilov Ice Cap (October Revolution Island)	x
45	G094940E29811N	RGI60-13.01391	94,920	29,799	2018	2018	Sedongpu	9
46	G079956E42288N	RGI60-13.04933	79,946	42,300	1000	2019	-	x
47	G074377E40704N	RGI60-13.10547	74,382	40,703	2017	2018	also G074380E40695N	x
48	G072730E39315N	RGI60-13.13025	72,729	39,297	2020	2021	SU5X14308255	3
49	G072771E39321N	RGI60-13.13078	72,752	39,298	2017	2019	SU5X14308257 Vali	3
50	G072795E39373N	RGI60-13.13080	72,790	39,398	2020	2021	SU5X14307213a Koman	3
51	G070714E38980N	RGI60-13.18270	70,721	38,992	1000	2017	SU5X14306513	2
52	G071925E38770N	RGI60-13.19075	71,922	38,772	1000	2018	SU5X14309264-266 Vanchdara	3
53	G071786E39242N	RGI60-13.19298	71,771	39,214	2017	2019	SU5X14308105	3
54	G071942E38870N	RGI60-13.19758	71,947	38,803	1000	2018	SU5X14309227 Garmo	2
55	G071776E38900N	RGI60-13.19763	71,794	38,888	2017	2021	SU5X14309188 Gando	3
56	G071322E38959N	RGI60-13.19863	71,322	38,982	1000	2017	SU5X14309085	2
57	G071768E38938N	RGI60-13.20255	71,716	38,960	2020	2021	SU5X14309783 Sugran	3
58	G091171E33460N	RGI60-13.24655	91,167	33,465	1000	2017	CN5K444B0064 Gangjiaquba Gl.	x
59	G090846E36001N	RGI60-13.33968	90,848	35,982	2020	2021	CN5Y542H0018	x
60	G091032E36060N	RGI60-13.33983	91,072	36,046	1000	2017	CN5Y542H0034 Monuomaha Gl.	x
61	G082292E35633N	RGI60-13.36869	82,292	35,633	1000	2022	slow surge, rapid advance?	x
62	G082321E35621N	RGI60-13.36874	82,283	35,596	1000	2017	CN5Y636I0041	x
63	G082326E35624N	RGI60-13.36874	82,326	35,624	1000	2019	CN5Y636I0041	x
64	G082061E35462N	RGI60-13.36977	82,046	35,473	2018	2021	CN5Y636J0050	x
65	G082093E35480N	RGI60-13.36983	82,093	35,480	1000	2017	CN5Y636J0044	x
66	G081483E35351N	RGI60-13.37603	81,503	35,384	1000	2018	CN5Y641F0046	x
67	G080462E35505N	RGI60-13.37809	80,472	35,564	2019	3000	CN5Y641H0074 West Kunlun Gl.	x
68	G080462E35505N	RGI60-13.37825	80,515	35,543	1000	2018	CN5Y641H0074 West Kunlun Gl.	x
69	G080574E35527N	RGI60-13.37842	80,565	35,559	1000	2017	CN5Y641H0067	x
70	G075116E38641N	RGI60-13.41755	75,093	38,625	2019	2020	CN5Y663C0009	x
71	G075248E38558N	RGI60-13.41792	75,213	38,534	1000	2019	CN5Y663D0004	x
72	G074990E38942N	RGI60-13.42165	74,990	38,942	1000	2017	-	x
73	G074821E39062N	RGI60-13.42219	74,821	39,062	1000	3000	advancing CN5Y663O0031	x
74	G074981E38974N	RGI60-13.42260	74,981	38,974	1000	2020	CN5Y663O0011	9
75	G074449E39260N	RGI60-13.42355	74,449	39,260	1000	3000	advance CN5Y664C0006 Ayilanama	x
76	G080334E42156N	RGI60-13.43483	80,514	42,192	2017	2019	tributary of CN5Y681B0016 Tugebieliqi Gl	x
77	G089776E35593N	RGI60-13.49228	89,783	35,590	2017	2018	CN5Z211I0007	x
78	G082268E34005N	RGI60-13.51476	82,276	34,017	2016	2016	CN5Z412C0008	9
79	G080875E34263N	RGI60-13.51630	80,926	34,278	1000	3000	CN5Z413E0008	x
80	G079424E33980N	RGI60-13.52277	79,457	33,969	1000	2020	CN5Z421F0009	x
81	G080879E35302N	RGI60-13.53720	80,901	35,243	2020	3000	CN5Z433D0008 Zhongfeng Gl.	x
82	G089071E33998N	RGI60-13.53878	89,075	34,015	2020	2021	CN5Z513B0023	x
83	G085885E34389N	RGI60-13.53958	85,915	34,400	1000	2021	CN5Z514H0005	x
84	G082378E35679N	RGI60-13.36881	82,378	35,679	1000	2022	slow surge, CN5Y636I0024	9
85	G072505E38831N	RGI60-13.13311	72,505	38,831	1000	3000	-	2
86	G071411E38982N	RGI60-13.19878	71,411	38,982	1000	3000	-	3
87	G076673E41922N	RGI60-13.09472	76,670	41,920	1000	2017		x

88	G077555E41028N	RGI60-13.09769	77.550	41.030	1000	2017		
89	G077576E41016N	RGI60-13.09770	77.570	41.030	1000	2018		
90	G075492E36566N	RGI60-14.02628	75,496	36,589	2018	2021	-	x
91	G074496E36424N	RGI60-14.03017	74,496	36,424	1000	2018	Hasanabad Glacier II	x
92	G075270E36240N	RGI60-14.03334	75,270	36,240	1000	2020	Yazgil	x
93	G075202E36377N	RGI60-14.03893	75,222	36,440	1000	2020	Mulungutti Glacier	0
94	G075545E36234N	RGI60-14.04244	75,520	36,228	2018	2021	tributary to Khurdopin glacier	x
95	G075492E36141N	RGI60-14.04404	75,485	36,253	1000	2018	Khurdopin Glacier	3
96	G075780E36040N	RGI60-14.04411	75,865	36,100	1000	2017	Braldu Glacier	2
97	G075403E36058N	RGI60-14.04477	75,308	36,080	1000	2017	Hispar Glacier	3
98	G076026E36022N	RGI60-14.04593	76,060	36,119	2019	2021	tributary to Sugatyanatjilga Glacier	3
99	G074679E36413N	RGI60-14.05446	74,606	36,388	2018	2019	Hasanabad Glacier I / Shishper gl.	3
100	G077439E35510N	RGI60-14.05890	77,564	35,340	2017	2021	IN5Q153E0011 Rimo Glacier	3
101	G076280E35948N	RGI60-14.05996	76,298	35,945	2020	3000	tributary to Chongtar	x
102	G076773E36052N	RGI60-14.06360	76,754	36,076	2017	2019	-	x
103	G076794E36050N	RGI60-14.06390	76,794	36,050	1000	2017	-	x
104	G076464E35937N	RGI60-14.06487	76,467	35,979	1000	2019	Chogori Glacier	3
105	G076280E35857N	RGI60-14.06580	76,339	35,892	2019	3000	Yanatsugat Glacier/North Chongtar	x
106	G076280E35857N	RGI60-14.06580	76,295	35,885	2021	3000	little gl at Chongtar south	x
107	G077483E35705N	RGI60-14.07022	77,539	35,745	1000	2019	-	x
108	G077896E34827N	RGI60-14.08555	77,962	34,820	1000	2019	IN5Q153C0055 North Kunchhang Glacier I	3
109	G079646E30986N	RGI60-14.26971	79,637	31,004	2018	2020	CN5Q222B0076	x
110	G077251E35355N	RGI60-14.07636	77,255	35,355	1000	3000	-	x
111	G075562E36642N	RGI60-14.02215	75,562	36,642	1000	3000	-	3
112	G084014E28561N	RGI60-15.04497	84,014	28,561	1000	2018	Sabche Gl.	x
113	G084014E28561N	RGI60-15.04497	84,014	28,561	1000	2017	-	x
114	G290243E33492S	RGI60-17.13796	-69,757	-33,414	2018	2019	Tupungato Sur/Tunuyan	3
115	G328550E68813N	-	-30,440	68,370	2017	2020	No RGI ID, connected to GIS	-
116	G329866E68661N	-	-30,550	68,300	2022	3000	No RGI ID, connected to GIS	-

Rather calving instabilities than surges:

G059756E80623N	RGI60-09.00747	59,533	80,601	2017	2020	FranzJosef, calving outlet inst, Tyndall ice cap	9
G337380E70010N	RGI60-05.13471	-22,593	70,005	2020	3000	also G337346E70014N	9

Unclear cases suggested or found during the review/revision process (see also Fig. S2).
Not included in main surge list but likely surge-type events:

G081220E35458N	RGI60-13.37555	81,220	35,458	1000	3000	
G077377E41074N	RGI60-13.09540	77,380	41,070	2016	3000	
G077462E41051N	RGI60-13.09756	77,462	41,050	1000	2018	
G075211E36750N	RGI60-14.01548	75,211	36,750	1000	3000	
G075251E36717N	RGI60-14.01752	75,251	36,717	1000	3000	
G074697E36096N	RGI60-14.04473	74,697	36,096	1000	3000	
G219787E60289N	RGI60-01.13696	-140,550	59,900	2021	3000	Sewart/Malaspina Gl.
G219155E61116N	RGI60-01.17614	-141,140	61,020	2018	2020	
G331192E68888N	RGI60-05.13667	-28,070	68,600	2018	2020	

Table S2: Compared to the analysis of 2018–19 Sentinel-1 data contained in Leclercq and others (2021) our data for 2018–2019 contain 14 surges less that we considered here to be too uncertain to be listed as clear surges when analysing the entire 2017–22 time series

RGI60-15.04151
RGI60-01.23649
RGI60-01.16122
RGI60-01.20796
RGI60-01.20791
RGI60-01.20783
RGI60-01.20984
RGI60-01.20891
RGI60-01.26729
RGI60-01.03622
RGI60-17.06074
RGI60-05.10033
RGI60-05.04143
RGI60-05.13667

Table S3: Clearly changing backscatter signals are also found on a number of outlet glaciers of the Greenland ice sheet, but it has been not further investigated in this study if these signals indicate exceptional flow instabilities or rather usual interannual fluctuations of ice speed and crevassing.

Name	Lon	Lat
Tracy Gl.	-65.763	77.652
Farguhar Gl.	-66.208	77.737
Melville Gl.	-66.634	77.741
Sharp Gl.	-66.933	77.732
Heilprin Gl.	-65.609	77.524
Harald Moltke Bræ	-67.625	76.571
Granville Fjord	-69.531	76.994
Pulsilik Fjord	-66.768	76.341
Yngvar Nielsen Gl.	-64.181	76.385
Upernavik Isstrøm	-54.123	72.953
Salliarutsip Sermina	-52.436	72.152
Rink Isbræ	-51.536	71.780
Kangerlussuaq Fjord	-51.261	71.452
Sermeq Silarleq	-50.673	70.853
Narsap Sermina	-49.414	64.738
Eqalorutsit Kangillit Sermiat	-45.744	61.366

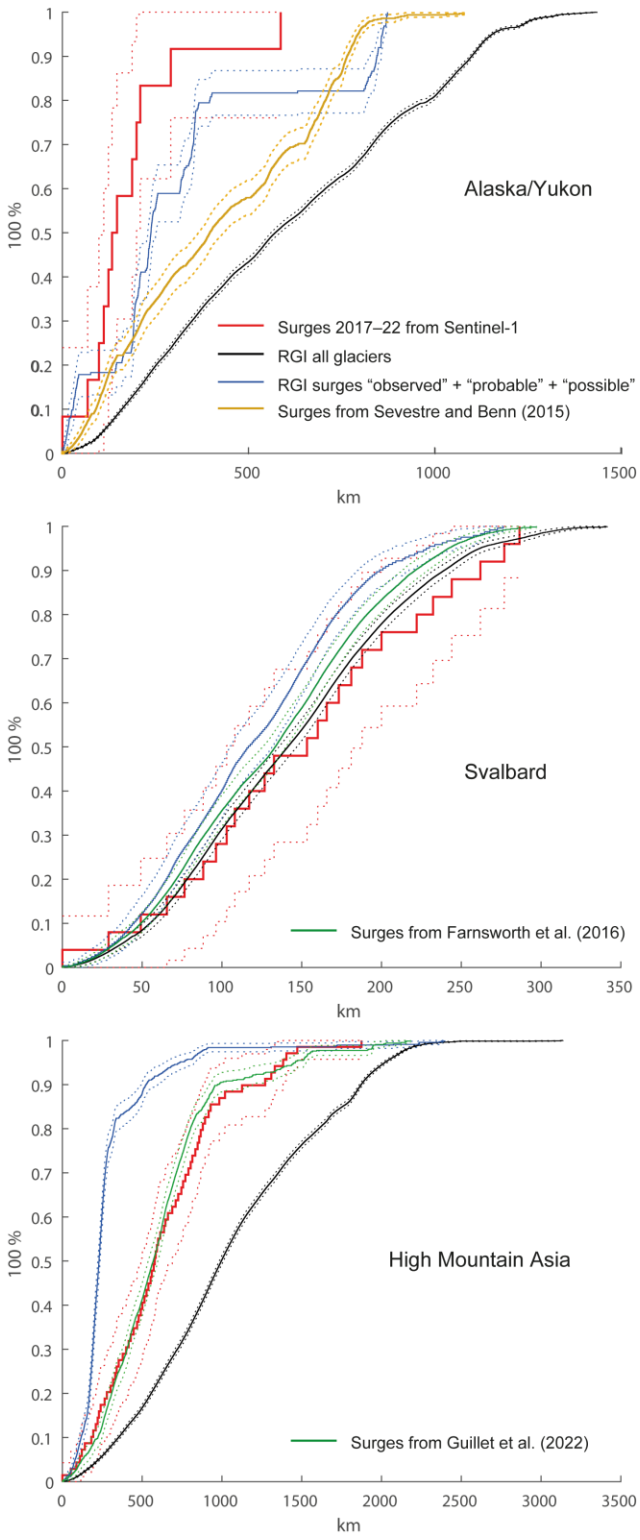
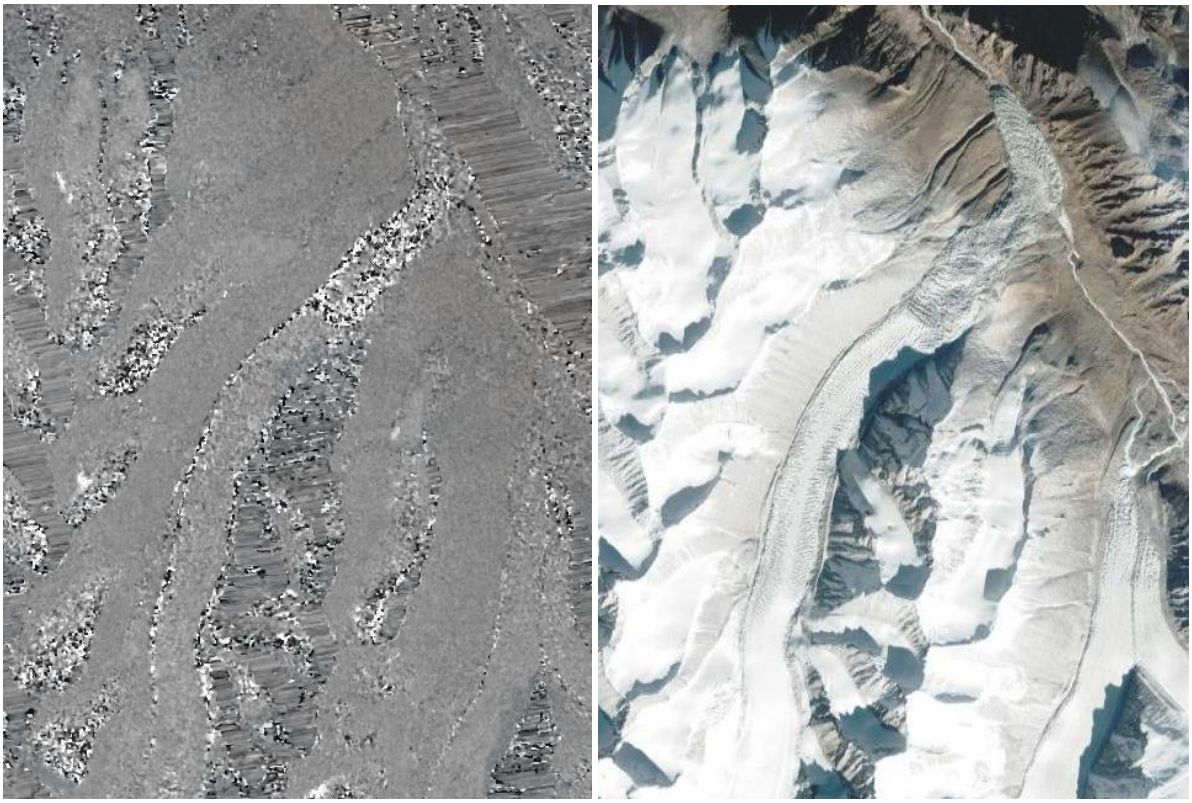
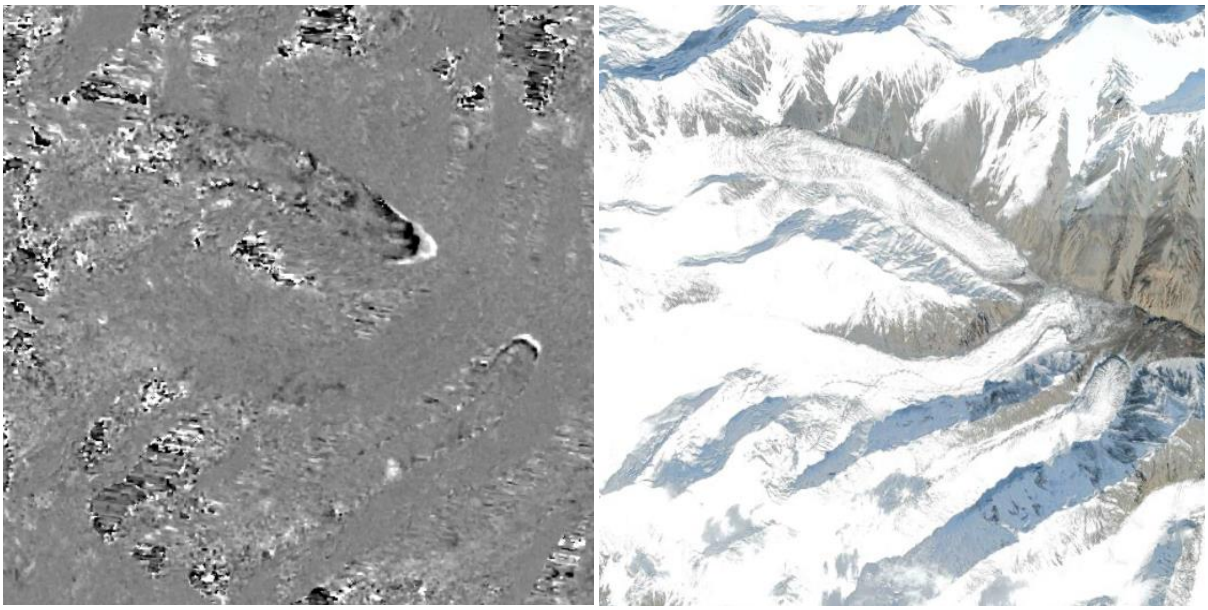


Fig. S1. Regional cumulative distribution functions of distances between glaciers of different classes. The dotted lines indicate the 95th percentiles.

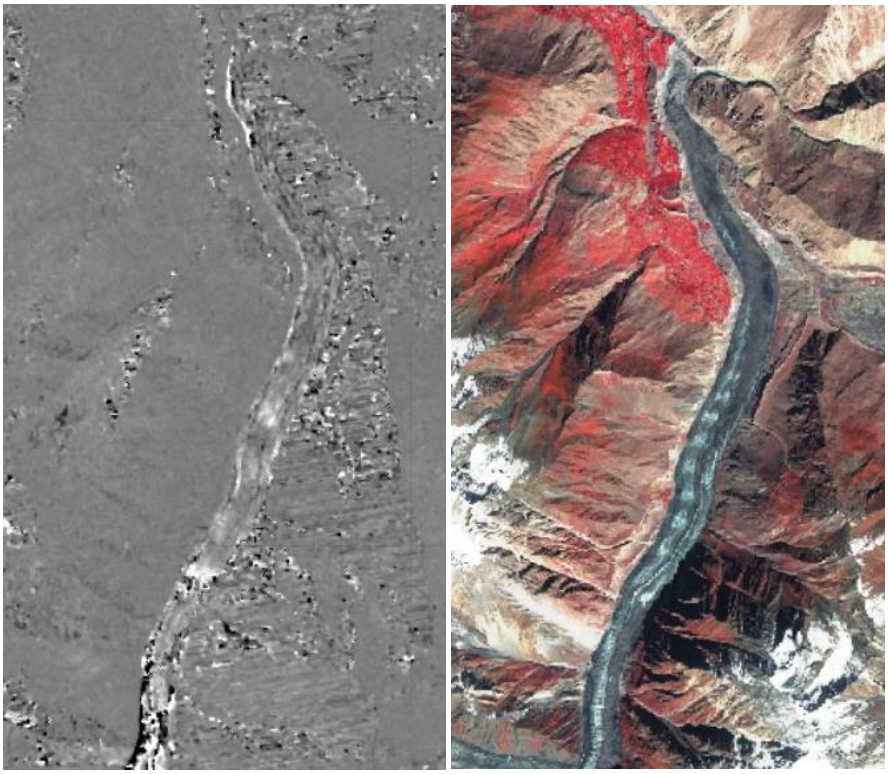
G081220E35458N. Satellite image to the right from 10 Jan 2020.



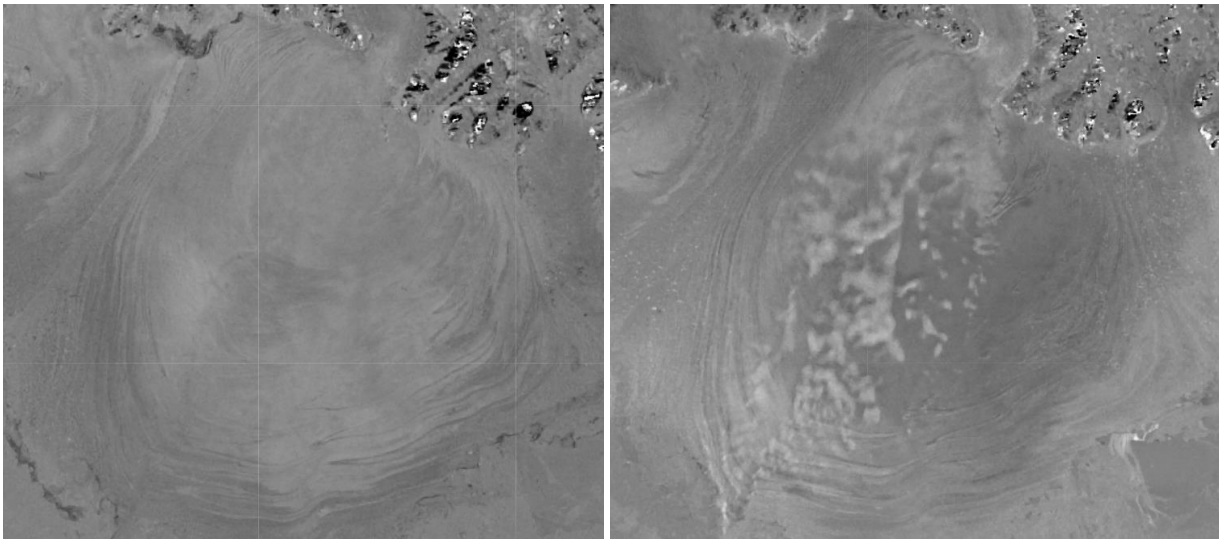
G075211E36750N and G075251E36717N. Satellite image to the right from 16 Oct 2017.



G074697E36096N. Satellite image to the right from 29 Sept 2022.



G219787E60289N (Malaspina):



Left: 2019-20 backscatter changes, right 2020-21 changes. Bright zones in 2020-21 agree well with new crevasse zones visible in optical images. See also Samsonov and others (2021).

Fig. S2. Backscatter changes of the unclear example cases listed as last group in Table S1. Optical images by Maxar/CNES/Airbus from GoogleEarth (nos. 1-2) and Sentinel-2 (no. 3).