Supplement of

Brief Communication: Updated GAMDAM Glacier Inventory over the High Mountain Asia

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Table S1. List of Landsat scenes used to delineate glacier outlines. attached ' TableS1_gamdam.xls'

Table S2. Summary of total glacier area in each region of the GGI18, GGI15 and RGI6.0.

	GGI18 (km^2)	GGI15 (km2)	RGI6.0 (km^2)	Difference (%) $\frac{(GGI18-GGI15)}{GGI15}$	Difference (%) $\frac{(GGI18-RGI6.0)}{RGI6.0}$
CentralAsia	50,519 ± 6,292	44,632 ± 6,695	49,302	13	2.5
SouthAsiaEast	15,895 ± 2,002	13,480 ± 2,022	14,734	18	7.9
SouthAsiaWest	33,034 ± 3,309	28,356 ± 4,253	33,568	16	-1.6
NorthAsia*	1,244 ± 188	1,114 ± 167	1,163	12	7.0
Total	100,693 ± 11,790	87,583 ± 13,137	98,767	15	2.0

*: Only Altay and Sayan

Table S3. Area comparison between the GGI18 limited to the NM18 domain and NM18 and between the GGI18 limited to the CGI2 domain and CGI2. Both overlapping areas and overlapping ratios are also listed.

**: This value includes glaciers of the first Chinese glacier inventory, where we have no glacier polygon in CGI2.

Name of inventory	GGI18 (NM18 domain)	NM18	GGI18 (CGI2 domain)	CGI2
Total area (km^2)	33,019±3,188	35,287±1,209	48,100±5,963	50563**
Overlapping area (km^2)	30,739		43,516	
Overlapping area ratio (%)	93 to total area of GGI18 limited at NM18 domain (= 33,019 km^2)	87 to total area of NM18 (= 35,287 km^2)	90 to total area of GGI18 limited at CGI2 domain (= 48,100 km^2)	86 to total area of CGI2 (= 50,563 km^2)

Table S4. List of Landsat scenes used to delineation tests. No. of scenes correspond to that of Fig. S4.

No.	Scene ID	Acquired date		
a	LT51400411995266BKT00	23	Sep	1995
b	LT51400411995282BKT00	9	Oct	1995
c	LT51400411998162BKT00	11	Jun	1998
d	LT51400411999117BKT00	27	Apr	1999
e	L71140041_04120001030	30	Oct	2000
f	LE71400412001290SGS00	17	Oct	2001
g	LE71400412001354SGS00	20	Dec	2001
h	LT51400412005149BKT00	29	May	2005
i	LT51400412009128KHC00	8	May	2009
j	LT51400412010163BKT01	12	Jun	2010

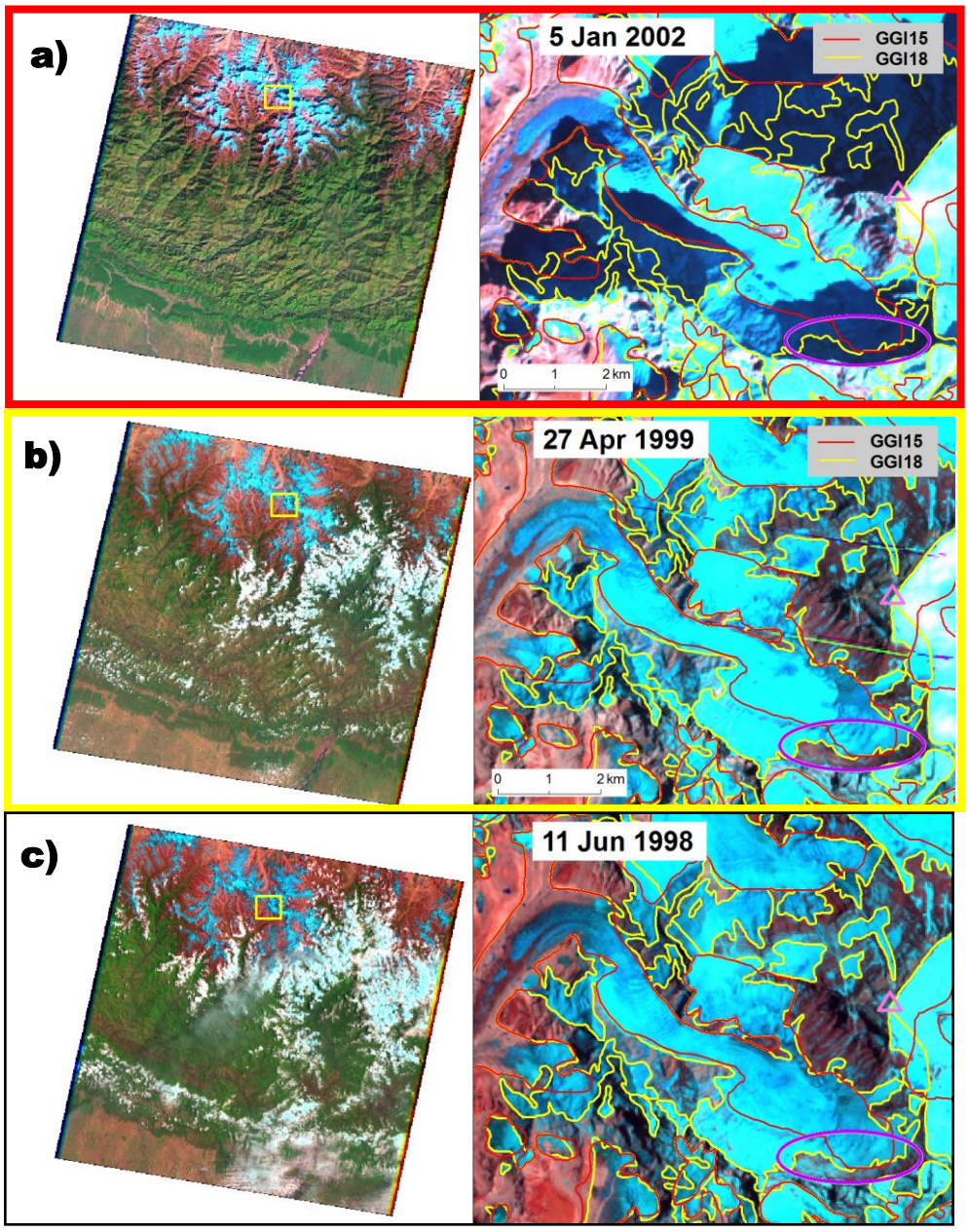

Figure S1: Example of selecting a Landsat scene for specific area. Left figures show the whole Landsat imagery with the location of the specific glacier (Khumbu Glacier) by yellow square. And right figures show accumulation area of the Khumb Glacier at 86°53'40.592"E 27°58'49.921"N (path140 row41 of WRS2) Date in the right figures indicate each acquisition date, and the peak of Mt. Everest (Qomolangma, Sagarmatha) are shown by a pink triangle. All images are false colour (bands 7, 4, and 2 as RGB) composite Landsat images. Glacier outlines are delineated using image taken in 2005 Jan 5 in the GGI15, but glacier area are shadowed and there are much seasonal snow a). In the process of revision, four images emerged as a candidate because they have less snow and no cloud at Khumbu Glacier b) and c). And image b) was selected due to clear outline at north-facing walls (purple ellipse) comparing to other images c).

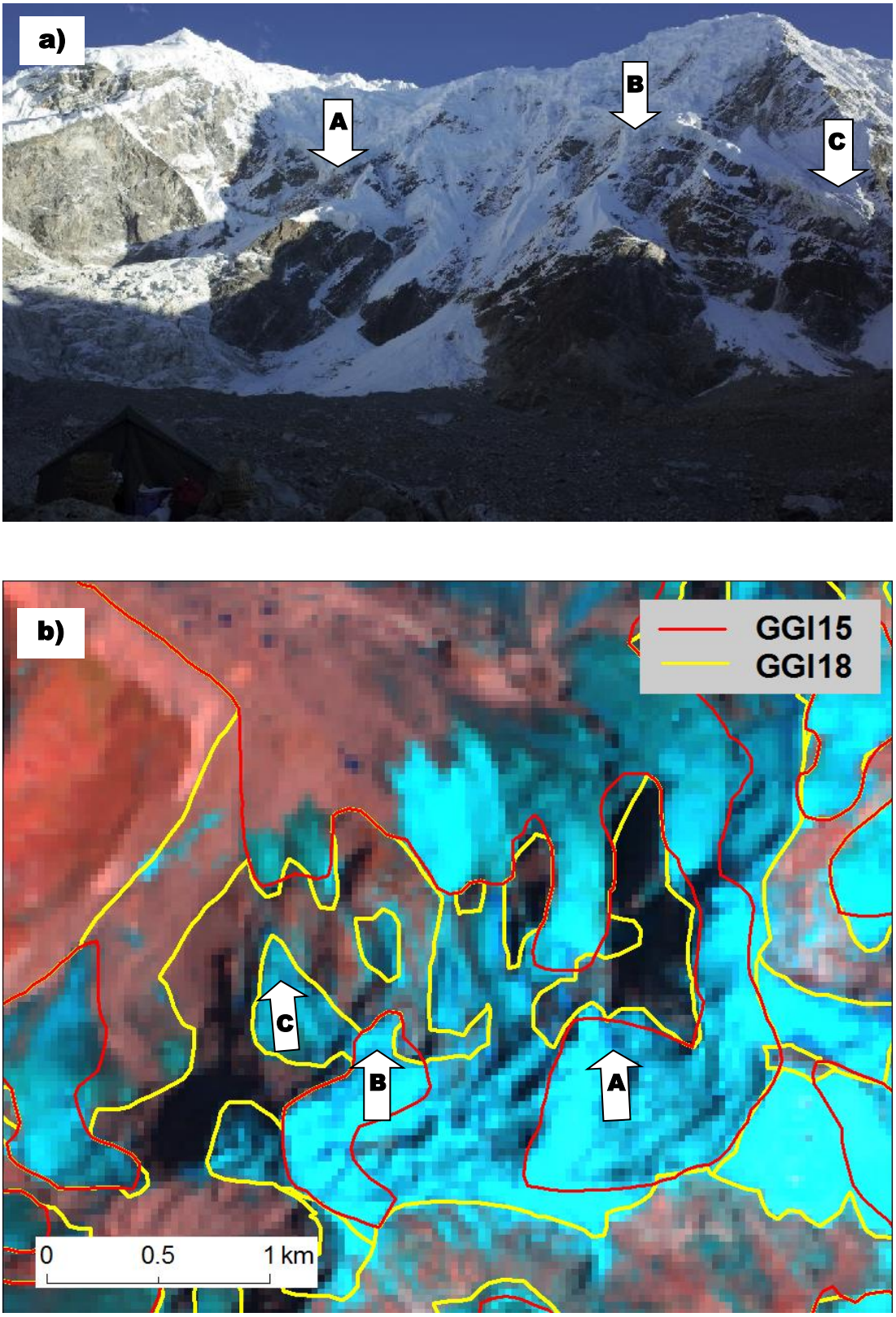

Figure S2: Glaciers at steep headwalls taken at the Trakarding Glacier (86°31'58.441"E 27°49'6.253"N path 140 row 41) in 2016 a), and the glacier outline b). Arrows from A to C indicate relatively thick hanging glaciers in a), each location correspond with those A to C in b). The background images of b) are false colour (bands 7, 4, and 2 as RGB) composite Landsat images taken on 27 Apr 1999.

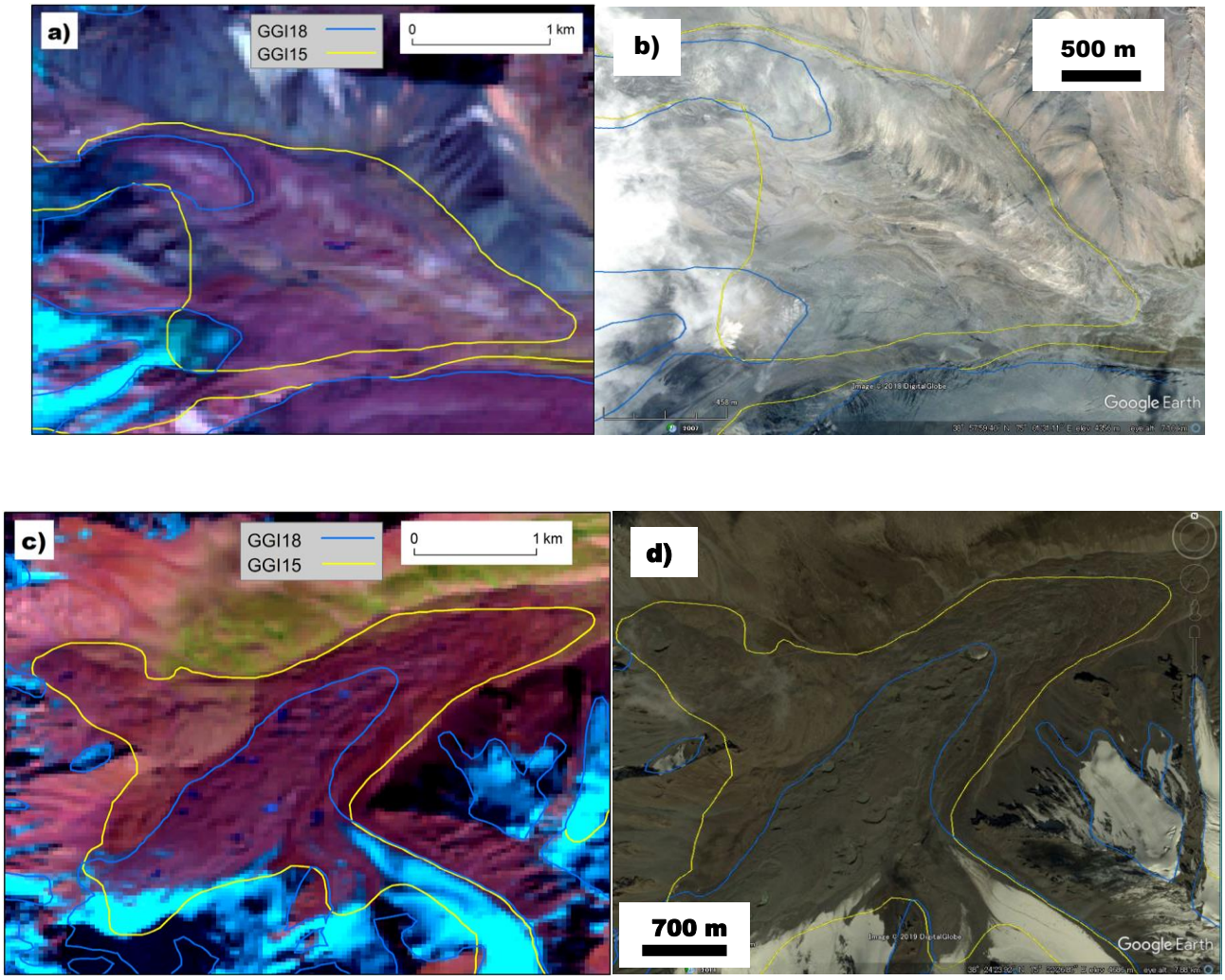

Figure S3: Example of excluded rock glacier-like geography in GGI18 at 75°1'55.261"E 38°57'22.842"N (path149 row33 of WRS2) a) and b), and at 75°23'9.322"E 38°23'47.306"N (path149 row33 of WRS2)c) and d). The background images are false colour (bands 7, 4, and 2 as RGB) composite Landsat images taken on 25 Sep 1999 a) c), Google Earth images on 4 July 2007 b), on 21 Aug 2011c), respectively.

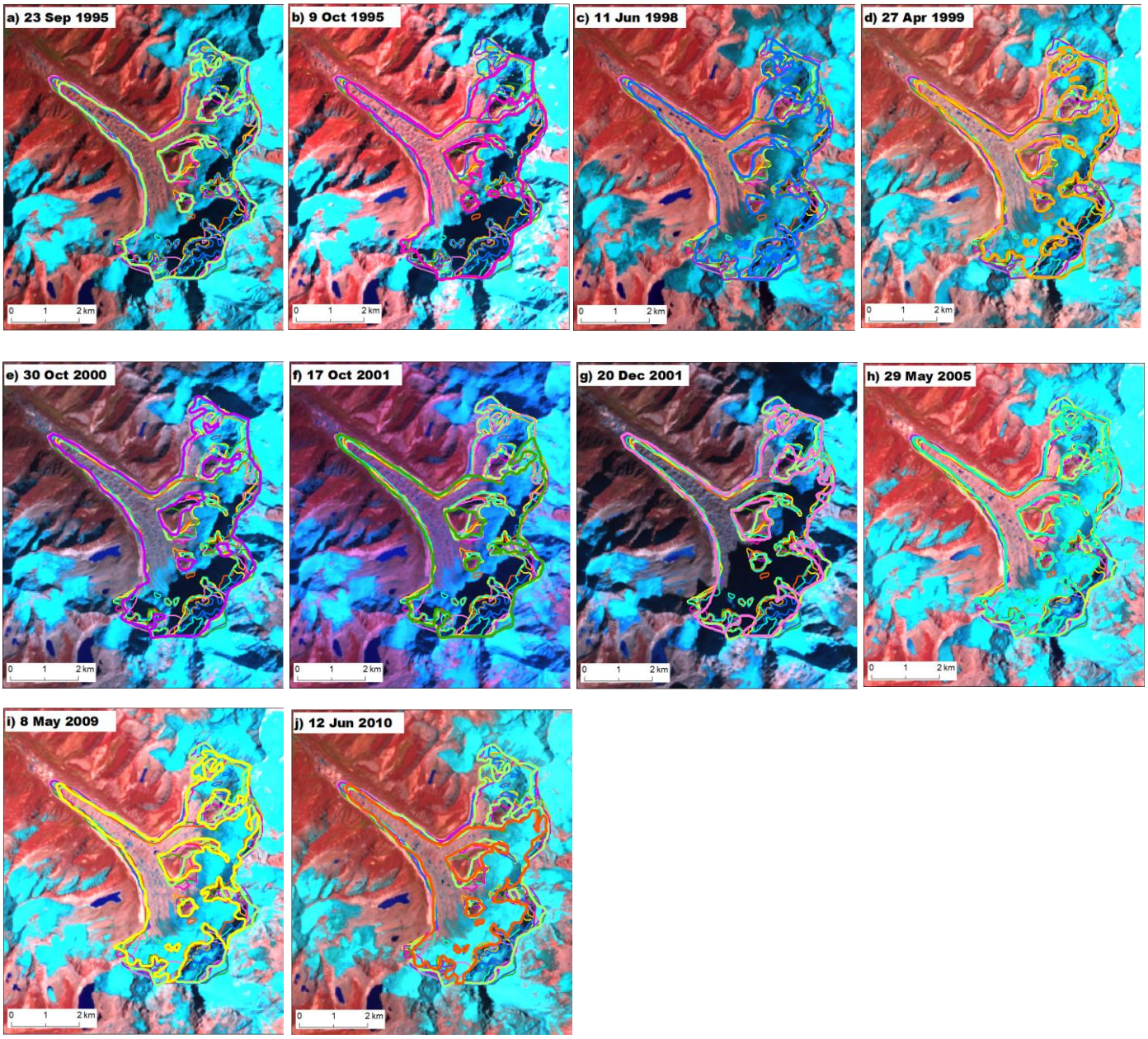

Figure S4: One example of delineation tests (86°31'52.046"E 28°5'7.04"N) to calculate normalised standard deviation of debris-covered glacier area (Fig. S5). Delineation test were carried out using 10 Landsat imageries at path140 row41 of WRS2, which information are listed in Table S4. One polygon were made for each imagery as shown by thick color lines. The backgrounds are false colour (bands 7, 4, and 2 as RGB) composite Landsat images. Each acquisition date were shown in each figure.

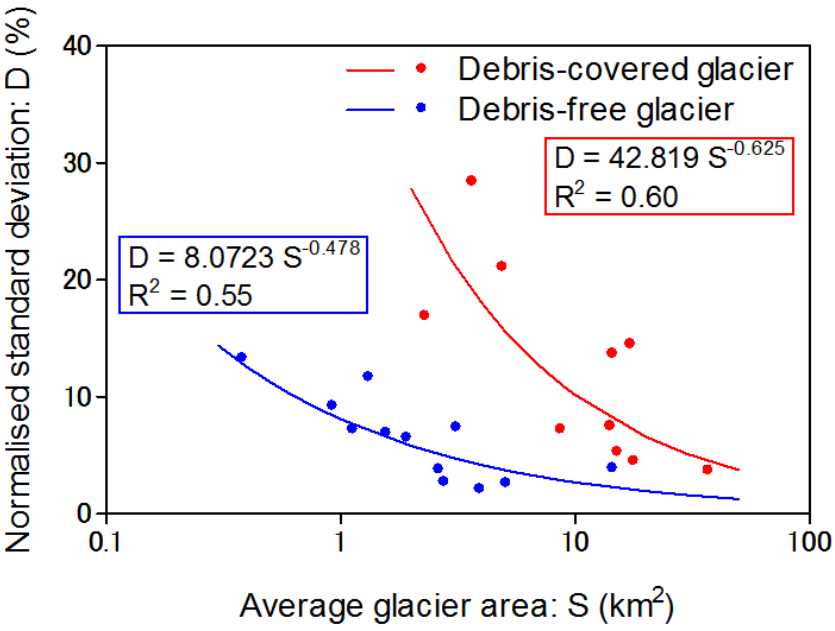

Figure S5: Normalised standard deviation of glacier area at each mean glacier area. Normalised standard deviation of glacier area are calculated standard deviation of glacier area based on delineations using 10 Landsat imageries divided by the mean glacier area for 10 debris-covered glaciers and for 12 debris-free glaciers.

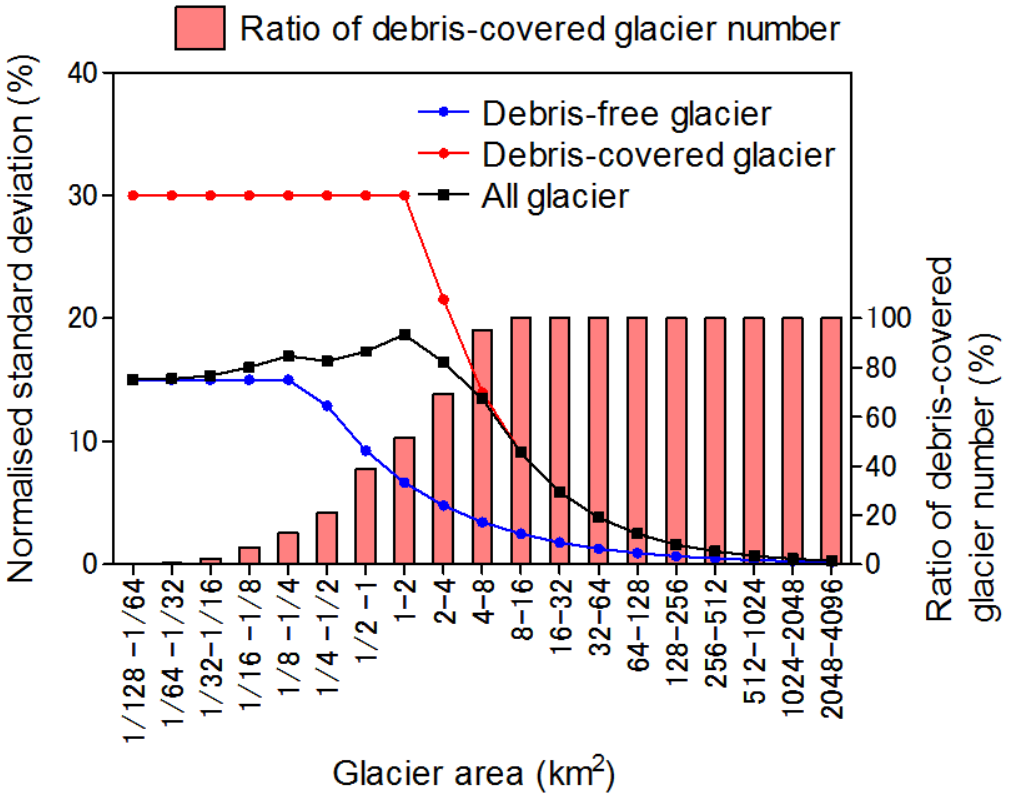

Figure S6: Normalised standard deviation (NSD) of glacier area and ratio of debris-covered glacier number at each glacier area class. NSD of debris-covered glacier area and debris-free glacier area are derived from the regression lines in Fig. S2 assuming that the NSDs are 30% for smaller (< 2 km^2) debris-covered glacier and 15% for smaller (< 0.25 km^2) debris-free glacier. NSD of all glaciers are calculated from number weighted average of NSDs of debris-covered glacier area and debris-free glacier area.

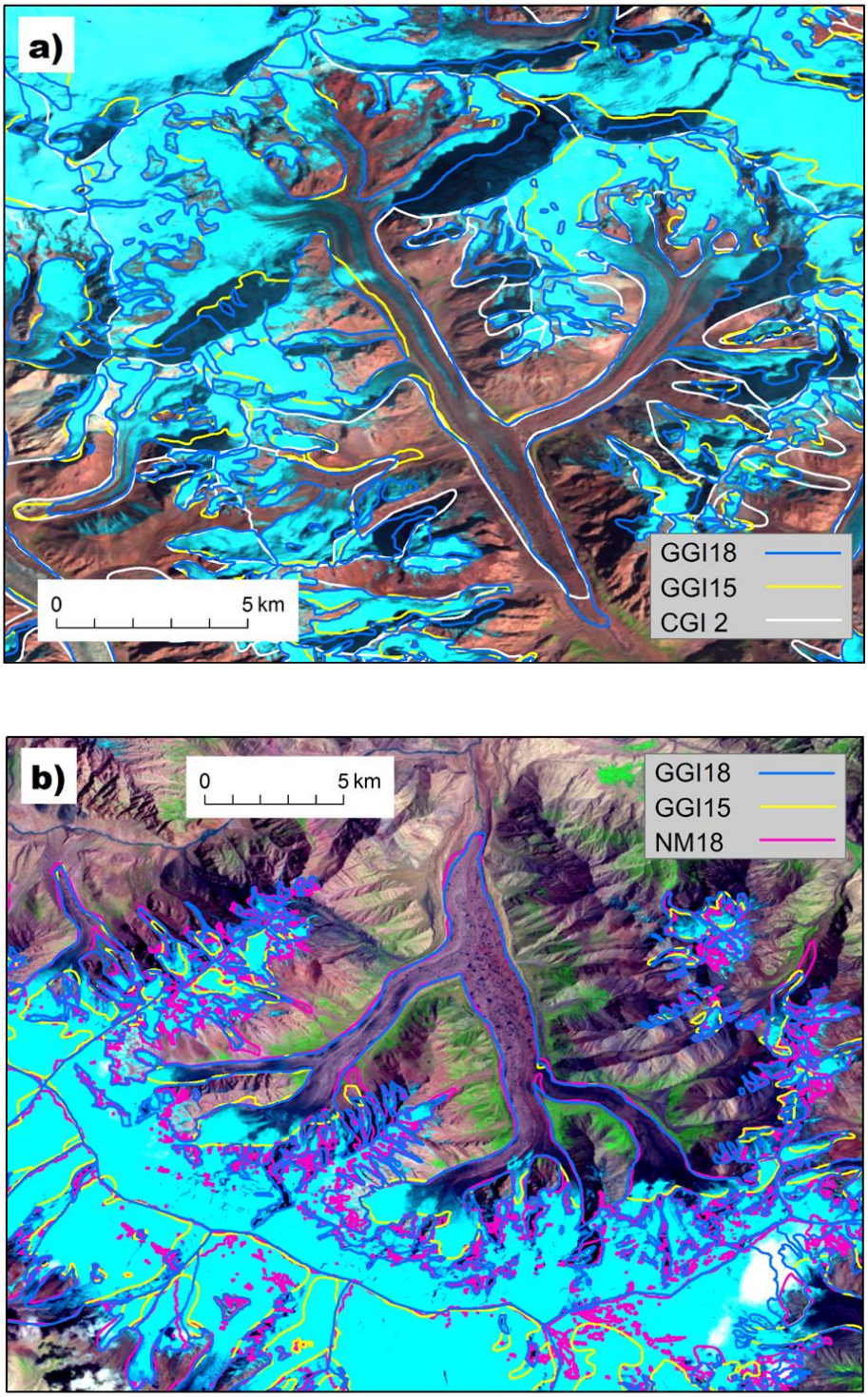

Figure S7: Comparison of the glacier outlines of each glacier inventory, GGI15, GGI18, and CGI2, at 80°21'36"E, 42°2'23"N (path147 row31 of WRS2) a). And comparison of GGI15, GGI18, and NM18, at 75°17'11"E, 38°39'54"N (path149 row33 of WRS2) b). The backgrounds are false colour (bands 7, 4, and 2 as RGB) composite Landsat images taken on 10 September 1996 (a), and 11 July 1994 (b), respectively.

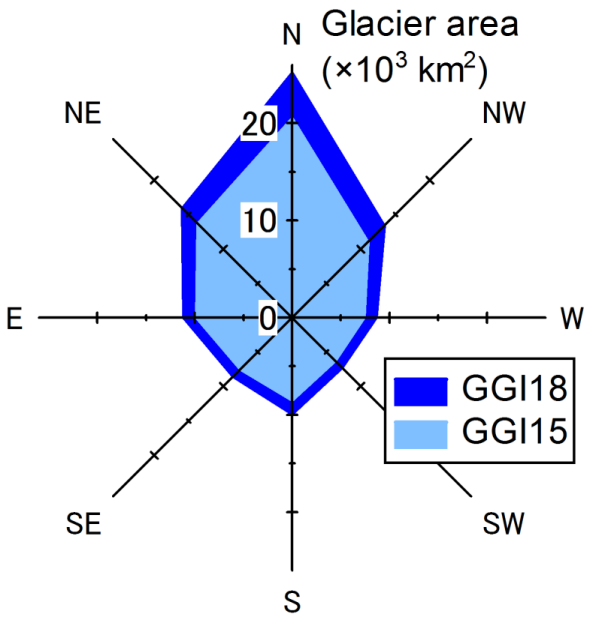

Figure S8: Glacier area distribution from different aspects with an interval of 45 degrees (eight azimuths). The area of aspect was calculated based on aspect of pixels in glacier polygons. Blue and light blue colours indicate the GGI18 and GGI15 for whole study regions, respectively.

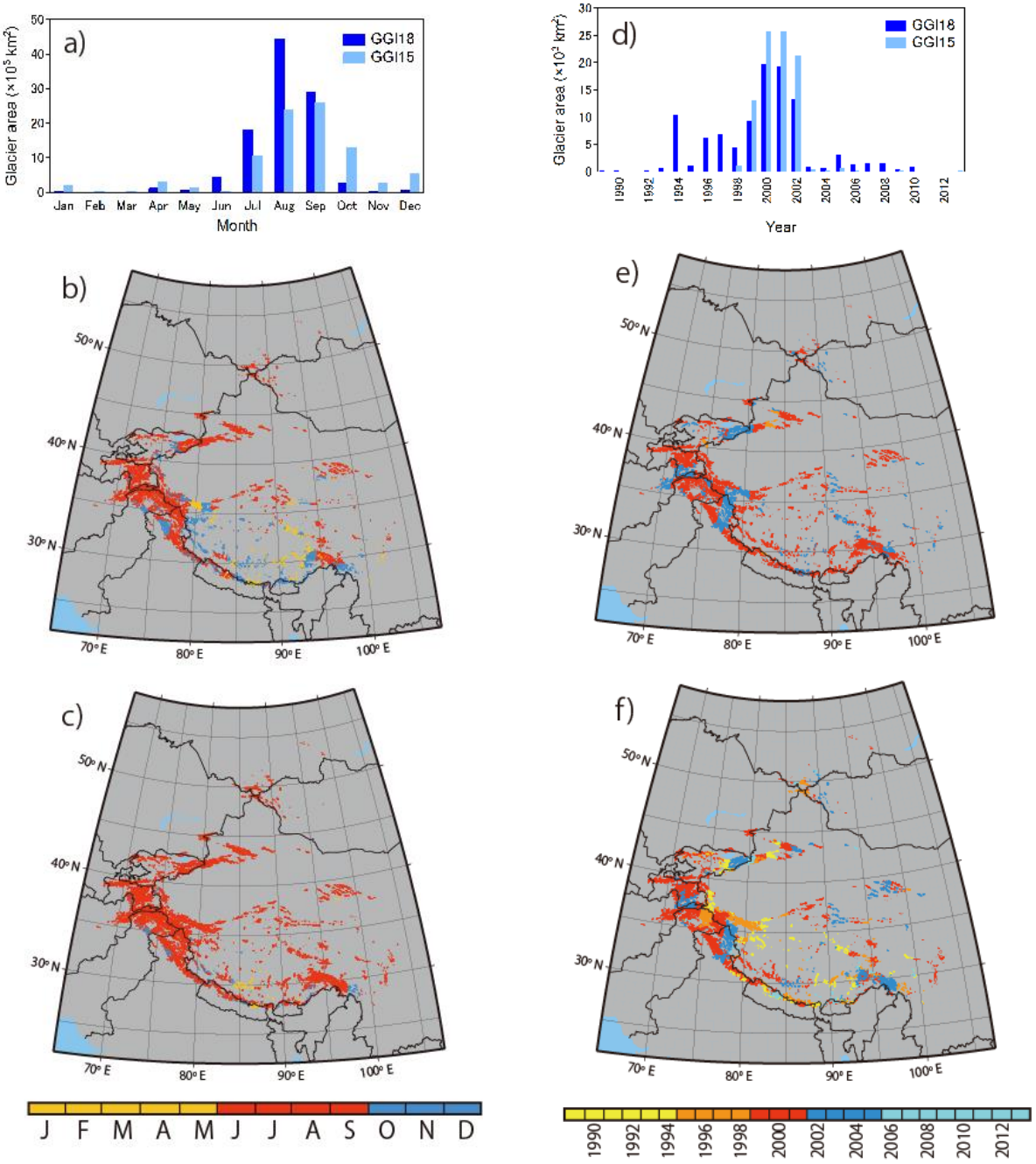

Figure S9: Frequency distribution of the acquisition month of the Landsat scenes used to delineate the glaciers in the GGI15 and GGI18 by glacierised area (a). Distribution of glacier area centre coloured by acquisition month in the GGI15 (b) and in the GGI18 (c). Frequency distribution of the acquisition year of the Landsat scenes used to delineate the glaciers in the GGI15 and GGI18 by glacierised area (d). Distribution of glacier area centre coloured by acquisition year in the GGI15 (e) and in the GGI18 (f).

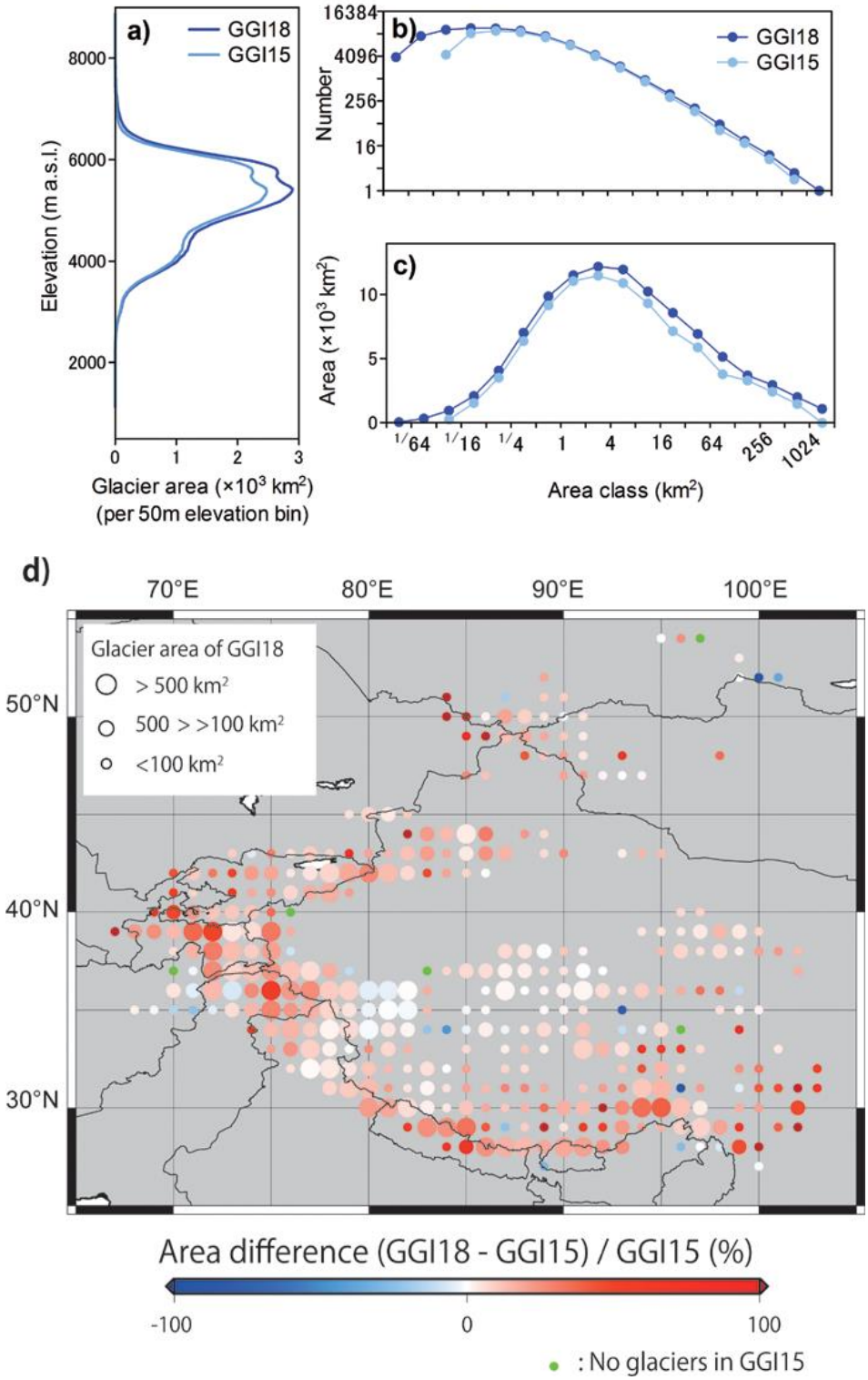

Figure S10: Comparison between the GGI15 and the GGI18. Each glacier hypsography a) at every 50-m elevation bin. Glacier number b) and total area c) at each area class. There is no data in the area class from 0.01 to 0.05 km^2 in the GGI15, because the minimum glacier area was set at 0.05 km^2. Glacier polygons were aggregated at each 1×1º grid based on center of each glacier polygon for each inventories for regional area difference between GGI15 and GGI18 d). The size of each circle indicates glacier area sum of GGI18 at each grid cell d).

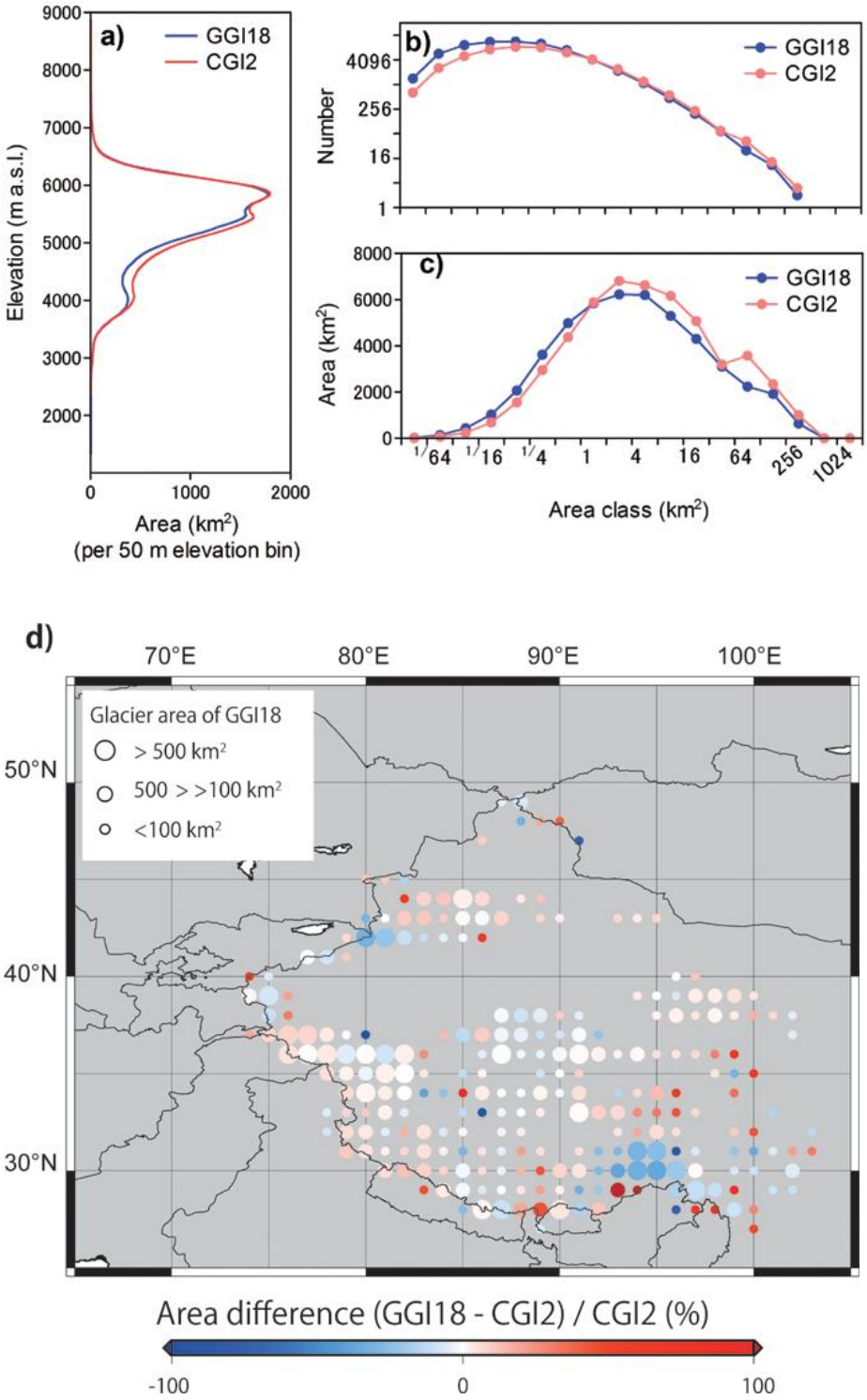

Figure S11: Comparison between the CGI2 and GGI18 limited to the CGI2 domain. Each glacier hypsography a) at every 50-m elevation bin. Glacier number b) and total area c) at each area class. Both inventories include only glaciers > 0.01 km^2 in area. Glacier polygons were aggregated at each 1×1º grid based on center of each glacier polygon for each inventories for regional area difference between CGI2 and GGI18 d). The size of each circle indicates glacier area sum of GGI18 at each grid cell d).

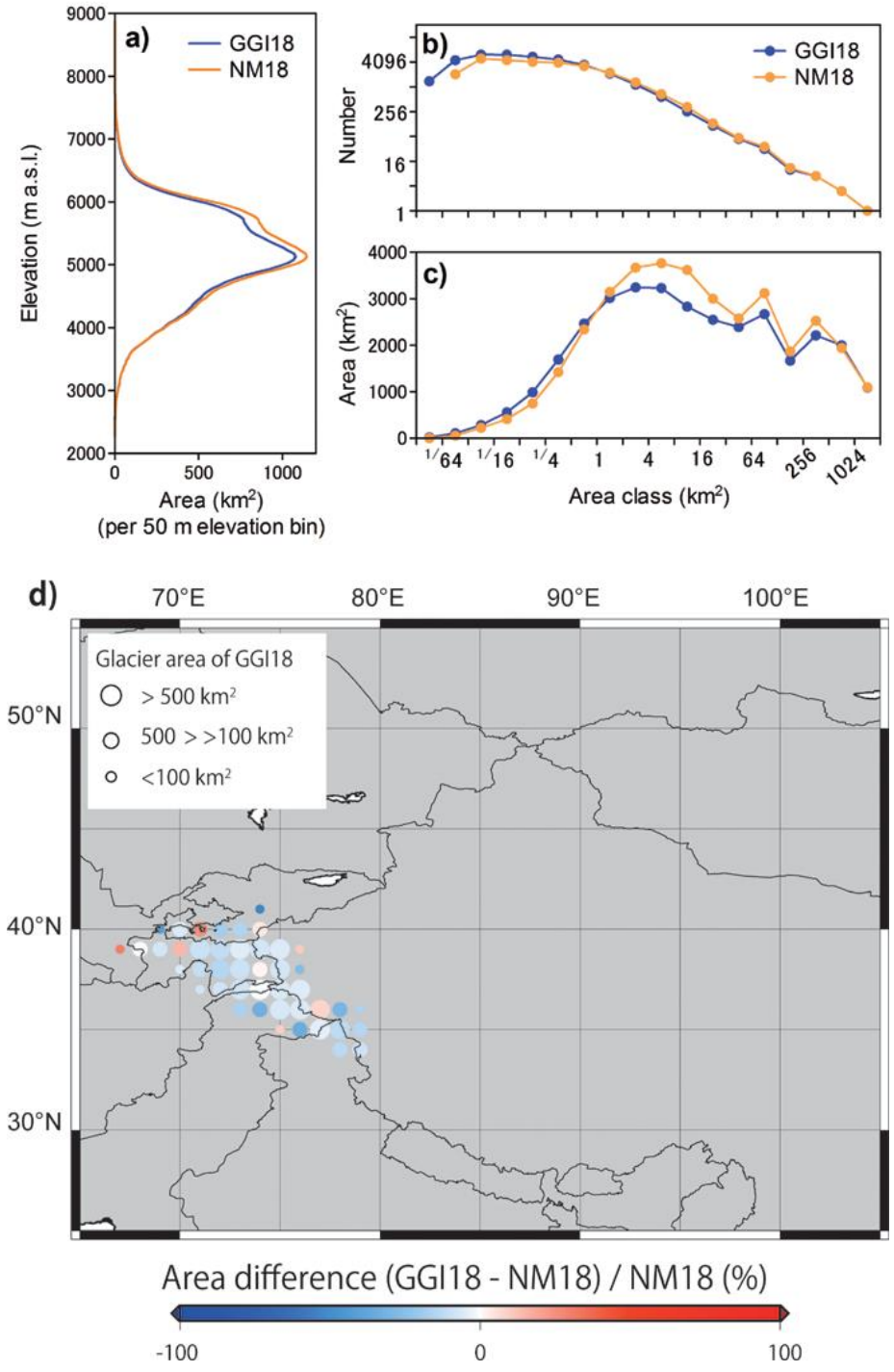

Figure S12: Comparison between the NM18 and GGI18 limited to the NM18 domain. Each glacier hypsography a) at every 50-m elevation bin. Glacier number b) and total area c) at each area class. There is no data in the area class from 0.01 to 0.02 km^2 in NM18 because only glaciers > 0.02 km^2 in the area were included. Glacier polygons were aggregated at each 1×1º grid based on center of each glacier polygon for each inventories for regional area difference between NM18 and GGI18 d). The size of each circle indicates glacier area sum of GGI18 at each grid cell d).

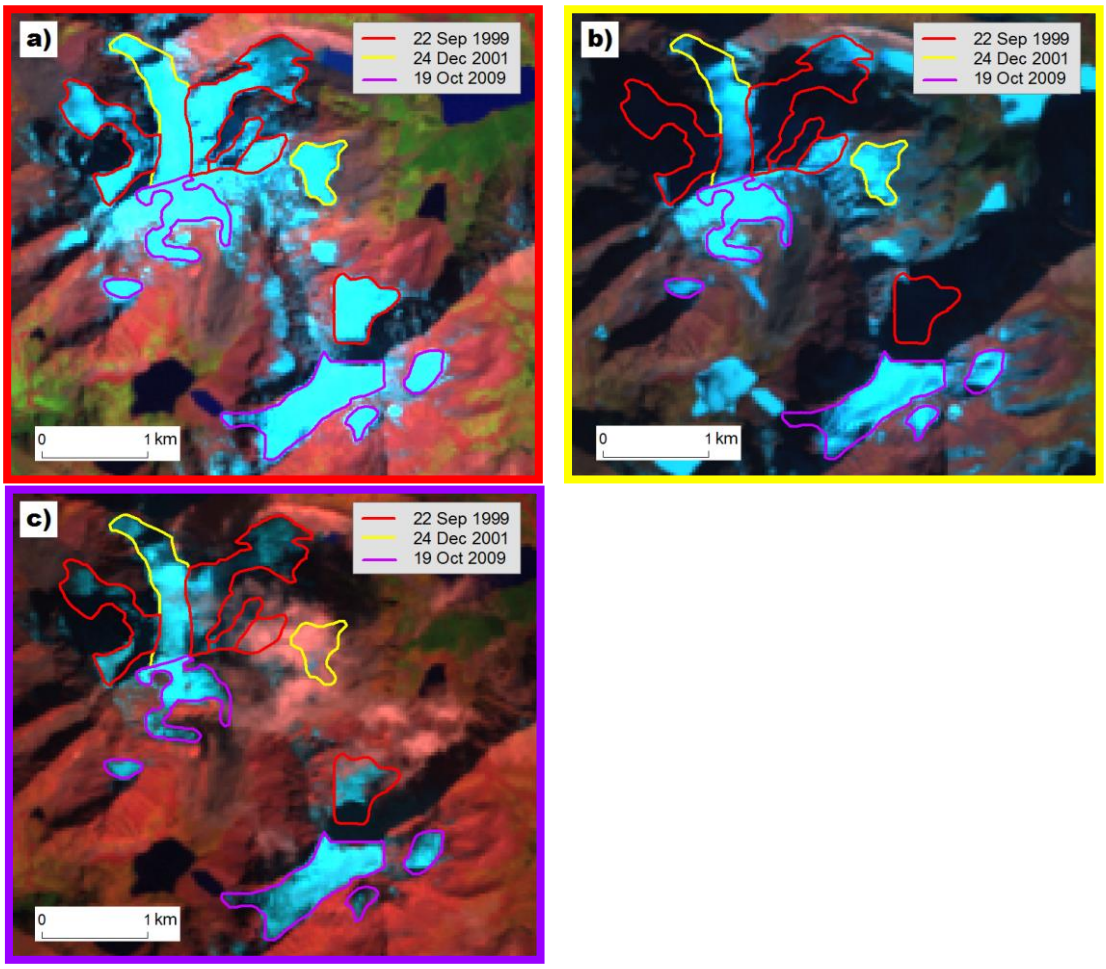

Figure S13: Example of delineation of glaciers using multiple Landsat scenes in GGI18 at 93°31'57.747"E 29°37'1.678"N (path136 row40 of WRS2). Each color of glacier outlines were digitized based on Landsat scenes framed by each corresponding colour. In this East Himalaya Mountain region, quality of glacier outlines are very low, since the cloud cover, seasonal snow and shadow hamper to delineate the glacier area. Then, I have to delineate glaciers through wisps of cloud and also cannot avoid using winter imageries. The background images are false colour (bands 7, 4, and 2 as RGB) composite Landsat images taken on 22 Sep 1999 a), 24 Dec 2001 b) and 19 Oct 2009 c), respectively.