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Post-LIA glacier changes along a latitudinal transect in the Central Italian Alps

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Correspondence to: F. Brardinoni (francesco.brardinoni@unimib.it)

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Supplementary Table S1. Glacier characteristics in the three sub-regions in year 2007.

Attribute		Sub-region		
		Livigno	**Disgrazia**	**Orobie**
GS (km^2)	Mean	0.07	0.20	0.04
	Median	0.02	0.04	0.02
	Range	0.003-0.37	0.002-2.31	0.002-0.22
ABR (n)	Low	-	3	-
	Moderate	4	5	-
	High	12	29	44
E_{min} (m a.s.l.)	Mean	2803	2788	2425
	Median	2765	2795	2451
	Range	(2707-3032)	(2229-3191)	(2030-2852)
ELA_0 $_{(AAR_0\ 0.67)}$ (m a.s.l.)	Mean	2864	2887	2473
	Median	2833	2890	2517
	Range	(2772-3047)	(2440-3210)	(2047-2879)
ELA_0 $_{(AAR_0\ 0.50)}$ (m a.s.l.)	Mean	2882	2914	2497
	Median	2862	2924	2527
	Range	(2775-3052)	(2447-3214)	(2054-2898)
E_{max} (m a.s.l.)	Mean	2973	3065	2604
	Median	2989	3083	2584
	Range	(2795-3178)	(2476-3634)	(2123-2796)
E_{ri} (m a.s.l.)	Median	2974	3109	2730
S (°)	Mean	27.8	28.7	30.0
	Median	29.2	27.1	29.1
	Range	(19.6-33.0)	(18.1-45.0)	(18.8-42.2)
CSR ($W\ m^2$)	Mean	176	210	149
	Median	172	213	145
	Range	(152-218)	(121-258)	(94-221)
MAP ($mm\ a^{-1}$)	Mean	1070	1295	1680
	Median	1065	1301	1682
	Range	(790-1200)	(1210-1370)	(1620-1770)

Area changes stratified in size classes

Data stratification into size classes reveals that most of the Disgrazia glaciers at the LIA maximum used to belong to the 0.1-to-0.5 km^2 class and that most of the total glacierized surface in this sub-region fell within the 2-to-5 and 5-to-10 km^2 classes (Table S 2). Interestingly, we record a progressive reduction both in area and number of glaciers in all sizes except the ≤ 0.1 km^2 class, which increases in number due to glacier fragmentation from 6 (total area = 0.4 km^2) (LIA) to 28 (total area = 1 km^2) (2003), and then declines slightly to 26 (total area = 0.6 km^2) (2007) due to glacier extinction.

In the Orobie sub-region, after the disaggregation of the Trobio glacier, the largest one (1.1 km^2) at the LIA apex, and the reduction of the Scais glacier (0.6 km^2), only the 2 low-magnitude classes are present. By 1954 we observe a sharp decrease of glacier count and area in the 0.1-to-0.5 km^2, which translates into an increase of smaller glaciers ($\leq$ 0.1 km^2) both in terms of number and area. Area contraction continues across the 1954-2007 period but glacier distribution in the 2 classes remains substantially unchanged.

At the LIA maximum the Livigno Mountains host the Mine glacier, a relatively larger ice body (1.5 km^2). By 1954, its disaggregation had generated 7 distinct glaciers. As a consequence of glacier fragmentation and progressive contraction, similarly to what observed in the Orobie mountains, by 2007 the distribution of glaciers across sizes displays the survival of the 2 smallest classes only. The main difference, in comparison to the Orobie cluster, is the presence of glaciers in the 0.5-to-1 km^2 class up until 1990, and the higher abundance of 0.1-to-0.5 km^2 ice bodies compared to the $\leq$ 0.1 km^2 category in every time interval.

Supplementary Table S2. Glacier count and area from 1860 to 2007 stratified in size classes.

Size Classes	1860		1954		1990		2003		2007	
Km^2	Count	Area	Count	Area	Count	Area	Count	Area	Count	Area
		km^2		km^2		km^2		km^2		km^2
Livigno										
<0.1	5	0.2	13	0.4	16	0.5	18	0.4	13	0.3
0.1-0.5	6	1.3	6	1.1	5	1.2	3	0.9	3	0.8
0.5-1	2	1.4	2	1.0	1	0.6	-	-	-	-
1.0-2.0	2	2.5	-	-	-	-	-	-	-	-
Total	15	5.4 ±0.53	21	2.5 ±0.20	22	2.3 ±0.07	21	1.3 ±0.03	16	1.1 ±0.02
Disgrazia										
<0.1	6	0.4	17	0.8	21	0.9	28	1.0	26	0.6
0.1-0.5	12	3.0	13	2.8	12	2.7	7	1.6	7	1.4
0.5-1	3	2.2	3	2.4	2	1.5	2	1.3	2	1.1
1.0-2.0	3	3.7	1	1.1	1	1.1	-	-	1	1.9
2.0-5.0	2	5.6	2	5.3	2	5.7	2	4.6	1	2.3
5.0-10.0	1	7.0	-	-	-	-	-	-	-	-
Total	27	22.0 ±1.28	36	12.4 ±0.59	38	11.9 ±0.22	39	8.4 ±0.10	37	7.3 ±0.09
Orobie										
<0.1	25	1.1	41	1.4	41	1.4	42	1.0	39	0.9
0.1-0.5	18	3.9	8	1.8	8	1.7	6	1.0	5	0.9
0.5-1	1	0.6	-	-	-	-	-	-	-	-
1.0-2.0	1	1.1	-	-	-	-	-	-	-	-
Total	45	6.7 ±0.93	49	3.2 ±0.31	49	3.1 ±0.12	48	2.0 ±0.06	44	1.8 ±0.05

Area change with glacier attributes – correlation matrix

Supplementary Table S3. Correlation matrix for 10 variables in Livigno sub-region. Correlation coefficients ≥ 0.4 are typed in bold.

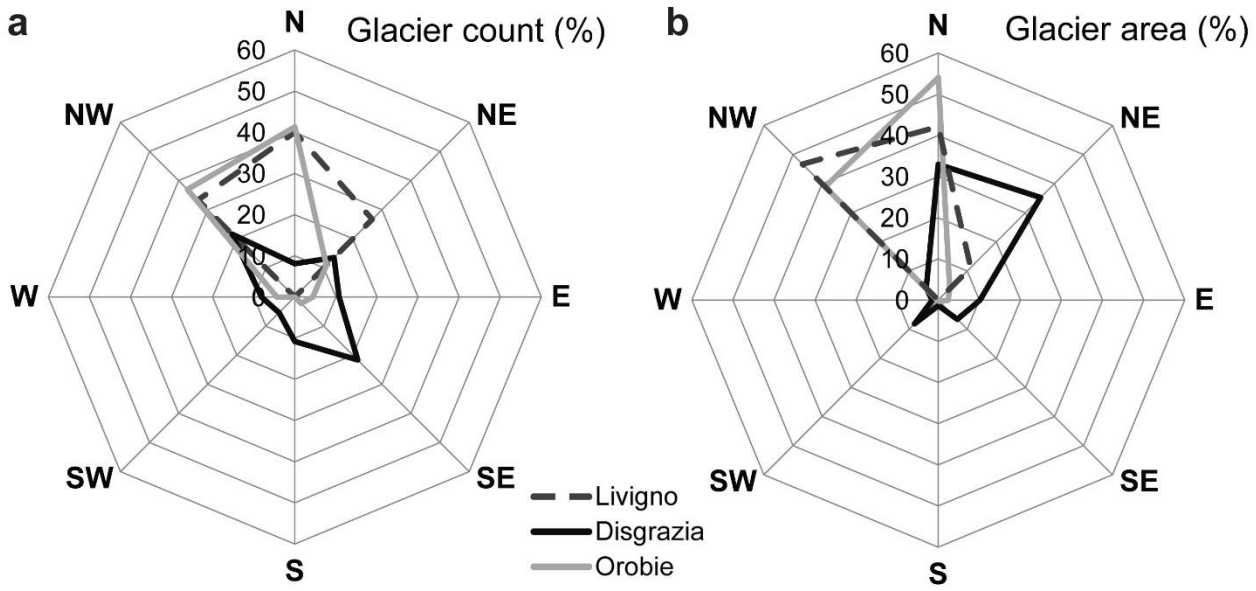
Livigno	**AC (%)**	GS	MA	S	E_{min}	E_{max}	ΔE	MAP	E_{rc}	CSR
AC (%)	1.00									
GS	**0.43**	1.00								
MA	-0.22	-0.31	1.00							
S	-0.38	-0.34	0.33	1.00						
E_{min}	**-0.46**	**-0.74**	0.37	**0.42**	1.00					
E_{max}	**0.72**	**0.67**	0.02	**-0.53**	**-0.54**	1.00				
ΔE	**0.65**	**0.81**	-0.23	-0.55	**-0.91**	**0.84**	1.00			
MAP	-0.20	-0.03	0.05	-0.24	0.20	-0.19	-0.23	1.00		
E_{ri}	**0.77**	**0.65**	0.12	-0.37	**-0.44**	**0.87**	**0.70**	-0.02	1.00	
CSR	**0.43**	0.36	-0.09	**-0.88**	-0.26	**0.77**	**0.57**	0.23	**0.56**	1.00

Supplementary Table S4. Correlation matrix for 10 variables in Disgrazia sub-region. Correlation coefficients ≥ 0.4 are typed in bold.

Disgrazia	**AC (%)**	GS	MA	S	E_{min}	E_{max}	ΔE	MAP	E_{rc}	CSR
AC (%)	1.00									
GS	**0.42**	1.00								
MA	0.01	-0.13	1.00							
S	-0.14	-0.12	-0.08	1.00						
E_{min}	-0.28	**-0.74**	**0.53**	0.17	1.00					
E_{max}	**0.45**	**0.63**	**0.51**	0.00	-0.18	1.00				
ΔE	**0.47**	**0.89**	-0.06	-0.12	**-0.81**	**0.73**	1.00			
MAP	-0.13	0.12	0.21	**0.50**	0.07	0.30	0.13	1.00		
E_{ri}	0.35	0.19	**0.73**	0.15	0.26	**0.85**	0.33	0.29	1.00	
CSR	0.11	-0.07	**0.84**	-0.32	**0.41**	**0.52**	0.00	0.05	**0.71**	1.00

Supplementary Table S5. Correlation matrix in Orobie sub-region. Correlation coefficients ≥ 0.4 are marked in bold type.

Orobie	**AC (%)**	GS	MA	S	E_{min}	E_{max}	ΔE	MAP	E_{rc}	CSR
AC (%)	1.00									
GS	-0.06	1.00								
MA	-0.15	-0.04	1.00							
S	0.00	-0.26	-0.13	1.00						
E_{min}	**-0.40**	-0.32	0.30	0.05	1.00					
E_{max}	-0.20	**0.48**	0.03	0.03	0.24	1.00				
ΔE	0.20	**0.64**	-0.24	-0.02	**-0.68**	**0.54**	1.00			
MAP	0.25	-0.03	0.33	0.23	-0.05	-0.12	-0.05	1.00		
E_{ri}	-0.03	0.31	-0.06	0.01	0.19	**0.75**	**0.40**	-0.01	1.00	
CSR	-0.35	0.29	0.58	**-0.51**	0.34	0.21	-0.12	-0.09	0.08	1.00



Supplementary Figure S1. Spider-web charts detailing the relative glacier abundance in number (a) and area (b) across slope aspects in the three sub-regions.