



DIPARTIMENTO DI SCIENZE DELLA TERRA
UNIVERSITÀ DI PISA

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Glacial reduction in the Gran Paradiso Massif (Western Italian Alps): multitemporal dynamic inventory since the Little Ice Age

Salvatore M.C.^{1,2}, Gennaro S.¹, Alderighi L.¹, Cerrato R.¹, Baroni C.^{1,2}

⁽¹⁾ Department of Earth Sciences, University of Pisa, Italy.

⁽²⁾ Geosciences and Earth Resources-Research Council of Italy (IGG-CNR), Pisa, Italy.





Alpine glaciers are sensitive key markers of climate variations and are among the most important natural proxies to study *climate change*



Main goals:
multitemporal qualitative and quantitative analysis of glacier variations



Photointerpretation and multitemporal analysis on a multitemporal dataset
combined with
geomorphological and glacial-geological field surveys

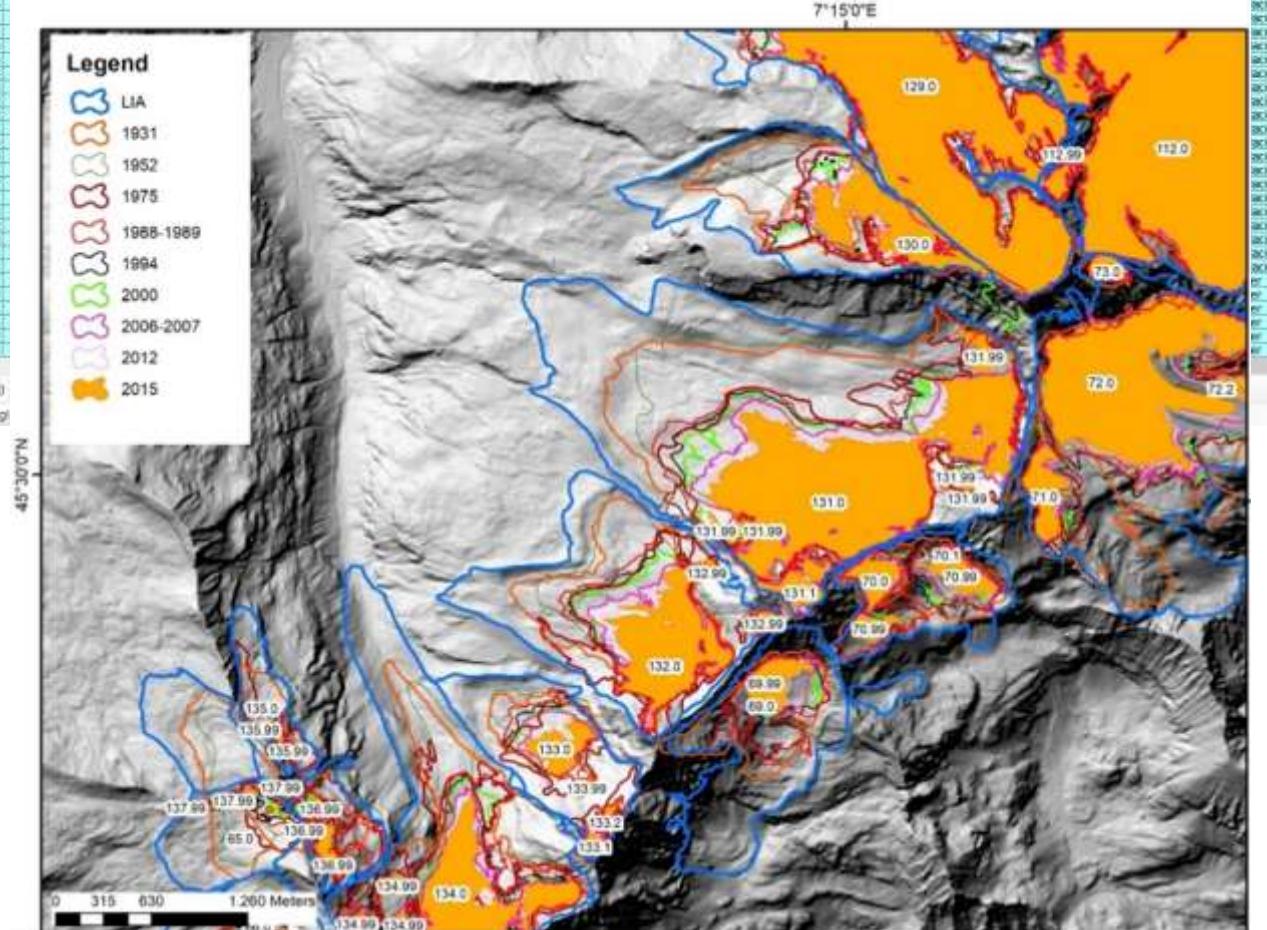


stereoscopic aerial photographs,
orthophotos, Lidar data,
historical maps, terrestrial
historic photographs, drawings,
front variation measurements

We built a **georeferenced dynamic multi-temporal glaciological inventory** of the Gran Paradiso Massif glaciers providing detailed snapshots of the state of the glaciers from the LIA to 2015.

following WGMS
guidelines
(WGMS, 1989,
2008; Paul et al.,
2009, 2010;
Salvatore et al.,
2015)

X_COORD	Y_COORD	CODICE	GL_NAME	PART	SECTOR	SECT_SUB	SUPERGROUP	GROUP	Primary Cl	Fon
7.153629	45.016783	142.99	Ghiacciaio della Valtellina	I	Western Alps	B North-Western Alps	7.I. Alpi Graie - Alpi	A Catena Gran Sassiere - Tsentri	I	Gallia
7.446204	45.060666	99.99	Ghiacciaio di Eaux Rouges	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	4	Senje - Chardonney
7.440373	45.052109	99.99	Ghiacciaio di Eaux Rouges	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	4	Senje - Chardonney
7.439505	45.051905	56.99	Ghiacciaio di Eaux Rouges	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	4	Senje - Chardonney
7.056528	45.520781	150.0	Ghiacciaio di Traversiere Centrale	I	Western Alps	B North-Western Alps	7.II. Alpi Graie - Alpi	A Catena Grande Sassiere	Ts	Grande Sassiere - Tsarneina
7.056875	45.521103	151.0	Ghiacciaio di Traversiere Nord	I	Western Alps	B North-Western Alps	7.II. Alpi Graie - Alpi	A Catena Grande Sassiere	Ts	Grande Sassiere - Tsarneina
7.077611	45.476762	186.2	Ghiacciaio del Fondo (Occidentale) Est	I	Western Alps	B North-Western Alps	7.II. Alpi Graie - Alpi	A Catena Grande Sassiere	Ts	Grande Sassiere - Tsarneina
7.058228	45.476764	148.0	Ghiacciaio di Gobba	I	Western Alps	B North-Western Alps	7.II. Alpi Graie - Alpi	A Catena Grande Sassiere	Ts	Grande Sassiere - Tsarneina
7.051446	45.480484	147.0	Ghiacciaio Sochies-Tsanterina (o Contolina)	I	Western Alps	B North-Western Alps	7.II. Alpi Graie - Alpi	A Catena Grande Sassiere	Ts	Grande Sassiere - Tsarneina
7.051005	45.523486	151.1	Ghiacciaio di Traversiere Nord Orientale	I	Western Alps	B North-Western Alps	7.II. Alpi Graie - Alpi	A Catena Grande Sassiere	Ts	Grande Sassiere - Tsarneina
7.057385	45.523386	162.0	Ghiacciaio del Truc Blanc	I	Western Alps	B North-Western Alps	7.II. Alpi Graie - Alpi	A Catena Grande Sassiere	Ts	Grande Sassiere - Tsarneina
7.000306	45.058794	155.0	Ghiacciaio dei Tormenti	I	Western Alps	B North-Western Alps	7.II. Alpi Graie - Alpi	A Catena Grande Sassiere	Ts	Grande Sassiere - Tsarneina
7.081881	45.477003	146.1	Ghiacciaio del Fondo (Occidentale) Centrale	I	Western Alps	B North-Western Alps	7.II. Alpi Graie - Alpi	A Catena Grande Sassiere	Ts	Grande Sassiere - Tsarneina
7.073031	45.477006	146.0	Ghiacciaio del Fondo (Occidentale)	I	Western Alps	B North-Western Alps	7.II. Alpi Graie - Alpi	A Catena Grande Sassiere	Ts	Grande Sassiere - Tsarneina
7.279747	45.592013	125.0	Ghiacciaio dell'Inferno Sud	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	3	Grotta Gran Serra
7.151073	45.524204	138.0	Ghiacciaio d'Avultura	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena Gran Sassiere - Tsentri	I	Gallia
7.413377	45.550439	101.1	Ghiacciaio dell'Arda Settentrionale	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	4	Senje - Chardonney
7.411883	45.547171	101.0	Ghiacciaio dell'Arda	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	4	Senje - Chardonney
7.38146	45.525058	103.0	Ghiacciaio di Valsesia	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	4	Senje - Chardonney
7.359337	45.515174	106.0	Ghiacciaio della Valtellina	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	2	Gran Paradiso - Roccaviva
7.354363	45.444153	107.6	Ghiacciaio di Patti Inferiore	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	2	Gran Paradiso - Roccaviva
7.359799	45.440105	108.0	Ghiacciaio di Pente Bianche (o di Patti Superiore)	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	2	Gran Paradiso - Roccaviva
7.355833	45.425284	119.0	Ghiacciaio di Monev	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	2	Gran Paradiso - Roccaviva
7.349229	45.309998	109.0	Ghiacciaio del Coupé di Monev	I	Western Alps	B North-Western Alps	7.IV. Alpi Graie - Alpi	A Catena del Gran Paradiso	2	Gran Paradiso - Roccaviva



In the framework of the [NextData Project](#), we provided an organic georeferenced dynamic multi-temporal front variation database of the Gran Paradiso Massif glaciers monitored by the Italian Glaciological Committee or under its coordination

103 Ghiacciaio di Valeille

Operatori: Valerio BERTOGLIO
e Piero BORRE - Controllo del 2016.09.24

Ancora potente la vasta zona con crepacciatura trasversale in zona centro-frontale. Davanti alla fronte è presente un deposito di limo glaciale misto a detriti di varia pezzatura. Il ghiacciaio risulta parzialmente coperto da detrito nel settore destro frontale.

Quota min. fronte: 2690 m

Segnale	Direzione della misura	DISTANZE (in m)		
		attuale	precedente	variazione
LP1 (cf)	190°	73	47	-26

DOI: 10.4202/GFDQ.2016.5928

RELAZIONI DELLA CAMPAGNA GLACIOLOGICA 2015

REPORT OF THE GLACIOLOGICAL SURVEY 2015

a cura di (editori) CARLO BARONI, ALDINO BONDESAN & GIOVANNI MORTARA

Click on the Italian Glaciological Committee banner to go to the website of the Annual Glaciological Surveys!



GL_NAME	CODE_SUBCODE	CODE	CODE_GL_NAME	WGMS_CODE	WGMS_NAME	WGMS_ID	PART	SECTOR	SECT_SUB	SUPERGROUP	GROUP	LATITUDE	LONGITUDE	MEAN_OR	Year	FRONT_VARIATION	CUMULATIVE_FRONT_VARIATION	QUALITA_TIVE_VARIATION	SURVEY_DATE	SURVEY_D_PATFOR_M_METH	REFERENCE_DATE	FO
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512019	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1925	20	20		19259999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1927	-8	12		19279999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1928	-5	7		19289999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1929				19299999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1930	-15	-8		19309999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1931	-7	-15		19319999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1932	-6	-21		19329999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1933	-10,5	-31,5		19339999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1934	-6	-37,5		19349999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1935	-7	-44,5		19359999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1936	1	-43,5		19369999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1937	-3	-46,5		19379999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1938	-10	-56,5		19389999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1939	-2	-58,5		19399999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1940	-2,5	-61		19409999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1941	-1	-62		19419999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1942				19429999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1943				19439999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1944				19449999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1950	-50	-112		19509999							
Ghiacciaio del Coupe di Mont 109.0	109	109	IT4L01512015 COUPE DE	1271	I Western B North-Western	7.IV	Alpi Gra A Catena del Gran I 2 Gran Pa	45,531	7,34922871	NW	1951	-12	-124		19519999							

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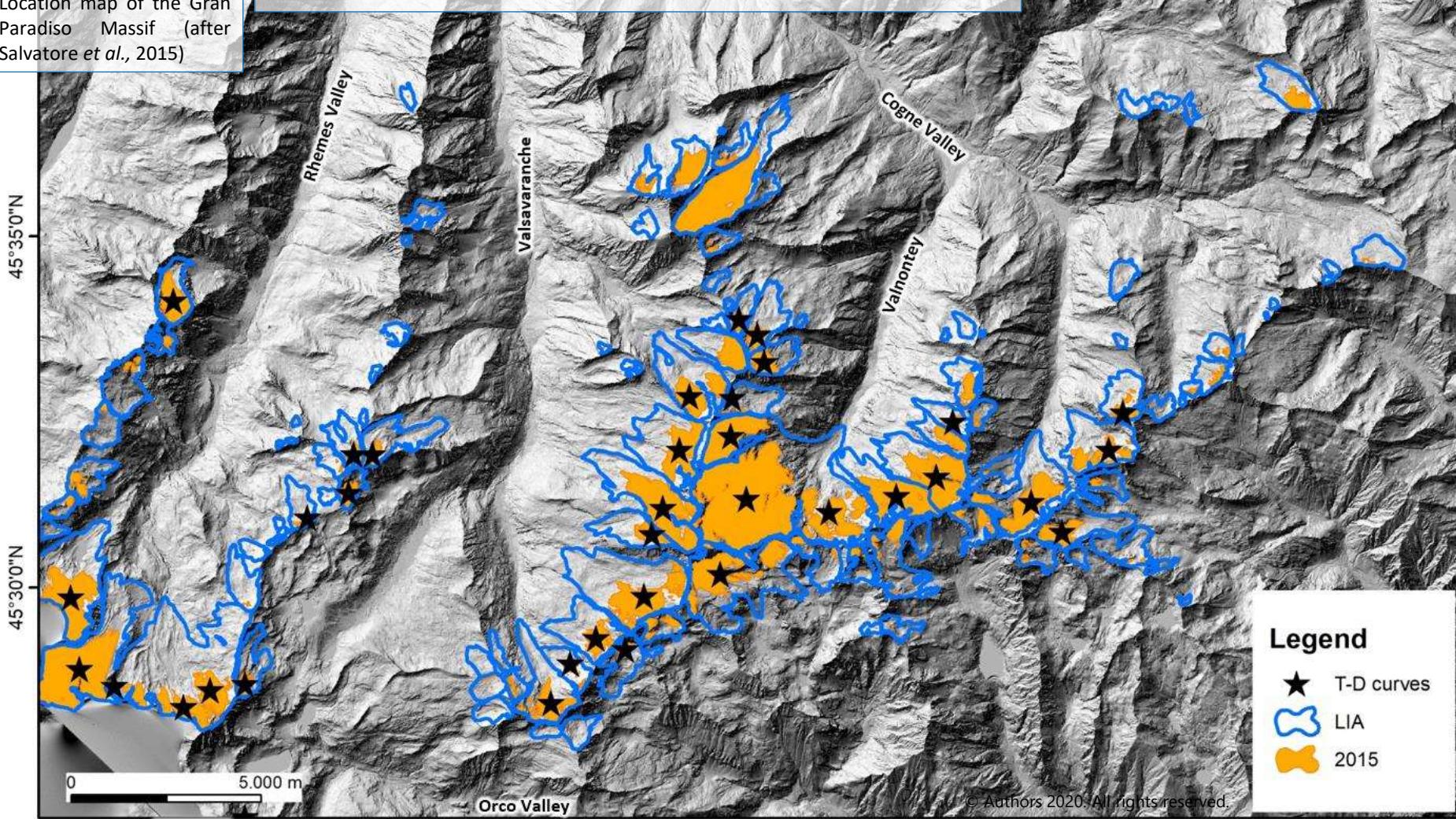
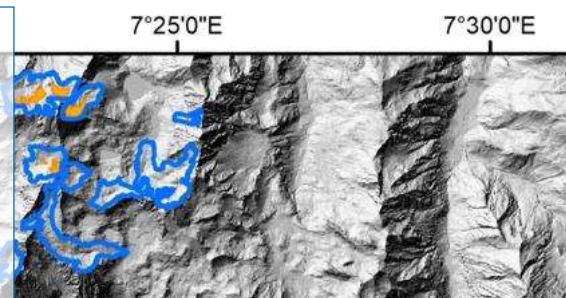
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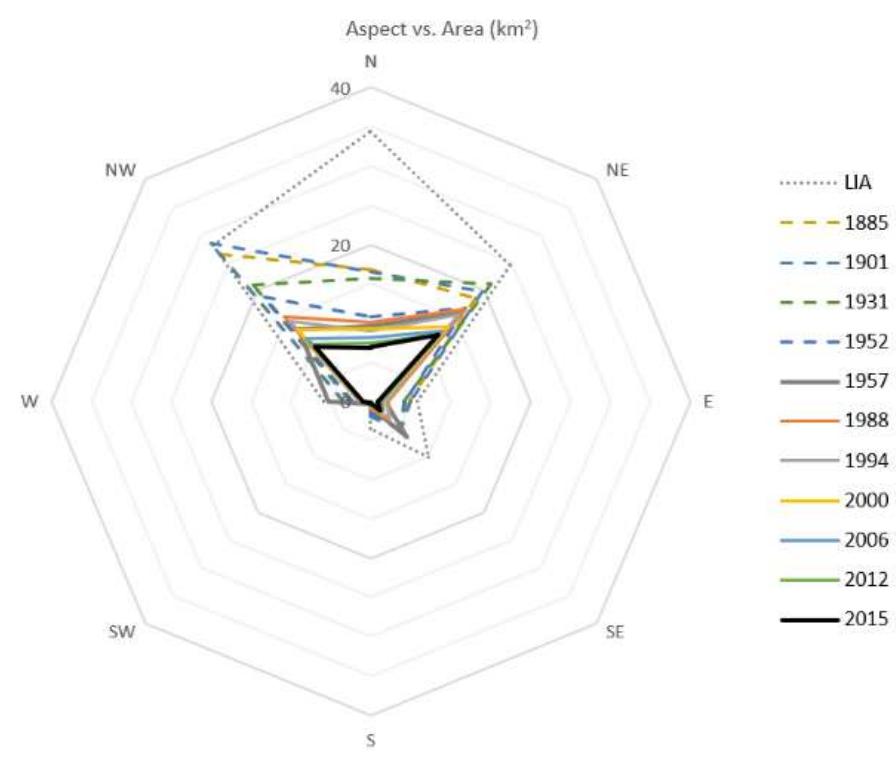


Location map of the Gran Paradiso Massif (after Salvatore et al., 2015)

Between LIA and 2015 Gran Paradiso glaciers lost about 70 % of their area. We assist to an important shrinkage of frontal margin as well as a strong reduction at the highest elevation.

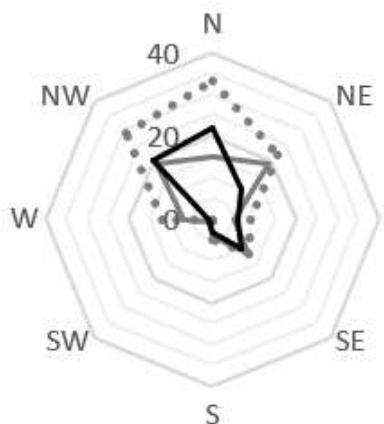
Here below, black stars indicate validated Time-Distance curves of frontal variations.



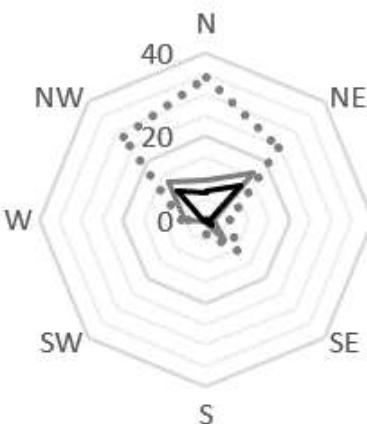


Glaciers distribution is strictly related to the orographic setting of the studied area as most of the Gran Paradiso glaciers face toward the Northern sectors.

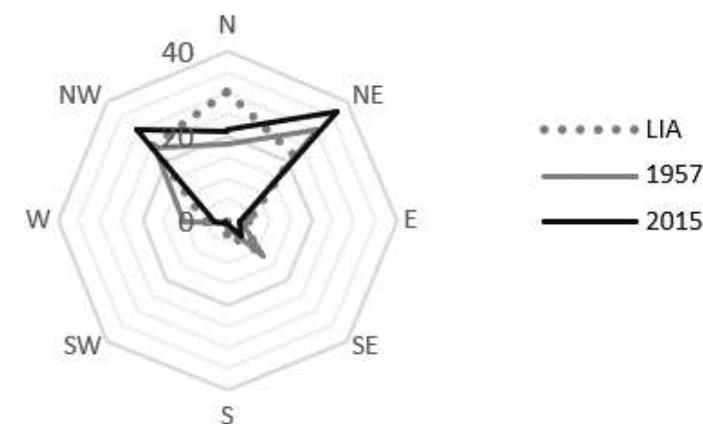
a) Aspect vs. Number of Glacial bodies



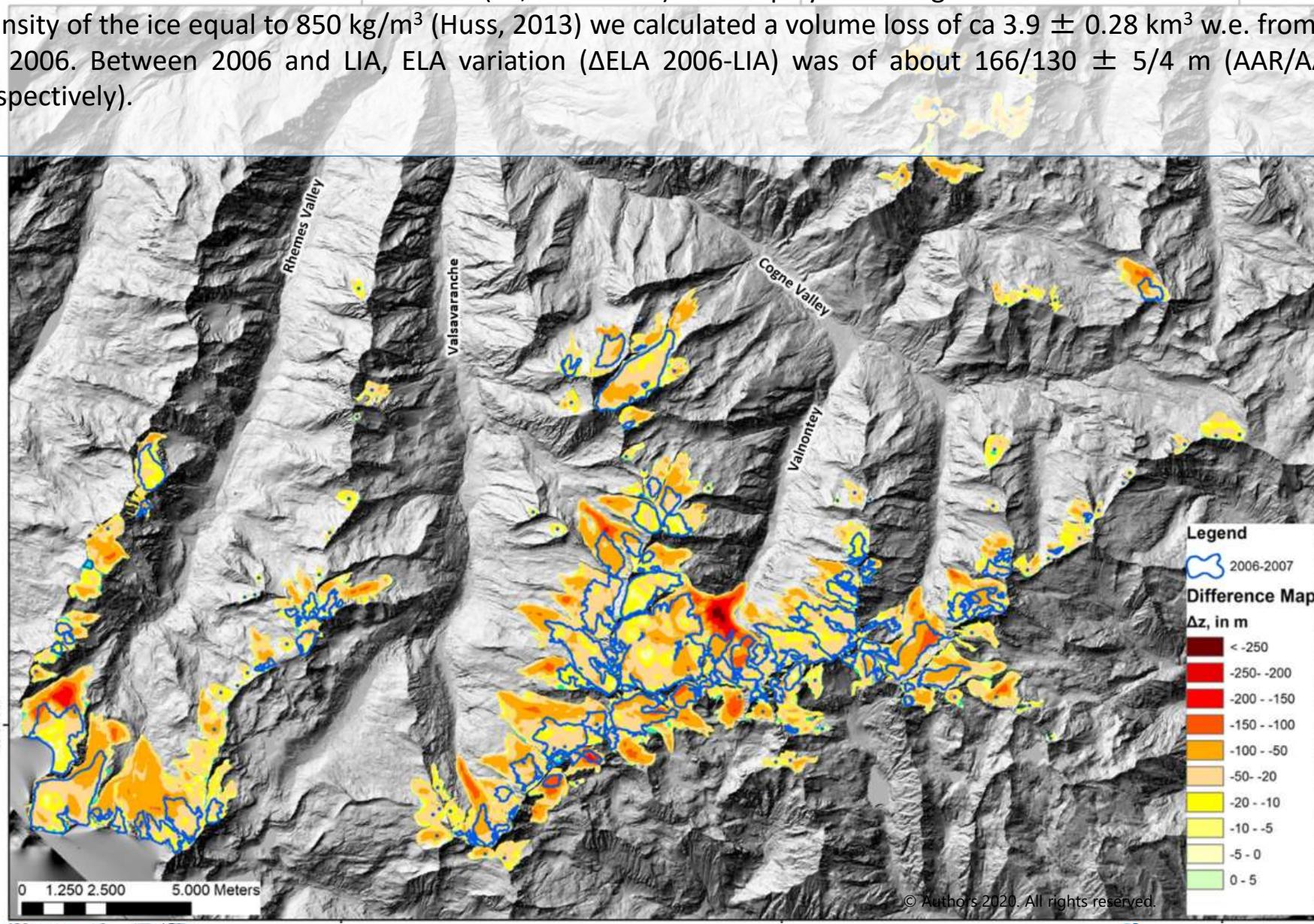
b) Aspect vs. Area (km²)



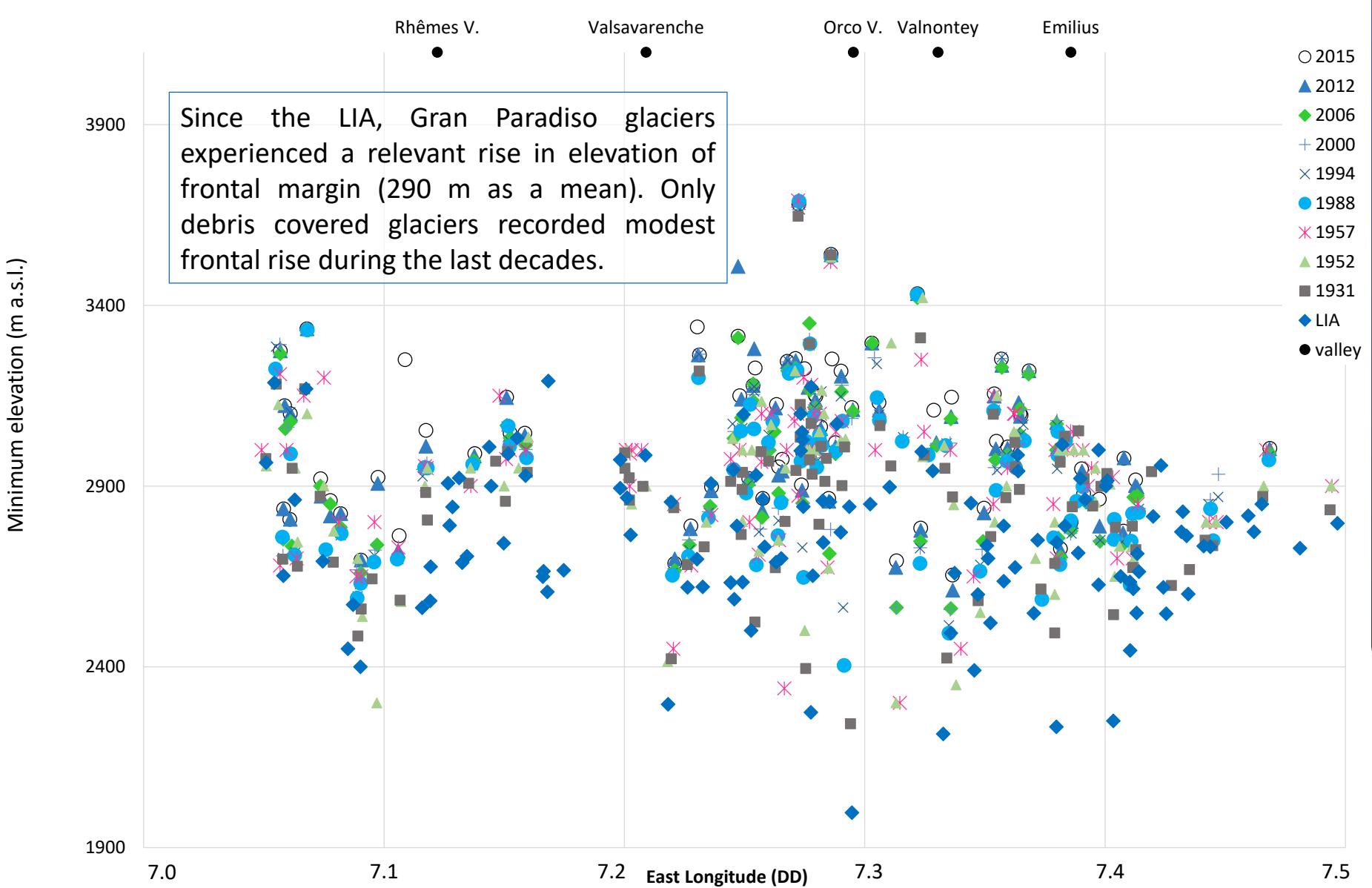
c) Aspect vs. Area (%)



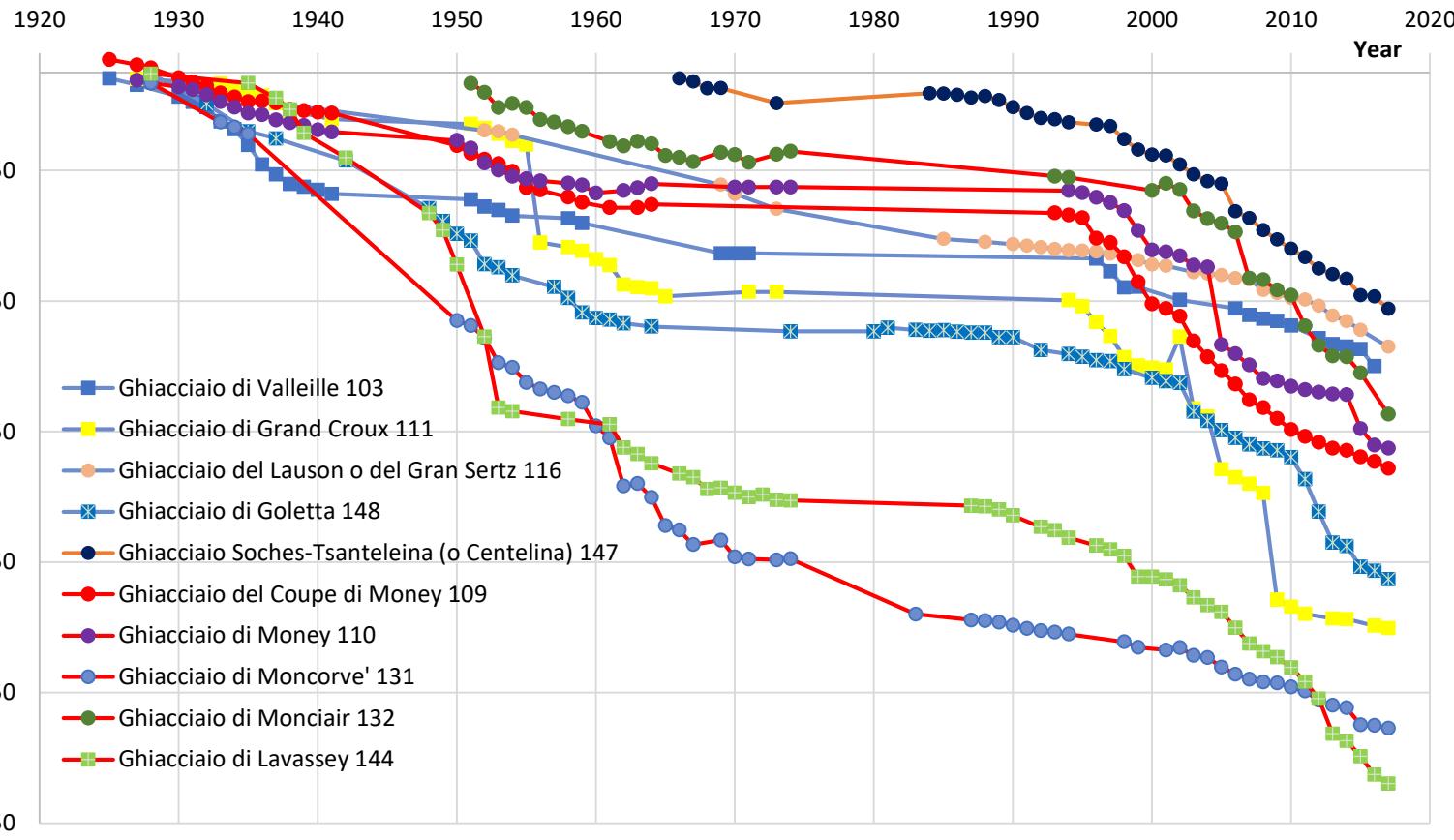
The amount of volume loss between the LIA and the 2006 time-steps was obtained by applying the geodetic mass balance. Classes of thickness variations (Δz , in meters) are displayed through a chromatic scale. Assuming a density of the ice equal to 850 kg/m^3 (Huss, 2013) we calculated a volume loss of ca $3.9 \pm 0.28 \text{ km}^3$ w.e. from LIA to 2006. Between 2006 and LIA, ELA variation (ΔELA 2006-LIA) was of about $166/130 \pm 5/4 \text{ m}$ (AAR/AABR respectively).



Altimetric distribution of glacier fronts vs. longitude

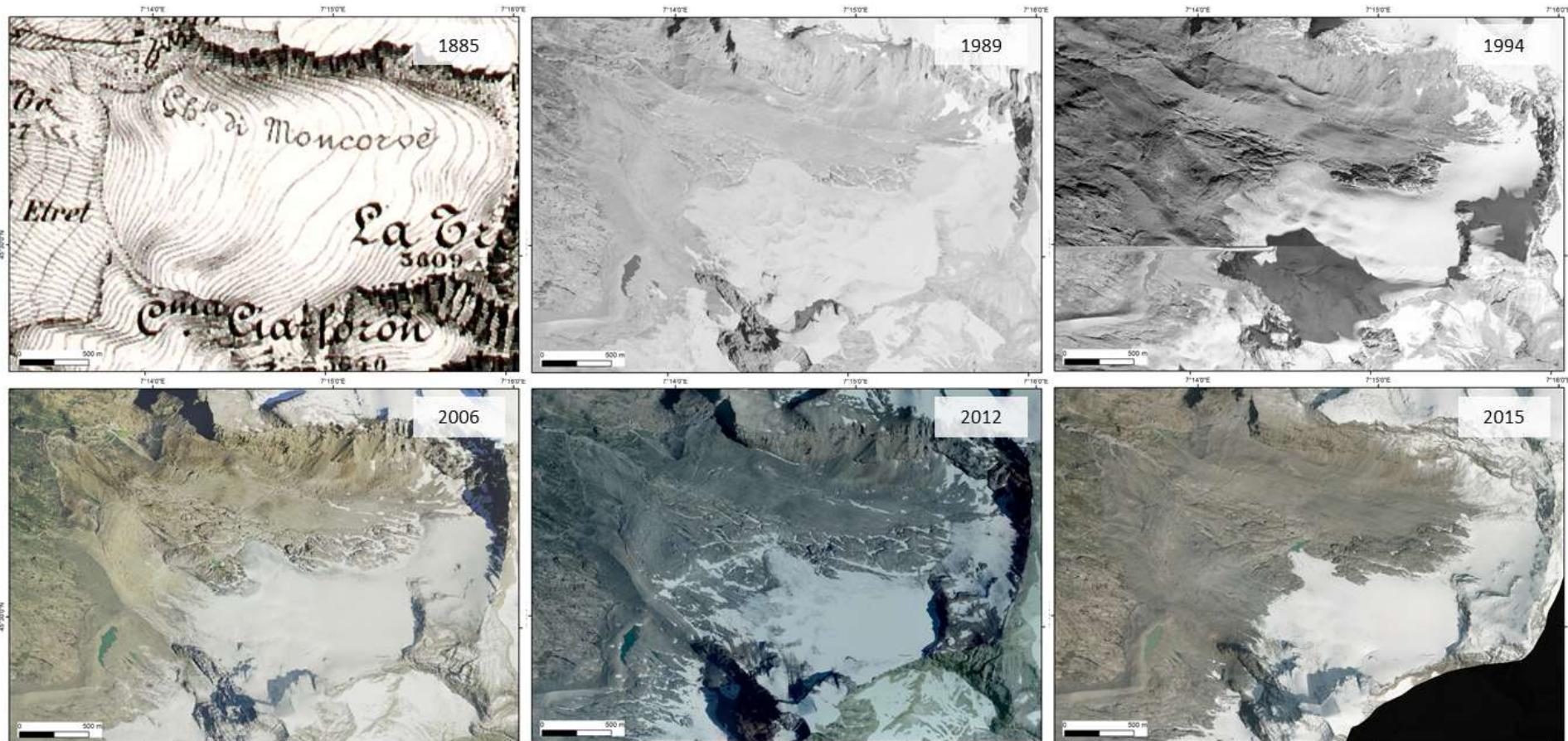


Cumulative Front Variation (m)



Time-Distance curves evidence a strong retreat almost since the beginning of the XIX century, interrupted by small advance phases. Lavassey, M. Concorve' and Grand Croux glaciers recorded the strongest retreat (-1089.4 m, -1004.4 and -851.5 m, respectively).





Our data show a strong acceleration in the reduction rates of the glacial bodies marked by dramatic shrinkage of frontal area and contraction also in the accumulation basin.

As a consequence, we assist to a progressive fragmentation of glaciers inducing an increase in the number of glaciers smaller than 0.1 km^2 and of the extinct glaciers.

Moreover glacier of the Gran Paradiso Massif recorded a dramatic reductions both in term of area and volume and, overall, our results underlined a strong increase of the reduction rates in the last decades - in particular since '90s - reflecting temperature anomalies increase.

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Glacial reduction in the Gran Paradiso Massif (Western Italian Alps): multitemporal dynamic inventory since the Little Ice Age



Thank you for
taking your time!

Salvatore M.C.^{1,2}, Gennaro S.¹,
Alderighi L.¹, Cerrato R.¹, Baroni C.^{1,2}

⁽¹⁾ Department of Earth Sciences, University of Pisa, Italy.

⁽²⁾ Geosciences and Earth Resources-Research Council of Italy
(IGG-CNR), Pisa, Italy.

