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Regional mass balance of Lombardy Alps (Italy) during 2007-2011

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Objectives

The project, developed by Servizio Glaciologico Lombardo (SGL), aims to estimate the mass balance of Lombardy glaciers (Central Alps, Italy) over the survey period 2007-2011.

Methods

A network of **52 stakes** was established, where measurements were taken yearly. The network was designed to cover 14 of the largest glaciers within the region, as well as to inspect all the glacierized mountain sectors. Given this geographical representativity, the methodology applied for surveying mass balance at a regional scale followed an elevation criteria.



Fig. 1: ablation stake measurements on Fellaria glacier (a), and Dosegù glacier (b,c). (Photographs P. Pagliardi and L. La Barbera – SGL)

The Lombardy glaciers and glaciarets, for a total surface of **90.4 km²**, were considered as one and a classical glaciological mass balance was implemented. Seven elevation ranges were identified, and stakes were positioned accordingly. The correlation between the specific balance and aspect of single stakes was so weak that this parameter was not taken into account. A mass balance value was associated to each altitude range, averaging the measurements taken at the correspondent stakes. In cases of stakes showing a considerably different trend in comparison to the average of the same altitude, a separate analysis was carried out and they were considered representative of the specific glacier only.

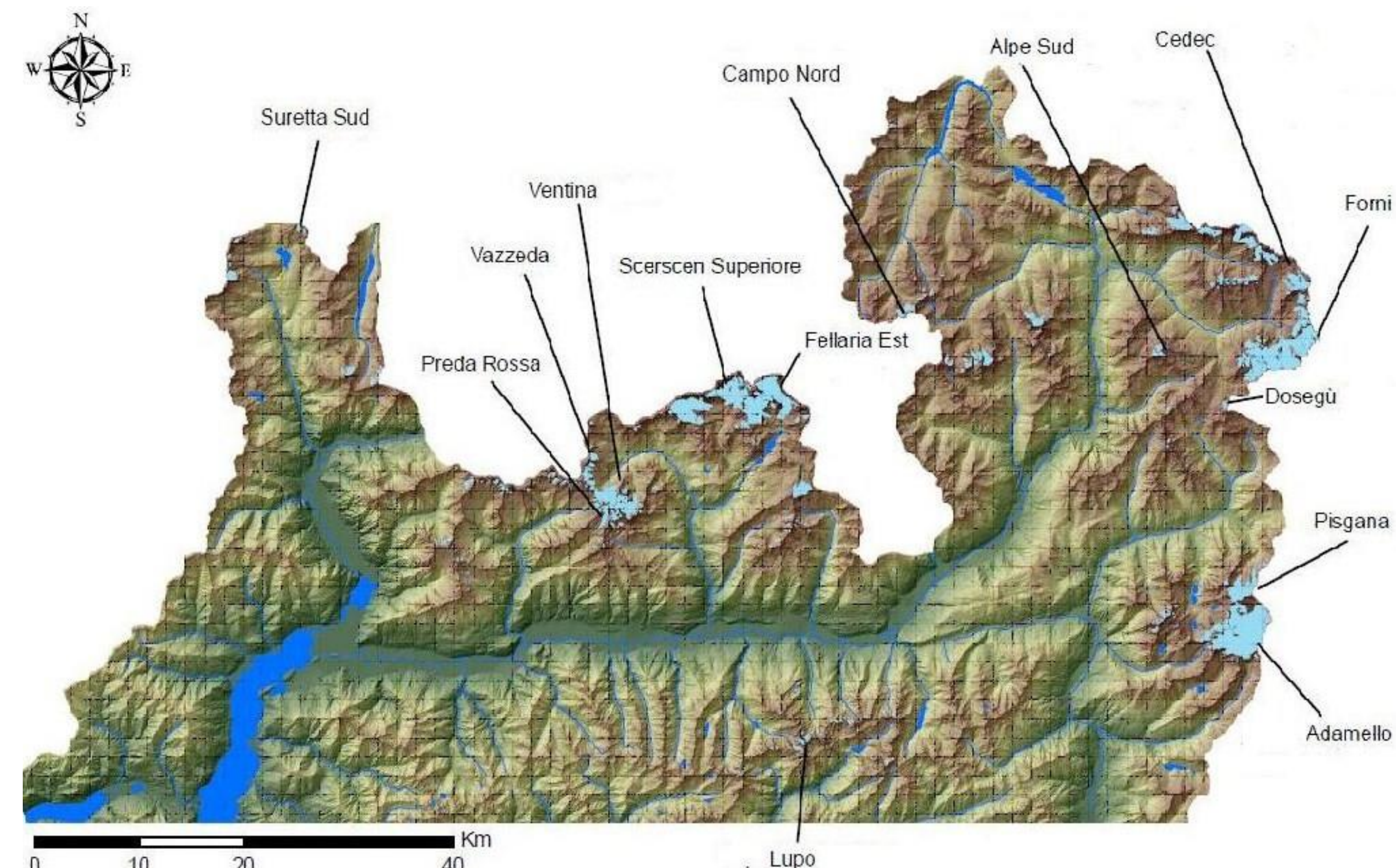


Fig. 2: Study area: the 14 Lombardy glaciers covered by the stake network.

Elevation range (m asl)	Glacier	Aspect	n° of stakes	Mountain sector
<2500	Ventina	N	1	Disgrazia-Mallero
	Lupo	N	5	Orobie
2500-2750	Forni	N/NW	5	Ortles-Cevedale
	Adamello	N	1	Adamello
2751-2900	Suretta Sud	S	1	Spluga-Lej
	Forni	N/NW	2	Ortles-Cevedale
2901-3050	Vazzeda	NE	2	Disgrazia-Mallero
	Dosegù	SW	2	Ortles-Cevedale
	Campo Nord	NW	1	Livigno
3051-3200	Scerscen Sup.	SW	2	Bernina
	Predarossa	S/SW	2	Disgrazia-Mallero
	Cedec	NW	1	Ortles-Cevedale
	Adamello	N	2	Adamello
	Forni	W	1	Ortles-Cevedale
	Alpe Sud	SE	2	Ortles-Cevedale
	Pisgana	N	2	Adamello
3201-3400	Forni	W	2	Ortles-Cevedale
	Fellaria Est	S	1	Bernina
>3400	Forni	NW	1	Ortles-Cevedale
total			36	

Tab. 1: distribution, elevation range, hosting glacier, aspect and mountain sector of the 36 ablation stakes used in this work (52 stakes established).

The consistency of the field measurements was confirmed by the evidences emerged from the monitoring data and pictures collected every year for the Servizio Glaciologico Lombardo glaciological survey, and from projects of glaciological and geodetic mass balance carried out on specific glaciers. Altitude ranges and glaciers surface have been updated to 2007 thanks to newly available Digital Surface Models and aerial photos.

Results

The results show a **strong negative mass balance: - 653 M m³** of water over five years (**- 7.4 m w. eq.**). The hydrological year 2006/2007 accounted for almost 30% of the loss while the less negative mass balance was recorded in 2008/2009 and 2009/2010 (accounting for 15% of the total loss each). Considering the regional glacier volume in 2007 (estimated in 3.43 billion m³ of water*), it is relevant to notice that **19% of the ice vanished** in the considered time span.

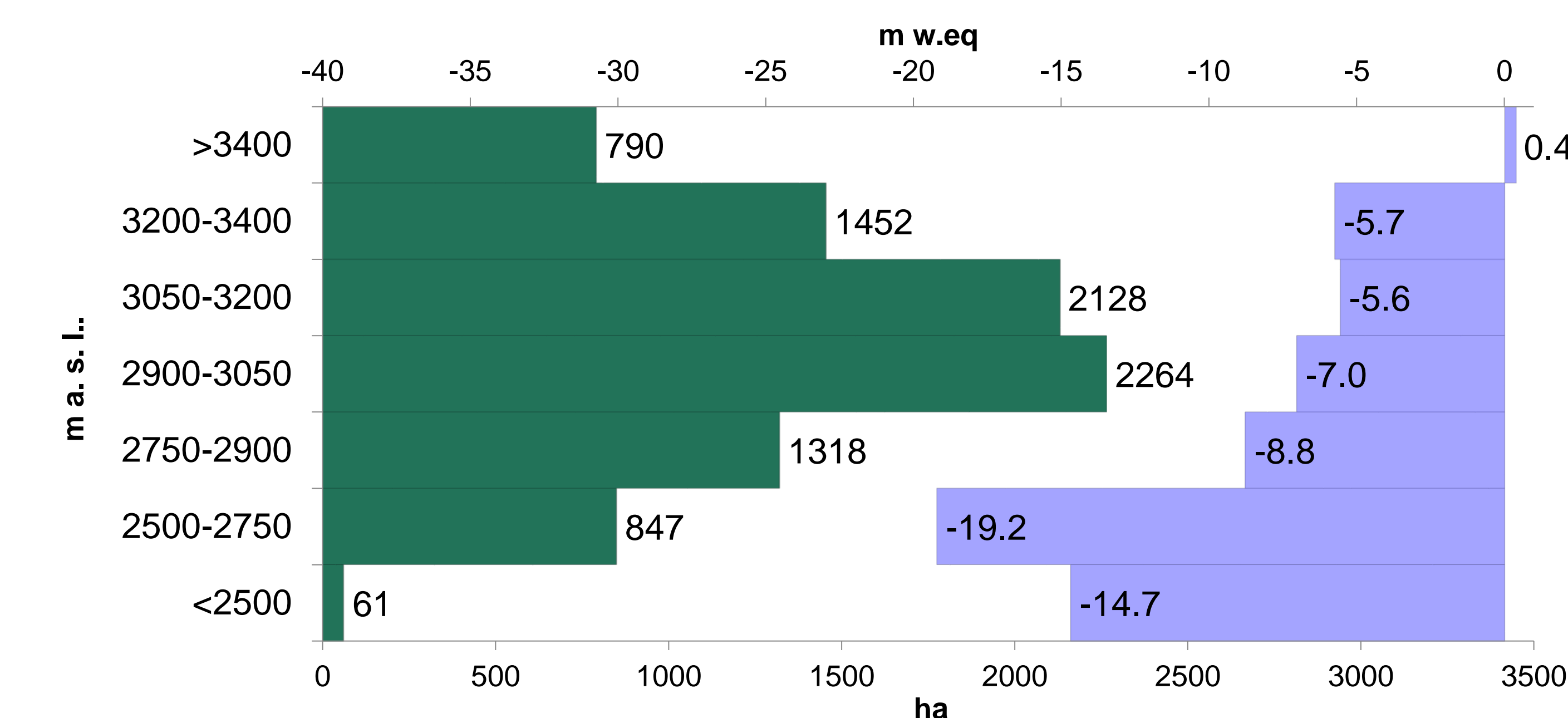


Fig. 3: Elevation distribution of Lombardy glacierized areas (ha) and mass balance during 2007-2011 (m w.eq.).

	1991-1999 (8n)	1999-2003 (4n)	2007-2011 (5n)
Total ice variation (M m ³)	-379	-388	-718
Total water variation (M m ³)	-345	-353	-653
Mean annual ice variation (M m ³)	-47	-97	-144
Mean annual water variation (M m ³)	-43	-88	-131

Tab. 2: Volume variation (M m³) of Lombardy glaciers in 1991-99, 1999-03 (Smiraglia and Diolatiuti, 2009) and 2007-11.

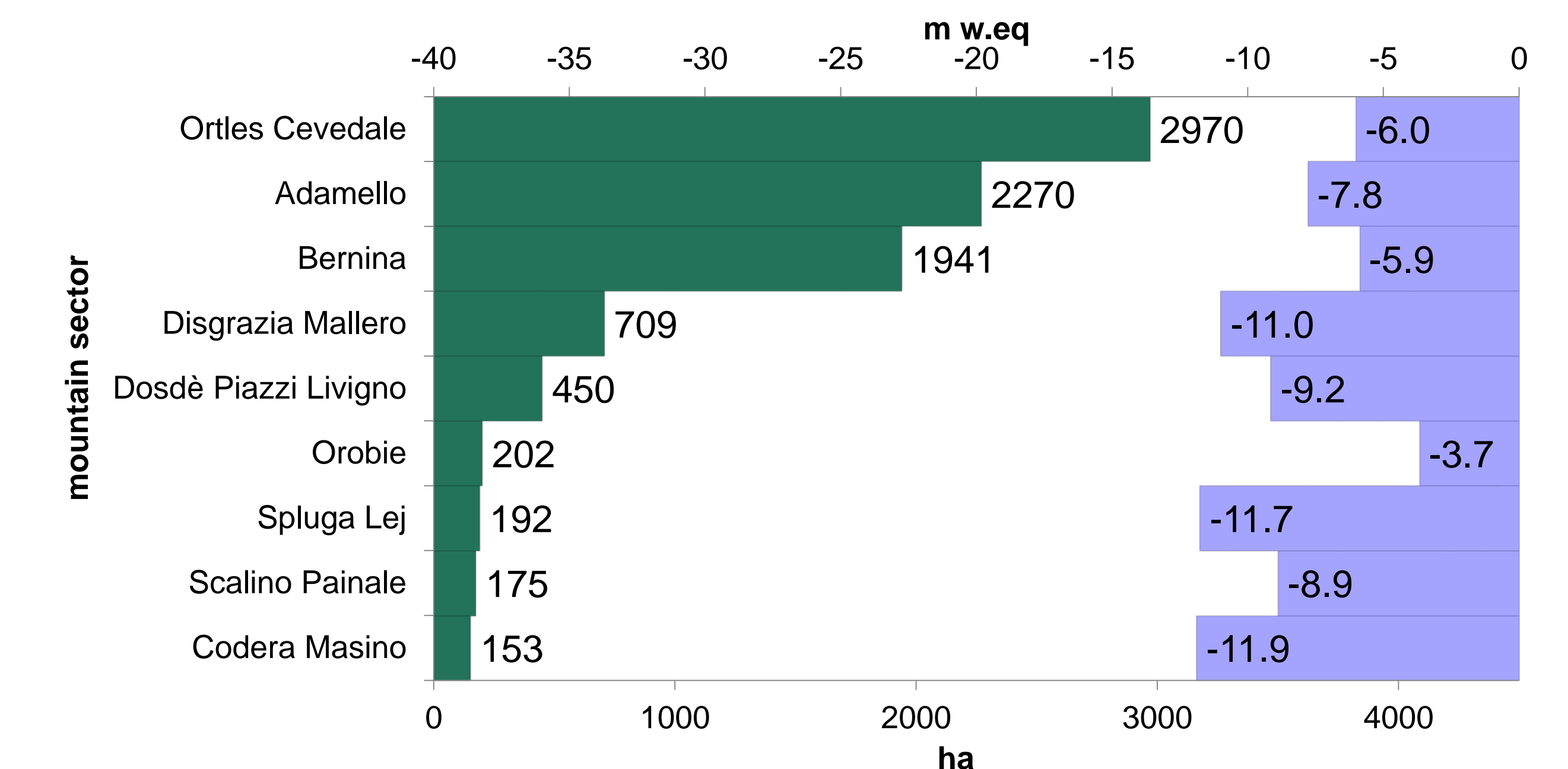


Fig. 4: Glacierized area per mountain sector (ha) and mass balance during 2007-2011 (m w.eq.). Mass balance data were obtained by attributing to the specific mountain sector the regional average values recorded per altitude range.

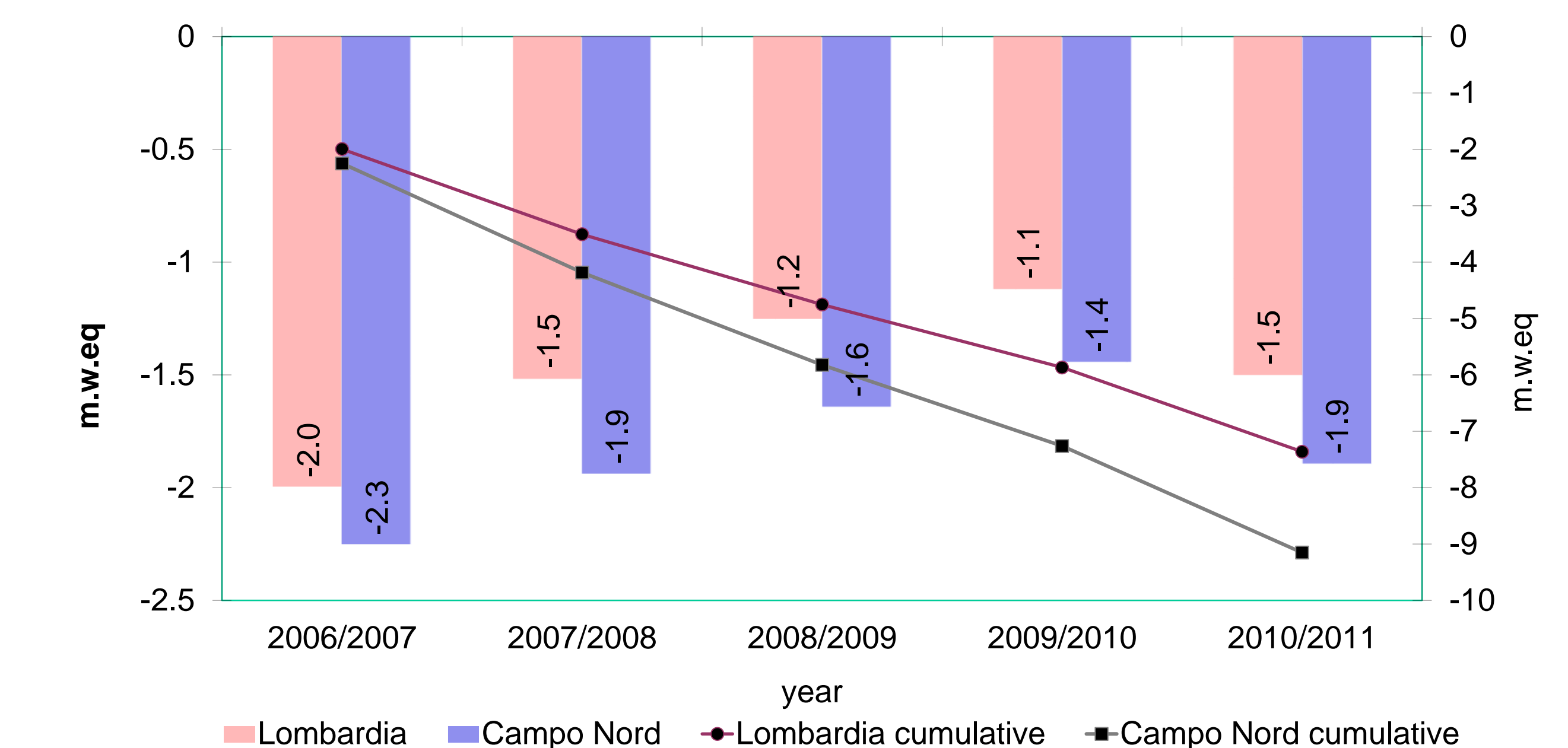


Fig. 5: A strong correlation was found between the data recorded at a specific stake, on Campo Nord glacier at 2969 m a.s.l., and the regional mass balance. Annual and cumulative mass balance recorded at Campo Nord stake and annual and cumulative mass balance for Lombardy region are shown in the graph (m w.eq.).

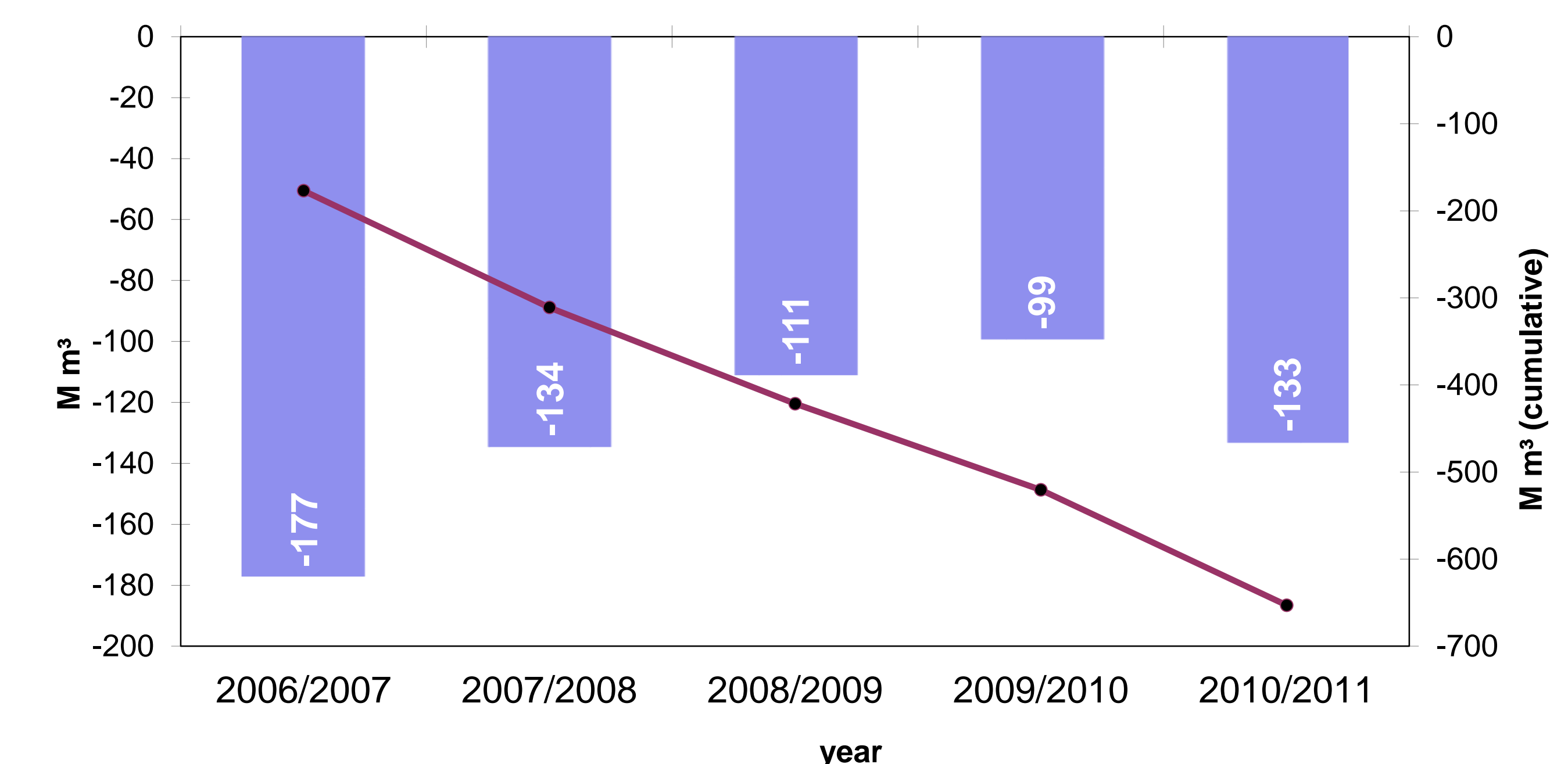


Fig. 6: Annual and cumulative mass balance of Lombardy glaciers in the investigated hydrological years.

*The volume was calculated using the algorithm proposed by Hoelzle and Haeberli (1995).