EGU2020-10734
https://doi.org/10.5194/egusphere-egu2020-10734
EGU General Assembly 2020

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

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Alpine glaciers are sensitive key markers of climate variations, as their geometry and shape are the results of adjustments in response to changes of their mass balance. Since the Little Ice Age the European Alps, as well as other mountain ranges, experienced a phase of generalized retreat, accentuated during the last decades. The availability of quantitative data on glaciers variations from major mountain regions represent relevant tools for better understanding the glacier behaviour in response to ongoing climatic changes. Here we present new data on Holocenic variations of glaciers hosted in the Gran Paradiso Massif, the first Italian National Park (Western Italian Alps).

We built the multi-temporal digital inventory of the Gran Paradiso Massif glaciers covering a time period of over 150 years, considering distinct time steps spanning from the Little Ice Age (LIA) to 2015. The multi-temporal dataset was built including glaciers outlines (derived from high resolution orthophotos and historical maps) and the data related to frontal variations (coming from annual glaciological surveys conducted by the Italian Glaciological Committee). Database was managed in GIS environment and populated following the guidelines suggested by the WGMS. Multi-temporal analysis supplied new quantitative data on the strong glacial decline occurred since the LIA and dramatically accelerated since the 90s.

During the LIA the Gran Paradiso Massif hosted more than 120 glaciers extended for about 112 km^2 reduced to 73 units in 2015 covering only about 32 km^2.

Our data underline a loss of about 50 ± 4 m w.e. and ELA variations of about 166/130 ± 5/4 m (considering AAR/AABR methods, respectively) from the maximum LIA position and 2006. The strong contraction and fragmentation of the studied glaciers is underlined by area loss of over 71% (with a reduction rate of -0.36% y^{-1}) from the LIA to 2015, as well as by the increase in the number of glacial bodies smaller than 0.1 km^2, and by the increase in the number of extinct glaciers (33 in 2015 respect to 1957). Furthermore, during the last decades, new data obtained show a dramatic acceleration in the contraction rates of the glacial bodies, which can lead to impressive landscape changes and to a relevant increase of geomorphological hazard.

The multitemporal data show a very detailed evolution of Gran Paradiso glaciers also considering

ice- mass loss and can contribute to modelling glaciers response to climate changes in a sensitive area of the Italian Alps, considering its location at the border of a “dry zone”. Improving the knowledge on the glacial resource could contribute in better understanding the impact of warming climate on mountain hydrology, as well as to increase the awareness of the population and authorities to be resilient in a near future with strong reduction of meltwater runoff.