



## Stages of glacial retreat in the French Alps since the termination of the Little Ice Age

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Since the end of the Little Ice Age (LIA), and especially since the 1980s, one of the most obvious impacts of climate change in high alpine mountain areas is the glacial retreat. This generalized shrinkage of the glaciers took place with periods of retreat, stagnation, and advance, building typical landforms. Glacial fluctuations are accurately known at local scale for several well documented glaciers of the French Alps but not at the regional scale. In order to fill this gap, we reconstruct past and survey present glacial extension in Massif de la Vanoise (French Alps), crossing geomorphology with historical documents (e.g. ancient maps and terrestrial photos).

An inventory of the present Vanoise glaciers was realized and integrated in a GIS. Based on present maps, high resolution orthophotos dating from 2006 (pixel 50 cm) and DEMs (25 m), it lists the 200 Vanoise glaciers, maps their limits, and implements a database (surface area, maximal and minimal elevations, aspect, debris covered area, coordinates). Proglacial margins are geomorphologically mapped using present orthophotos, and completed by field check. This is needed because of low quality orthophotos and debris- or snow-covered glacier margins, and to complete the maps derived from low quality DEMs or orthophotos with shadow. Geomorphological maps are integrated in the same SIG that the inventory.

By crossing this geomorphological database with historical documents, we reconstruct the stages of the glacier retreat since the end of LIA, and the quantification of the glacier retreat rates since 150 years. This work was carried out at the scale of Vanoise massif. Its glaciated area was 94 km<sup>2</sup> in 2006; it has decreased by more than 50% since the end of the LIA, and by c. 33% since the end of the 1960s. During the last forty years, c. 200 small glaciers and glacierets disappeared while the number of glacial lakes insides proglacial margins has increased.

This work takes place into the EU-funded project GlaRiskAlp (Alcotra France-Italy). The Vanoise inventory will be extended to the whole French Alps, merged with the ones in Valley of Aosta and Piemonte (Italy), and integrated to international databases. It will constitute the base for the recognition of Western Alps areas prone to glacial-related hazards, especially in the context of the present glacial retreat.