



"Dynamic Geodiversity" of glacial environments: new techniques for monitoring landscape variations on Alpine areas. Examples from the Gran Paradiso National Park

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The importance of keeping memory of past morpho-climatic events is particularly evident in recently deglaciated areas. The survival of glaciers is now very uncertain, due to climate changes and related effects occurring in the last decades. In the Western Alps, many glaciers are now extinct or show a dramatic reduction of area and thickness. Permafrost and periglacial areas are also responding promptly to climate changes as glaciers do, but they are not good "visual" indicators of climate changes, because they are not easily recognizable. Indeed, Italian glacial elements are constantly monitored by the Italian Glaciological Committee (CGI) in the last two centuries. The volunteers of CGI constantly monitor variations of glacier snout position of a great majority of Italian glaciers. CGI is not only a very important source of historical documentation and information, but also a very important scientific reference of the studies conducted in glacial areas. Particularly, thanks to CGI, an inventory of Italian glaciers was created. Anyway, due to recent rapid changes, it is difficult to quickly update the inventory, also considering the difficulty of reaching alpine high mountain areas. The recent use of Geomatics in geological and geomorphological studies can be applied to evaluate landform changes in glacial and periglacial areas. The combination of remote sensing and on field techniques (i.e. aerial photogrammetry, GPS, Terrestrial photogrammetry, satellite images and LiDaR) provides constant monitoring of landform changes and updating inventories.

The Gran Paradiso National Park (Piemonte and Valle d'Aosta Regions, Western Italian Alps) represents an excellent example of conservation of geodiversity. Many key-elements of the high mountain landscape are present here: glaciers, glacial cirques, rock glaciers, moraines (not only from Holocene, but also from Little Ice Age, of XVI-XIX centuries), steeped peaks, rock walls, roche moutonnée, ravines, debris fans, torrents, falls, lakes; being "starting points" for studying geodiversity of the Park, they have been mapped in detail. Updates of historical geomorphological maps, monitoring of glacier outline evolution and detailed digital field surveys have been conducted through Geomatics techniques within this area thanks to the support of several research programs: 1) seasonal activities of the Italian Glaciological Committee; 2) the MIUR-PRIN 2011 Project "Response of morphoclimatic system dynamics to global changes and related geomorphological hazards"; 3) the planning program of the National Park; 4) activities in the framework of GlaRiskAlp project n.56 Alcotra 2007-2013. At a local scale, detailed analysis have been performed by using integrated geomatics techniques such as in the Capra Glacier site, in the Orco Valley, near Serrù Lake (Piemonte Region). Results have been obtained in tracing changes of "dynamic geodiversity" features that can trigger natural processes (e.g. moraines, lakes, debris). These are useful features for preventing natural hazards in touristic or anthropized areas, by means of proper planning of access of the area and geodiversity exploitation measures.

Results demonstrated that knowledge on dynamic geodiversity of glacial environments is crucial for understanding how these high altitude dynamic landscapes are changing, not only for their external appearance, but also for their complex internal mechanisms and values.