CIVIL AND ENVIRONMENTAL ENGINEERING

DIATI - Observing and measuring glacier evolution due to climate change

Funded By	Dipartimento DIATI
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Context of the research activity	Mountains and cryosphere are key elements for the future, especially in the Alps, where Climate change impact more, , leading to an increase occurrence of natural hazards. Alpine regions, particularly in periglacial areas, have shown evidence of vulnerability to extreme events and their monitoring will be increasingly crucial. Their complex systems requires to integrate different techniques of measurement able to solve arising problems such as the difficulty in accessing with the classical methods and the large areas to cover.
	Integrated measurement techniques will be increasingly important in environmental monitoring and in the prevention of climate change risks, especially in the next future. The use of visible images and photogrammetric techniques is mandatory and well established for monitoring the alpine cryosphere, especially for geomaticians. Nevertheless, it is necessary to study the new possibilities that new sensors allow in monitoring glaciers and the Alpine territory. In this scenario is fundamental to develop both the theoretical aspects and the organizational and logistical capabilities that measurements in extreme environments requires for the survey and processing of geomatic datasets. One of the aims of the research is the multi-temporal monitoring of glacial masses and deformations of the territory in the Alpine environment with integrated and multi-scale geomatic techniques, like satellite, aerial, drone and terrestrial remote sensing. The objective is to arrive at an integrated survey system that allows the measurement of glacier variations and the speed of movement of the glacier body, taking into account the extreme environment in which the measurements are carried out. To develop research activities, it is necessary to develop knowledge on photogrammetric and integrated IMU and GNSS sensors, RGB photographic sensors, thermal, multispectral and hyperspectral sensors, studying their potential and limits in cryospheric applications. The aim is to develop know-how in their advanced uses and consequently to define optimal data acquisition and processing techniques, with statistical analysis on the

Objectives	precision of cartographic and DSM products. These products accuracy and precision become crucial especially for the estimation of volumes, mainly due to the considerable extension of some glaciers, even several km2, which makes significant the impact of heights errors computation. These errors not only affect the determination of volume variations, but also any parameter that is estimated with geomatic measurements. Traditional RGB photogrammetric images must be integrated with multispectral and thermal images. The study of the correct use of these images on the analysis of the land surfaces left free by glaciers will be at the basis for an evaluation of the vegetation on the lands free from ice that causes the formation of new ecosystems. Thus, the possibility of measuring the planimetric variation of the glacier fronts with alternative techniques to photo interpretation, often uncertain due to the debris cover, must be studied. This represents a challenge that could find a solution starting from the study of the potential of thermal cameras and the optimal acquisition conditions. Another aspect of monitoring concerns the estimation of the sliding speed of the glacial body. It can be measured starting from the position of photographic details, natural or artificial, found in the images time-series. Alternative solutions to study are related to image analysis for the recognition and "tracking" of repetitive patterns, such as crevasses as well as high elevation GNSS sensors. The high-altitude environment traditionally involves the analysis of measurement errors related to refraction. They must be reconsidered with respect to traditional approaches due to the high precision and resolution achievable with modern sensors and processing techniques. In fact, atmospheric refraction causes bias in GNSS measurements at the highly variable altitudes typical of the Alpine environment, which are difficult to model in networks of permanent GNSS stations with receivers placed at low altitudes. Even in photogrammetry, the analysis of refraction errors requires refining what already exists in the literature, which is valid for small-medium scale cartography. The study of refraction corrections can be useful for improving the precision of DSM or large-scale cartographic products, especially in remote areas where ground measurements are particularly expensive or difficult to implement.

Skills and competencies for the development of the activity	Expertise from various Geomatics disciplines: knowledge of GNSS, photogrammetry, GIS, remote sensing, and related data processing. Experience on field measurement activities and ability to move in alpine terrain. Speak and write correct English; good written and oral communication skills; strong motivation and independence.