



## **Monitoring of the Grand Croux Centrale Glacier Lake Outburst Flood (Aosta Valley - Italy).**

Fabrizio Troilo (1), Valerio Segor (2), Alberto Godio (3), Diego Franco (3), Elena Motta (1), Paolo Perret (1), and Simone Gottardelli (1)

(1) Mountain Safety Foundation, Glaciers and Permafrost Office, Courmayeur, Italy (ftroilo@fondms.org), (2) Struttura assetto idrogeologico dei bacini montani – Dipartimento programmazione, risorse idriche e territorio - Assessorato Opere pubbliche, difesa del suolo e edilizia residenziali – Regione Autonoma Valle d’Aosta, Quart, Italy (v.segor@regione.vda.it), (3) DIATI – Politecnico di Torino – Torino, Italy (alberto.godio@polito.it)

The Grand Croux Centrale Lake is a proglacial lake that has started forming since year 2000 on the left snout of the Grand Croux Centrale Glacier, located in the Valnontey Valley (Aosta Valley – Italy). The lake gave evidence of subglacial outburst flood in 2016, when local authorities documented it and more than 60 people had to be evacuated from the area. Regular observations of the lake formation started by means of Sentinel 2B satellite optical images monitoring. Even though the lake did not form again in 2017, observation of PlanetScope satellite optical images in 2018 led to the observation of lake formation in late spring. Thus, an UAV survey was performed to assess the actual lake area. The results the survey demonstrated a consistent lake area expansion since 2016. Local government decided to undertake specific monitoring actions considering that (i) sudden emptying of the lake could happen again, that (ii) debit of the flood could be higher, as the water volume have been increasing since 2016, and that (iii) the higher probability of GLOF happening, is during the summer season, when the touristic frequentation of the valley is at its peak. Monitoring actions consisted at first in a bathymetric survey (estimated water volume 45000m<sup>3</sup>) and the installation of a pressure sensor in order to receive an alert in case of a sudden water level decrease. A GLOF simulation was performed on adopting the HEC-RAS software. The procedure allowed us to map the areas exposed to the flooding risks downstream to the lake area. . The risk assessment analysis allowed the local authorities to define actions for the population safety. First of all a detailed topographic survey by means of UAV photogrammetry and RTK GPS was performed on the lake area and the adjacent ice dam. This permitted the properly installation of water pumping system. A ground penetrating radar (GPR) survey of the ice dam was performed to assess ice thicknesses; the snow depths were measured to estimate the SWE availability. Water pumping started immediately to lower the GLOF risk level. A safety water level was reached and another UAV survey of the dried lake area was carried on to design a drainage channel excavation for the permanent water level lowering. The water level reduction by means of water pumping was proven to be efficient, and prevented any GLOF event during the summer. The excavation was subsequently finalized in October, and the water level was lowered permanently by 3.7 m (with a volume reduction of 30.000 m<sup>3</sup>). Multi-temporal UAV surveys performed from June to the end of the field activities gave an detailed insight on the evolution of the lake (Average Ortho-mosaic pixel size 2 cm, 9 surveys from June to October). Thus, evolution scenarios were provided by combining the GPR data with the expansion rates of the lake. A prospective future intervention plan has subsequently been realized as a result of the scenarios.