Modelling the impact of a GLOF scenario at Parón lake, Cordillera Blanca, Perú, using a novel multi-phase topographical and geological procedure

Hilbert Villafane[1], Juan C. Torres[1], Adriana Caballero[1], Harrinson W. Jara[1], Enver L. Melgarejo[1], Julia E. Araujo[1], Christian Yarleque[1], Stephan Harrison[2], Ryan Wilson[3], Joanne L. Wood[2], and Neil F. Glasser[4]

[1]National Research Institute for Glaciers and Mountain's Ecosystems, [2]University of Exeter, [3]University of Huddersfield, [4]Aberystwyth University

Study area

This study is focused on the northern part of the Cordillera Blanca encompassing the Llullán-Parón River subbasin, covering a total area of 148.5 km^2. This region includes mountain peaks: Mt. Huandoy, Mt. Hatunraju, Mt. Pisco, Mt. Chacraraju, Mt. Piramide, Mt. Parón, Mt. Artesonraju, Mt. Caraz and Mt. Agujas with elevation between 5,600 m.a.s.l. and 6,395 m.a.s.l., plus the Parón lake (~3.5km long, 60.5m maximum observed depth; 63.2x10^6 m^3 volume , surveyed in april 2017) and Caraz city (located in the alluvial fan of the subbasin).

Methodology

The present flow chart shows the methodology used in the analysis of a GLOF:

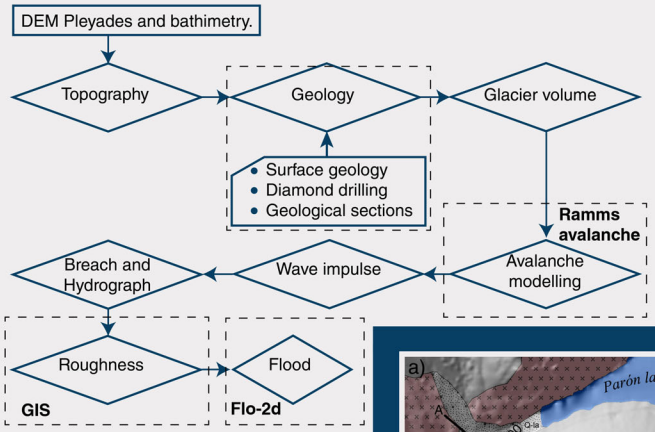
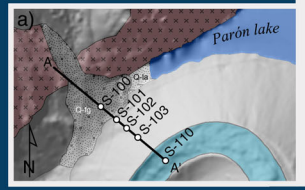


Fig. 1: Methodology



Results

In the Hatunraju glacier, two hazard blocks(B1 and B2) were identified with volumes of 1.52x10^6 m^3 and 0.81x10^6 m^3 respectively. With the modeling of avalanches (scene 1 and scene 2), an impact volume of 0.52x10^6 m^3 and 0.136x10^6 m^3 was determined towards the Parón lake (see fig. 2), generating impulse waves and overtopping by the natural dam.

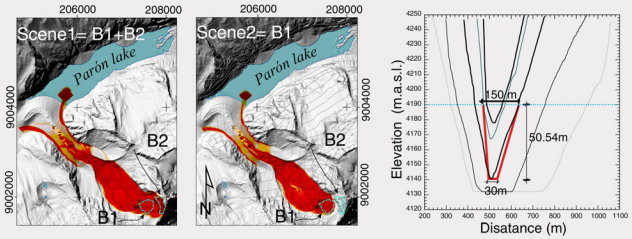


Fig. 2: Avalanche modelling and breach

Through the interpretation of the drill holes (fig. 3), it is determined that the natural dam is made up of quaternary deposits (heterometric clasts with blocks and gravels from 70 mm to 300 mm; with a matrix of sand and fine sediment <= to 2mm in addition to it empty <= 1m).

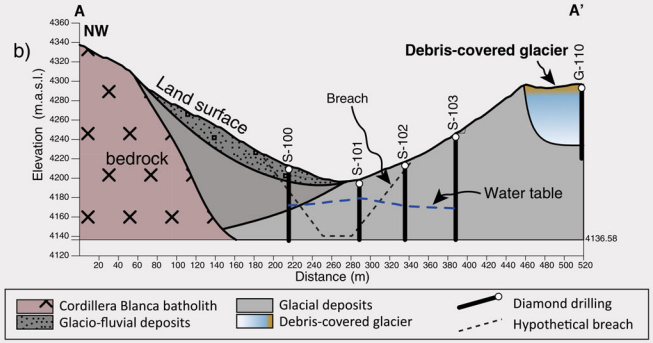


Fig. 3: Geological section: (a) Plan view and (b) profile view

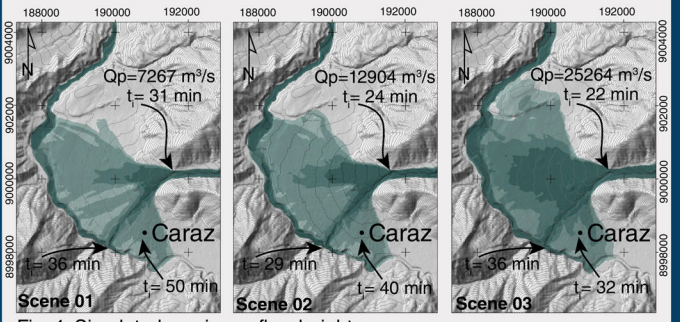


Fig. 4: Simulated maximum flow height

Before a possible failature of the natural dam, the peak flows were estimated by the empirical method with values: min. 7267 m^3/s (Costa, 1988), max. 44059 m^3/s (Popov, 1991) and a mean 25264 m^3/s, also using the NRCS (Natural Resources Conservation Service) method of 12904 m^3/s; the formation of flood scenarios was carried out considering the uncertainty of the peak flow (fig. 4).

Conclusions

For each scenario shown, it is concluded that the city of Caraz and populations located in the floodplain of the Llullán-Parón river are at risk from a GLOF event from the Parón lake.

Regarding the methodology used, the determination of potentially unstable blocks implies uncertainty, as well as the use of empirical formulas in the calculation of the peak flow of the rupture hydrograph, however, the one that best fits the numerical model is the NRCS methodology.

The natural dam material composed of coarse and fine materials are easily erodible for high velocity flows showing their susceptibility to GLOF harards.