



Reconstruction and modelling of the 1977 Glacial Lake Outburst Flood (GLOF) of the Engaño Lake, Chilean Patagonia.

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Floods from moraine-dammed lake failures can result in severe damage to mountain communities. GLOFs can also cause long-standing effects in riverine landscapes, due to the high intensity (i.e. great depth and high velocities) and long reach capacity of these events. GLOFs may increase in frequency as glaciers retreat and new lakes develop, highlighting the need for a better understanding of GLOF dynamics and the measures to reduce their negative outcomes. In Patagonia at least 16 moraine-dammed lakes have failed in historic time, however, data about GLOF dynamics and impacts are limited since GLOFs have mainly affected uninhabited areas and ungauged rivers. In March 1977, however, a GLOF flooded a small village (~130 inhabitants) in Chilean Patagonia. We reconstruct the dynamics of this event by semi-structured interviews, interpretation of satellite images (Landsat MSS) and two dimensional (2D) hydraulic modelling (using HEC-RAS 5.0 BETA and the SRTM v4 DEM). This reconstruction provides insights into GLOF behaviour, as well as the planning issues that led to socioeconomic consequences, which included relocation of the village.

We mapped the flood extent and compiled data of flood depth and timing to constrain the 2D GLOF simulations. Modelling shows that the water released by the GLOF was in the order of 12-13 million cubic metres and that the flood reached Bahía Murta Viejo, located ~26 km from the failed lake, 2-3 hours after the moraine dam was breached. The flood lasted for about ten hours (at the village), although the peak discharge occurred after only one hour at this site. The maximum water depth at Bahía Murta Viejo was 1.5 m, however, water depths of up to 20 metres were simulated in upstream constricted reaches. The overall flood dynamics suggested by interviews and geomorphic mapping, including hydraulic ponding upstream of bedrock gorges, was well represented in the 2D simulations in spite of the coarse resolution (~80 m) of the DEM used. The simulated flood intensity and the damage to buildings reported by Bahía Murta inhabitants also showed a good correspondence.

The Engaño Lake had several characteristics in common with other failed lakes in Patagonia. For example, it was dammed by a narrow and steep moraine, and the lake was in contact with a retreating glacier at the time of breaching. However, the GLOF hazard was not identified prior the 1977 flood. Thus, lack of awareness and planning amplified the negative socioeconomic consequences of the GLOF. The 1977 GLOF contributed to the village's gradual relocation to a higher and safer place a few kilometres from the original settlement. The Río Engaño GLOF shows the utility of the HEC-RAS 5.0 2D capabilities in GLOF modelling and illustrates a small-scale and short-distance migration as a coping strategy to a natural hazard which may increase in frequency as atmospheric temperature rise and glaciers retreat.