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882 lakes of the Cordillera Blanca: An inventory, classification, evolution and assessment of susceptibility to outburst floods

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Abstract

An inventory of the lakes within the Cordillera Blanca of Peru was made based on manual analysis of high resolution optical images and was verified during field surveys. In total, 882 lakes were detected, classified and described by several qualitative and quantitative characteristics. The majority of the lakes were characterised as moraine-dammed lakes (35.2%), followed by bedrock-dammed lakes (31.3%), while ice-dammed and landslide-dammed lakes were quite rare with 3.5% and 2.6%, respectively. Two thirds of the lakes (66.5%) have a surface area < 10,000 m2 and are classified as being small, while only 7.3% are classified as large lakes with an area > 100,000 m2. The majority of the large lakes are characterised as moraine-dammed lakes (48.4%) and the share of landslide-dammed lakes is significantly increased to 12.4% in this class. In the 1950s, most lakes were situated in the elevation range of 4250–4600 a.s.l. (Concha, 1951), while 49.4% of the lakes are currently situated above 4600 m a.s.l. This elevational shift is considered to be a result of ongoing environmental change and glacier retreat within the Cordillera Blanca. By analysing multi-temporal aerial images covering the period from 1948 to 2013 it was shown that glacial lakes in already deglaciated catchments may persist for long periods of time without any areal change. It was also shown that glacial lake outburst floods (GLOFs) originated from moraine-dammed lakes in the earlier stages of glacier retreat (1940s and 1950s) and from bedrock-dammed lakes in later stages (recently); however, no clear trend was revealed regarding the starting elevation of GLOFs. The susceptibility of all of the large lakes (n = 64) to outburst floods was assessed. Monitoring of young proglacial lakes and large moraine-dammed lakes, systematic susceptibility reassessments considering potential future changes, and flood modelling are recommended.