



Assessing the variability of glacier lake bathymetries and potential peak discharge based on large-scale measurements in the Cordillera Blanca, Peru

Alejo Cochachin (1), Christian Huggel (2), Cesar Salazar (1), Wilfried Haeberli (2), and Holger Frey (2)

(1) Unidad de Glaciología y Recursos Hídricos (UGRH), Autoridad Nacional del Agua (ANA), Huaraz, Perú (jcochachin@ana.gob.pe), (2) University of Zurich, Department of Geography, Zurich, Switzerland

Over timescales of hundreds to thousands of years ice masses in mountains produced erosion in bedrock and subglacial sediment, including the formation of overdeepenings and large moraine dams that now serve as basins for glacial lakes. Satellite based studies found a total of 8355 glacial lakes in Peru, whereof 830 lakes were observed in the Cordillera Blanca. Some of them have caused major disasters due to glacial lake outburst floods in the past decades. On the other hand, in view of shrinking glaciers, changing water resources, and formation of new lakes, glacial lakes could have a function as water reservoirs in the future.

Here we present unprecedented bathymetric studies of 124 glacial lakes in the Cordillera Blanca, Huallanca, Huayhuash and Raura in the regions of Ancash, Huanuco and Lima. Measurements were carried out using a boat equipped with GPS, a total station and an echo sounder to measure the depth of the lakes. Autocad Civil 3D Land and ArcGIS were used to process the data and generate digital topographies of the lake bathymetries, and analyze parameters such as lake area, length and width, and depth and volume. Based on that, we calculated empirical equations for mean depth as related to (1) area, (2) maximum length, and (3) maximum width. We then applied these three equations to all 830 glacial lakes of the Cordillera Blanca to estimate their volumes. Eventually we used three relations from the literature to assess the peak discharge of potential lake outburst floods, based on lake volumes, resulting in 3 x 3 peak discharge estimates.

In terms of lake topography and geomorphology results indicate that the maximum depth is located in the center part for bedrock lakes, and in the back part for lakes in moraine material. Best correlations are found for mean depth and maximum width, however, all three empirical relations show a large spread, reflecting the wide range of natural lake bathymetries. Volumes of the 124 lakes with bathymetries amount to 0.9 km³ while the volume of all glacial lakes of the Cordillera Blanca ranges between 1.15 and 1.29 km³. The small difference in volume of the large lake sample as compared to the smaller sample of bathymetrically surveyed lakes is due to the large size of the measured lakes. The different distributions for lake volume and peak discharge indicate the range of variability in such estimates, and provides valuable first-order information for management and adaptation efforts in the field of water resources and flood prevention.