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Estimating the global frequency, magnitude, and hazard of glacier lake outburst floods

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Many thousands of glacier lakes have formed from glacier retreat in high mountains since the beginning of the 20th century. These water bodies are impounded by glaciers and moraines and can release sudden glacier lake outburst floods (GLOFs), with potentially disastrous downstream consequences. Estimates of GLOF frequency, magnitude, and hazard at global or regional scales remain controversial because of unsystematic reports and inconsistent regional flood databases. We compile the largest GLOF inventory to date, containing 2,000 cases (AD 1901—2018) from 700 different sources. We find that the annual number of reported GLOFs has increased more than fivefold in our study period. This increase could be due to physical reasons such as atmospheric warming or because of growing research interest in glaciers. We tested this notion by comparing annual GLOF counts with the annual number of glacier surveys and the mean annual temperature extracted from all burst lakes. Our models show that research interest in glaciers has a higher impact on GLOF reporting, suggesting that historic documentation in earlier decades was likely biased towards more accessible mountain ranges such as the European Alps. Despite improved GLOF detection, reported flood volumes and peak discharges have become smaller since the 1960s. We analysed volume changes of glaciers that dammed burst lakes, and found that these glaciers have thinned considerably in past decades. Rapidly melting glaciers may thus impound smaller lakes and produce floods of decreasing magnitudes. Using extreme-value statistics, we will investigate how GLOF return periods or return levels have changed in past decades. Our regional GLOF hazard assessment will focus on mountain ranges with increasing exposure of population and infrastructure such as the Andes, the Pacific Northwest, Iceland, the European Alps, Scandinavia, and High Asia. These estimates of GLOF hazard will provide quantitative support for practitioners to identify regions that have a high demand for strategies in GLOF risk management.