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Glacier changes since Local Last Glacial Maximum in the South-West slope of Nevado Hualcán, Cordillera Blanca, Peru, deduced from moraine mapping and GIS-based analysis

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Anticipating and assessing hazards and risks associated with the shrinking of surface and subsurface ice in cold mountain chains is facilitated by empirical-quantitative data on present and past rates of change, as well as by a general understanding of related landforms and landscape evolution through time. Rock/ice avalanches and devastating outburst floods from glacial lakes indeed constitute a major cause of severe damage in populated mountain areas such as the Cordillera Blanca whose combination of tectonic, topographic and glaciological characteristics make it a threatened region. This study focuses on the Río Chucchún catchment above the city of Carhuaz, which was recently affected by a flood/debris flow from a rock/ice avalanche impacting a recently grown lake (Laguna 513). Traces left by past glaciations strongly affect the current geomorphodinamic behaviour of the catchment. For instance, a prominent sediment-filled glacial overdeepening behind Younger Dryas (YD) moraines (Pampa de Shonquil) with its retention function strongly influenced the chain of processes initiated by the outburst of Laguna 513.

The aim of this study is to reconstruct earlier glacial phases in the SW slope of Nevado Hualcán (Río Chucchún catchment), in order to compile quantitative information on surface areas and Equilibrium Line Altitudes (ELAs). To do so, glacier stages were assigned to five different glacial phases, through photointerpretation and moraine cartography: 2003; 1962; Hualcán-I-LIA (15th to 18th centuries); Hualcán-II-YD (∼12,5 ka BP); and Hualcán-III-LLGM (∼34 to 21 ka BP). Glacial stages Hualcán-I-LIA, Hualcán-II-YD and Hualcán-III-LLGM present relative dating based on previous studies from different authors in the Peruvian Andes. Once glaciers were delimited, their surface areas and Equilibrium Line Altitudes (ELAs) were calculated. For ELA estimation three different methods were used: the mid-range elevation, the Accumulation Area Ratio (AAR), and the Area x Altitude Balance Ratio (AABR).

The results show a decrease in surface area with respect to Hualcán-III-LLGM of 16% for Hualcán-II-YD; 50% for Hualcán-I-LIA; and 74% for 2003. With respect to 2003, ELAs shifted ∼520 m since the Local Last Glacial Maximum (LLGM), ∼470 m since a marked late-glacial stage (YD?), ∼130 m since the Little Ice Age (LIA) and about ∼100 m since 1962. If the changes are exclusively attributed to temperature effects, warming since LLGM can be estimated at some 3°C and since the maximum glacier extent of LIA at about 0.8°C. Such values are rather close to mean global temperature change during the corresponding intervals. Most of the ELA shift since LIA appears to have taken place during recent decades characterized by very rapid glacier shrinkage, although air temperature does not seem to have risen considerably during the last 30 years. These results along with other environmental and social approaches will contribute to a better understanding of impacts from climate change and glacier shrinkage in order to develop adaptation, mitigation and disaster risk reduction strategies in the Peruvian Andes.