Geophysical Research Abstracts
Vol. 17, EGU2015-7396, 2015
EGU General Assembly 2015


# Paired proglacial lake sediment and cosmogenic ages reveal the timing of Late Glacial and Holocene glacier fluctuations in the Huaguruncho Massif of Peru

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The pairing of cosmogenic ages on moraine boulders and radiocarbon-dated lake sediments provides a powerful tool for reconstructing past climates based on former ice positions. Surface exposure ages (10Be) and clastic sediment records from a proglacial lake at Nevado Huaguruncho, Peru, document the waxing and waning of tropical alpine glaciers in the Eastern Cordillera during the last ca. 15 ka. Moraine ages indicate that glaciers were advanced at ca. 14.1 $\pm$ 0.4 ka, a pattern that is consistent with cooling associated with the Antarctic Cold Reversal. Yanacocha is located immediately upvalley from this 14.1 ka moraine, and lake sediments and cosmogenic ages also suggest that glaciers advanced just prior to, or at the start of, the Younger Dryas from 13.1 to 12.5 ka. Lake sediments and cosmogenic ages then indicate that glaciers retreated after ca. 12.5 ka, and again advanced during the early Holocene between ca. 12 and 9 ka. Short-lived increases in clastic lake sediment values suggest that ice margins advanced briefly at times through the middle Holocene from ca. 8 to 4 ka, and the lack of moraine boulders dating to this interval suggest that glaciers were less extensive than during the late Holocene. Lake sediments suggest that glaciers experienced a relatively limited advance at the start of the late Holocene from ca. 4 to 2 ka, followed by retreat until the start of the Medieval Climate Anomaly at ca. 1.1 ka. Clastic sediment values in the lake sediments then suggest that ice began advancing during the MCA, and the most pronounced Holocene advance at Huaguruncho occurred during the Little Ice Age (ca. 0.4 to 0.2 ka) under colder and wetter conditions. The pattern of glacier variability in Huaguruncho during the Late Glacial and Holocene provides further evidence that tropical Atlantic Ocean conditions drove much of the observed temperature and precipitation changes along the Eastern Cordillera.