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Younger Dryas glacial stillstands on the Bolivian Altiplano: pattern and climatic implications

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Modifications of the global climate during the last deglaciation have been characterized by regional reorganization that may have in turn amplified or attenuated the global changes. Notably, the respective influences of the Southern and Northern Hemispheres are poorly understood in the Tropics. This underlines the importance of studying past climate variations in the Tropics, particularly in the poorly documented tropical moutain areas.

Cosmogenic exposure dating applied to the glacial landscapes provides temporal constraints on glacier fluctuations in response of climate variations. This permits high-resolution reconstructions of regional climates.

In this work we present new cosmogenic ages from two different locations of the Bolivian Altiplano, the Nevado Sajama volcano (S18.11° - W66.88°) and the Zongo Valley (S16.25°- W68.11°).
On the Sajama, new cosmogenic 3He dates support a late local glacial maximum, synchronous with the plaeolake Tauca highstand (ca. 16 ka) and contemporary to the north Atlantic Heinrich 1 (H1) event, with an equilibrium line altitude (ELA) at ca. 5200 m. Our data document also several recession episodes with the youngest one, characterized by an ELA of 5350 m, that seems to correspond to the Younger Dryas (YD) stadial (ca. 12 ka).
In the Zongo valley, two recessional moraines have indistinguishable cosmogenic 10Be ages of ca. 17 ka, synchronous with the transgression of the Lake Tauca, with respective ELA of 4760 and 4640 m. Upstream, we identified an intermediate recessional moraine that could either be synchronous with Heinrich 1 or with the Antarctic Cold Reversal episode. Upward along the valley, a Younger Dryas stadial is clearly established by well-clustered cosmogenic 10Be ages, yielding a moraine age of ca. 12 ka, contemporary with the paleolake Coipasa highstand, with an ELA of 5000 m.

These results confirm the sensitivity of South Hemisphere tropical glaciers to North Atlantic climate events, such as H1 or the YD. These glacial stadials are probably strongly driven by the wet conditions that prevailed during the central Altiplano palaeolake episodes. The identification of a Younger Dryas stadial in the Zongo valley, and also probably on the Sajama and Tunupa volcanoes (dating dupliquates are still in progress), is an unprecedented report in this region. During the YD event, the ELAs were $\sim$150m (Sajama) to $\sim$300 m (Tunupa, Zongo valley) higher than during the H1 event. Whereas glaciers advances and paleolake data indicate that the YD in the tropical Altiplano was characterized by higher temperature and lower precipitation than during H1, the climatic conditions during the YD in the Southern Tropics must have been far colder and wetter than today. Indeed, present day ELAs are more than 400 m higher in the Zongo, and more than 600 m higher in the Sajama and the Tunupa than they were during the Younger Dryas.