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A multi-centennial humid anomaly in the Altiplano: tropical and extra-tropical drivers of the South America Summer Monsoon during recent millennia

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Abstract

The South American Summer Monsoon (SASM) is the most important atmospheric system in tropical South America, being the major supplier of precipitation north of 20°S. Modern climatological studies indicate that year-to-year changes of the SASM are influenced by large-scale modes of atmospheric circulation sourced in the tropics such as the Intertropical Convergence Zone (ITCZ) and El Niño Southern Oscillation (ENSO). The interplay between these modes results in pronounced precipitation anomalies in the tropical Andes and the Altiplano which impact numerous socioeconomic activities. The drivers behind SASM variations at longer timescales are, however, far less understood due to the shortness of modern instrumental timeseries and the relative low number of paleorecords. This prevents an evaluation of past feedback mechanisms, and whether or not the historical ranges of variation represent the expected boundaries for future conditions.

In this presentation we will show three new pollen-based climate reconstructions expanding the last 4000 years from the Chilean Altiplano (18-21°S), two lake sediment records and one series of 32 fossil rodent middens. The Chilean Altiplano is located at the southern margin of the SASM influence, where up to 90% of annual rainfall derives from the easterly penetration of the SASM during the austral summer. These precipitation patterns exert a tight control on the altitudinal distribution of the main vegetation communities. Hence, our pollen reconstructions allowed a fine characterization of past vegetation changes caused by shifts in the strength of the SASM during recent millennia.

The chronology of the two lake cores is based on multiple AMS ^{14}C dating, while all rodent deposits were individually dated, providing key complementary short-term information at punctual times. Our pollen records reveal significant changes in vegetation at multi-centennial timescales, most notably a marked expansion of high-Andean vegetation along with significant increases in terrestrial plant productivity and lake levels between ~2200 and ~1400 cal yr BP. We interpret this evidence as a multi-centennial interval of increased precipitation due to a strengthening in the mean state of the SASM. Comparisons with other records from the Altiplano, the Tropical Andes and the Pacific Ocean suggest that this rainfall anomaly was largely decoupled from variations in the ITCZ and ENSO at that time. Additionally, we distinguish a marked latitudinal gradient in proxy responses where sites in the southern Altiplano display this wet anomaly more markedly than sites further north. This evidence is consistent with an extra-tropical source of moisture for the SASM. Our results suggest that the drivers of the SASM variability during recent millennia may have been more complex and variable than previously thought, and therefore caution is required in assuming that the tropical controls of this system observed in the instrumental record are stationary in time.