Dominant ENSO frequencies during the Little Ice Age (LIA) in the rainshadow of the Andes - The laminated record of proglacial Lago Frías, northern Patagonia (Argentina)

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The global character of the time interval known as the Little Ice Age (LIA) is at present relatively well established. The forcing mechanisms behind this cooling interval, however, are still elusive. Investigations in annually-laminated sediments have shown that varved sediments are among the best climatic archives to tackle these questions.

Proglacial Lago Frías in northern Patagonia is fed by the Tronador ice cap (3554 m). Previous investigations have shown that this glacier has reacted sensitively to climate change during distinct episodes such as the Late Glacial-Holocene transition (Ariztegui et al., 1997; Hajdas et al, 2003), and the Medieval Warm Epoch and the LIA, with well identified major glacial advances between A.D. 1800-1850 (Rabassa et al., 1979; Villalba et al., 1990).

A meteorological record for the 1969-1985 interval at the Mascardi weather station, located at 20 km from the Frías Glacier, shows a mean annual temperature of 7.6 °C, varying from 12.9 °C in January to 2.4 °C in July. Additionally, these data indicate a strong precipitation gradient between Mascardi (1409 mm year $^{-1}$) and the River Frías valley (4300 mm year $^{-1}$).

During the twentieth century the El Niño/Southern Oscillation (ENSO) and ENSO-like phenomena have dominated climate variations in the Americas on interannual and decadal time scales, respectively. The ENSO impact on local climate has been well determined using meteorological, historical and a dendrochronological approach at the Frías valley. More recently, a sediment trap study in Lake Mascardi covering the 1992-1998 interval combined with meteorological data have shown changes in sedimentation rates that can be linked to ENSO climatic events. Since both proglacial lakes, Frías and Mascardi, are fed by the Tronador ice cap, the laminated sequence of Lago Frías can provide a continuous record of ENSO and ENSO-like variations through time.

Results of a multiproxy study of Lago Frías sediments reflect variations in the transport of glacially derived clay and silt to the basin that can be directly linked to changes in climate. Sedimentological evidence combined with a good chronological model indicate variations in varves thickness showing two frequencies centered at 16.4 and 10.5 years that have been previously attributed to the solar cycles and the Tropical Atlantic Sea Surface Dipole (TAD), respectively. The main frequency is, however, located between 2.5 and 3.0 years pointing towards a dominant ENSO signal. Thus, the Lago Frías record provides new insights about the myriad of complex forcing mechanisms behind the cooling during the LIA in an area of the planet with a paucity of high-resolution climate records. It also points out the need to develop regional networks of well-understood paleoclimate archives such as lake systems with a reliable chronology. They will be critical evaluating the impact of the various mechanisms triggering environmental changes at different spatial and temporal scales.

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