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Climatic interpretation of the length fluctuations of Glaciar Frías, North Patagonia, Argentina

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We explore the climatic information contained in the record of length fluctuations of Glaciar Frías, in the north Patagonian Andes of Argentina. This record is one of the longest and most detailed glacier records in southern South America, starting in 1639. The length record is compiled from a combination of dendrochronological dating of moraines, historical sources, field measurements and remote sensing. Since the maximum Little Ice Age extent in 1639 to 2009, the glacier showed an overall retreat of 1.9 km.

In order to make a quantitave interpretation of the length variations of Glaciar Frías, we model the dynamical glacier response to changes in the climatic forcing with a simplified surface energy-balance model in combination with a flow-line model. The simplified energy balance model divides the surface energy fluxes into the net solar rediative flux and a second term that represents all other atmospheric fluxes as a function of temperature only. The glacier surface mass balance is calculated from monthly gridded precipitation and temperature data. Due to the maritime climate and the steep topography, Glaciar Frías has a short response time of 14 year and a climate sensitivity of 2700 m C^{-1}.

The overall retreat of the glacier observed over 1639–2009 is best explained by an annual mean temperature increase of 1.16 C or a decrease in annual precipitation of 34%, most of which would have occurred during the 20th century. The glacier model is also forced with independent proxy-based reconstructions of precipitation and temperature, based on tree rings and a composition of documentary evidence, tree rings, sediments, corals, and ice cores. The uncertainties in the presently available proxy reconstructions are rather large, leading to a wide range in the modelled glacier length. Most of the observations lie within this range. However, in these reconstructions, the mid-17th century is too cold and the early 19th century too warm to explain the observed glacier lengths.