

Revista Científica de Glaciares y Ecosistemas de Montaña 1

Article

700,000 years of tropical Andean glaciation

<https://doi.org/10.1038/s41586-022-04873-0>
Received: 27 October 2021
Accepted: 10 May 2022
Published online: 13 July 2022

Open access

Check for updates

Our understanding of the climatic teleconnections that drive ice-age cycles has been limited by paucity of well-dated tropical records of glaciation that span several glacial-interglacial intervals. Glacial deposits offer discrete snapshots of glacier extent but cannot provide the continuous records required for detailed interhemispheric comparisons. By contrast, lake ice cores with glacial varves can provide continuous archives of upstream glacial activity, but few such records extend beyond the last glacial cycle. Here a piston core from Lake Junin in the uppermost Amazon basin provides the first, to our knowledge, continuous, independently dated archive of tropical glaciation spanning 700,000 years. We find that tropical glaciers tracked changes in global ice volume and followed a clear approximately 100,000-year periodicity. An enhancement in the extent of tropical Andean glaciers relative to global ice volume occurred between 200,000 and 400,000 years ago, during sustained intervals of regionally elevated hydrologic balance that modified the regular approximately 23,000-year pacing of monsoon-driven precipitation. Millennial-scale variations in the extent of tropical Andean glaciers during the last glacial cycle were driven by variations in regional monsoon strength that were linked to temperature perturbations in Greenland ice cores; these interhemispheric connections may have existed during previous glacial cycles.

The $\delta^{18}O$ record of marine benthic foraminifera (B $\delta^{18}O$) has provided the foundational framework for our understanding of Cenozoic ice ages. However, because about 80% of global ice volume change over glacial-interglacial cycles occurred in the middle to high latitudes of the Northern Hemisphere (NH)¹, the marine $\delta^{18}O$ record tells us little about the timing and extent of glaciation in the Southern Hemisphere (SH) and in all-tropical mountain ranges. Radiometric dating of moraines in the SH² confirms that the last glacial maximum occurred roughly at the same time as the last peak of global ice sheet volume (marine isotope stage 2 MIS2). However, moraine records are inherently discontinuous, with younger glacial advances commonly obscuring older ice positions, making it challenging to make interregional comparisons of the timing of ice build-up and decay over several ice-age cycles using moraine chronologies alone. By contrast, lake sediment records can provide continuous archives of up-valley glaciation³, but long lacustrine records of tropical glaciation have thus far been limited by a lack of sufficient independent age control and/or a lack of clarity about the glacial signal preserved⁴.

Here we report an approximately 700 thousand year (ka) continuous and independently dated lacustrine record of alpine glaciation from the central Peruvian Andes that is directly comparable with records of extratropical temperature change, global ice volume and atmospheric greenhouse gas (AGWG) concentrations. We show that tropical Andean glaciers waxed and waned with the NH on orbital timescales but that the relative amplitude of glacial-interglacial cycles has not been constant. During much of MIS 7–11, tropical Andean glacier extents were enhanced relative to global ice volume, and this enhancement may have been related to increased precipitation coupled with reductions in the concentration of atmospheric CO₂ (ref. 5). Millennial-scale perturbations in Andean glacier extent during the last glacial cycle were similar in timing to both regional core records of precipitation and to temperature fluctuations recorded in Greenland ice cores; this pattern of change may have also occurred during previous glacial cycles. Thus, persistent multidecadate interhemispheric climatic teleconnections affected tropical Andean glaciers during much of the past 700 ka.

Department of Geological Sciences, University of Florida, Gainesville, FL, USA. ²Department of Geological and Environmental Sciences, University of Pittsburgh, Pittsburgh, PA, USA. ³Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA. ⁴Nuclear and Chemical Sciences Division, Lawrence Livermore National Laboratory, Livermore, CA, USA. ⁵College of Earth, Water, and Environment, University of Virginia, Charlottesville, VA, USA. ⁶Universitat de València, Institut de Ciències de l'Espai, Burjassot, Spain. ⁷Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI, USA. ⁸Department of Geological Engineering and Geotechnical Science, The Hong Kong Polytechnic University, Kowloon, Hong Kong. ⁹Department of Earth and Environmental Sciences, University of Minnesota-Duluth, Duluth, MN, USA. ¹⁰Department of Earth and Environmental Sciences, University of Wisconsin-Duluth, Duluth, MN, USA. ¹¹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ¹²Department of Geological and Atmospheric Sciences, Iowa State University, Ames, IA, USA. ¹³Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ¹⁴Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ¹⁵Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ¹⁶Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ¹⁷Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ¹⁸Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ¹⁹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ²⁰Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ²¹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ²²Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ²³Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ²⁴Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ²⁵Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ²⁶Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ²⁷Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ²⁸Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ²⁹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ³⁰Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ³¹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ³²Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ³³Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ³⁴Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ³⁵Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ³⁶Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ³⁷Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ³⁸Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ³⁹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁴⁰Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁴¹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁴²Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁴³Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁴⁴Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁴⁵Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁴⁶Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁴⁷Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁴⁸Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁴⁹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁵⁰Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁵¹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁵²Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁵³Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁵⁴Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁵⁵Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁵⁶Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁵⁷Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁵⁸Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁵⁹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁶⁰Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁶¹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁶²Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁶³Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁶⁴Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁶⁵Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁶⁶Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁶⁷Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁶⁸Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁶⁹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁷⁰Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁷¹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁷²Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁷³Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁷⁴Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁷⁵Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁷⁶Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁷⁷Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁷⁸Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁷⁹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁸⁰Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁸¹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁸²Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁸³Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁸⁴Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁸⁵Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁸⁶Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁸⁷Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁸⁸Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁸⁹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁹⁰Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁹¹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁹²Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁹³Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁹⁴Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁹⁵Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁹⁶Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁹⁷Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁹⁸Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ⁹⁹Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA. ¹⁰⁰Department of Earth and Environmental Sciences, University of Wisconsin-Madison, Madison, WI, USA.

Nature | Vol 607 | 14 July 2022 | 301

Autor

Rodbell, D.T., Hatfield, R.G.,
Abbott, M.B., Tapia, P. M., et al.

Enlace de descarga

<https://doi.org/10.1038/s41586-022-04873-0>

