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press release

Presentation of the article published in *Science Advances,* August 29th 2018:

Lake Tauca highstand (Heinrich Stadial 1a) driven by a southward shift of the Bolivian High.

by

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Lake Tauca and the paleoglaciated volcano Tunupa 15 500 years ago (artist's concept, credit: Edouard Mazaré)

Present-day landscape of the Salar de Uyuni (crédit: PH Blard)

Comparaison of the Altiplano landscapes in the centre of the Salar de Uyuni

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Summary

Using an innovative method, researchers built a paleoprecipitation map of the Tropical Andes 15 500 years ago, and managed to understand the atmospheric process involved in the abrupt changes of the water cycle in South America.

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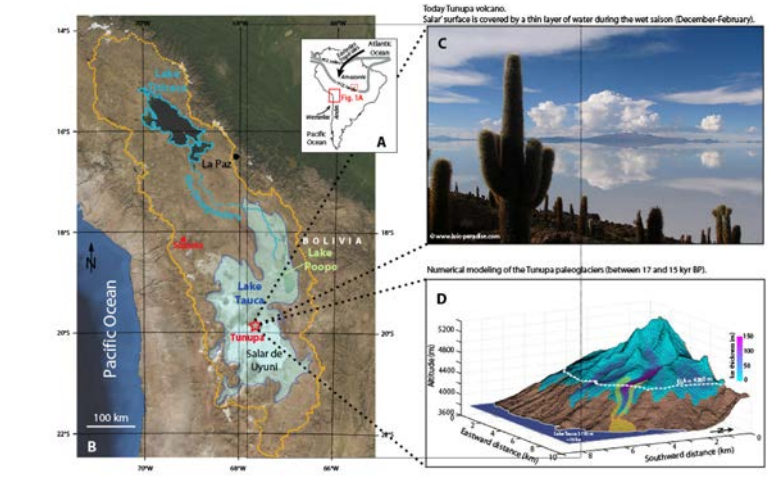
Some more details ...

Major hydrological changes in the Tropical Andes during the deglaciation

At the millennial timescale, the Earth's climate was affected by important natural fluctuations, notably since the end of the last Ice Age, that occurred between 20 000 and 10 000 years before present. Climate archives from oceanic sediments and polar ice show that, during this deglaciation, temperatures showed drastic and abrupt oscillations in the Northern Hemisphere, and, to a lesser extent, in the Tropics. The spatial distribution and intensity of rainfall also seems to have been affected by these oscillations. These climatic changes seem to be paced by the oceanic circulation, but understanding how these perturbations are propagated to the continents and how they modify the atmospheric circulation remains an important research topic.

In the South of the Tropical Andes, on the Bolivian Altiplano, climate is today extremely arid, making possible the existence of the largest salty desert of the world: the Salar of Uyuni (Fig). However, 15 500 years before present (-13 500 years Before Christ), a giant paleolake, the Lake Tauca, could be observed in this region. During more than 1000 years, Lake Tauca covered an area of 52 000 km^2, a size comparable to the one of Lake Michigan, with a maximum depth of 120 m. We already know that greater rainfall and lower temperature was necessary for the development of Lake Tauca, but we still have to discover the atmospheric mechanisms that led to this reorganization of precipitation's intensity and repartition in South America. Several scenarios have been proposed to explain the origin of the humidity necessary to the formation of Lake Tauca. This lack of knowledge was due to the fact that, up to now, there was no efficient method to reconstruct a regional precipitation field. In this new article published in Science Advances, CRPG researchers (CNRS and Lorraine University) and colleagues used glacial deposits of the Altiplano to set an innovative methodology. Lake and glaciers have contrasted sensitivities to precipitation and temperature, this being



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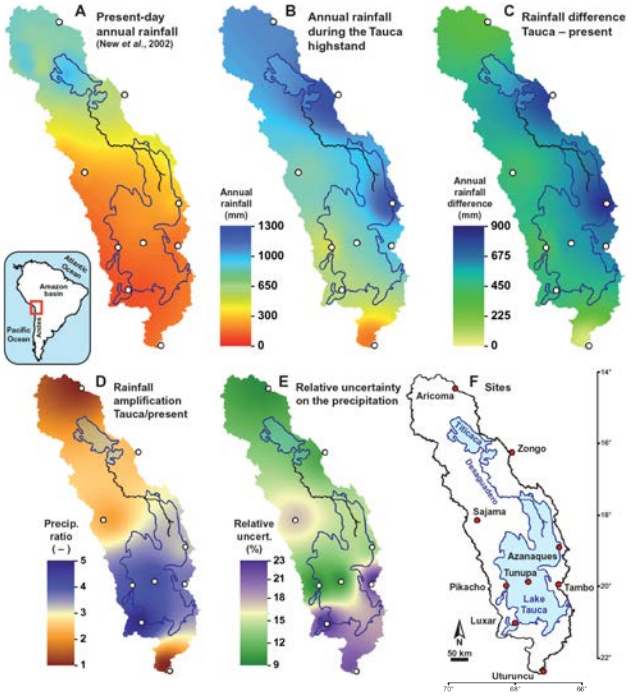
due to the different values of the latent heat of water vaporization (that contributes to a lake budget) and the one of ice fusion (that matters in a glacier mass balance). Researchers first reconstructed the spatial position of ancient glaciers synchronous with Lake Tauca, 15 500 years ago, and they then exploited this characteristic to determine the precipitation change (×2.3 regional mean) and the temperature drop during the Lake Tauca episode, 15 500 years ago. The main result of this research work was to create for the first time a regional map of paleoprecipitation for the whole Altiplano.



A) Cartes des précipitations actuellement observées sur l'Altiplano, B) Carte des précipitations reconstruites à partir du modèle couplant bilan de masse des paléoglaciers et bilan hydrique du Lac Tauca, C) Carte des différences entre précipitations «Tauca» et actuelles, D) Carte des ratios de précipitations «Tauca»/ actuelles, E) Incertitude relative sur les précipitations reconstruites, F) Localisation des sites paléoenglacés étudiés (Martin et al., Science Advances, 2018)

The so-obtained precipitation map displays a rainfall maximum on the eastern part of the Altiplano. Researchers interpret this feature as a result of a southward shift of the Bolivian High by about 500 km during the second part of the Heinrich event 1, 15 500 years ago. This hypothesis relies on the observation of modern climate: the position and the strength of this anticyclone control the amount of humidity conveyed from the Amazonian basin to the Eastern part of the Altiplano. Taking into account all paleoclimatic and modern data, the most probable scenario is that the great periods of cooling in the North Hemisphere induce a southward shift of all atmospheric circulation cells at the continental scale, in pace with a slowdown of the Atlantic circulation.

Precipitation map of Altiplano: an innovative method

A new method was developed to yield a precipitation map for the whole Altiplano. This result was achieved thanks to three innovations:

1) Important progress done during the last 5 years to improve the accuracy and the precision of the dating methods based on cosmogenic nuclides. The CRPG group has largely contributed to this international effort, notably by discovering several production rates calibration sites in the Andes, and by developing a new online calculator: www.crep.crpg.cnrs-nancy.fr

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2) A joint numerical modeling of the hydrological budget of the lake and the mass balance of the glaciers, both having contrasted sensitivities to precipitation and temperature.

3) The use of glaciers as high spatial resolution pluviometers, since they accumulate snow over watersheds of several km^2 only.

Implications - future work

Glacial fluctuations are often interpreted as the result of temperature changes only. This study underscores the important role of precipitations in the dynamic of glaciers, notably for their ability to induce regional variability. Ignoring this may lead to inaccurate interpretation of glacial changes.

The innovative method proposed in this article for reconstructing paleo-precipitation is an important achievement. This approach could ne used in other regions where lakes and glaciers co-existed, such as Tibet or the Rocky Mountains.

This article published in Science Advances presents a paleo-precipitation map for a given and limited time period (over 1000 years) 15 500 years ago. A similar transient approach between 18 and 10 kyr is now applied. This future work will permit to better understand how and at which speed the global climatic oscillations impact the Tropical Andes.

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