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## 10 000 years of Andean glacier melt explained

IRD researchers and their partners<sup>1</sup> have succeeded in explaining 10 000 years of glacial melt in the Andes through work recently published in *Nature*. They showed that the Telata glacier in Bolivia retreated 3 km during the Holocene epoch covering that time and continuing in the Present. This regression was linked mainly to a 3°C increase in atmospheric temperatures resulting from warming of the tropical Pacific Ocean, itself a response to a rise in insolation<sup>2</sup> in the tropics.

The research team used a recent dating method to make the first reconstitution of the chronology of these ten millennia of glacier fluctuations. The technique entails measuring the concentration of chemical elements which build up in rock contained in moraines – accumulations of rock debris deposited by the glacier after the ice disappeared. The glaciologists then applied past-climate models to find the exact causes of Telata glacier's variations in volume.

This research moreover indicated a strong retreat of the tropical glaciers since the beginning of the industrial era. It highlights the high vulnerability of these masses of ice – perched high at 5000 m altitude where warming will probably be at its most intense.



Telata glacier, in the Cordillera Real of Bolivia, has retreated 3 km in 10 000 years, 2 km of which since the early 19<sup>th</sup> Century.

Melting of the glaciers has been widely demonstrated in various parts of the world, but the particular case of tropical glaciers is still poorly known. Most of them are situated in the heights of the Andes, often perched high at over 5 000 m altitude. They are extremely sensitive to climate warming owing to their tropical location and their elevation. Many observations indeed prove that they have been receding substantially for several decades\*. However, to identify the exact causes of this retreat, it is important to trace the history of these ice masses back over a much longer period of time.

### Faster melting began 200 years ago

In this context, IRD scientists and their research partners<sup>1</sup> have built up the first reconstitution of a glacier's history over the past 10 000 years, the Holocene geological epoch. Recently published in the journal *Nature*, this work was conducted on the

Bolivian glacier Telata, about 30 km north of La Paz, the capital. Results showed that in 10 000 years the glacier surface shrank by more than 90% and that the ice front had receded by 3 km. This regression started very slowly, but accelerated strongly from the early 19<sup>th</sup> Century retreating another 2 km between 1820 and today.

### Evidence of past positions

On this high-altitude site, the scientists focused their attention on deposits consisting of rock accumulations left behind by the glacier. These deposits, moraines, give valuable evidence of past positions of the glacier front. Their abundance and excellent state of conservation make Telata an exceptional unique site in the tropics. This location provides an almost continuous record of the successive stages of the glaciers. To retrace the phases of the front's retreat and advance, the research team determined the age of these deposits and their chronology,

using a recently developed dating method. This technique rests on measurement of the concentration of elements –in this particular case  $^{10}\text{Be}$ – beryllium-10– in the rocks contained in the moraines. When the rock is not covered by the glacier, the cosmic radiation<sup>3</sup> striking its surface prompts a nuclear reaction which triggers the formation of certain minerals of these elements –in this case quartz. Measurement of their concentration by accelerator mass spectrometry<sup>4</sup> allowed determination of the duration of the rock's exposure since the glacier retreated.

### The ocean warms up, the glaciers melt

The team then determined the causes of the ice melt on Telata. For different past positions of the glacier, they linked the volume of ice to the temperatures and precipitations which prevailed at the time. Their calculations showed the retreat to be related above all to atmospheric warming of about 3°C over the entire Holocene period. This appears to be due to a rise in sea surface temperature of the tropical Pacific Ocean over the course of these ten millennia owing in turn to a gradual increase in the quantity of solar radiation received at the Earth's surface –commonly called “insolation”. However, although temperatures have risen substantially, precipitation

was shown by numerical simulations with climate models not to have altered significantly enough over these 10 000 years to influence the glacier's progress.

The Telata ice masses therefore waxed and waned over geological time in close correlation with the tropical Pacific. Glaciologists already knew that the current melting of the Andean glaciers was related to this ocean, but they had hitherto obtained no data on the existence of this relation in the past.

This investigation, tracing back the history of tropical glaciers, emphasizes how extremely vulnerable they will be in the coming decades. Future climatic projections for the Andes predict a temperature rise of around 4 to 5°C by 2100 –the highest in the world. More intense warming than that observed for the whole of the Holocene, which has already led to strong retreat of Telata glacier.

*\* see bulletin n°127 - Petits glaciers des Andes tropicales : une disparition annoncée et n°96 - L'humidité fait fondre les glaciers tropicaux*

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1. This research work was conducted in partnership with CNRS and Université Joseph Fourier, Grenoble and an American researcher of the University of Albany.
2. Amount of solar radiation received.
3. Cosmic radiation is the flux of particles which move throughout the Universe at nearly the speed of light.
4. The national instrument used for this research is the ASTER mass spectrometer located at CEREGE in Aix en Provence.



Moraines (left, foreground, rocky deposits) provide ways of reconstituting a glacier's history (here at Charquini). Meteorological measurements (right, at Zongo) used to calibrate climate models, have allowed correlation of Telata glacier retreat with temperature variations in the course of the Holocene.

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