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NERC SCIENCE OF THE ENVIRONMENT

Timing and magnitude of late glacial and Holocene climate change in the tropical Andes, Peru. Ref IAP-16-16

Newcastle University, School of Geography, Politics & Sociology

In partnership with CASE partner: NERC Isotope Geosciences Laboratory, British Geological Survey; University of Cantabria, Santander

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Overview

Elucidating the role of the tropics in global climate change is essential to constraining future climate trajectories. In particular, the relationship between climate change in tropical and extra-tropical regions, and the role of 'tropical' forcing in causing ice ages, and abrupt climate variability. As the majority of Earth's energy is received at the tropics the region has huge potential to trigger and/or amplify climate change (Pierrehumbert, 2000). There is now compelling evidence for major shifts in tropical temperature and precipitation during the Holocene and over the last few millennia, and this has challenged the typical view of tropical climate stability during this time. However, the timing, magnitude and expression of these climate perturbations are highly variable, especially across South America (e.g. Rodbell et al., 2009; Smith et al., 2005, 2008).

Lake sediments are widely accessible natural archives of environmental change in the Andes, and they have the potential to provide insights into both long- (millennial) and short-term (decadal) changes in climate. In the tropical Andes, palaeolimnological records have provided evidence of changes in the El Niño Southern Oscillation (ENSO), palaeohydrology and South American monsoon; demonstrating that climate is highly dynamic, and modulated by both Pacific and Atlantic Oceans.

The PhD project will target a formerly glaciated region in northern Peru at ~5°S. The student will generate multi-proxy lake sediment records to track ENSO variability over the last 2,000 years, and to provide evidence of palaeohydological changes since deglaciation. As fundamental questions remain about climate variability in the tropical Andes, especially synoptic-scale mechanisms that cause changes in hydroclimate, the studentship will address the following:

1. What is the timing and frequency of ENSO-driven shifts during the late Holocene?

2. What is the magnitude of centennial and millennial-scale climate events since the deglacial?
3. What are the spatio-temporal linkages between ENSO, equatorial Pacific sea surface temperatures and North Atlantic climate variability?

Methodology

Field expeditions will involve two seasons in 2018 and 2019, and will be undertaken in northern Peru. The key objective of the first field season will be to target specific lakes and identify appropriate locations for coring, as well as undertaking limnological investigations e.g. temperature, conductivity, nutrients, stable isotopes. A joint geophysical survey (swath bathymetry, seismic sub-bottom profiling, ground penetrating radar) will be undertaken on lakes and wetlands at the site. These data will be acquired and processed in collaboration with a parallel PhD project, investigating glacial geomorphology of the region. Results will help identify sediment packages within the lake, and suitable coring locations.

Short cores will be collected during the first field season to establish suitable proxies in the lakes over the last 2000 years. In the second field season, long cores stretching back through the Holocene and deglacial will be taken and integrated with previous short cores. Lake sediment analysis will focus on documenting fluxes in clastic and organic material using well-established sedimentological and geochemical techniques (total carbon, organic and inorganic carbon, biogenic silica, magnetic susceptibility, grain size, XRD, scanning μ-XRF, colour reflectance, stable isotopes). Chronology for the cores will be established using radiometric dating (^{210}Pb/^{137}Cs) and radiocarbon (^{14}C).

Timeline

Year 1
- Review of existing lake sediment records from the Andes.
- Planning and organisation of field expedition 1.
- Field expedition – Season 1 (Jan 2018).
- Multi-proxy analysis of short sediment cores.
- Establish ^{210}Pb/^{137}Cs-based chronology.
- Processing and analysis of geophysical data.

Year 2
- Interpretation and synthesis of data from short cores to reconstruct environmental change in northern Peru over the last 2000 years.
- Planning and organisation of field expedition 2.
- Field expedition – Season 2 (Jan 2019).
- Multi-proxy analysis of long sediment cores.
- Establish preliminary radiocarbon age model.

Year 3
- Refine radiocarbon chronology.
- Complete outstanding multi-proxy analysis.
- Interpretation and synthesis of data from long cores to reconstruct environmental change in northern Peru since deglaciation.
- Present results at an international conference.
- Begin write-up of thesis.

Intended outputs from the PhD are:

1. A reconstruction of environmental change in northern Peru over the last 2000 years.
2. Post-glacial climate evolution of northern Peru based on multiple proxies.
3. An evaluation of the linkages between the El Niño Southern Oscillation and lake sediment records in northern Peru.

Training & Skills

The student will be trained in a broad range of palaeolimnological and geophysical techniques. The student will receive bespoke training in field skills e.g. limnology and sediment coring, and laboratory skills in working with lake sediments e.g. core description, inorganic geochemistry, sedimentology, and chronology. In-house training will be provided in geophysical data acquisition and processing, gaining skills in software packages such as ReflexW and Opendtect. They will also have the chance to attend NERC-recognised short courses on stable isotope analysis, radiocarbon dating and Bayesian chronological analysis, and statistics for geoscientists.

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