Past cultural adaptation to abrupt Holocene climate change in the Peruvian Andes

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During the Holocene, global palaeoclimate reconstructions based upon a variety of proxy data have identified periods of abrupt millennial-centennial scale climate change: 9000-8000, 6000-5000, 4200-3800, 3500-2500, 1200-1000 and 600-150 years ago. In the Peruvian Andes, despite a growing body of high resolution palaeoclimate (derived from marine, ice and cave speleothems) and palaeoecological (derived from sub-fossil biological records, especially pollen, diatoms and charcoal) data the impact of these events on the environment and human civilizations remains poorly understood. Today, global warming is already causing significant changes in agricultural productivity and water availability in these mountain ecosystems, enhancing poverty and leading to out-migration from rural areas. Enhanced adaptation strategies to mitigate the impact of climate change are urgently needed to avoid major socio-economic problems.

Figure 1: Glacial landforms and lakes in the Cordillera Viuda, Peruvian Andes.

In the recent past, combined palaeoclimatic and palaeo-socio-economic data tentatively suggest that abrupt climate changes at, for example, at 1400-1000 cal. BP and at 650 cal. BP led to the implementation of highly sophisticated, widespread adaptive strategies including technological innovation in water management and agricultural terrace construction. Palaeoenvironmental and palaeoeconomic data also tentatively suggest that vegetation communities and agro-pastoral farming practices changed as a response. Given that the human history of the Peruvian Andes extends back to the Early Holocene, the region presents an excellent opportunity to investigate the resilience and adaptive capacity of human communities and their mountain ecosystems to abrupt climate change events. The following research questions will be addressed: What was the precise timing and nature of abrupt climate change in the Peruvian Andes during the Holocene, based upon lacustrine and peatland records [integrated with palaeoclimatic records from marine, ice and cave speleothems]? What was the cause of these abrupt climate changes? What was the impact on mountain ecosystems and the palaeoeconomy? Is there evidence for social and technological changes including water management infrastructure and cultural practices that can be precisely correlated with these climate and environmental changes?

The approach to addressing these questions will be unique in the Peruvian Andes by coupling palaeoenvironmental and palaeoeconomic records with agent-based modelling to advance our understanding of climate-environment-human interrelationships by improving understanding of the timing of key events, and quantifying the impact of climate change on the landscape, environment and people. To achieve these objectives, the project will involve a mixed method approach including fieldwork in the Peruvian Andes to collect continuous, undisturbed sediment core samples from lakes and peatlands (*bofedales*) in three climatically distinct zones - Cordillera Blanca (northern), Cordillera Viuda (central), and the Cordillera Huanzo (southern). Laboratory analysis of the geochemical and sedimentary properties using ITRAX (NOC Southampton), X-ray particle size analysis and mineral magnetics will act as indicators of landscape erosion and lake water level change, whilst sub-fossil pollen grains and spores, non-pollen palynomorphs and testate amoebae will be used as indicators of vegetation succession, land-use change, and palaeohydrology. The application of testate amoebae analysis is new in a Peruvian context and will involve the development of a new transfer function. Age modelling based on a high-resolution radiocarbon chronology using Oxcal/Bacon will enable spatial and temporal correlation of events. Critical to the research is integration of secondary data from archaeological sites that will enable correlation with major changes in regional socio-economic development and cultural history and will enable palaeo-agent-based modelling to explore environmental and socio-economic responses to climate change. Models will be developed in the Netlogo programming environment to assess the implications of the combination of climate changes and resource strategies for the distribution and structure of humans in the landscape. We will use existing palaeoclimate reanalyses, in conjunction with information derived from the lakes and wetlands to provide climatic boundary conditions, overlain on high-resolution topography and land cover.

Training opportunities:

There will be numerous training opportunities during the PhD including fieldwork in Peru, supervisor training in pollen and testate amoebae analysis, and attendance at training workshops in both techniques offered by the Integrated Microscopy Workshop at the University of Reading (organised by SAGES). Training courses offered by NERC at the Oxford University radiocarbon dating laboratory in age modelling, and at BOSCORF, National Oceanographic Centre, Southampton in ITRAX geochemical analysis. Attendance at seminars in Peruvian archaeology offered by the Peruvian Society and Institute for Latin American Studies in London to develop wider knowledge in the cultural history. Attendance at webinars organised by the partnership ‘Food Production and Climate Resilience in Peru: Past, Present and Future’ (https://foodclimateperu.com/) with colleagues from the UK, Peru, Colombia and Argentina that will provide valuable insights into themes relevant to the project. Supervisor and research group discussions and seminars related to agent-based modelling, and online course in agent-based modelling.

Student profile:

This project would suit a student with a quantitative background and a keen interest in past climate change, and the impact of climate change on the environment and human communities. Some knowledge of basic computer programming is desirable, e.g. Python, R, Matlab, NetLogo. Similarly, some knowledge of palaeoecological and/or geochemical techniques, including field methods, would be desirable, especially pollen, testate amoebae and ITRAX. A degree in physical geography, biology or meteorology would be appropriate.

https://research.reading.ac.uk/scenario/