Climate variability and societal responses in Pre-Columbian South America

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Photograph of agricultural terraces in current use in rural communities in the Peruvian Andes (Singarayer, 2017)

Global warming is causing significant changes in rainfall, water availability, and agricultural productivity across tropical South America, increasing poverty and leading to migration out of rural areas. Enhanced adaptation strategies to alleviate the impact of climate change are urgently needed. Pre-Columbian societies across the continent responded to periods of abrupt climate change over the last two millennia with a range of strategies that are relevant to issues today (e.g., terracing, irrigation canals). Archaeological and palaeoclimate records suggest relationships between agricultural systems, societal structures, and resilience to climate change events. However, the datasets over tropical South America on which this understanding is derived are sparse.

Over recent years the number of archaeological records over tropical South America has increased significantly. These demonstrate widespread complex societies and large populations prior to European colonisation. The number of palaeoclimate records has also increased, but remains thinly and unevenly spread over the continent, making it challenging to constrain the timings and the spatial patterns that likely impacted past societies. This project addresses the important questions of: what were the likely spatial and temporal patterns of climate change over pre-Columbian tropical South America? Do past climate events correlate with palaeoenvironmental change and societal transformations of culture and/or technology? What mechanisms driving climate change are most relevant to societal impacts?

The project will use multiple methodologies to address these questions. To get a better understanding of the spatiotemporal climate patterns over tropical South America the project will use and develop an existing palaeoclimate ‘reanalysis’, which incorporates past climate proxy data with models to produce a physically consistent time series of climate variables. New records will be incorporated and sensitivities to the climate model and prescribed land cover will be explored. Comparing recent syntheses of regional archaeological and

palaeoenvironment records with the climate reanalysis, the student will be able to investigate how the temporal patterns of climate variables (such as rainfall, soil moisture, and drought index) correlate with environmental and cultural change. The project will explore how sensitive regional environments may have been and how different land-use systems may have influenced the resilience of different pre-Columbian cultures to climate events.

The student will also have the exciting opportunity to look more closely at past societal responses to climate change through 'agent-based' simulations of pre-Columbian cultures. Agent-based models (ABMs) simulate the actions and interactions between individuals or groups and their environments to understand the behaviour of a system. This approach allows us to reduce the assumptions we make about the timing and reasons for climate change impacts. Several such models of South American cultures are currently in development in our research group and can be developed to respond to climate changes from the climate reanalysis to explore how various technological and social responses lead to different potential outcomes and resilience.

Training opportunities:
There will be numerous training opportunities during the PhD, including attending international summer school in palaeoclimatology (Italy) and the National Centre for Atmospheric Sciences Climate Modelling summer school (UK). There will be opportunity for attendance at seminars in the archaeology of South America 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 climate modelling and agent-based modelling. There may be opportunity to join fieldwork in Peru or Bolivia, although this is not necessary for the project itself but useful for understanding the local environmental history. The student will be able to attend training in agent-based modelling, both internally in the research group and via an international summer school, should they choose to explore this option in their research.

Student profile:
This project would suit a student with a quantitative background in physical or environmental sciences with a keen interest in past climate change, and the impact of climate change on the environment and human communities. Knowledge of basic computer programming is desirable, e.g. Python, R, Matlab, NetLogo. A background awareness of numerical/statistical techniques is desirable. Knowledge of climatology, palaeoecology, biogeography, and modelling would be advantageous. At least a 2.1 BSc degree in a physical or environmental science is required.

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