Reconstructing seasonality in continental vegetation and climate in response to Indian Monsoon variability

Vegetation, aridity, Plio-Pleistocene, Monsoon, paleoclimate

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Collaborator: Firoze Quamar (BSIP, India), Oscar Romero (Bremen), Marci Robinson (USGS)

Yes ☒
No ☐

Project Highlights:
• Reconstructing vegetation (pollen) and aridity (charcoal) variability in response to changing Indian Monsoon strength across the Pliocene
• Training in multi-proxy climate reconstructions and data-model integration
• International collaboration with IODP expedition (353) scientists

Overview (including 1 high quality image or figure):

The Indian Monsoon, a subsystem of the Asian Monsoon, is one of the best examples of coupling between solid Earth and atmospheric processes. Climate and vegetation are known to be interlinked but how vegetation impacts climate, and vice versa, is poorly constrained. A shift from C₃ to C₄ biomes in response to the development of the seasonal summer monsoon precipitation in the beginning of the late Pliocene has been observed in Australia [1], which is asynchronous with observations from Asia, Africa and Americas. Records from the Indian Monsoon region indicate precipitation and vegetation linkages during the late Miocene [2] and Pleistocene glacial-interglacial intervals [3], however, orbital controls on vegetation, aridity and rainfall in the Pliocene have not been investigated. Our ongoing work indicates a general increase in Indian Monsoon strength linked to intensification of Northern Hemisphere Glaciation (iNHG), as well as long term evolution since 10 Ma, which are yet to be coupled with vegetation and fire history. The International Ocean Discovery Programme expedition 353 Sites, proximal to major river system output in the Bay of Bengal, provides a unique opportunity to study climate and vegetation coupling in a well dated sedimentary archive. This project, therefore, will apply multi-proxy approach to reconstruct vegetation, aridity and seasonality of monsoon runoff on a variety of time scales (e.g., 500 yr – sub-millennial and 2 kyr – sub-orbital) from the core Indian Monsoon region of the Bay of Bengal. New records from this project will help evaluate changing vegetation pattern during the warm intervals (interglacials) of the Pliocene and the Pleistocene and evaluate relative importance of drivers of vegetation using a data-model integration approach [4]. This project will help address some of the key questions: how were vegetation and Indian Monsoon rainfall patterns linked across the evolving boundary conditions of the Plio-Pleistocene? What is the relative importance of drivers of vegetation in the monsoon region? How are Indian Summer Monsoon vegetation dynamics linked to the other tropical regions? New records generated in this project will be compared with published contemporaneous terrestrial records to identify the nature of the linkage between the Indian, Asian and global Monsoons.
Figure 1: This project will utilise samples from the Bay of Bengal (IODP Exp. 353, Sites U1445, U1447/48 and U1444).

Methodology:
The method will include processing of ocean sediments to extract pollen, dinocysts and charcoal. These samples will be processed following method established at the OU [5]. We will obtain data on pollen and spore assemblages and assessment of microscopic and macroscopic charcoal. These data will be used to determine patterns in both terrestrial vegetation and local marine conditions (dinocysts). Pollen work will also inform vegetation changes that will provide useful information on our ongoing work on organic geochemical proxies ($\delta^{13}$Cwax) from the same sample and/or measure targeted samples through a national facility grant.

Training and skills:
The student will receive specific training on pollen and charcoal preparation at the Open University by Dr Mander. This project will benefit from an ongoing collaboration with regional pollen expert (Dr Quamar) and will primarily utilise continuous sedimentary successions from the last interglacial and the Plio-Pleistocene of IODP Expedition 353 (samples are available from sites U1445, U1447/48 and U1444). Finally, a data-model integration will help assess the drivers for vegetation change (Dr Holden).

Specific skills that will be acquired during this project include:
- Pollen preparation and taxonomic techniques
- Data handling and interpretation from a wide variety of sources
- Scientific communication through writing, poster and oral presentations to academic and non-academic audiences
- Co-supervision on your own devised OU’s master’s project and teaching research methods to A level Nuffield funded summer students.

Partners and collaboration: This project will benefit from international collaborations and networking opportunities with IODP 353 expedition scientists. In particular, there will be collaboration with scientists working on regional pollen (Firoze Quamar, BSIP, India), diatom and
Dinocyst proxies (Oscar Romero, AWI) and planktic foraminifera-based proxies for oceanographic changes (Marci Robinson, USGS) across the Pliocene on the expedition samples.

Possible timeline:

Year 1: Investigate pollen taxa from the study site and familiarise with the pollen composition using available training set and atlas. Obtain training in sample processing on pollen and charcoal. Obtain long term data for the study site. Present data at UK-IODP Annual Meeting.
Year 2: Generate age model data by picking benthic foraminifera of samples from early/mid Pliocene. Process pollen and charcoal samples from targeted orbital cycles of the early/mid Pliocene. Present data at Pal(a)eoPERCS seminar.
Year 3: Finish remaining analytical work, data analyses, and present results at an international conference and write up thesis and manuscripts.

Further reading:


Further details:

Please contact Supervisor (Supervisor@open.ac.uk) for further information and informal discussion about this project.

Applications should include:

- A covering letter that includes:
  - Your motivation to study for a PhD in general
  - Your interest in this project in particular
  - The project-specific skills, aptitude and experience you bring to the project
- an academic CV containing contact details of three references, one of whom should be able to comment on your academic abilities.
- and an Open University application form.
  - If you are living in the UK and have residency rights then use the Home form
  - If you are living abroad then use the International form

Applications should be sent to STEM-EEES-PHD@open.ac.uk by the end of the day on Wednesday 11th January 2023.