EEES Project Proposal Form – 2022 entry

Project Title	**OU13 - Reconstructing vegetation and fire history in response to past Indian Monsoon changes**
Key words	Palaeoclimate, Pliocene, IODP
Supervisory team (including email address	**PI: Pallavi Anand** **Co-I: Luke Mander (OU), Kate Littler (Exeter)** **Collaborator: Firoze Quamar (BSIP, India), Charuta Kulkarni (Independent researcher), Oscar Romero (Bremen), Marci Robinson (USGS)**
Is the PhD suitable for part time study?	Yes ☒ No ☐

Project Highlights:

- Reconstructing vegetation (pollen) and aridity (charcoal) variability in response to changing Indian Monsoon strength over the Early-mid Pliocene
- Training in multi-proxy climate reconstructions
- International collaboration with IODP expedition 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 C_3 to C_4 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 Summer 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 an opportunity to study climate and vegetation coupling. This project, therefore, will apply multi-proxy approach to reconstruct vegetation, aridity and seasonality of monsoon runoff on a variety of time scales (500 yr – sub-millennial, 2 kyr – sub-orbital, or 100 kyr – sub-tectonic) from the core Indian Monsoon region of the Bay of Bengal. New records from this project will be put in context with the continental monsoon climate records [e.g., 4]. These records will help address some of the key questions: how were vegetation, aridity and Indian Monsoon rainfall strength linked? What is the response of vegetation to changing Monsoon precipitation? How are Indian Summer Monsoon vegetation dynamics linked to the other Asian and global Monsoon 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.

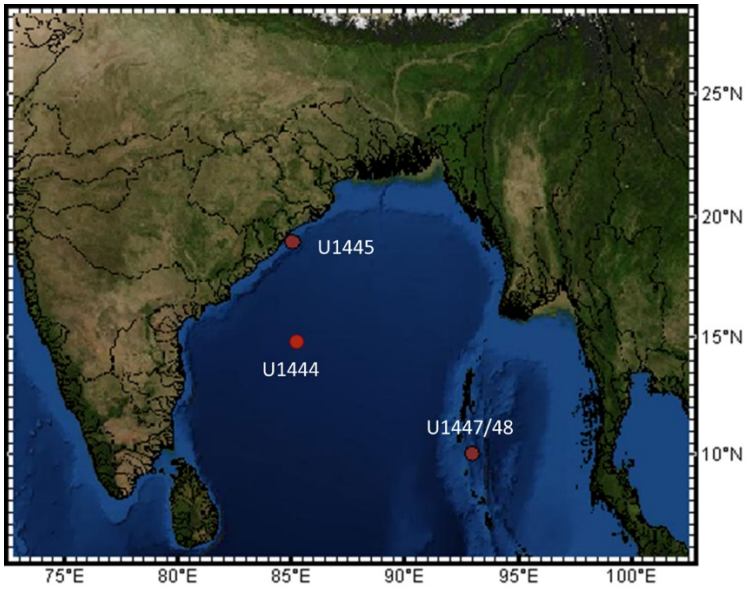

Figure 1: *This project will utilise samples from the Bay of Bengal (IODP Exp. 353, Sites U1445, U1447/48 and U1444).*

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 (δD_{wax}) from the same sample, which is part of other ongoing projects.

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 early–mid Pliocene of IODP Expedition 353 (Sites U1445, U1447/48 and U1444).
The student will receive a diverse set of training courses offered by the OU throughout their PhD.

Specific skills that will be acquired during this project include:

- Cutting edge geochemical 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), planktic foraminifera-based proxies for oceanographic changes (Marci Robinson, USGS), and drivers of monsoon modelling (Phil Holden, OU).

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:

[1] Andrae, J. W. et al. (2018) Initial expansion of C_4 vegetation in Australia during the late Pliocene, Geophysical Research Letters, 45, 4831-4840
[2] Tipple, B. J. and Pagani, M. (2007) The early origins of terrestrial C4 photosynthesis, Annual reviews of Earth and Planetary Sciences, 35, 435-461.
[3] Chen, X. et al (2014) Vegetation history, climatic changes and Indian Summer Monsoon evolution during the last glaciation (36,400 – 13,400 cal yr BP) documented by sediments from Xingyun Lake, Yunnan, China, Palaeogeography, Palaeoclimatology, Palaeoecology, 410, 179-189.
[4] Hazra, T., Spicer, R.A., Hazra, M., Mahato, S., Spicer, T.E., Bera, S., Valdes, P.J., Farnsworth, A., Hughes, A.C., Jian, Y. and Khan, M.A., 2020. Latest Neogene monsoon of the Chotanagpur Plateau, eastern India, as revealed by fossil leaf architectural signatures. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *545*, p.109641.
[5] Kulkarni, C.**,** Finsinger, W., Anand, P., Nogue, S., and Bhagwat, S. A. (2021) Synergistic impacts of anthropogenic fires and aridity on plant diversity in the Western Ghats: Implications for management of ancient social-ecological systems, Journal of Environmental Management, *accepted.*

Further details:

Students should have a strong background in palaeoclimate, and enthusiasm for lab based geochemical methods.

If you're not sure whether your academic background is suitable, please contact one of the supervision team or Olivia Acquah at STEM-EEES-PhD@open.ac.uk. We'd be happy to hear from you.

The successful student will join well-established teams researching in Palaeoenvironmental Change at the Open University and researchers at BGS.

Applications should include:

- An OU STEM application form, downloadable from: OU STEM application
- A CV with the names of at least two referees (preferably three and who can comment on your academic abilities)
- And an Open University application form, downloadable from: Home OU application form (if you are resident in the UK) or an Overseas OU application form (if you are an international applicant).

Applications should be sent to STEM-EEES-PhD@open.ac.uk by **12 noon** on **Friday, 7th January 2022**.