

Project Proposal Form – 2022 entry

Project Title	OU1 - Indian Summer Monsoon variability in response to Pliocene climate
University (where student will register)	The Open University
Which institution will the student be based at?	As above
If other	
Theme (Max. 2 selections)	Climate & Environmental Sustainability <input type="checkbox"/> Organisms & Ecosystems <input type="checkbox"/> Dynamic Earth <input checked="" type="checkbox"/>
Key words	Monsoon, Geochemical proxies, Pliocene, Foraminifera
Supervisory team (including institution & email address)	PI: Pallavi Anand Co-I: Clara Bolton (CEREG), Kate Littler (Exeter University), Phil Holden (OU) Collaborators: Mel Leng (BGS), Marci Robinson (USGS), Masafumi Murayama (Kochi University, Japan)
Is the project co-designed by a student?	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Is the PhD suitable for part time study?	Yes <input checked="" type="checkbox"/> This is a requirement of NERC

Project Highlights:

- Reconstruct first orbital-resolution Pliocene Indian monsoon runoff
- Training in multi-proxy geochemical and micropaleontological reconstructions
- International collaboration with IODP expedition scientists

Overview (including 1 high quality image or figure):

The Indian Monsoon (IM) precipitation is the main seasonal driver of water availability, supporting billions of people. The future projection of mean annual ISM rainfall is highly variable under different warming scenarios and an increase in the frequency of extreme precipitation has been suggested if global mean temperature increases ≥ 3 °C¹. Our ongoing proxy and modelling work suggest multiple competing controls on IM dynamics (precipitation and wind) during the Plio-Pleistocene linked to atmospheric carbon dioxide (CO₂), global cooling, orbital forcing factors and gateway closure². Nevertheless, the past evolution of IM remains elusive since it is grossly under-represented in Asian monsoon palaeoclimate proxy records. This project aims to produce new proxy records to test competing forcing factors affecting IM dynamics during the early to mid-Pliocene (3 to 5 Ma), capturing the prevailing warm, high atmospheric CO₂ conditions and gateway closure³.

This project will apply a multi-proxy approach to reconstruct ISM rainfall/runoff, seasonality of monsoon rainfall/runoff and marine productivity in response to ISM wind variability on orbital timescales from the core ISM region of the Bay of Bengal (BoB). The selected International Ocean Discovery Programme (IODP) sites boasts from X-Ray Fluorescence (XRF) elemental ratios and

foraminifera assemblage data (collaborator Robinson). New records from this project will be compared with published monsoon and climate records to identify the nature of the linkage between Asian Monsoon subsystems and global climate. This project will primarily utilise continuous sedimentary successions from the BoB (IODP Expedition 353, Sites U1444, U1445 and U1443 and legacy ODP site 722 in the Arabian Sea) to address some of the key questions: what is the response of ISM dynamics during the evolving boundary conditions of early- and mid-Pliocene? How are ISM dynamics linked to the other Asian and global monsoon regions?

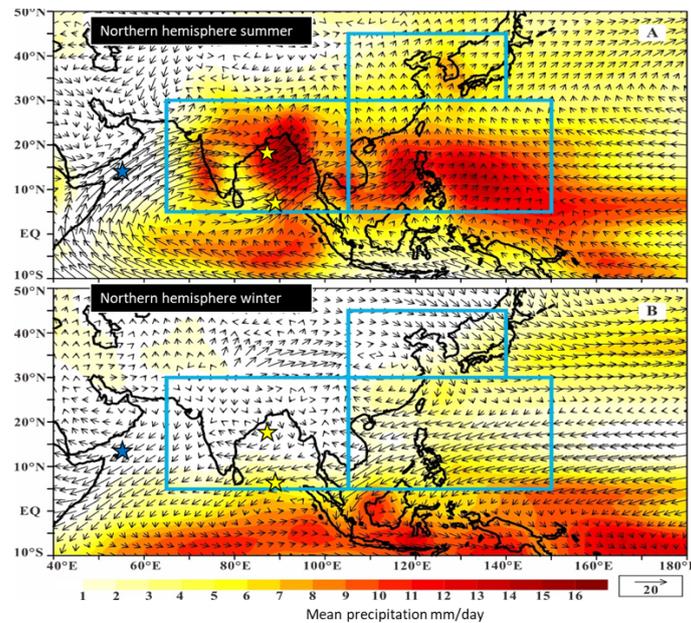


Figure 1: Modern rainfall superimposed with wind stress in Asia during the northern hemisphere summer and winter showing different monsoon regions (modified after Wang et al., 2003). Samples are available from IODP Exp 353 Sites (yellow stars) and ODP site 722 (blue star) for this project.

Methodology:

The deep-sea mud samples will be washed and the coarse fraction (>150 µm) will be used for picking foraminifera for geochemical work (oxygen and carbon isotopes measurements) and shell size from the same sample in the fully equipped laboratories at The Open University. Benthic foraminifer oxygen isotope measurements will be used to extend the ongoing work on Pliocene stratigraphy. Tooth-pick samples will be used for obtaining coccolithophore assemblage data at CEREGE (Dr Bolton). The study sites already have XRF scanned bulk sediment geochemical data which will be coupled with coccolithophore and foraminifera (in collaboration) assemblage data to infer changes in surface water stratification, productivity and runoff in response to monsoon variations. Further, targeted intervals will be used for multi-species planktic foraminifera geochemical (coupled trace element and oxygen isotope) data to reconstruct ISM dynamics. Additionally, planktic foraminiferal geochemical data will be utilised to infer orbital and/or seasonal scale variations in rainfall/runoff and put in context with model output⁴.

Training and skills:

Students will be awarded CENTA2 Training Credits (CTCs) for participation in CENTA2-provided and ‘free choice’ external training. One CTC equates to 1/2 day session and students must accrue 100 CTCs across the three years of their PhD.

In addition, the student will receive specific training on coccolithophore assemblage data collection and interpretation from Dr Bolton (at CEREGE) and work closely with collaborators.

The student will receive project specific training with supervisors (PA and PBH) and additional OU training.

Specific skills that will be acquired during this project include:

- Nannofossil assemblage and geochemical analyses
- 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 (including CASE):

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 the Pliocene for stratigraphy, foraminifera assemblage (Marci Robinson, USGS) and productivity proxies (Emmeline Gray, OU).

COVID-19 Resilience of the Project:

We will have a binocular microscope available for student to work from home. Lab protocols video will be available for online training and support via skype/teams. Also, we have a proven online method for training student for foraminifera taxonomy which we will continue to use for training if covid restrictions continue. The project boasts from availability of washed samples, equipment/microscope to take home and online training for washing and taxonomy, providing mitigations for covid restrictions. Once the samples are picked, it will be delivered for oxygen isotope measurements at the British Geological Survey following OU risk assessment for travel.

Possible timeline:

Year 1: Obtain training in sample processing of core material for microfossils (taxonomy), inorganic geochemical and stable isotope techniques. Generate benthic oxygen isotope stratigraphy and coccolithophore productivity data and interpret together with existing XRF data. Present at UK-IODP annual meeting.

Year 2: Prepare a manuscript based on age model, productivity and XRF data. Generate planktic geochemical data to support preliminary observations (yr 1) from the BoB sites. Present geochemical data at the Geochemistry Research in Progress meeting or Palaeopercs 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. Bhowmick, M. Sahany, S., and Mishra, S. K. (2019) Projected precipitation changes over the south Asian region for every 0.5C increase in global warming, Environmental Research Letters, 14, <https://doi.org/10.1088/1748-9326/ab1271>.

2. Thomson., J., Holden P., Anand, P., Harris, NWB, Porchier, C, and Edwards, N. (2021) Tectonic and climatic drivers of the Asian Monsoon evolution, *Nature Communications*, 4022 (12), doi.org/10.1038/s41467-021-24244-z
3. Dowsett, H. J., Robinson, M. M., Stoll, D. K., Foley, K. M., Johnson, A. L. A., Williams, M. and Riesselman, C.R. (2013) The PRISM (Pliocene palaeoclimate) reconstruction: time for a paradigm shift, *Philosophical Transaction of Royal Society*, 371, p. 20120524
4. Nilsson-Kerr, K., Anand, P., Holden, P. B., Leng, M. J., and Clemens, S.C. (2021) Dipole patterns in tropical precipitation were pervasive across landmasses throughout Marine Isotope Stage 5, *Communications Earth and Environment*, 2, doi.org/10.1038/s43247-021-00133-7

Further details:

Please contact **Pallavi Anand**, pallavi.anand@open.ac.uk for further information.

Applications should include:

- an academic CV containing contact details of three academic references
- a CENTA application form, downloadable from: [CENTA application](#)
- 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 must be sent to STEM-EEES-PHD@open.ac.uk by Friday 7th January 2022 (12 pm, noon)