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High-frequency Variations in the Indian Ocean Dipole During the Past Millennium Reconstructed from East African and Indonesia Lake Sediment Cores

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Abstract The Indian Ocean Dipole (IOD) is a natural mode of coupled ocean-atmosphere variability in the equatorial Indian Ocean that affects the lives of billions of people in Africa and Asia. During positive IOD events, the western Indian Ocean warms while the east cools, triggering extreme flooding and drought in East Africa and Indonesia, respectively. Observational data indicate that the IOD has varied at interannual to decadal time-scales during the 20th century, and investigations of East African paleoclimate suggest that the IOD plays a key role in past climate variability on orbital to decadal time-scales. However, reconstructions of the IOD only cover the past ~150 years, too short to investigate decadal IOD variability and its role in controlling the duration and intensity of high-frequency tropical climate variations.

We propose to reconstruct decadal variability of the Indian Ocean Dipole during the last millennium by producing new, high-resolution, multi-proxy reconstructions of rainfall and its isotopic composition from sediment cores from lakes in tropical East Africa and Indonesia. This research takes advantage of recent findings in climate modeling, stable isotope climatology, organic geochemistry, and fieldwork in East Africa and Indonesia that have: A) Shown that East Africa and Indonesia experience large and antiphased changes in the isotopic composition of rainfall (δprecip) during Indian Ocean Dipole events; B) Demonstrated that long-chain fatty acids preserved in lake sediment record the isotopic composition of regional precipitation, providing direct insight into the atmospheric processes governing rainfall, and C) Provided a unique set of new, often laminated, sediment cores from lakes in East Africa and Indonesia with extremely rapid sedimentation rates, ideal for the high-resolution analysis proposed here.

We propose to generate new, decadal-resolution records of δprecip from East Africa and Indonesia by applying proven organic geochemical tools of hydrogen isotopic analyses of organic biomarkers (specifically terrestrial leaf waxes) to radiometrically-dated sediment cores from multiple lakes in East Africa and Java, Indonesia. Our new datasets will be directly compared to assess antiphased variability in the IOD's two centers of action, providing a direct reconstruction of decadal variability in δprecip related to the IOD and climate in these two regions. We will investigate and calibrate these records through both empirical comparison to IOD indices during the late 19th and 20th century, and using simulations from isotope-enabled climate models to generate a millennium-long, decadal resolved record of the IOD.

This research intersects several areas of emphasis of the NOAA paleoclimatology program. Our overarching goal is to extend the observational record of the IOD across the past 1,000 years to investigate its long-term variability, trends, and its role in controlling extreme, decadal-scale rainfall events in tropical East Africa and

Indonesia. This work will advance our understanding of 'natural modes of variability and their role in historical extreme events' in two densely inhabited regions with economically vulnerable populations. Our work will also test the ability of models to simulate forced and unforced changes through comparisons of simulations from isotope-enabled general circulation models to our reconstructions.