An El Niño Mode in the Glacial Indian Ocean

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Despite minor variations in sea surface temperature (SST) compared to the other tropical oceans, coupled ocean-atmosphere dynamics in the Indian Ocean cause widespread drought, wildfires, and flooding across the densely populated regions flanking its rim. Currently, it is unclear whether mean climatological changes in the Indian Ocean can support stronger seasonal and year-to-year SST variability, and hence, more intense climatic extremes and associated hazards. This is a pressing issue because state-of-the-art climate simulations are in disagreement regarding how the Indian Ocean will respond to greenhouse warming: whereas some models indicate lesser SST variability over these short timescales, others project strong increases in climate variability and extremes in the future. Unfortunately, the brevity of human-made SST measurements & the vastly different boundary conditions imposed by anthropogenic greenhouse levels preclude using these observations to constrain future trajectories. To address this deficit, in this talk, I will focus on paleoclimate model-data considerations for the Last Glacial Maximum (LGM; 19,000–21,000 years before present), a globally cool state when Northern Hemisphere ice-sheets were at their maximum extent. During this period, the mean climatology of the Indian Ocean was vastly different and could have been conducive to support stronger climate variability. I will present reconstructions of climate variability during the LGM which were generated using oxygen isotope geochemistry in planktic foraminiferal shells, a type of microzooplankton, found in cores from the eastern Indian Ocean. Although planktic foraminifera have been widely used in paleoceanography, we apply a novel method by measuring individual shells (lifespan <1 month) within the LGM sediments to investigate changes in seasonal and interannual climate variability relative to modern conditions. Our results indicate that SST variability was much larger during LGM. In comparing our data with paleoclimate simulations, the increase in year-to-year variance is consistent with the emergence of an equatorial mode of climate variability, which is currently not active in the Indian Ocean but strongly resembles the El Niño phenomenon in the Pacific Ocean. I will explore the dynamics behind this hypothesized "Indian Ocean El Niño" and how it differs from other modes of climate variability which exist today. I will also present results from climate modeling simulations which strongly suggest the possibility of a future activation of an Indian Ocean equatorial mode with continued greenhouse gas forcing. Although the LGM and our future greenhouse world are polar opposites in their mean states, I will show how increases in Indian Ocean SST variability relative to modern conditions are consistent across both of these climates. Finally, I will explore the impacts of an "Indian Ocean El Niño" mode, if it were to arise, on future climate change in the Indian Ocean sector.