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Eccentricity forcing on Tropical Indo-Pacific Ocean Seasonality

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The amount of radiative energy received at the Earth's surface depends on two factors: Earth-Sun distance and sunlight angle. Because of the former factor, high eccentricity cycles can induce the appearance of seasons in the tropical ocean. To describe this phenomenon, we used the Earth System Model IPSL-CM5A2 and its ocean biogeochemistry component PISCES-v2 to simulate Sea Surface Temperature (SST) and Primary Production (PP) with various eccentricity configuration. We performed simulations under six precession configurations at high eccentricity (0.053), and one simulation at the low eccentricity (0.006), representing the two eccentricity extremes of the Quaternary period. The results revealed that high eccentricity induced enhanced seasonal variability in SST, resulting in an annual thermal amplitude of approximately 2.2°C, compared to less than 0.5°C at low eccentricity, in low latitude ocean surface waters. PP displayed inherent seasonality under low eccentricity conditions, which significantly intensified during periods of high eccentricity. Consequently, we found that on long timescales, SST seasonality followed only the eccentricity cycles, while PP seasonality also exhibited variability at precessional scale. We introduce the term "eccentriseasons" to describe distinct annual thermal differences observed in tropical oceans exclusively during high eccentricity periods, leading to a gradual shift of seasons throughout the calendar year. Our findings were further corroborated by coccolithophore proxy records from the Indo-Pacific Ocean, strengthening the validity of the simulations. These results have significant implications for understanding climatic phenomena in low latitudes affected by seasons, including the El Niño-Southern Oscillation and monsoons.