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Reef productivity and preservation during the Late Neogene

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During the glacial-interglacials cycles that prevailed during Plio-Pleistocence times, the pace of sea level oscillations exerts a major control on coral reef growth and expansion. We designed a numerical model to quantify reef productivity and carbonate preservation that accounts for sea level oscillations, reef growth, erosion and subsequent geomorphological carving. We carried out a parametric study of a variety of processes (reef growth, erosion, local slope, uplift and subsidence, relative sea level, etc) towards a probabilistic analysis of reef productivity and carbonate production. We further test the effect of the frequency and amplitude of sea level oscillations using sea level curves derived from both the 18O isotope record of past sea level change and synthetic sinusoidal sea level curves. Over a typical climate cycle, our model simulations confirm that the rate of sea level change is the primary controlling factor of reef production, as it modifies the productivity by several orders of magnitude. Most importantly, reef productivity increases during periods of sea level rise, and decreases during sea level stands, while conversely, the morphology records the opposite in a misleading fashion: Reef terraces expand during sea level stands due to the joint effects of erosion and patient reef growth at a stationary level until the accommodation space is filled up. On the long-term, over the Plio-Pleistocene period, vertical ground motion also significantly alters the production: moderate uplift or subsidence can boost reef productivity up to tenfold with respect to a stationary coastline. Last, the amplitude and frequency of the sea level oscillations (typically 40 kyrs vs. 100 kyrs periods) moderately impact reef productivity. These results can be ultimately converted into estimates of carbonate production and carbon sequestration during the Late Neogene, provided relative sea level is documented in the tectonically agitated intertropical zone.