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Middle Miocene climate rhymths: From “Greenhouse“ to “Icehouse“

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About 13.9 million years ago, the Earth’s climate cooled dramatically after an extended period of relative warmth. This key transition in Earth’s climatic and biotic evolution, which marked the final stage of stepwise Cenozoic cooling, remains one of the most enigmatic episodes in Earth’s Cenozoic climate history. Perhaps the most striking feature of this extraordinary interval is the long-lasting positive carbon-isotope excursion (the “Monterey Excursion” of Vincent and Berger, 1985), which started at $\sim$ 16.3 Ma during global warming, and ended at $\sim$ 13.5 Ma following major expansion of the Antarctic ice-sheet. We present astronomically-tuned multiproxy (benthic and planktic stable isotopes, B isotopes and Mg/Ca paleothermometry) climate records (12.7-16.6 Ma) in two continuous sedimentary successions from the northwestern and southwestern Pacific (ODP Sites 1146 and 1237), which shed new light on middle Miocene paleoceanography and climate evolution. The “Monterey” carbon-isotope excursion overall consists of seven 400 kyr sub-cycles, showing a $\sim 40 \pm 20$ kyr (95 % C.I.) phase lag with the long eccentricity period. Superposed on these low frequency oscillations are high frequency variations (100 kyr), which follow the amplitude modulation of the short eccentricity period. In contrast to δ^{13}C, the δ^{18}O signal also shows significant power in the 41 kry band and closely tracks the 1.2 Myr modulation of the obliquity period. Our data document that glacial expansion at $\sim$ 13.9 Ma was coincident with a two-stepped decline in ocean acidity and a fundamental re-organization in Pacific circulation at the onset of the most pronounced global δ^{13}C increase.