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Early to middle Miocene climate evolution: New insights from IODP Sites U1335, U1337 and U1338 (eastern equatorial Pacific Ocean)

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The lower to middle Miocene ($\sim$20 to 13 Ma) carbonate-rich sedimentary successions recovered at Integrated Ocean Drilling Program (IODP) Sites U1335, U1337 and U1338 allow unsurpassed resolution over the Climatic Optimum (16.9-14.7 Ma) and the transition into a colder climate mode after 13.9 Ma with re-establishment of permanent Antarctic ice sheets. High-resolution (1-10 kyr) stable carbon (δ^{13}C) and oxygen (δ^{18}O) isotopes of well-preserved epibenthic foraminifera (*Cibicidoides mundulus* and *Planulina wuellerstorfi*) from these three sites show that the Climatic Optimum was characterized by high-amplitude climate variations and intense perturbations of the carbon cycle. Episodes of peak warmth coincided with transient shoaling of the carbonate compensation depth and enhanced carbonate dissolution in the deep ocean. The U1335 and U1337 records additionally reveal that the rapid global warming and/or polar ice melting event, marking the onset of the Climatic Optimum at $\sim$16.9 Ma, was coupled to a massive increase in carbonate dissolution, indicated by sharp drops in carbonate percentages and accumulation rates and by the fragmentation or complete dissolution of planktonic foraminifers. After $\sim$14.7 Ma, stepwise global cooling, culminating with extensive ice growth over Antarctica at $\sim$13.8 Ma, coincide with enhanced opal and benthic foraminiferal accumulation rates, suggesting that increased siliceous productivity and organic carbon burial may have contributed to CO_2 drawdown. Integration of age models derived from orbitally-tuned, high-resolution isotopes, biostratigraphic data and magnetic reversals allows further constraints on the temporal sequence of events and helps unravel the drivers of early to middle Miocene climate variations.