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Eccentricity-paced ice sheet variability and obliquity-driven bottom-water changes during the Oligocene-Miocene

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Variations in solar insolation exert a fundamental control on the high-latitude climate–cryosphere system. Controversy, however, exists about the relative importance of orbital eccentricity versus axial tilt (obliquity) in driving pre-Quaternary Antarctic ice sheet variability. This problem is particularly acute during the late Oligocene-to-early Miocene interval (Oligo-Miocene, ~27-21 Ma), because several benthic foraminiferal oxygen isotopes ($\delta^{18}O$) records show strong pacing by obliquity, while others primarily show eccentricity pacing. The differences in orbital pacing are impossible to reconcile with the globally congruent imprint of ice volume on benthic $\delta^{18}O$ on orbital time scales. Here we present a new astronomically tuned $\delta^{18}O$ record generated at Integrated Ocean Drilling Program (IODP) Site U1406 (north-western Atlantic Ocean), a key area in modern-day thermohaline circulation. Clear imprints of both obliquity and eccentricity on the $\delta^{18}O$ record are observed at Site U1406 throughout the study interval, irrespective of changes in sedimentation rate. The eccentricity variations at Site U1406 are remarkably similar to those seen in all other $\delta^{18}O$ records, suggesting that eccentricity exerts a strong control on the high-latitude climate–cryosphere system via the modulation of the precession cycle. In contrast, the $\delta^{18}O$ sensitivity to obliquity is globally variable, suggesting the influence of temperature in different bottom-water masses.