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Late Miocene climate and orbital time scale reconciliation from a deep-sea perspective

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The late Tortonian to early Messinian (8-6 Ma) is characterised by a long-term reduction in benthic foraminiferal δ^{18}O, with distinctive short-term δ^{18}O cycles superimposed. Coevally, a permanent –1‰ change in oceanic $\delta^{13}C_{DIC}$, the late Miocene carbon isotope shift (LMCIS), marks the last major permanent shift in the carbon cycle expressed in all oceanic basins, after which near-modern δ^{13}C gradients are established around 6.7 Ma. Accurate age control is crucial to ascertain the origin of the δ^{18}O cyclicity and the LMCIS, as constraining the precise timing of such events can allow temporal and causal relationships to be established between the deep-sea, terrestrial and cryosphere records.

Here, we present the first independent high-resolution chemo-, magneto-, and cyclostratigraphy for the interval between 8.3-6.0 Ma from a single deep-sea site. Generated at equatorial Pacific Integrated Ocean Drilling Program (IODP) Site U1337, our integrated astronomically tuned benthic stable isotope stratigraphy (1.5 kyr resolution) and magnetostratigraphy is suitable to test the current Tortonian-Messinian Geological Time Scale (GTS2012), currently based on astronomically calibrated Mediterranean sections. Between 7.7-6.9 Ma, the new benthic δ^{18}O and δ^{13}C data from IODP U1337 show distinctive obliquity-driven saw-tooth patterns suggesting that high-latitude forcing dominated late Miocene climate dynamics. For the first time, the LMCIS is astronomically calibrated and anchored to the GPTS between Chrons C4n.1n and C3An.2n. Anchoring the LMCIS facilitates comparison with terrestrial records of the C3/C4 vegetation shift, which has been linked to the LMCIS. The astronomically calibrated Site U1337 magnetostratigraphy additionally provides robust ages for polarity Chrons C3An.1n to C4r.1r, with ages changing by 2-50 kyr relative to the GTS2012. The new integrated deep-sea stratigraphy from Site U1337 has potential as a new stable isotope and magnetic polarity reference section for the 8.3-6.0 Ma interval.