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Fingerprinting the climatic heartbeat of the late Miocene

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Accurate stable isotope stratigraphies are fundamental to investigating the influence of orbital forcing on past climate. The global LR04 (Liseicki & Raymo, 2005) and regional Ceara Rise (Wilkens et al., 2017) benthic deep-sea stable isotope stacks have greatly advanced our understanding of Plio-Pleistocene climate dynamics. However, a comparable late Miocene compilation does not exist.

Here, we present the first global late Miocene global benthic $\delta^{18}O$ and $\delta^{13}C$ stacks spanning 8.00-5.33 Ma. The combined chemo- and magnetostratigraphies from IODP Sites U1337 and U1338 represent a Pacific endmember. We then targeted ODP Sites 982 (N), 926 (E) and 1264 (S) to obtain equivalent Atlantic records. We verified existing splices, generated high-resolution isotope data to fill gaps and extend records to 8.0 Ma, and established independent astrochronologies. This approach was crucial to avoid misalignment and aliasing of short-term excursions, as late Miocene benthic $\delta^{18}O$ is notoriously low-amplitude.

The new global late Miocene benthic $\delta^{18}O$ and $\delta^{13}C$ stacks represent a stratigraphic reference section back to 8.00 Ma comparable to LR04. We recognise 68 new $\delta^{18}O$ Marine Isotope Stages (MIS) between 7.7 and 6.5 Ma. The benthic $\delta^{13}C$ stack shows that the late Miocene carbon isotope shift (LMCIS) actually consists of 4 separate shifts, rather than a single –1‰ shift: an initial +0.5‰ shift at 7.9 Ma, followed by three –0.5‰ shifts at ~7.5, 7.1 and 6.7 Ma. These shifts roughly occur every 400 kyr, indicating that eccentricity drove the LMCIS.

Between 7.7-6.9 & 6.4-5.4 Ma, there is exceptional agreement between different sites. A strong 40 kyr heartbeat dominates these intervals, marking the initial onset (~7.7 Ma) and later strengthening (~6.4 Ma) of the late Miocene 40-kyr world. The 40 kyr rhythm is expressed as asymmetric cycles, indicating that these cycles partially represent ice volume variability. The benthic $\delta^{18}O$ stack displays remarkable discordance between 6.9-6.4 Ma, indicating a regionally diverse response to orbital forcing. The Pacific and South Atlantic records are characterised by stable, high $\delta^{18}O$, in contrast to the strong obliquity beat dominating the North Atlantic, indicating this region experienced dynamic climate variability.

With these benthic stacks, we have taken a major step towards accurately fingerprinting the deep-sea heartbeat of late Miocene climate. The final puzzle piece remains improved benthic stable isotope stratigraphies spanning 12-8 Ma. Looking forward, we present upcoming work that will complete this process.