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Revision of the middle Eocene astronomical time scale - new high-resolution stable isotope records between 38 and 49 Ma

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Exploring and understanding causal relationships of climate change during the past 100 million years is strongly dependent on assembling accurate age models of geological archives. Astronomical age models are key to climatic reconstructions, in particular, because they provide high resolution and outstanding accuracy. Establishing a robust astronomical time scale for the middle Eocene between 38 and 48 million years ago has previously proved difficult due to a lack of records of sufficient quality. The middle Eocene has thus remained a 'gap' in the coverage of the Paleogene astronomical timescale. Astronomical tuning of bulk stable isotope and XRF core scanning data from ODP Sites 702 and 1263 spanning the middle Eocene gap was recently challenged by interpretation XRF core scan and magneto-stratigraphic records from IODP Sites U1408 and U1410 (IODP Exp. 342, Paleogene Newfoundland Sediment Drifts, Northwest Atlantic). Notably, the duration of magnetic polarity Chron C20r estimated from the Exp. 342 records is almost 500 kyr shorter in duration than in the 2012 Geomagnetic Polarity Time Scale (GPTS) and more than 600-kyr shorter than astronomically calibrated GPTS estimates derived from the interpretation of data from Sites 702 and 1263.

Here we present new magnetostratigraphic as well as high-resolution bulk and benthic stable isotope records from ODP Sites 1051 (Blake Nose, western North Atlantic) and 1263 (Walvis Ridge, South Atlantic) covering the key middle Eocene interval (38–49 Ma, Chrons 18n to 22n). Our new high-resolution benthic stable isotope record from Site 1263 has an average resolution of 5 kyr encompassing the cooling after the Early Eocene Climate Optimum, the Late Lutetian Thermal Maximum, and the Middle Eocene Climate Optimum in unprecedented detail. These records allow further fine tuning of the astronomical time scale for the middle Eocene.

Both bulk and benthic carbon isotope data from Sites 1051 and 1263 document overall dominance of eccentricity cycles in global carbon cycle dynamics that allow construction of new astronomical age models. For example, we can now demonstrate that the composite Exp. 342 records (from Sites U1408 and U1410) are erroneous resulting partly in incorrect orbital cycle interpretations as well as revealing extensive gaps and disturbed intervals especially for magnetic polarity Chrons C18r and C20r.