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# New astronomical timescale for the Toarcian carbon isotope excursions from Dotternhausen, SW Germany

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The pronounced negative carbon isotope excursion (CIE) that marks the Toarcian Oceanic Anoxic Event, ca 182 Ma, is considered to reflect one of the most dramatic carbon cycle perturbations of the Phanerozoic. Previous high-resolution carbon isotope records of the event have revealed that the CIE occurs in successive steps, which have been interpreted as precession or eccentricity-forced pulses of isotopically light carbon release. These different orbital interpretations imply large differences in the astronomical timescale of the CIE and associated changes in carbon cycling, and thus have fundamental implications for their possible underlying cause(s). In this study, high-resolution (748 datapoints) total organic carbon (TOC) measurements, covering ∼12 m of uppermost Pliensbachian to mid Toarcian marine succession of the Dotternhausen reference section (SW Germany), have been used to reconstruct a new floating astronomical timescale of the Toarcian CIE. Spectral analyses reveal significant cycles of ∼17 cm and ∼50 cm throughout the succession studied, which are interpreted as forced by the ∼37 ka obliquity and ∼100 ka eccentricity cycles, respectively. According to the resulting astronomical timescale, productivity/organic matter preservation was mainly controlled by the obliquity cycle at the studied site, while black shale (TOC>5 percent) deposition lasted more than 2 Ma. A similar, temporally expanded (>2 Ma) interval of black shale deposition is also evident from English, French and Siberian records, suggesting that stressful, poorly oxygenated conditions were not restricted to the CIE but sustained for some considerable time after its onset. Comparisons with available low-resolution organic and carbonate carbon isotope records from the study site indicate that the broad shift towards lighter values at the base of the CIE occurred in less than 2 eccentricity cycles while the whole CIE (including the following positive carbon isotope shift) spans ∼9 eccentricity cycles. Distinct carbon isotope steps towards lighter values at the base of the CIE coincide with 100 ka-cycles, suggesting that these smaller excursions were forced by eccentricity rather than precession cycles. New high-resolution carbon isotope measurements covering the onset of the CIE will be presented to further constrain the shape of these steps and hence the astronomical climate parameter(s) at their origin. These new records will also allow us to constrain the timing of the first CIE previously recorded close to the Pliensbachian-Toarcian boundary at several sites and hence place Toarcian events of carbon cycle perturbation within a robust, high-resolution astronomical timeframe.