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A new chronology and probabilistic assessment of sea-level variability over five glacial cycles

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On geological timescales, changes in sea level give an indication of the global glaciation state. To fully portray how Earth's glaciation state varied in the past, we need to consider the timing and amplitude of sea-level changes during both glacial and interglacial intervals. Ideally, we also need to consider such changes over several glacial-interglacial cycles, so that *i)* any systematic sea-level/ice-volume relationships can be discerned, and *ii)* more reliable estimates of sea-level change rates under different boundary conditions can be determined. While an increasing number of well-dated sea-level records exists for periods within the last glacial cycle, older time intervals are much less represented. For example, available reconstructions of sea level prior to the last interglacial tend to be discontinuous or of low resolution, contain large sea-level uncertainties, or have orbitally tuned chronologies that are biased by assumptions about climate: ice-volume phasings. To address these issues, we have developed a robust, radiometrically constrained timescale for continuous and centennial-resolution records of sea level and rates of sea-level change, over the last five glacial cycles (∼500,000 years). Our method is based on synchronisation of Red Sea dust and relative sea-level (RSL) records to a speleothem δ^{18}O record from Sanbao Cave (China). We have also used Bayesian and Monte Carlo-style methods to assess chronological and sea-level uncertainties, which has resulted in the first probabilistic records of sea level and sea-level change rates for periods before the last interglacial. This provides an opportunity for detailed comparisons with existing sea-level/ice-volume reconstructions, and for validating models of sea-level rise and ice-sheet dynamics. Finally, to illustrate an implication of our new sea-level records, we explored the relationship between natural (pre-anthropogenic forcing) sea-level rise rates and 'glaciation state', where the latter is defined as the past relative to present-day global ice volume. Our results suggest that maximum sea-level rise rates remained below 2 m per century following periods with up to twice present-day ice volumes, while substantially higher rise rates were attained for greater ice volumes.