Inherent characteristics of sawtooth cycles can explain shifts in glacial periodicity

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Around 1 Ma, a major transition in the paleoclimate dynamics took place, as the dominant periodicity of the glacial-interglacial cycles shifted from 40 to 100 kyr. We argue that this Mid-Pleistocene Transition may be the result of a spontaneous change that systems exhibiting sawtooth cycles can experience when periodically forced. This is illustrated with a simple model describing the dynamical interaction between calcifying organisms and ocean alkalinity. The model generates sawtooth cycles in alkalinity, corresponding with observed reverse sawtooth cycles in atmospheric CO2, as well as sharp spikes in calcite production at the glacial-interglacial transitions. When applying a sinusoidal forcing with a fixed period, there emerges a rich variety of sawtooth cycles with different periodicities, each being a multiple of the forcing periodicity. It is shown that the dominant periodicity of the resulting cycles can change, while the forcing amplitude and periodicity remain fixed, due to internal dynamics or noise. Whenever such a change occurs, the amplitude of the sawtooth cycle changes by about the same factor as the periodicity which is consistent with observations. Furthermore, the magnitude of the calcite spikes increases when the periodicity and amplitude of the sawtooth increase: a prediction that could be tested against new high-resolution marine sediment records.