Bioturbation: How much is it messing up our view of the past?

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What we know about past climates and their relationship with life on this planet primarily comes from marine sediments in the form of 'proxies'. Proxies can be based on indicative fossil species, fossil shell size and weight, or the trace metal and isotopic composition of individual fossils or bulk sediments. However, the disturbance of the seafloor by the activities of living animals, known as bioturbation, has profound effects on the physical and geochemical properties of the sediment. For instance, shells are displaced by the activity of animals which can be size-selective, highly discontinuous and stochastic, or even co-vary with environmental change. This biogenic sediment mixing alters marine proxy records by smoothing actual climatic and oceanographic signals which then obfuscates the timing, duration and magnitude of recorded events. Hence, since the colonisation of the seafloor by benthic fauna in the early Cambrian, reading the sediment record as a time-line has become more complicated, particularly when the thickness of sediment accumulating over the duration of an environmental perturbation closely corresponds to the depth of mixing. Specifically, bioturbation acts as a low-pass filter by reducing and shifting the signal amplitude and by eliminating high-frequency variations, making it particularly problematic for the reconstruction of very rapid and short lived climate events.

By using an explicit particle model we illustrate how bioturbation can distort various environmental events by considering both a range of conceptual shapes of proxy records as well as various modes and intensities of bioturbation. Additionally, we explore the uncertainty in observed proxy records introduced by the generally small sample sizes used for isotope measurements. In summary, our results provide a conceptual framework which can be used to better understand and interpret Palaeozoic proxy-records, and ultimately will improve our understanding of past climates.