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Orbitally-driven nutrient pulses linked to Cambrian oxygenation and animal radiations

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During the Cambrian Explosion, episodic radiations of major animal phyla occurred in concert with repeated carbon and sulfur isotope excursions. These isotope patterns are thought to reflect oscillations in atmospheric O_2, which drove evolutionary events. However, the reason for isotopic and redox variation is unclear.

Here we show that these synchronous carbon and sulfur isotope cycles, as well as marine oxygenation, can be driven by long-period orbital forcing and its effects on weathering and nutrient delivery. We use spectral analysis to confirm that the isotope periodicities correspond to the long-period eccentricity obliquity cycles, and then explore the effects of this orbital forcing using a combined climate-biogeochemical model.

The model produces a fluctuating bioavailable phosphorus flux, which results from the changing latitudinal distribution of temperature, and drives pulses of photosynthetic productivity and organic carbon burial. The model also reproduces the unusual co-variation of carbon and sulfur isotopes, which occurs due to low Cambrian sulfate concentration.

We conclude that the redox-driven evolutionary changes in the Cambrian can be well-explained by recurrent nutrient inputs to the ocean, which probably resulted from climate change caused by long-period orbital cycles. Such long-period cyclicity may explain other time periods that saw biogeochemical oscillations on these timescales.