Biogeochemical susceptibility of ancient oceans to extreme isotopic events
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It has been suggested that Precambrian oceans (before 543 million years ago) contained a pool of dissolved and suspended organic carbon which was significantly more concentrated than the modern ocean. This high concentration is traced to its accumulation in the water column, prior to the evolutionary innovations that caused organic matter to sink. Oxidation of a small part of this large reservoir can create a large isotopic signal in the smaller inorganic pool, thereby explaining the large fluctuations of isotopic composition of carbonate in the late Precambrian geologic record. Here we construct a simple continuous model to analyze the mechanisms by which such an organic-rich ocean can be created and investigate its stability with respect to oceanic circulation and evolutionary changes. Our model describes the biological, geochemical, and physical interactions of oceanic organic carbon, dissolved oxygen, and dissolved inorganic nutrients as a function of depth. It is formulated as coupled advection-reaction-diffusion equations. We first verify that, in the presence of sinking organic matter, the model simulates modern depth profiles of oxygen, carbon, and nutrients such as phosphorus. We then explore the consequences of producing neutrally-buoyant organic matter.