Playing 'telephone' with the PETM—tracing carbon isotopic excursions among reservoirs

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As an episode of rapid global warming associated with the release of massive quantities of carbon to the atmosphere and oceans, the Paleocene-Eocene Thermal Maximum (PETM, 56 Ma) is often used as an analog for modern anthropogenic carbon emissions. While the exact mass and isotopic composition of the carbon source responsible for this event is still a matter of debate, existing records do provide a likely range of between 3000 to 6000 Pg C. However, the rate of carbon release during the PETM is still a major area of uncertainty, precluding straightforward comparisons between the paleo-record and the modern. The rate of carbon release is deduced from the sedimentary carbon isotope excursion and evidence for carbonate dissolution, but variation among depositional settings (e.g. sedimentation rate, sediment type, water depth, and the carbon reservoir sampled) results in a wide range of apparent rates of onset among records.

Here we use the Earth system model cGENIE to interpret the consequences of carbon emissions rates on the isotopic record of different carbon reservoirs. All scenarios involve a total mass of emissions consistent with existing estimates for the PETM, such that differences in the magnitude and timing of carbon isotope excursions among various reservoirs are a function of emissions rate alone. We test a range of emissions scenarios—from years to millenia and constant versus pulsed emissions rates, and trace the resulting carbon isotope records within the atmosphere, with depth in the ocean, and in the sedimentary record. In particular, we calculate the characteristic difference in carbon isotope excursion size between atmospheric CO_2 and oceanic dissolved inorganic carbon (DIC) as a function of the rate of carbon emissions. These experiments provide an interpretive framework for hypotheses about rates of carbon emissions during the PETM derived from sedimentary records.