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Rapid warming at the Palaeocene-Eocene Thermal Maximum drives rapid hydrate dissociation but only modest and delayed methane release to the ocean

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During the Palaeocene-Eocene Thermal Maximum (PETM), the carbon isotopic signature δ13C of the ocean-atmosphere system decreased abruptly – the record in deep sea benthic foraminifera shows an excursion of at least 2.5 to 3.0 ‰ VPDB. This global carbon isotope excursion (CIE) has been attributed to large-scale methane hydrate dissociation in response to rapid ocean warming. There is increasing evidence for warming-induced hydrate dissociation in the modern ocean and the PETM may represent an analogue for this process. We ran a thermohydraulic modeling code to simulate hydrate dissociation due to ocean warming for a range of possible PETM scenarios. Our results show that hydrate dissociation in response to such warming is rapid but methane release to the ocean is modest, and delayed by hundreds to thousands of years by transport processes through the hydrate stability field. In our simulations most of the dissociated hydrate methane remains beneath the seabed, either in solution or as free gas below the irreducible gas saturation, and the small fraction ($\leq$0.13) released to the ocean is delivered over several kyr. We conclude that hydrate dissociation cannot have been largely responsible for the CIE unless the late Palaeocene hydrate inventory greatly exceeded most current estimates.