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The Paleocene-Eocene Thermal Maximum: Forcing, Orbital Chronology, and Earth System Response

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The largest Cenozoic hyperthermal, the Paleocene-Eocene Thermal Maximum (PETM, 56 Ma) was associated with about 5 K global surface warming and an estimated total carbon release of several thousand Pg. The PETM is widely considered the best analogue for present/future carbon release. Over the next few centuries, with unabated emissions of anthropogenic carbon dioxide (CO2), a total of several thousand Pg C may enter the atmosphere, causing CO2 concentrations to rise sharply, global temperature to warm by several degrees, and surface ocean pH to decline substantially. A carbon release of this magnitude is unprecedented during at least the past 66 million years and the outcome accordingly difficult to predict. In this regard, the geological record may provide foresight to how the Earth system will respond in the future. Here, I analyze the long-term legacy of massive carbon release into the Earth's surface reservoirs, comparing the Anthropocene with the PETM. I examine climate forcing and response, orbital chronology, and time scales of CO2 neutralization that determine the atmospheric lifetime of CO2 in response to carbon release. I compare forcings in terms of carbon release rate, i.e., the duration of carbon release during the Anthropocene vs. PETM and the ensuing effects on climate and ocean chemistry. Furthermore, I point out differences in forcing such as orbital configuration and report recent progress in determining geological ages and chronologies of hyperthermals using astronomical calculations. I will also discuss the conundrum that the observed duration of the PETM appears to be much longer than predicted by models that use first order assumptions. Understanding the long duration of the PETM is critical for predicting the long-term consequences of anthropogenic carbon release.