Coupled model-data approach to terrestrial methane cycling during Paleogene greenhouse climates

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Although methane is a critical greenhouse gas (GHG), there are no proxy methods for reconstructing its ancient atmospheric concentration. This is especially important because biogenic methane emissions are controlled by environmental conditions, such as temperature and precipitation, such that methane could be a significant positive or negative feedback on global climate. Understanding how methane emissions and cycling acted in the high pCO_2 greenhouse worlds of the Paleogene potentially bridges the gap between our understanding of other, better (although arguably still poorly-) constrained GHGs and global temperature.

We apply an advanced three dimensional global modelling strategy to the problem of Eocene trace GHG concentrations and show how important these may be in high-CO_2 worlds, with as much as 2.7 ºC of global warming contributed by increased trace GHGs.

We compare the model results to an indirect proxy for Paleogene methane cycling afforded by the distributions and carbon isotopic compositions of hopanoid lipid biomarkers with ^{13}C-depleted isotopic compositions indicative of enhanced methane cycling. Examination of literature-derived and new hopanoid carbon isotopic analyses supports the spatial relationships between temperature, precipitation and methane cycling observed in the biogeochemical model.

Together, the biogeochemical model and organic proxy data apply new constraints on ancient methane emissions in high-CO_2 worlds.