Long-term terrestrial temperature changes across the Cenozoic: applications of organic geochemical proxies to lignite deposits

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Earth's climate evolution during the Cenozoic is marked by the transition from greenhouse conditions, characterised by high levels of atmospheric carbon dioxide (pCO_2) and high temperatures, to an icehouse world, dominated by the expansion of large continental ice sheets. Existing temperature reconstructions are mainly derived from sea surface temperature (SST) proxies, whereas terrestrial temperature proxy records are sparse and significantly lower than marine estimates. The discrepancy between marine and terrestrial temperature estimates complicates our understanding of climate dynamics and is difficult to reconcile with Earth climate models. This mismatch can be explored via new independently calibrated terrestrial temperature records across pivotal climate transitions.

The Latrobe Valley in the Gippsland Basin, southeastern Australia, contains more than 400 m of thick immature lignite deposits from the Eocene to the Miocene. These fossilised sub-tropical peat deposits are an ideal archive for the preservation of organic matter, and offer the potential to record the long-term temperature evolution from the onset and expansion of Antarctic ice sheets and the opening of Southern Ocean gateways, to the middle Miocene.

We apply newly developed branched glycerol dialkyl glycerol tetraether (brGDGT) MAAT temperature calibrations for peat to these lignite deposits dating from the Oligocene to the Miocene. This approach indicates generally warm temperatures throughout this time, consistent with palaeobotanical evidence for sub-tropical peat conditions. We observe the transition from colder Oligocene temperatures to stable warm estimates throughout the Miocene interval. Furthermore, we analyse the distribution of organic biomarkers in the Latrobe Valley seams, comparing our results with palynological and sedimentological data, to reconstruct changes in their paleoenvironments through time.