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Very high sea surface temperatures associated with significant climatic variability at 55°S during the early Paleogene as recorded by biomarker assemblages

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The Paleogene spans 65 to 34 Ma and is thought to be characterised by generally high pCO2 levels and a "greenhouse" climate. The Early Eocene Climatic Optimum (EECO) at 52 Ma marks what is believed to be a temperature maximum for the Paleogene with global temperatures increasing gradually throughout the Paleocene and the initial stages of the Eocene before starting to slowly decrease. However, recent records from Tanzania, developed from well preserved foraminifera and organic biomarkers, reveal that tropical sea surface temperatures (SSTs) remained relatively constant throughout the middle Eocene. Here we present results from two high latitude sections from the Canterbury Basin in New Zealand, the mid-Waipara River and Hampden Beach sections, for which we reconstruct SST and continental mean annual air temperature (MAAT) from the late Paleocene to the middle Eocene using a combination of geochemical proxies including foraminiferal 18O values and Mg/Ca ratios and the organic TEX86 and MBT/CBT proxies.

Temperatures vary dramatically (ca. 15°C) throughout this interval with markedly lower SSTs in the Paleocene, an increase into the early Eocene, culminating in maximum SSTs of ca. 35°C and MAATs of ca. 28°C during the EECO, and a subsequent SST decrease during the middle Eocene while MAATs remain relatively constant. These trends result in significant variability in the land-sea temperature (at 55°S) and latitudinal SST gradients. Further organic biomarker investigation reveals significant changes in soil pH and terrigenous organic matter input, both linked to changes in the land-sea temperature gradient: a link appears to exist between a weak land-sea temperature gradient, low soil pH (reflecting increased precipitation) and elevated runoff on both long (Myr; mid-Waipara) and short (Milankovitch; Hampden Beach) timescales.

At this site, the warm climate of the EECO seems to be associated with aridity and low runoff with a subsequent increase in precipitation and associated runoff into the middle Eocene. Conversely, the climate of the latest Paleocene does not appear to be influenced as heavily by changes in temperature gradients. SSTs and MAATs suggest a weaker greenhouse climate, more similar to that of the present day than the Eocene. A dramatic increase in the BIT index associated with a positive carbon isotope excursion could further reflect a drop in sea level at this time. These new data sets indicate that the climate of the early Paleogene was not a uniform "greenhouse" but was characterised by dramatic shifts in climate state.