



Cooling, vegetation shift and decline in monsoonal rainfall in NE Tibet through the greenhouse to icehouse transition

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Understanding how and why global climate tipped from greenhouse to icehouse conditions remains a major challenge. This critical shift is well documented in the marine realm characterized by a steady decline in global temperature until a large and rapid cooling step at the Eocene-Oligocene Transition (EOT). However, the chronology and mechanisms of cooling on land remain unclear. To reconstruct Paleogene climate conditions for the Tibetan Plateau and the Asian continental interior, clumped isotope thermometry and palynology in accurately-dated continental records from northeastern Tibet, are here combined with climate and vegetation simulations. Our results show two successive dramatic (>9 °C) drops in soil carbonate temperature, at 37 Ma and at 33.5 Ma associated respectively with the appearance and dominance of high altitude conifer forests. Such large temperature decreases associated with ecological reorganisations cannot result from regional cooling alone. They require shifting of the rainy season to cooler months, which we interpret to reflect a decline of monsoonal intensity. Our results suggest that the response of Asian temperatures, monsoonal rainfall and vegetation to the decline of atmospheric CO₂ and global temperature through the late Eocene occurred in two steps separated by a period of climatic instability. Our results support the onset of the Antarctic Circumpolar Current coeval to the Oligocene isotope event 1 (Oi-1) glaciation at 33.5 Ma, reshaping the distribution of surface heat worldwide; however, the origin of the 37 Ma cooling event remains to be determined.