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Atmospheric CO2 during the Late Miocene Cooling

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Alkenone sea surface temperature records recently observed suggest a substantial long-term and large-magnitude ocean surface cooling during the Late Miocene. At the same time, starting about seven million years ago, both hemispheres on Earth witnessed synchronous cooling and large areas of the continents experienced drying and enhanced seasonality. Coinciding with this climatic shift were significant changes in ecology, including the rise of C_4-photosynthesizing terrestrial plants and the emergence of so-called "vital effects" in oceanic coccolithophores. These changes are collectively hypothesized to be induced by declining atmospheric CO_2. However, the sparse proxy data available for this time interval limits our understanding of the link between these changes and atmospheric greenhouse gas fluctuations and has let people to propose a "climate-CO_2 decoupling".
In this study, the alkenone based pCO_2 proxy is used to reconstruct atmospheric CO_2 for the time interval between 4.5 and 8.5 Ma. Estimations are based on the carbon isotopic fractionation during photosynthesis (εp) and a new statistical multilinear regression model based on an analysis of culture and sediment data. Past coccolithophore growth rates are reconstructed using foraminiferal isotopic-based proxies, related to water column structure which favour or limit nutrient supply to the photic zone. A thorough sensitivity analysis of modern and past εp values and its influencing factors in the Southern Ocean yield to a new, high resolution pCO_2 record. Estimated pCO_2 concentrations synchronously decline with the observed long-term cooling (5°C) from 6.8 to 5.9 Ma, periodically decreasing to sufficiently low values of <200 ppm, potentially inducing ephemeral Northern Hemisphere glaciation. CO_2 concentrations during the Late Miocene Cooling Event are thus successfully reproduced in this study and allow a reasonable interpretation of past conditions as has not yet been previously achieved in the relevant literature.