

Reconstruction of past climate changes using sedimentary molecules

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Reconstructing past natural climate is essential for understanding low-frequency variability at decadal- to centennial-scale, and long-term climate trends and improve future predictive models. Organic biomarkers, molecular fossils derived from terrestrial and marine organisms preserved in sediments, have emerged as powerful proxies for paleoclimate studies. Here, we review the main biomarker-based proxies used to reconstruct past sea surface temperatures (SST), continental hydrology, and vegetation dynamics over geological timescales, focusing on key compound classes such as alkenones, *n*-alkanes, sterols, and IP25. We showcase application cases using their isotopic composition, such as the δD of plant wax *n*-alkanes, to investigate hydrological cycle shifts and vegetation changes. We highlight recent advances in analytical techniques, proxy calibration, and enhanced temporal resolution in marine sediment records that together have improved the quality and robustness of biomarker-based reconstructions. Furthermore, we discuss multi-proxy approaches and the integration of paleo-reconstructions with numerical climate model simulations to disentangle the role of natural external forcings, e.g., volcanism and solar activity, from anthropogenic drivers, providing critical insights into Earth system sensitivity under global warming scenarios.

