

Increased synchronization of Antarctic and global climate across the Mid-Pleistocene Transition – implications for the carbon cycle

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As an integral part of Earth's climate system, the Antarctic Ice Sheet (AIS) impacts global sea level and interacts with Southern Ocean climate on a variety of timescales. A lack of long and continuous records of AIS variability on orbital timescales, however, has challenged our understanding of the complex interplay between the AIS, ocean, atmosphere, and biogeochemical cycles and its contribution to the evolution of Plio-Pleistocene climate. Here we use well-dated, high-resolution sediment records from Iceberg Alley Site U1537 (IODP Expedition 382) from the Antarctic Zone of the Southern Ocean in combination with climate and ice-sheet model simulations to show that key components started to synchronize with orbitally-paced global climate change since ~1.5 million years ago (Ma), 0.3 Ma before the Mid-Pleistocene Transition (MPT) started, with implications for the carbon cycle. Since ~1.5 Ma, productivity (upwelling) and dust proxies of Site U1537 covaried on orbital time. From ~1.5–~0.9 Ma, a long-term trend of modelled Southern Hemisphere sea-ice increase was accompanied by a similar long-term decrease in reconstructed sea-surface temperature. During that period, modeled Antarctic ice volume also increased. Since ~0.9 Ma, all climate components show increased synchronization with global climate and higher amplitude variability on orbital time scales. A final step-change in synchronization is documented for the Mid-Brunhes event (~0.45 Ma). Since then, all components of the Antarctic climate and ice-sheet system were locked into an orbital rhythm with high-amplitude, glacial-to interglacial variability. The weak response of this system to orbital forcing prior to 1.5 Ma indicates sensitivity thresholds for the Southern Ocean and the AIS. Specifically, the sea-ice increase and sea-surface temperature decrease in combination with Antarctic ice-sheet growth played an increasing role in regulating the carbon cycle across the MPT.