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Seasonal temperatures in West Antarctica during the Holocene

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Disentangling the drivers of mean annual temperature change in Antarctica requires an understanding of seasonal temperature change. A high-resolution climate record capable of resolving summer and winter seasons could address long-standing questions about the role of orbitally-driven insolation in driving Antarctic mean-annual temperature change. What drives summer and winter climate in West Antarctica? How does this relate to insolation intensity, seasonally integrated insolation, or season duration? Here, we present a continuous record of water isotope ratios from the West Antarctic Ice Sheet (WAIS) Divide ice core that reveals both summer and winter temperature change though the last 11,000 years. We use complex (HadCM3) and intermediate (energy balance) modeling to interpret the records. Observed summer temperatures increased through the early-to-mid Holocene, reached a plateau at 4 to 2 ka, and then decreased to the present. The observed changes are explained primarily by changes in maximum summer insolation. In the early to mid-Holocene, additional summer warming results from the retreat and thinning of the WAIS. The magnitude of observed summer temperature change constrains the lowering of the WAIS surface to less than 100 m since the early Holocene, consistent with geologic records. Importantly, annual mean temperatures cannot be fully explained by orbital forcing and ice sheet elevation change alone; in the early Holocene, large wintertime temperature excursions overwhelm the summer signal. These winter excursions indicate that regional heat transport anomalies, rather than local thermodynamics, can dominate the annual mean.

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