

Multi-millennial-scale climatic variations in Antarctica during the last eight glacial cycles

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Climatic variability on millennial timescales, characterized by abrupt temperature changes in the Northern Hemisphere and inter-hemispheric seesaw, have been well documented for the last glacial period by many paleoclimatic records. It is also evident that very large inter-hemispheric seesaw occurred during the last deglaciation. The cause for these variations is thought to be the variations of freshwater flux into North Atlantic ocean from surrounding ice sheets, which can change the strength of meridional overturning circulation and associated poleward heat transports. Therefore, millennial-scale variations in Antarctica or elsewhere may tell us about ice sheet variability in the Northern Hemisphere. However, the frequency and magnitude of such events are uncertain for older glacial periods and terminations because of the lack of suitable climatic records. Here we present a 720,000-yr ice-core isotopic record along the second Dome Fuji ice core, East Antarctica. Synchronizing and stacking this record with existing Dome C ice-core record permits robust identification of multi-millennial-scale Antarctic warming events over the last eight glacial cycles. Dust proxies in Marine Isotope Stage 16 in the Dome Fuji core (oldest glacial period in this core) show that the millennial-scale variations of dust flux are negatively correlated with Antarctic temperature for all identified events. This demonstrates that changes of aridity in the dust source region, presumably Patagonia, occurred in concert with Antarctic climate changes. A bandpass filter (3,000 - 15,000 yr periodicities) was applied to the stacked isotope record to account for loss of resolution in the old (deep) part. This allows us to identify large Antarctic warming events with a constant criteria through 800,000 years. We find a positive relationship between repetition period of multi-millennial-scale events and Antarctic temperature, with exceptions in glacial maxima. The data suggests instability of Northern Hemisphere ice sheets in intermediate glacial condition and also a role of climatic precession, presumably through Northern Hemisphere summer insolation, affecting ice sheet mass balance. Multi-millennial-scale events becomes infrequent in times of large precession variations in early parts of glacial periods, implicating long freshwater release due to strong summer insolation forcing. Very large multi-millennial-scale events are identified at glacial terminations, suggesting that the terminations in general involve abrupt and large climatic transitions which are overlaying on the slow orbital-scale variations.

Keywords: Dome Fuji ice core, Antarctica, Millennial scale climatic changes, Orbital variations, Bipolar seesaw, Glacial terminations