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Northern Hemisphere insolation forcing of glacial cycles implied by absolute dating of Antarctic ice cores

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Climate variations over the last 700,000 years are characterized by orbital periodicities of ∼100, ∼41 and ∼23 ky. While 23- and 41-ky components are understood as linear climatic responses to forcings by precession (modulated by eccentricity) and obliquity, respectively, the 100-ky cycle cannot be explained as a linear response to eccentricity. An accurate chronology for deep Antarctic ice cores has been awaited to compare the timing of glacial-interglacial changes relative to summer insolation at high northern latitudes, which is critical test of the Milankovitch theory of glacial cycles. It has also been suggested that the 100-ky cycle is caused by skipping of higher frequency beats which results in the bundling of either 4 or 5 precession cycles (Raymo, 1997, Paleoceanography), or 2 or 3 obliquity cycles (Huybers and Wunsch, 2005, Nature), each grouping resulting in an average ∼100 ky periodicity. However, verification of these competing hypotheses has not been possible because of the lack of accurately dated climate proxies. We present here new chronologies of the Dome Fuji and Vostok ice cores based on the O_2/N_2 ratio of trapped air, which records local summer insolation. They provide an accurate chronology of Antarctic climate for the past 360,000 years covering the last four Terminations. The timing of rapid Antarctic warming at Terminations is found to fall within the rising phase of June 21 insolation at 65N, with

Termination II and IV (I and III) being relatively early (late). Further, using statistical tests of the new chronology, we show that precession pacing is statistically more significant than obliquity pacing for the last five terminations. Here the timing of termination V was estimated by shifting the Dome C (EDC3) timescale to match the timing of MIS 11.3 of the Vostok O_2/N_2 chronology. Our results are consistent with the hypothesis that high northern latitude summer insolation is the primary pacemaker of the late Pleistocene glacial cycles, with phase modulation by obliquity and ice volume. Currently efforts are being made to measure O_2/N_2 along the second Dome Fuji core to better constrain the Antarctic chronology for MIS 10 and older. The result available by the meeting will also be presented.