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Paleoclimatic reconstruction from bubble number-densities in glacier ice: quantifying abrupt and gradual climate changes

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Ice cores provide outstanding records of past climate changes. Confidence in reconstructions is improved by having multiple, independent, physically based indicators. Past allowable accumulation rate/temperature combinations can be estimated from the measured number-density of bubbles in an ice core, using a new technique. Density increase and grain growth in polar firn both are controlled by temperature and accumulation rate, and their integrated effects are recorded in the number-density of bubbles as the firn changes to ice. A physical model of these processes, optimized to fit published data on recently formed bubbles, reconstructs accumulation rates from recent temperatures with a two-sigma uncertainty of only 26%. Bubble number-densities in samples from the Siple Dome, Antarctica, ice core reveal changes in accumulation rate consistent with other paleoclimatic indicators and lead us to conclude that bubble number-densities will be a valuable, and in some cases essential, source of information when reconstructing past climate. Keywords: Firn; densification; paleoclimate; paleoclimatic indicator; bubble number-density; temperature; accumulation rate.