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Physically based reconstruction of summer temperature from ice layers in ice cores

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Previous studies, which have reconstructed summer temperature from ice layers in ice core, relied on approximate relationship between ice layer and instrumental temperature observed nearby station. Here we demonstrate a novel method to reconstruct summer temperature from ice layers in ice core using an energy balance model, in which heat conduction through firn and refreezing of meltwater are taken into account. Parameters used in the model are firstly calibrated with 2-year meteorological data observed at the SIGMA-A site, northwest Greenland. Using the ERA-Interim reanalysis dataset, we calculate amount of refrozen water within firn under different settings of summer temperature and annual precipitation, and then prepare a lookup table containing summer temperature, annual precipitation, and refrozen amount. We then estimate summer mean temperature from refrozen amount and annual accumulation, which are available from an ice core, by referring the lookup table. We apply this method to three ice cores under different climates; Belukha in the Russian Altai, Aurora in the Alaska, and SIGMA-A in the northwest Greenland. Reconstructed summer temperatures show large inter annual variability, which is comparable to those of observed temperature, but show some biases, which are affected by albedo setting. This method allows us to estimate summer temperature using information solely available in ice core without making any approximate relationship between temperature and ice layer.