S1. Decay of thermal signal created during drilling compared to observed temperature changes

An analytical model describing the thermal decay from linear heat sources in ice is obtained from the solution to a line source within an infinite media presented by Carslaw and Jaeger (1959):

$$T(l,t) = \frac{Q}{4\pi k\rho C t} e^{-\frac{l^2}{4kt}} \tag{S1}$$

where *l* is the linear distance away from the heat source, *t* is the time that has elapsed, *Q* is the amount of heat per unit length of the line source, *k* is the thermal diffusivity, *ρ* is the density of the of the medium, and *C* is the specific heat capacity.

Humphrey and Echlemeyer (1990) modified Eq. (S1) to estimate the temperature at time *t* for sensors installed in a borehole using a hot water drill. Setting *l* = 0 removes the exponential term from the equation. Humphrey and Echlemeyer (1990) also substituted thermal conductivity (*K*) for ($k\rho C$) and added the term T_0 to account for the ambient temperature of the ice before being disturbed by drilling. This leads to equation 24 in Humphrey and Echlemeyer (1990):

$$T(t) = T_0 + \frac{Q}{4\pi K t} \tag{S2}$$

Equation (S2) illustrates the asymptotic temperature decrease which is proportional to inverse time. The *Q* term is amount of heat per unit length of the borehole and includes both sensible heat during drilling and latent heat from the water refreezing. The sensible heat required to raise the temperature of ice to its melting point is small compared to the large amount of latent heat required to melt the borehole. *Q* is given by:

$$Q = m_w L_f + m_i C \Delta T \tag{S3}$$

where the right-hand terms are the latent heat of refreezing in the borehole and the sensible heat to warm the melted ice up to 0 °C. The mass of water in 1 m of the borehole is:

$$m_w = \rho_W \pi r^2 h \tag{S4}$$

Here *r* is the radius of the borehole, which we assume equals 5 cm if the boreholes have approximately a 10 cm diameter. The mass of ice raised to its melting temperature is represented by m_i and is found by solving Eq. (S4) but substituting the density of ice for the density of water.

The temperature of the borehole decays towards the ambient ice temperature. After 1 year < 0.1% difference remains between the borehole temperature and ambient ice temperatures. For ambient ice temperatures below -1 °C, this is well below sensor resolution and does not affect our observational data. To avoid any potential contamination of both the static and temporal trend of the sensor temperature data from the thermal disturbance of installation, we ignore the first year of data in our analysis.

S2. Estimating the temporal change of temperature in a stepped digital record

The lengths of our temperature records are restricted by the date of installation after the borehole was drilled, and the date of the last data collection in July 2017. The time change of temperature is near the digital resolution of the temperature sensors, which can result in a stair stepping of the record over only a few steps and over the entire record (see Fig. S1 for an extreme example). Applying a linear regression to the raw data can lead to a biased estimate of the rate of change of temperature. As an example of this problem, we look at a full sensor record showing a decrease of approximately 0.1 °C through time (Fig. S1).

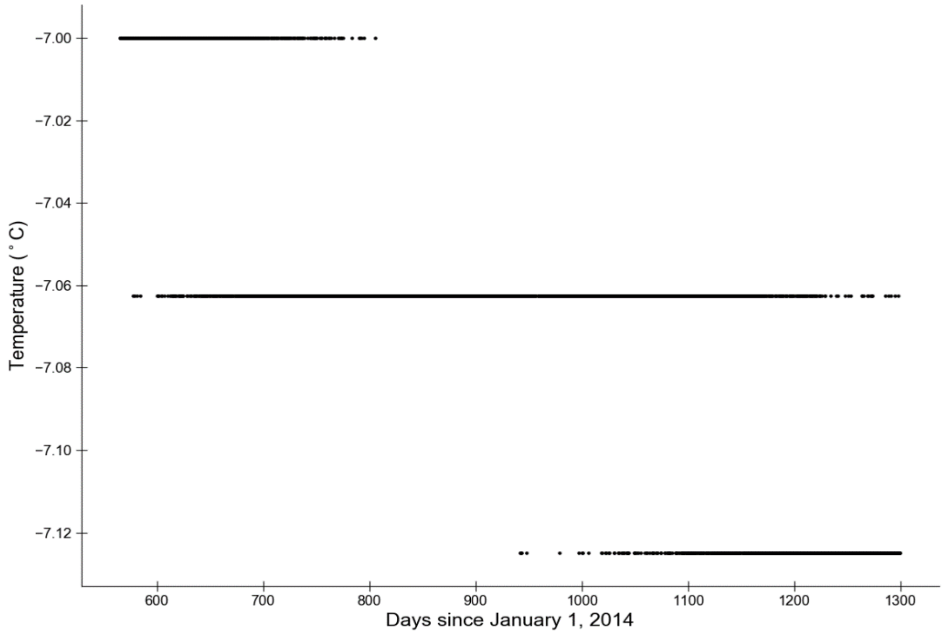

Figure S1. Temperatures (black dots) recorded over two years by sensor #15, which is 200 meters above the bed in borehole 14SA. When plotted over time, the temperatures display characteristic stair-stepping pattern between resolution steps of the sensor.

Both the first and last digital steps of this record have fewer entries recorded due to the restrictions of the sampling window. Assuming that temperature change is close to linear with time, we expect that with a longer record, the sensor would record approximately the same number of readings at each resolution step. Short data lengths occurring at either the beginning or end of the records are likely truncated by the restricted time period of our study. To correct for our restricted sampling time, we pad the first and last steps in our data to match the length of a fully-recorded resolution step. This is performed by copying the required length of data from a full resolution step, and pre- or post-appending it to the truncated data, while equating the temperatures. This procedure is illustrated in Fig. S2, which also shows the difference in derived rates of temperature change over time.

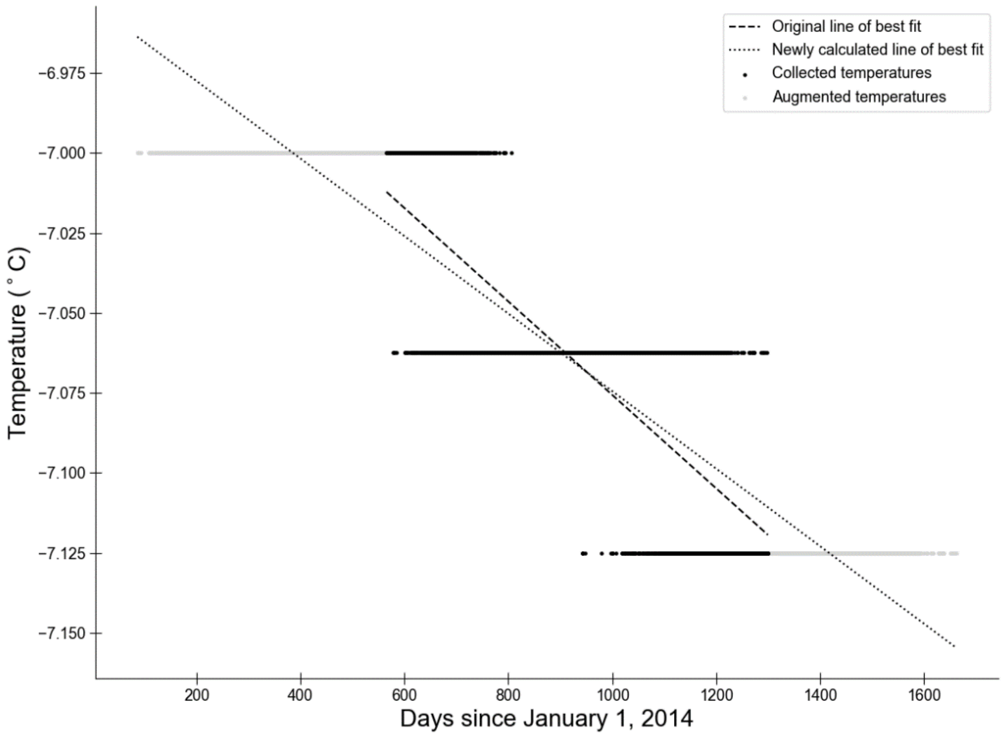

Figure S2. Temperatures (black dots) recorded over two years. The augmented records are shown with light grey points. The original least-squares line of best fit is shown with the black dashed line and the dotted line is the newly calculated trend using the augmented data.

S3. Modeling distributed cooling from multiple basal crevasses

We model a field of 3 basal crevasses that are 1 m thick with a 1-D diffusion model in the direction perpendicular to the crevasses and at some height above the bed. Our finite difference model domain is 800 m wide, covering 3 crevasses spaced 100m apart. Initial ice temperature is -4 °C, which is the average temperature in the lowest 200 m of the ice column from our borehole temperature measurements. To simulate three basal crevasses, 1 m wide, 0 °C nodes are located at 300, 400 and 500m. Boundary nodal temperatures are fixed at -4 °C, while temperatures throughout the rest of the domain evolve following Eq. (2) for 30 years. The model duration is chosen based on our timescale analysis, which suggests that crevasses occurring ~20 - 30 years ago could produce the cooling rates in each borehole.

References

Carslaw, H. S. and Jaeger, J. C.: Conduction of Heat in Solids, 2nd ed., Clarendon Press., 1959.

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