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Climate of the Past
Discussions

Interactive comment on "Physically based summer temperature reconstruction from ice layers in ice cores" *by* Koji Fujita et al.

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Ice cores have long been used to reconstruct past surface temperatures, however in areas of surface melting this is not always possible. This paper presents a new method for reconstructing summer temperatures from melt layers in ice cores. The new method, based on an energy balance model, provides a valuable alternative to traditional surface temperature proxies, however the potential limitation is that melt must be present.

General comments: I found the term "ice layer" confusing. What you are referring to is "melt layers" or even "ice lenses" that occur in the firn.

Line 127. I am unsure of the assumption "water refreezing alters the snow density up to the ice density (pi, 900 kg m–3), but does not prevent the water percolation". Can

the water percolate through the ice layers? One of my concerns with the method is that melt layers act as a barrier for further melt percolation. Thus what might appear to be a large melt layer could be comprised of several smaller melt events. In this case you would over estimate your summer temperature reconstruction. This is also a drawback of using the annual ice layer thickness (line 194). Is the assumption therefore that the melt occurs in a single event each summer?

I think you need more information about the ice core data used. Either in the text description or in table 1. How were the ice cores dated? What is the approximate dating uncertainty? Are your years from summer to summer or winter to winter? How was the ice layer thickness determined? Visual? Line scanner? How accurate are these measurements? Can you determine small melt layer or just large melt events? Is it possible to identify multiple smaller melt events? Can you identify melt layers at depth or is it only possible in the firn?

I am not sure if there is a better term for "look-up tables" but I found the term strange. Would calibration tables be better?

How well does ERA-interim capture conditions at the ice core sites? Have there been any studies to demonstrate this? My concern is that the approach is heavily dependent on the reanalysis data, but for many ice core sites (especially those subject to melt) the spatial resolution of ERA-interim may not be suitable. Is there a way you can demonstrate that ERA-interim is suitable?

I think the issue of impurities in the ice could be a limitation to this method. The authors include a caveat in the discussion that the albedo scheme needs improving. I think this is especially important for coastal or continental sites, which may be subject to local dust sources. The surface mass-balance model by Goelles and Boggild includes a dynamic ice albedo component. In addition to dust and black carbon, this model includes clouds and the angle of the sun. GOELLES, T., & BØGGILD, C. (2017). Albedo reduction of ice caused by dust and black carbon accumulation: A model ap-

plied to the K-transect, West Greenland. Journal of Glaciology, 63(242), 1063-1076. doi:10.1017/jog.2017.74

I think a new method of reconstructing temperature that is not reliant on stable water isotopes is important. However, stable water isotopes are a well-established method. I wonder if it would strengthen your case to include the stable water isotopes for these ice cores in your figures (Fig. 7), or a supplementary figure, to demonstrate the imperfect nature of the stable water isotopes – temperature relationship. I found the correlation between SMT and ERA-interim convincing but clearly it is not an exact match. However, if you presented the stable water isotopes you would also expect differences.

Is the SMT reconstruction from stable water isotopes better or worse than your method? Is it even possible to get a summer mean temperature from isotopes? I think you should include some additional background in the introduction about the drawbacks of other temperature reconstructions and how the information can be lost in the presence of surface melt. Future climate warming means we need additional methods of extracting climate information from ice cores that may be subject to melt.

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