The Cryosphere
Discussions

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Interactive comment on "Where is the 1-million-year-old ice at Dome A?" by Liyun Zhao et al.

Anonymous Referee #2

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Review of Where is the 1-million-year-old ice at Dome A? Liyun Zhao, John C. Moore, Bo Sun, Xueyuan Tang and Xiaoran Guo

The study aims to locate areas around Kunlun Station that contain ice older than 1Myr, and the manuscript describes results from simulations with the Elmer/Ice model, a 3D, thermomechanical, Full-Stokes, finite-element model. The model parameters are constrained by observations of surface velocity, ice fabric and radar isochrones. The authors test different ice fabrics and geothermal heat fluxes and conclude through the comparison with observations that the geothermal heat flux is likely between 55mW/m2 and 60mW/m2. From the model results, areas that potentially contain ice older than 1Myr are identified based on these two geothermal heat flux values. Overall, the manuscript is well written and is definitely of interest to the glaciological community

especially those concerned with ice-core sites and the retrieval of "the oldest ice". I have some main points that I would like to see addressed, as well as some minor points that might improve readability.

Main points

1 I am missing a more thorough discussion of the uncertainties or rather the confidence the authors have in their results (Figs. 6 and 8). Firstly, a comparison with the results from van Liefferinge and Pattyn (2013) would be interesting in order to give insights into how coarse vs. fine grid, and shallow-ice vs. full-Stokes might affect results. Secondly, the vertical distribution of ice fabric is not in line with the findings of Wang et al. The authors state that they obtain the same results for two or four layers of fabric but the same what? Age-depth distribution? Surface velocity? 153.3kyr isochrone depth? Based on the figures in Wang et al., I would say that an assumption of two layers is fine around Kunlun station but does not appear to be valid further away from the station. Could the variability of T3 and T4 explain the variation in fit with the isochrone? Finally, the fact that the model has a tendency to underestimate the depth of the 153.3kyr isochrones indicates that the model could be overestimating the amount of 1Myr old ice (with the possible exception of triangle 4). Especially triangle 3 is problematic and perhaps by extension the age of the valley.

2 Most of the figures are small and hard to interpret. Please add legend and/or title so that main points of the figures are understandable without consulting the figure caption. The symbol for Kunlun Station, the letters distinguishing the figures and the axes labels are hard to read.

3 The structure of the paper could be improved. For example, the introduction and the discussion/conclusion appear fragmented rather than cohesive sections (e.g., the introduction contains a section about Kunlun, then a section about ice fabric and vertical velocities and then another section about Kunlun). I am also missing an introduction to the datasets in Section 2. The surface velocity data, the polarimetric data and the

isochrones depths should be mentioned in Section 2 before they are used in Section 4.

Minor points

Lines 13-33: The abstract should also state the aim of the study.

Line 13 (and other places): age/depth or age-depth?

Line 25 and 313: Typo "polarimetric"

Lines 35-42: This part of the introduction needs a few more sentences about the background for the search a 1Myr ice, for example, with references to the IPICS white paper and to Fisher et al., 2013 (https://www.clim-past.net/9/2489/2013/)

Lines 56-62: There is no information about the Dome A ice core. Since an ice core has been drilled, is there no information about ice fabric, age-depth profile or temperature from that? Line 69: Is Parrenin et al., 2017, the correct reference here?

Lines 96-107: What is the original resolution of the AGAP data and the Chinese data? How does the resolution compare to that of the model?

Line 130: Word missing?

Line 131: Add that the strain rate tensor will be discussed in more detail below

Line 145: Typo: "Gudmundsson"

Line 157: what is n equal to?

Lines 160-165: These values might be better summarised in a table

Section 4: I would like a table in this section where different simulations are listed with least-square age error, vertical surface velocity, age at the bedrock and the magnitude of the difference between measured and modelled horizontal velocity. This would allow readers to judge the difference between the model results and how well they agree with observations.

<div align="center">C3</div>

Lines 360-364: explicitly refer to the figure that is being discussed (5C, 5D etc.) otherwise it is hard to follow.

Line 402: I agree with reviewer #1 re. the comparison with accumulation + basal melt rate.

Line 442: please indicate on a figure where this valley is.

Line 455: The hydraulic potential should be shown on a figure or in the supplementary material. The description here does not help the reader.

Line 522: Considering that Dome A has very low accumulation rates, how can an ice-core from the area provide the highest resolution record?

Fig. 1: Both figures appear pixelated and especially 1A is not very informative.

Fig. 2: this figure is hard to read, why not split it into two figures?