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GENERAL INFORMATION

Manuscript title: How old is the ice beneath Dome A, Antarctica?

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GENERAL COMMENTS

This manuscript presents some very interesting results in regards to the age distribution in the interior of an ice sheet. Particularly, the focus on the influence of the ice fabric is of relevance to the scientific community. I do have some reservations and concerns that need to be addressed. Some of these might be met by clarifying why certain decisions were made for the model set-up, but there are also paragraphs where I would like the authors to elaborate in their presentation and interpretation of the results. I recommend that this manuscript is accepted with minor revisions.

SPECIFIC COMMENTS

My main concern is the question of a constant accumulation rate. The authors explain that the fixed geometry (and by that I assume they mean the surface elevation?) implicitly determines the accumulation rate. Maybe I'm missing something here but it is unclear to me why that is. Cannot the horizontal fluxes out of the domain be forced to match the surface accumulation and thus keep the surface elevation constant? Or do the authors mean something else by "fixed geometry"? Since the accumulation rate often is the key factor in determining the age distribution it seems very odd not to include this, and I would like a better explanation of why this is disregarded.

In some sections the manuscript is a bit too brief and I would like both the results and the discussion sections expanded. Particularly, I would like to see a longer discussion of the results presented in Fig 3. For example, when comparing the run S,I ,W,50 with S,I,W,60 there is a difference of approx. 10mm/yr in surface velocity. As far as I understand this figure, the only difference between the two runs is the geothermal heat flux. Why does this lead to such a big difference in surface velocity? I assume that that basal melt rate equals the vertical velocity at the base, thus the melt rate is only a few mm different in the two runs.

Another example is the difference between the runs with warm and cold surface temperatures (e.g. S,1/3,C,60 and S,1/3,W,60), that seems to be similar in size or larger than the variations induced by difference in ice fabric (e.g. S,1/3,C,60 and S,2/3,C,60). Based on the results is it more important to get the ice fabric correct or the temperature? Or are they equally important? This leads back to the previous question re. a constant surface accumulation rate, since higher/lower accumulation rates significantly affects the transport of cold surface snow down in the ice column thus influencing the internal temperatures

I suggest including a table of the predicted ages for the different model runs. It is very hard to extract information from Fig 3 as it is (see also my comment below about figures).

Finally, I'd like to see a mention of the Fischer et al., 2013 paper (www.clim-past.net/9/2489/2013/). This study concludes that there most likely is very old ice at Dome A. A brief discussion of the difference between

the findings presented by Fischer et al., and the findings presented in the manuscript here would strengthen the conclusions.

MINOR COMMENTS

Abstract

Line 21: Missing "an" in "... than 1.5 million years old is *an* active and key question..."

Main text

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Lines 4-5: Is the average accumulation rate also based on the Hou et al, 2007 study? The way the sentence is written is not clear if there is missing a reference here.

Lines 12-13: Remove the parenthesis. Also it should be "suggest" not "suggests"

Lines 15-17: There should be a sentence here explaining why thicker ice leads to higher basal temperatures. I know this is fairly obvious, but since the paragraph includes an explanation of why basal melt leads to less of old, basal ice, it might as well also explain the influence of thick ice.

Lines 19-20: The reference Svensson et al., 2007 is incorrect? It is a paper about the NGRIP and GRIP ice cores. A more appropriate reference would be, for example, Durand et al., Supp. Issue Low Temperature Science, 68, 91–106, 2009. However, I do not understand why there is a mention of anisotropy developing close to the surface at all. The model runs only include anisotropy at depth. Another possible reference could be the Fujita et al., JGR, 1999 paper where anisotropy was directly observed from radar at Dome F.

Lines 28-29: Ice cores in Greenland do not necessarily exhibit a single maximum fabric. It is the case for the GRIP core because it is mainly influenced by vertical compression. In the NorthGRIP and NEEM ice cores a girdle pattern has been observed. One could argue that Dome A is most likely dominated by vertical compression since it is a true dome. There is a paper in review in "The Cryosphere Discussions" on the ice fabric of Greenland ice cores that might be helpful: Fabric measurement along the NEEM ice core, Greenland, and comparison with GRIP and NGRIP ice cores, M. Montagnat et al., 2014.

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Lines 20-25: how dense is the radar dataset? Is the choice of ~300m horizontal resolution based on the constraints imposed by our knowledge of the bed (due to radar data coverage) or is it based on model considerations?

Lines 24-25: It is unclear to me what is meant by "... a zero-flux condition is applied to the temperature field..." Does this mean that there is no heat flux into or out of the domain?

Line 26: In glaciology the term "hydrostatic approximation" is not commonly used and it would be kind to readers to remind them what this entails. I assume that the authors mean that acceleration terms are disregarded, but perhaps more stress terms are included than in the shallow ice approximation? A better explanation or at least a reference to an appropriate study would be useful here.

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Lines 1-4: I highly recommend making a figure to illustrate this. It would make it much easier to understand.

Lines 7-10: this sentence is confusing to me. I guess it just needs clarification that assuming the fabric at Dome A is similar to that at Dome F, the ice fabric will be isotropic in the upper parts of the column and therefore the age of the ice (in this part) can be calculated using thinning rates for isotropic ice.

Line 22: what is meant by a steady state velocity profile? Do the horizontal velocities equal the balance velocities?

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Lines 10-11: This line seems slightly at odds with the figure caption for Fig. 4 where it says that simplistic expectations suggest a surface velocity of 14mm/yr (why?). A few lines explaining the distribution of RMS for different ice fabrics would be valuable.

FIGURES

Fig. 1: it is very difficult to see which numbers correspond to which colour on the colourbars. Also the colourbars should have a value at the end of the scale. In Figure 1c the contours are almost invisible. If possible I'd prefer a larger figure of the bed topography, while Figure 1a with the location map could easily be smaller.

Fig. 2: I have the same comment re. the colourbar as in Fig. 1. I assume the (almost invisible) white contour lines outline areas of temperatures above the pressure melting? If that is the case please make this clear in the figure caption.

Fig. 3: It is too difficult to get information out of this figure. The colours of the lines are not different enough to make it easy to distinguish them and the reader has to study the caption in great detail to make any sense of what the lines mean. I suggest either splitting it up into several figures or plotting fewer lines. Also, it is a bit confusing that the y-axes go to 3500m but the lines do not.

Fig. 4: Would it be possible to colour code the red dots also, so readers can see what the contour lines are based on?

Fig. 5: It is unclear what the "best fit" criteria are. Best fit in terms of the radar isochrones? But it was just stated in the text that this was not enough to constrain the age at depth. I am not keen on this figure and would suggest that it is not used, and that Fig. 6 is used instead. If the authors prefer to have Fig. 5 included then please mark the location of Kunlun station on this transect, and it would be nice if the radar data could be made a bit clearer.

Fig. 6: Same comment re. the colourbar as Fig. 1 and 2.