Climate
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Discussions

Interactive comment on "Using ice-flow models to evaluate potential sites of million year-old ice in Antarctica" *by* B. Van Liefferinge and F. Pattyn

Anonymous Referee #3

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General comments:

The authors present work that applies numerical modelling of ice temperatures in combination with an assessment of uncertainty in knowledge of geothermal heat flux datasets in order to identify potential locations of ancient ice in Antarctica. The work is scientifically well conceived and executed, and first applies a simplified model to assess thermal conditions in the ice divide regions, before applying a 3-dimensional thermomechanical model to enable assessments in regions where horizontal advection is more significant. Input geothermal heatflux datasets are corrected using available temperature profiles from ice core drill sites, surface temperatures and accumulation rates to result in modelled temperature profiles are as close to observed as possible. A correction for the location of known subglacial lakes (and this basal melting condi-

tions) is applied. The numerical models are then used to conduct sensitivity tests using the suite of data and corrections. The 3D model generates similar results to the simple model, providing a useful methodological comparison. Suitable potential areas for drilling to million year old ice are located in limited portions of the ice divide areas. The paper is clear in its presentation of this work, but in places could be improved by using slightly more precise language. Only minor changes need be made, and overall this work is thoroughly worthy of being published.

Specific comments:

The abstract doesn't actually say why you want to find 1 million year old ice (i.e. to investigate key climate transition).

In respect of the feedback mechanisms that drive the MPT, you neglect to mention any role for the ocean (e.g. McClymont et al., 2013, Earth Science Reviews). Furthermore, you don't quite finish off the introduction by bringing it full-circle to say that by extending an ice core record into the time of the MPT it will therefore enable the changes across this important boundary to be examined, helping the controls upon the MPT to be identified. I think you could make this more explicit before moving into your discussion (line 23) on the possibilities of finding such a long record by locating areas with no basal melting.

There are a number of locations mentioned in the text. For clarity, I think a location map should be provided that is independent from your result maps. This could show the ice core locations, as well as locations that are discussed, including some of the lakes.

You correct for the locations of subglacial lakes, but do not do so for locations where subglacial melting and water-flow has been ideitified (e.g. Bell et al, 2011, Science; Wolovick et al., 2013, Journal of Geophysical Research: Earth Surface). Perhaps useful to check your results against locations where Wolovick et al identify water routing.

The discussion and conclusions section is largely discussion. I would like to see the key results identified at the end of this section – e.g. re-iterate where the potential sites are, show you have improved geothermal heat flux boundary conditions, indicate that your models produce results that correspond well. Overall, make it easier to find the findings. Perhaps separate into 2 sections – discussion vs. conclusions.

Technical corrections:

P2860,L12 – basal conditions – do you mean 'basal thermal conditions'? Be specific.

P2861,L16 – change 'going back for more than 800000 yr' to 'which extends over 800 ka into the past'.

P2862,L1 – with sufficient – should be 'at sufficiently'

P2862,L3 – 'several' – say how many. Thermodynamic models – models of what? Ice flow?

P2862,L16 – 'bedrock should be at pressure melting point' – you mean 'basal ice should be at pressure melting point'. Also – add 'therefore destroying bottom layers' to the end of the sentence.

P2864,L4 – provide a citation for the low accumulation.

P2864,L6 to L7 – rephrase/write out fully to remove the parentheses. Might need to break into 2 sentences.

P2864,L9 – 'Uncertainties in Antarctic GHF and the oldest ice' –uncertainty in what specifically in relation to the oldest ice? Location of oldest ice? Also, doing what about uncertainties? Estimating Uncertaintes?

P2864,L12 – 'hence the vicinity of ice divides' – remove this as its repeated later in the paragraph anyway.

P2866,L16 to L19 – flip this around to describe the large difference first, and then

indicate the that the rectangular area points to most suitable conditions.

P2866,L23 – Remove the sentence on colour scale and make sure it is in the figure caption instead. Its not required in the main text.

P2866,L24 – 'is obviously corresponding to' – change to 'corresponds to'.

P2867,L3 – 'accidented' – describe what you mean.

P2867,L8 – 'more acceptable' – replace with 'likely'.

P2867,L11 – remove the '-' dashes and insert commas.

P2867,L12 – 'In the next section we' – replace with 'We therefore extend the model that doesn't include horizontal flow and'. This will provide a better lead in.

P2868,L15 – do you mean 'observed ice surface velocities'?

P2862,L19 – provide a reference for the error associated with slow flow.

P2869,L14 to L19 – split into shorter sentences.

P2870,L8 – provide citations on the discrepancies.

P2870,L11 – 'as close as possible the' change to 'as closely as possible with the'
P2870,L20 – 'sufficient' should be 'sufficiently'.

P2871,L8 – 'brought their number on 145' change to 'contained 145 lakes'.

P2871,L13 – 'corroborating' change to 'corresponding to' and remove the parentheses.

P2871,L14 – 'corroborating' change to 'which are the result of'.

P2871,L19 – 'spot' change to 'location'.

P2872,L24 to 25 – change to 'cold-based sites are not precisely situated at those locations, but lie nearby in locations where ice is thin enough to reduce basal ice temperatures.

P2781,L28 – 'larger spread of' change to 'wider'.

P2873,L5 to L6 – explain why you combine the dataset.

P2873,L10 to L11 – change latter part of sentence to 'we apply a set of constraints to select the suitable sites for preservation of million year old ice'.

P2873, L11 to L16 – explain your choices as at present they seem somewhat arbitrary.

P2874,L8 – remove 'due to'

P2874,L14 – 'for a longer timespan' be specific about the timespan – how many kyrs? Also – are these supposed to represent mean conditions over glacial-interglacial cycles? If so, say so.

P2874,L20 – 'one needs to keep in mind' change to 'we note'.

P2874,L23 – 'Nevertheless' doesn't work here. Can you simply say 'We suggest that the results presented here should not be used as a sole guide...

P2874,L26 – 'bedrock variability' – do you mean bedrock relief or bed roughness? Also, change 'well be suitable from a thermal point of view, the topographic variability' to 'be thermally conducive to the preservation of ancient ice, but the topographic variability...'

P2875,L4 to L6 – can you modify the language here to be more clear? Break it into 2 sentences and say ice that travels over hundreds of km before reaching the core sire introduces somplecity in the thermal history. Furthermore, ice divides shift over glacial-interglacial timescales (provide a reference – e.g. Pollard and DeConto 2009) and therefore also influence the direction of ice flow over time. In the regions identified in this analysis small shifts in ice divide could result in significant change, or even reversal, of ice flow direction.

P2875,L11 – 'overseen' change to 'not identified'.

Figures:

In the map-based figures – should the eastings and northings be put into a polar projection (lat,long) rather than a rectangular grid. This would be a more standard approach.

Figure 5 figure caption – highlight that the cold areas are small, and tend to correspond to a higher RMSE.

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