The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC2
https://doi.org/10.5194/tc-2022-204-RC2, 2022

Comment on tc-2022-204

Anonymous Referee #2

Referee comment on "A one-dimensional temperature and age modeling study for selecting the drill site of the oldest ice core near Dome Fuji, Antarctica" by Takashi Obase et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-204-RC2, 2022

"A one-dimensional temperature and age modeling study for selecting the drill site of the oldest ice core around Dom
e Fuji, Antarctica" by Obase et al. details experiments utilising one dimensional age and temperature modeling of the Antarctic ice sheet. The validity of the model is demonstrated by comparisons with ice-core based age reconstructions and temperature measurements at both Dome Fuji and the EPICA Dome C core sites. Parameter sensitivity and selection studies for the Dome Fuji region are then conducted, and finally the optimised model applied to a ground-based radar survey in the region, and the simulated age horizons compared to isochrones from the radar survey.

Overall, the paper is well written and easy to follow and is worthy of publication in the Cryosphere, after minor re visions as detailed below.

Minor issues
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L83-85 The logic here isn't quite correct. While a lower accumulation rate is necessary to increase the number of years in a given thickness of ice, a lower accumulation rate will also reduce the vertical advection of cold from the surface down into the interior of the ice sheet, therefore increasing the temperature of the ice. So accumulation rate plays a dual and potentially competing role, but in terms of basal melt rates, lower accumulation is not necessarily a good thing.

L104-106 Parrenin et al 2017 (doi:10.5194/tc-11-2427-2017) applied a time varying rate factor to both the accumulation and melt rates in there 1-D modelling around EDC. This rate factor was based on variations from the EDC ice core for the last 800ka and was constant before 800ka.

L139-140 Need to make it clear that "m" is Fischer et al's equivalent to "p". Suggest re-

wording from "in the case of m=0.5 in their study" to "where their parameter m fulfils a similar role to p in this study, the case of m=0.5"

L141-142 m=0.5 is only smaller than p=3 for zeta<0.3. Suggest re-wording from "with a smaller vertical velocity, particularly near the base of the ice" -> "with a smaller vertical velocity in the lower approximately third of the ice" or "with a smaller vertical velocity near the base of the ice"

L161 Are you really calculating the temperature gradient at ice-bedrock interface using a central difference? If so you would need to be modelling the temperature down into the bedrock. If you are doing this, you should mention that the thermal domain extends down into the bedrock and give the boundary conditions at the bottom of the rock domain. If you are only modelling the thermal domain in the ice, then you must be using a one-sided difference discretization at the ice-bedrock interface

L224-226 I think that you have swapped around your "above" and "below" in this sentence. Surely the age modelling based on orbital tuning of the gas record is for the oldest, and therefore the deepest, part of the ice core, and the matching with AICC2012 is for the younger and shallower part of the core.

L247-248 If the simulated temperatures are colder, especially in the middle of the ice column, this suggests that the downward advection of surface cold is probably too large, indicating that the p value might not be optimal. It might be worth adding a sentence here outlining this.

L272-273 Your estimate of an annual layer thickness of 0.1mm (Figure 6b, dark blue line) is for a GHF of 52 mW/m^2. You state on lines 250-251 that there has been no melt for a GHF of 52 mW/m2, therefore the age will be greater than 1.5Ma. At a minimum, you need to delete "of 1.5 MA BP ice" on line 272 because you don't know the age in this case.

L302-314 It is somewhat ambiguous as to what you mean by "different amplitude of temperature changes", especially given your comment on lines 308-209 "because mean temperature over the glacial cycles increased if we reduce a small temperature amplitude of glacial-interglacial cycles." Presumably, this means that you have kept the interglacial temperatures unchanged and increased the glacial temperatures to change the "amplitude of the changes". If thiis is the case you should state this somewhere in Section 3.4

L317-326 You might also want to mention that the GHF may vary over the spatial scale of the radar survey, (e.g. Carson et al 2013, doi:10.1144/jgs2013-030), especially given the sensitivity to GHF that you mention on line 276

L348-349 is the impact of the spatial distribution of SMB minor because 1) the sensitivity to SMB is low and/or 2) the spatial variability of SMB is low?

L390 For the radar transect between DF and NDF, while the old ice occurs "where the ice is thin", this is at the expense of the age resolution. It would be good to add some words to point that out.

L466-470 The model-data discrepancy at 14-18 km from DF corresponds with a relatively cold ice-bedrock interface (Figure 15). This suggests that perhaps the estimated GHF of 55 mW/m^2 is too low locally, leading to cold ice with little/no basl melt and therefore vertical velocities that are too low. This is consistent with the model estimating ages that are too shallow. Such fine spatial scale GHF variations have been noted elsewhere in Antarctic, (see comment above for lines 317-326).

L485-487 See comment above for L272-273

Specific edits
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L2 "around" -> "near"
L29-30 This sentence could do with a reference, perhaps something like Shakun et al 2015, doi 10.1016/j.epsl.2015.05.042
L41 "critically scientific challenges" -> "critical scientific challenge"
L59 "in the south" -> "to the south"
L63 it is unusual to talk about an "areal extent", i.e. an area and then give its size in units of length ("50km") rather than area.
L63 "NDF" has not be defined
L78 "Horizontal velocity" -> "Horizontal surface velocity"
L81 "experiments" -> "simulations"
L95-96 "convey the information of surface temperature" -> "advect and diffuse the surface temperature"
L124-124 "zeta=s/H" -> "zeta=z/H"
L131 "ablation" -> "basal melt"
L138 delete "induce"
L145-146 define "T" from equation 4
L159 "335,000 J kg^-1" -> "335 kJ kg^-1"
L242 Even though the section heading mentions "DF" it would be worth making it clear in the opening sentence. Suggest changing "temperature profiles" -> "DF temperature profiles"
L261 for clarity, suggest changing "reconstructed profiles" to "ice core based reconstructed profiles"
L268 suggest either deleting "as an indicator of old ice" or changing "as an indicator of old ice" -> "as an indicator of sufficient resolution for dating ice based on chemical and isotopic methods"
L289 "Table 2" -> "Table 1"
L330 the results in section 3 included varying GHF, so therefore you need to delete "other"
L382-383 change "using seven colored lines" -> "for seven selected ages"

Figure 2 caption : "Equation [1]" should be "Equation [3]"
Figure 15 caption : need to include what "p" and GHF values are used for this experiment. Presumably p=3 and GHF=55 mW/m^2