

thank you for your thorough revision of your manuscript. You rigorously considered the comments by the referees and revised your calculations accordingly, thus clarifying major issues. Given the quality of the present version, I am happy to accept your manuscript in principle for publication in The Cryosphere. Below you find a list of comments regarding the revised version I ask you to consider and address before I can finally accept your manuscript for publication. The ATC2 pdf with the comments is attached as well.

Page and line refer to the Author Track Changes version 2 (ATC2).

We appreciate the thoughtful review and comments. The editor's comments are quoted in italic, and our answers follow. The revised sentences of the manuscript are indicated in **red text**.

32: remove past

done

57: BEDMAP2 datasets (Fretwell et al., 2013): Also in Bedmap3? In is available as ESSD revision, so worth pointing out.

Yes, as JARE datasets are used in Bedmap 3, we have referred to it in the manuscript.

63: ground-based

done

64: please use horizons instead of layers when referring to radar; layers have a finite thickness. Moreover, radar images boundaries in the ice (horizons). Although the term layer is widely used, I suggest to use the more accurate term horizon (or internal reflection horizon).

Thanks for your suggestions. We have decided to use “horizons” throughout the article, but we hope to keep the term "internal layer" in parallel at the first appearance. Glaciological studies frequently use layer terms to express strata within ice sheets or firn. Internal reflections can occur due to layered changes (e.g., acidic layers) of permittivity or conductivity of ice sheets. The radar images give boundaries (horizons) within the ice sheet, meantime, we also observe layered structures from radar images. As the term “internal layer” has been used in a previous study related to oldest ice (e.g., Tsutaki et al., 2022), we would like to use the term in parallel at the first appearance.

JARE (2017–2018 and 2018–2019 Antarctic summers) conducted ground-based radar surveys to investigate the internal reflection horizons (internal layers) of ice sheets over

a distance of ~ 5650 km (Tsutaki et al. 2022)

78 *age distributions of ice.*

79 *change "as" to "to estimate"*

80: *domes*

We have changed as suggested

97: Do you want to mention that reasonable resolution is also important to be able to analyse the ice core?

Yes. We have changed the sentences for clarification:

The reasonable resolution of ice core containing climate signals which can be analyzed with current methods is important. Particularly, Saito et al. (2020) presented a numerical scheme of ice advection calculation for an improved representation of annual layer thickness of the ice, and conducted numerical simulations using idealized glacial cycle forcings.

105: *used the pseudo steady-stage assumption, i.e.*

We have changed the sentence as suggested:

Fischer et al. (2013) used pseudo steady-state assumption, i.e., a constant climate forcing.

135: *"where s is the surface elevation" - s is not used anymore, please correct*

We have deleted definition of s, as it is unnecessary.

152: *an -> a*

166: *K-1. (colon)*

We have corrected them

188: *any references for these values?*

We have add the reference for the parameters (Parizek and Alley, 2004).

235: *I understand SMB as the akronym. It would be more consistent to use a letter as the actual surface mass balance rate variable*

We changed equation 11, using "a" to represent SMB.

(e.g. \dot{b} , compare also Table 1) than using the informatic slang SMB (which one might use in a program) in an equation. Moreover, "SMB rate" would also be more consistent

with what you use for basal melting, where you use rate (see line 311 in ATC2).

SMB rate (in table 2 and manuscripts)

291: balance ->> balance rate (as you use mm/a)

292: balance rate

293: balance rate

We have changed to “SMB rates” in Tables 1 and 2, and captions therein.

256: "We used ... history; we used ..." - Wording a bit strange, please rephrase

We have rephrased the sentence:

We used a result of transient simulation obtained by a 3-D ice sheet model IcIES, which computes dynamics and thermodynamics of ice sheets using the shallow-ice approximation to simulate past ice thickness history.

472: change format to TC style: 17 December 2017

done

491: Please provide information on the traveltime-depth conversion of the radar data (e.g. wave speed, firn correction) shown in Fig. 15.

This information is described in Tsutaki et al., (2022). We briefly provide it in this manuscript.

The ice thickness at the time of observation was converted from the two-way travel time from the surface to the ice-bed interface under the assumption of a propagation velocity, with calibration at DF ice coring site (Tsutaki et al., 2022).

497: layer -> horizon

503: The reader cannot see the traced horizon, so cannot see the difference. Either provide an age on the left y-axis (from DF) or indicate this particular layer of 128 ka BP mentioned in the text also in Fig. 15.

For consistency please replace tracked by "traced" and layer by horizon (see later in ATC2).

We have changed layer to horizon. We have revised Figure 15 and show rough estimate of the horizon corresponding ~128 ka.

542: temperature -> air temperature

done

568: "should be complex": It is a bit unclear what you mean - should be considered more complex in the simulation rather than simple? In the previous sentence you already say that deformation is complex. Please try to clarify.

We have revised the sentences for clarification:

According to analyses of the DF ice core (Azuma et al., 1999; Saruya et al., 2022) or 3-D ice sheet modeling (Seddik et al., 2011), deformation of the ice or flow regime towards the bottom of the ice is complex, suggesting parameterizing vertical velocities is difficult particularly near ice bottom. Improving velocity fields in ice sheet model would be an important issue for future studies.

571: I do not agree that resolution is an indicator - either the ice is there or not. Resolution is a requirement to obtain an ice core which 1) still contains climate signals which were not destroyed by e.g. diffusion and 2) can be analysed with current methods. Easiest would be to remove "one indicator of old ice". If I misunderstand something here please clarify.

We agree that the resolution itself is not an indicator of old ice. We have removed "one indicator of old ice" here to avoid confusion.

573: 2750 should be 2765 (Lilien et al provide 2764 +/- 20 m, so 2750 is not justified as an approximate ice thickness imo).

573: I would also add: "2765 m, including a thickness of a basal unit of ~200 m and thus an effective ice thickness of 2565 m)". The free lower boundary is an important difference to your model approach.

574: Please remove "in contrast". You are at a different site (EDC), so you cannot claim to have contrasting results with BELDC.

579: Please add "... profile. In addition, Lilien et al. (2021) also allowed a finite thickness of a basal unit, which further reduced the effective ice thickness." As mentioned above, this is an important difference.

We have revised the sentences using your phrases:

It is worth mentioning that the approach in ice thickness are different between Lilien et al. (2021) which used ice thickness of 2765 m, including a thickness of a basal unit of ~200 m and thus an effective ice thickness of 2565 m.

580: Figs -> Fig.s

581: ice -> effective ice

582: in -> for

583: *in* -> *of*

585: *ice* -> *effective ice*

585: 2750 -> 2565

Done

589: *horizons (a layer has a finite thickness, whereas a horizon is created by a reflection at the interface of two layers with different properties)*

591: *layers* -> *horizons*

591: *traced: please show this traced horizon in the figure*

We have changed sentences using the term horizon. We have changed Figure 15 to show the traced horizon.

~150 m above the isochrone horizons traced from DF

593: *distribution* -> *variation*

601: *reflection horizons*

We have changed as suggested.

605: *.* -> *:*

609: *Fig.s*

done

635: *information on glacial-interglacial times scales.*

We have added the phrase.

643: *altitude should be changed to height for consistency with other figures*

Fig. 2: y-axes should read height instead of altitude for consistency with other figures

We have changed them. (Altitude -> height)

Fig. 4: in other figures you use Kelvin as a unit. I suggest to use also K here on the x-axis in order to avoid a confusion with the degree scale, which for instance can easily happen in Fig. 15 (e.g. -2°C could be interpreted as the actual temperature rather than -2° below the PMP). Same suggestion also for other figures (a suggestion, up to you to decide).

We have changed °C -> K in Figures 4, 7, 9-11, 15.