Response to review 2

Reviewer comments
Author replies
New text in manuscript

We thank the reviewer for their comments and provide a response to their suggestions below.

Chung et al. use a 2.5D flowband model and dated internal layers to estimate the age of basal ice along a flowline from Dome C to the Beyond EPICA drill site of Little Dome C. The model finds the best fit spatial pattern of accumulation rate, velocity shape function, and mechanical ice thickness, which can then be translated to either stagnant ice thickness or basal melt rate. The primary result is that the age of basal ice (for Little Dome C this is just above the layer of stagnant ice) is younger than previously suggested, which has implications for the Beyond EPICA ice core.
The modeling is novel and well described. The manuscript is clearly written with a clear and well supported conclusion. There is acknowledgement of the unknown basal process which adds to the excitement of what Beyond EPICA will find when the drilling is completed this season (assuming good fortune). The discussion of ice cores having younger ages than the model predicts is interesting and useful component. The paper is ready for publication, but I hope the authors will consider the including the points below.

The one area that I suggest more of is a discussion of the age results with Lilien et al., 2021. While Lilien et al., 2021 is mentioned in multiple places, it is not clear how this age scale differs. Lilien et al. suggested that a 1.5Ma age, rather than a 1.1Ma age, is likely to be reached, but I think this is not so much a difference in the depth-age relationship as in the definition of "interpretable ice", with this paper using a value of 20 ka/m while Lilien et al. find 14 ka/m. It is a bit difficult for people outside of Beyond EPICA to keep the differences straight, so providing discussions and summaries of the differences more clearly is quite helpful.

We agree that the discussion between past age scales and the one presented here need to be made clearer. In fact we compare not only to the work in Lilien et al. 2021 but also to that of Chung et al. 2023 which both use a 1D model rather than the 2.5D model presented in this work.
We have therefore added some clarifications:

The maximum age of measurable ice at Beyond EPICA from the 2.5D model is 1.12 Ma at age density of 20 kyr $m-1$. This is significantly lower than previous estimates using 1D models (Fischer et al., 2013; Parrenin et al., 2017; Lilien et al., 2021; Chung et al., 2023b) and is a direct result of the consideration of horizontal flow in this study, combined with basal melt along the path that ice follows to reach the BELDC site. As ice flowing from the direction of DC encounters the mountainous bedrock relief at LDC, the ice sheet thickness decreases, effectively squeezing the layers and increasing thinning. This increases age density.

Therefore the threshold of 20 kyr $m-1$ is reached when the ice is younger than the 1D modelling in Chung et al. 2023a. Lilien et al. 2021 applied a similar 1D model at BELDC. However, they used the threshold of 60 m above the mechanical ice depth as this was the basal layer thickness at EDC. Moreover, given the unknown nature of the stagnant ice layer, using this criterion at BELDC may not be appropriate.

A few other minor comments:

- The discussion of ice fabric is appreciated and not including ice fabric in your model is understandable. However, it seems like the effects of fabric could be parameterized through constraints on the shape of the velocity, i.e. the p value. This is obviously future work, but I think considerable progress could be made without trying to model fabric evolution.

As the value of p is optimised by fitting to the isochrone observations, there is only a single value. Therefore, in this type of model we cannot separate the effects of ice fabric from other factors which change the value of p.

- The last sentence of the abstract is frustrating. Why end on such a sour note? Can you finish instead with a concluding note about the progress you have made?

We wanted to be clear about the limitations of the model but we have rearranged the abstract to end more positively.

Line 5: We present a 2.5D inverse model that determines the age–depth profile along a flow line from Dome C (DC) to LDC that is assumed to be stable in time meaning that low line features such as flow direction and dome location have not changed over the time period considered.

Line 17: Given that the age estimate from the 2.5D model is younger than previous estimates, this work shows the importance of considering the representation of the effects of horizontal flow when modelling the age profile.