This paper describes the Paleochrono (1.1) model, which is intended to allow the construction of consistent age models for different sites and archives. This is likely to be a very important tool, particularly for the ice core community but potentially for other palaeoclimate communities. It carries out an important task that has not been accessible in an available program before. The methodology is carefully described, and appears logical, even if one could questions some aspects of the way errors are combined. The program's application is illustrated with a nice cross-archive example, and the computing performance is clearly described. Overall, I found this an important paper that should be published with only minor corrections.

Most of my comments are very minor single word clarifications. I have just two broader issues to raise.

¶

We warmly thank Pr Eric Wolff for his careful review of our manuscript.¶

In lines 310-320, the mid-point of DO transitions is synchronised with an uncertainty. This rests on the assumption that there are no or minimal lags between DO onsets in different sites and archives. For speleothems from different regions this is precisely what was shown by Corrick et al 202, using U/Th dates from different speleothems. However while they inferred it as likely, Corrick et al did not specifically demonstrate synchroneity between DO events in spelothems and in Greenland ice (or methane in Antarctic ice). This was rather done in Adolphi et al 2018. This illustrates a point that needs to be made more generally: that it is only OK to use tie points between archives if there is an a priori reason (mechanism (volcanic eruption), independently verified dates (U/Th dates in spelothems), or linkages (cosmogenic nuclide wiggle matching between ice and speleo)) to assume they are synchronous, and if the limit of synchroneity is specified (as it is at 100 years for speleo-ice at DO events). I know the authors know this but I think it needs spelling out, and the justification from the Adolphi and Corrick papers emphasised, to avoid the danger that genuine asynchroneity is falsely ignored by future users.

¶

Yes, we agree.
Paleochrono can take into account stratigraphic links in-between sites, but it is up to the user to check these links have been proven to link synchronous events.
We propose to clarify the description of our example AICC2023-Hulu dating experiment with the following modifications:¶

We link the records at the onset of each abrupt Dansgaard-Oeschger (DO) events (Figure 2) using a mid-slope approach by assuming a global synchroneity in the timing of the rapid warming transitions ***in ice cores and of the $\delta^{18}O_{calcite}$ changes in speleothems (Adolphi et al., 2018; Corrick et al., 2020).***¶

I cannot claim to understand the details of how the cost function is calculated. I understand that each marker or correlation comes with an uncertainty. However I would have appreciated some discussion of how the priors are weighted compared to the age markers etc. Possibly this is a parameter inside the model?

The λ parameter sets the weighting for the prior, since any interval with a length of λ has a weight of 1. Any observation also has a weight of 1. We propose to specify this in section 2.3.1:¶

Setting these correlation matrices for the prior allows to have a weighting which does not depend on the resolution chosen for the inversion grids. ***Indeed, each interval of length λ will have a weight of 1, which is the same weight as one observation.*** *As a consequence, the cost function converges towards a single value when the resolution is increased.*¶

Minor comments

Line 67. “an event dated by radiometric analysis”. Shouldn’t this be a “layer dated by radiometric analysis”?

¶

Yes, layer is more precise, corrected.¶

Line 101. needs a “)” after “surface”.

Thanks.

Line 133. Maybe mention reversals as well as hiatuses (reversals occur in deep Greenland ice for sure, and in some Antarctic ice).

Thanks for the comment. We added the following sentence:¶

If there is a reversed section in the archive (e.g. the section 3,320-3,345 m in the Vostok ice core, Raynaud et al., 2005), this section should be considered as a different site and its depth axis should be inverted. ¶

Line 165. “D is the (dimensionless) relative density of the snow/ice material”. Clarify that this is relative to pure bubble free ice, not to (for instance) water.

¶

A relative density is always relative to the pure material, but sure we can make it even more clear:¶

…D is the (dimensionless) **density relative to pure ice** of the snow/ice material…¶

Line 350 and line 487. Neither m nor mn seem like good abbreviations for minutes. I suggest spelling out or using “mins”.

¶

Thanks, using “mins”.¶

Line 400. I know you refer to it later but here would be a good place to reference Mulvaney et al 2023.

¶

Yes, sorry, this was missing, corrected.¶

Figure 1. I found the legend on the right confusing for the diouble-headed blue and purple arrows, because they are labelled as ice-air or ice-ice links, but could equally refer to speleo-air or speleo-ice links. I assume that was the meaning of putting ice in () but this is nowhere stated. It perhaps should be for clarity (ie add a statement that (ice) should be taken to refer to whatever sediment is used, eg speleothem or marine sediment as well as ice).¶

Yes, for a simple archive, there is only one material so no need to specify it. This is why we put "ice" in parentheses. We propose the following text in the legend to clarify Figure 1:¶

The blue colour refers to the primary material (ice for an ice core), while the red colour refers to the secondary material (air for an ice core). The pink colour refers to mixed information involving the primary and secondary materials. In the legend, the term "ice" is in-between parentheses, since for a simple archive* (e.g. such as a sediment core or a speleothem)*, there is no need to specify the material which is unique.