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Climate of the Past Discussions

Interactive comment on "The Antarctic ice core chronology (AICC2012): an optimized multi-parameter and multi-site dating approach for the last 120 thousand years" *by* D. Veres et al.

Anonymous Referee #1

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1 General Comments

The paper presents a new timescale, AICC2012, and applies it to four Antarctic ice cores (Vostok, EPICA Dome C, EPICA Dronning Maud Land, Talos Dome) and one Greenland core (NGRIP) over the period 0–120 ka BP. The timescale is developed using inverse methods (the Bayseian tool 'Datice'). The Datice tool was previously used in Lemieux-Dudon et al., Quat. Sci. Rev. [2010] to revise yet earlier timescales for the Vostok, EDC and EDML cores. The major new contributions of the paper are (i) the availability of new dating tie points to synchronise the records and (ii), improved estimates of the age difference between ice and gas phase signals in the ice cores.

Previous techniques to estimate this age difference (Δage) relied on firn densification models which have recently been shown to be flawed when applied under glacial conditions to the deep Antarctic ice cores [Parrenin et al., 2012]. Here, following Parrenin et al. [2012], instead of densification models the authors make use of δ^{15}N data to estimate lock in depths and in turn Δage. Due mainly to the improved Δage estimates there is a systematic reduction in the ice ages of the Antarctic records compared to earlier chronologies, e.g. by around 500 years in the timing of the Antarctic Isotope Maxima throughout MIS 3. There authors provide some discussion of the differences between the AICC2012 timescale and previous timescales and also some very brief discussion of the implications of the timescale for our understanding of climate dynamics and the bipolar seesaw theory.

The authors have convinced this reviewer that the AICC2012 timescale is an improvement over that presented in Lemieux-Dudon et al., [2010] and that it merits publication in Climate of the Past. However, there are a number of issues, outlined below, that must be addressed prior to publication.

2 Specific Comments

1. The AICC2012 timescale for Vostok, EDC, EDML and Talos Dome must be made available upon publication of the manuscript. Ideally this would be as a SOM to the paper and as an entry in a publicly accessible online database e.g. NOAA's WDC for Palaeoclimatology with a link in the paper. Estimates of the uncertainly range for the timescale should also be published with the SOM/database files.

2. The many timescales available for Antarctic cores can be confusing. It would help the wider palaeoclimate community if a clear statement was included (I'd suggest in the abstract) about whether the AICC2012 timescale is intended to replace all previous timescales as the state-of-the-art for these cores (including NGRIP)

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and/or a clear statement about what particular circumstances/applications the authors recommend using AICC2012 and in what circumstances/applications they recommend using earlier timescales.

3. **P6014, L21–25 (abstract):** This conclusion appears in the abstract with insufficient justification or discussion in the main text. As I read it, these lines are saying that the peak of the isotope maxima at EDC are synchronous with abrupt transitions at NGRIP whereas at EDML the isotope maxima have flatter tops and *'precede the transitions by several centuries'* and that these observations 'confirm the regional differences in the millennial scale variability over the last glacial period'. It would be a big result if the difference in timing was really confirmed. I don't think it is. If a point is to be made about regional differences then specific language is required about what part of MIS3/which AIMs are being referred to, how the timing of the AIMs is selected and what the relative dating errors are between the curves. More discussion is needed (see also my comment further below about P6027 L4-9).

4. **P6014, L20–22:** Severinghaus et al., [1998], from which the 8-16°C figure comes, should also be cited: Severinghaus, J. P., T. Sowers, E. J. Brook, R. B. Alley, and M. L. Bender (1998): Timing of abrupt climate change at the end of the Younger Dryas interval from thermally fractionated gases in polar ice. Nature, 391, 141-146.

5. **P6016 L11–14:** Is there any evidence to support that the convective zone at the top of the firn did not increase significantly during glacial periods? As the method for estimating the LID hinges on this assumption I think it is needed to provide some evidence or at least some additional discussion.

6. **Supplementary figure 6:** This figure should be moved to the main text; it is important that the timescale uncertainties are clearly communicated. Also, please

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clarify whether the standard deviation in ice ages can be interpreted as a 1-sigma dating uncertainty.

7. **P6019 L1–2:** Were the six orbital climate links really all for T1? Briefly explain why these orbital points are removed for AICC2012. There is a note in the SOM on this but I think the reasons for excluding certain tie points (for Vostok and the other cores) should be explained in plain language in the main text.

8. **P6014 L26:** I think the paper promises too much in the introduction e.g. 'we present the absolute and relative dating implications of the new chronology over the last glacial inception and for the bipolar sequence of events associated with the seesaw mechanism over middle MIS3'. I think it would be more accurate to say 'we provide some examples of absolute and relative dating implications.. etc'. Same comment also applies to P6027 L12-13.

9. **P6019 L18:** I don't think that it is needed to give the timescale uncertainty for the >130 ka part of EDC on the EDC3 chronology given that it is not the interval or timescale that the paper is focused on.

10. **P6026 L15:** I'm not convinced about point (2). How can the inter-hemispheric gradient explain an offset up to a few centuries? Obviously it can't explain any part of the offset between the four Antarctic records. Please clarify.

11. **P6027 L4–8:** These lines read as though we are about to hear an explanation for why EDML has different shaped AIM to those observed at EDC, but none is in the end offered. Please clarify and provide additional discussion.

12. **P6027 L5:** TALDICE is not shown in Figure 4.

13. **P6027 L4–8:** Be specific about which AIMs occur earlier at EDML compared to EDC. It is not obvious from the Fig. 4 that this is the case for AIMs 5–7 or AIMs 10–11. It may arguably be the case for AIMs 8 and 12 but it would depend on how

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you defined the actual AIM (which is not specified); e.g. you may get a different result if you smooth the curve to reduce what may be site specific noise. More discussion is required here including of the relative dating errors of the EDC and EDML curves. This goes to the point made about P6014, L21-25 of the abstract.

14. **P6028 L12:** Are you saying here that the AICC2012 chronology is a better/more reliable chronology than GICC05modelext for this part of the NGRIP core? Can you make a statement here about under which circumstances/applications you recommend using AICC2012 and in what circumstances/applications you recommend using GICC05modelext?

15. **Table 1 and Section 4.2:** Uncertainties in the event duration on the AICC2012 timescale should be included in the Table. (Quoting from the SI: 'The aim is to ... build coherent and precise timescales with associated estimates of uncertainty range'.)

16. **Table 1:** Regarding the pers. comm. citation to Seierstad: If Rasmussen et al [2008] has been followed then there is no need to report the details elsewhere, if there are differences then they should be noted in the main text or SOM.

17. **Figure 1:** It would help the reader if labels were added to the figure denoting the AIM and GI/GIS numbers.

18. **P6030 L20-22:** The error bars for AICC2012 (when added to Table 1) could also be referred to at this point in the text.

3 Technical Corrections

1. **P6014 L4:** 'best-studied in environmental science' is a big call; suggest best-studied in paleoclimatology.

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2. **P6014 L16:** latitude records
3. **P6014 L26:** approximately 2°C
4. **P6016 L13:** 'modulated by the bipolar seesaw mechanism' suggest replace with 'predicted by the bipolar seesaw hypothesis'.
5. **P6015 L24:** difference, called Δage, reflects..
6. **P6018 L16:** 'shifted -705 years' it's not clear if this means it was shifted 705 years younger or 705 years older, please clarify.
7. **P6024 L10:** Rather than be redundant wouldn't such information help to refine and test the pairing?
8. **P6025 L24:** GICC05
9. **P6028 L15–16:** constraint
10. **P6032–6033:** The conclusion and outlook are nicely written.

4 References

Lemieux-Dudon, B., Blayo, E., Petit, J. R., Waelbroeck, C., Svensson, A., Ritz, C., Barnola, J. M., Narcisi, B. M., and Parrenin, F.: Consistent dating for Antarctic and Greenland ice cores, Quaternary Sci. Rev., 29, 8–20, 2010.

Parrenin, F., Barker, S., Blunier, T., Chappellaz, J., Jouzel, J., Landais, A., Masson-Delmotte, V., Schwander, J., and Veres, D.: On the gas-ice depth difference (Δdepth) along the EPICA Dome C ice core, Clim. Past, 8, 1239–1255, doi:10.5194/cp-8-1239-2012, 2012b.

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