Climate of the Past Discussions

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Review of Sinnl et al.: GICC21

Anonymous Referee #2

Referee comment on "A multi-ice-core, annual-layer-counted Greenland ice-core chronology for the last 3800 years: GICC21" by Giulia Sinnl et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-155-RC2, 2022

Review of Sinnl et al. A multi-ice-core annual timescale…GICC21

Sinnl et al present a timescale revision to the first 3800 years of the GICC – creating a new start to the timescale termed GICC21. The work presented is painstaking and involves revisions of only a handful of years per millennium. Having a timescale accurate to 2 years, rather than 5, allows much stronger conclusions and the effort is worthwhile. The manuscript is well written and organized. It is also long, but I found everything relevant. The analysis of the water isotope and accumulation signals after volcanic events and the discussion of Mediterranean volcanic events are not necessary but are worthwhile.

I am particularly happy to see the Maximum Counting Error (MCE) no longer form the basis for the uncertainty. The new method of calculating and describing the uncertainty, which utilizes the objective uncertainties of straticounter while acknowledging the inherent difficulty in assigning rigorous quantitative uncertainty, is itself a major step forward.

I have three primary questions/concerns. The first is about the improved match to IntCal. It seems like the reason for developing a new chronology was the disagreement with IntCal identified by previous work (e.g. Adolphi and Mueschler, 2016). I worry that statements like GICC21 is "found to be in alignment with IntCal20" make it seem like GICC21 is an independent check of IntCal. Instead, I think GICC21 is more accurately described as an updated chronology seeking improved agreement with IntCal that respects the annual layer interpretation and uncertainty. Improving the agreement of GICC with IntCal is a reasonable and useful thing to do – and the presented methodology an effective way to do it.

The second question/concern is the underlying data. Specifically, where is the EastGRIP and NEEM data? Substantial improvements in multi-parameter CFA have occurred and both of these cores should be providing fantastic multiparameter CFA data, but only Figure

7 shows any CFA data, and it's only Na and a snapshot from a relatively unimportant section of the timescale which has not been significantly revised. I see in the data availability section that there is a vague plan for publishing the data – which lists 3 papers, two of which are only in preparation. It is important that other researchers can assess the data that underlie the timescales, and therefore can make their own arguments about the validity. This is something GICC05 has lacked. GICC21 should not be published until the data used is available. While publishing the EastGRIP data could be complicated since the core is not yet completed, all of the other cores are quite mature. If the data are not already published, then they should be normalized (to prevent scooping with quantitative values since only the cycles are important for annual layer identification) and given their own DOI.

The third question/concern is about the ammonium (or -ECM log transform) matches. These seem to be used extensively, but are not well justified. Looking closely at Figure 2, many of the ammonium matches are little more than mini blips in most of the cores, with many substantially more prominent peaks being skipped. Further, two pairs of the 6 cores are from the same locations, so that the figure makes it look like there is better agreement than if only the geographicly separate cores were shown. I also don't understand the major vs. minor distinction and how it is applied in the alignment of cores. More support for why the ammonium matches add value isneeded. Is ammonium deposited consistently enough across a large enough portion of the ice sheet to be a chronological marker? and are the measurements are sufficient to resolve ammonium? ECM is susceptible to apparent low conductivity due to weak electrode contact such that it's possible the ammonium peaks may be misidentified.

Specific comments:

L69 – add sulfate, black carbon, as well as electrical conductivity measurements, and insoluble particles (i.e. dust). This seems too focused on water isotopes.

L69 – change "heavy" to something that does not imply weight, like "significant"

Section 1.3 – The first paragraph focuses on sulfate for volcanic event identification, then the second paragraph switches to acidity. I think you are likely referring to ECM rather than a direct measure of acidity. Please add more discussion around how the sulfate (and sulfur), ECM, and acidity measurements are interrelated and used together.

L98 – I understand what you are going for with a volcanic event being recorded differently as various sites, but GRIP and DYE-3 are both about the same distance from an Alaska volcano. Seems like Iceland might be a better example.

L105 – There is no reference for the matching of ammonium records among cores. As indicated above, this portion of the timescale development needs to be better supported. I'm not aware of this being widely used before. If it has been, please add a paragraph with references here. If it has not, please dedicate a section of the paper to the ammonium matches.

L107 – add a reference to Taylor et al., 1996: Biomass burning recorded in the GISP2 ice core: a record from eastern Canada?, The Holocene unless there is an even earlier reference for the ECM/ammonium/biomass burning relationship

L130 – This paragraph provides a nice description.

L157 – "bias in the counting process" should be changed to "bias in the interpretation process". The counting has never been the issue – the identification of annual layers is the issue. If you can identify each year, the counting is easy ð□□□

L182 – "includes all available data from Greenland deep ice cores" is not true – GISP2 is excluded. An explanation for why GISP2 is excluded, despite having publicly available data that allows annual layer identification, should be added. There should also be a transfer function for GISP2 to GICC21.

L335 – "major and minor" – I don't see any distinction in the ammonium matches in the remainder of the manuscript. I also think this is a suspect approach. Since there are lots of wiggles in the ammonium and ECM records, it seems like a lot of "matches" could just be of noise. Figures 2 and 3 do not convince me that the ammonium matches are anything more than non-unique wiggles that happen to fall at about the right age. As mentioned above, more analysis needs to be provided to support these matches.

L480 – I don't understand why the uncertainty estimates are based on just 4 sections. The straticounter probabilities are available for all sections, as is the manually fine-tuned timescale. This process should be done for all of the timescale.

L485 – convolved not convoluted

L543 – Figure 6 – This figure is the most important in the paper. But it is hard to interpret, particularly the uncertainties. If the primary point of the paper is that a multi-core analysis yields a better timescale, then why plot each of the individual timescales, some of which don't really exist – i.e. is there really an independent EastGRIP timescale? I think you should make this into a two panel plot. The top panel should have a comparison of only published timescales – GICC05, NS1-2011 (this is the Sigl15 timescale, right?) GICC21, and GISP2 (an oldie but a goodie). This should allow the uncertainties to be better visible, but importantly, the GICC05 uncertainty should be plotted clearly. It is an important point that the GICC21 timescale is a revision that is outside the GICC05 timescale.

Then in a lower plot, you can make a plot that uses the individual timescales as you've done.

L615 – Of course GICC21 is in better alignment with IntCal; the disagreement, as pointed about by previous work, is why you went to all the effort to update GICC05 in the first place! I think you can rephrase this section to be clear you have developed an annual timescale that reconciles the previous offset within uncertainty. This is an important thing to do!

L642 – I don't understand this paragraph. I think the main point of Figure 9b is that the purple (Be10 on GICC21) and the black (Be10 on Adolphi-Mueschler16) are very similar. But the main visual is the difference between the green (IntCal production) and the purple/black. The wording in the paragraph is hard to follow. Is the green important? Or could you just plot the purple and black?

L655 – How is the averaging done? Do you perform an initial average for the geographically similar cores, and average those together? I don't see this in Appendix B either.