Climate of the Past Discussions

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Comment on cp-2021-176

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Referee comment on "Comprehensive uncertainty estimation of the timing of Greenland warmings in the Greenland ice core records" by Eirik Myrvoll-Nilsen et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-176-RC1, 2021

The manuscript introduces a statistically robust uncertainty estimate of the glacial section of the layer counted Greenland ice core chronology GICC05 given certain assumptions. The result is then applied to provide precise estimates of the timing and the duration of the abrupt warming transitions observed in the Greenland climate records for the 11-60 ka period. I find the study relevant and well presented, but I encourage the authors the take a step further and compare their results to results of existing studies and to make further application of their results in order to increase the relevance of the study to the paleo community. Although it appears reasonable, I have to admit that I am unable to judge the validity of the details of the statistical approach. I hope that somebody more skilled will be able to assess that part. I do have a few comments of more general character as outlined in the following.

General comments:

It is stated repeatedly that the error estimation method provided in this study is a general method that can be directly applied to other types of layer counted records. If that is so, I suggest the authors provide examples of what other types of layer counted datasets the method could be applied for. If the method is not directly applicable to other types of records, I suggest that is reflected in the title of the manuscript. Note that some of the assumptions made along the way - eg that there exists a linear relationship between d18O and snow accumulation or that there is a linear trend in d18O within stadial or interstadial periods (lines 144-145) - are not general features that will be found in records from other types of archives (their validity can also be discussed for ice cores, but that is not the point here.)

A comment on notation. The Dansgaard-Oeschger (DO) events are quite well defined in the Greenland ice cores records, most detailed in [Rasmussen et al., 2014] that you are citing. There are 25 major events and numerous sub-events throughout the last glacial period. You therefore risk to create confusion when you state in the manuscript (eg in the Table 1 caption and line 285) that you have identified 29 DO events in the 14-60 ka period alone. Name them 'abrupt warming transitions' or something else, but not DO-events.

There are numerous studies in which the timing and duration of the onsets of the last-glacial abrupt warming events have been investigated (apart from [Rasmussen et al., 2014]), and I think it would be useful to compare your results to some of those. Perhaps the most obvious study to compare to is that of [Capron et al., 2021] in which the duration of the warming transitions is determined in several Greenland ice cores and for several types of records. Another study that determines the timing of the mid-point of the NGRIP d18O warming transitions is that of [Buizert et al., 2015]. Other approaches are taken in [Rousseau et al., 2017] and [Lohmann, 2019]. How does your results compare to the existing studies, for which applications is your approach superior, and why are the timing and periods different from study to study (if they are)? It would be great to visualize the timing or duration comparison in a figure somehow. Providing the exact numbers as done in Table 1 is of course important, but if you visualize the differences in a figure we will better be able to judge how important the differences are and if there are systematic offsets of some kind.

In the following, I have a few suggestions for how the new findings may be applied to progress our understanding of the abrupt climate change occurring during the last glacial period. I am not expecting the authors to comment on all of the suggestions, but I think the results of the manuscript would benefit from being put into a broader context:

- Stacking of warming (or cooling) transitions. A way to investigate the general nature of the warming transitions is to stack them across warming events, similar to the approach of [Buizert et al., 2015] Figure 2b (Greenland only). If you have obtained a more precise timing of the warming transitions than in other studies, the stack of events is likely to be more abrupt in 'your stack' compared to those applying other timings of the warming transitions (following the idea of [Svensson et al., 2020] Figure 5b, where the stacking is based on two different onset determination methods)?

- Application to other Greenland ice cores. Identification of the precise timing of warming events in the NGRIP ice core is great, but what if the transitions or the timing of the transitions look different in other Greenland ice cores (this appears to be a conclusion of the [Capron et al., 2021] study)? There is no reason to think that the NGRIP isotope record is superior to that of the other deep Greenland ice cores (eg GRIP, GISP2, NEEM). All of the Greenland ice cores have been precisely synchronized by volcanic events [Rasmussen et al., 2013; Seierstad et al., 2014], so it should be possible to investigate the timing of the warming events in multiple Greenland cores or in a stack of cores (see an example of how important the differences are between cores for the onsets of the Greenland warming transitions: https://cp.copernicus.org/preprints/cp-2020-160/ Figure 2)?

- Application to other data series: You are focusing on the d18O record that is indeed seen as the main ice-core climate proxy record. In [Rasmussen et al., 2014], however, the climate transitions are also identified in the Calcium record that has higher temporal resolution and may show a different climatic features. I was wondering if your method could also be applied to the NGRIP Calcium record? Or perhaps the dust record as applied in [Lohmann, 2019] and [Rousseau et al., 2017]. How does the transition onset times compare for the different records using your uncertainty estimate?

- Extending the approach to the entire last glacial period. Since your approach to estimate the time scale uncertainty is not relying on the layer counting uncertainty (MCE) your method should be equally applicable to a modelled time scale? We are currently lacking precise estimates of the warming transitions for the early part of the last glacial period, so why not extend the study to cover the entire last glacial period?

Specific comments:

Line 3: stadial and interstadial periods may not be known to all readers.

Line 67: 'up' or 'down' to depth z?

Line 125: I guess snow can both be removed and added by wind? Sublimation is another factor. Maybe not necessary to introduce those effects here.

Line 301 onwards: There are several reasons why the transition depths derived in [Rasmussen et al., 2014] may differ from those of the present study other than that they are obtained in 20 yr resolution from visual inspection. Rasmussen et al., identify the transitions in three Greenland ice cores using two different proxies (d18O and Calcium), whereas you determine the transitions in a single record from a single core. For a direct comparison, you should - in principle - derive the transitions from the same six records.

Figure 6, caption: in the last line there is mentioning of a red vertical line that has not shown up in my version of the figure.

In Table 1 there seems to be an error for the Z* CI column where all numbers are identical?

Line 314: You are describing a general framework, but not all paleo-archives apply d18O as a climate proxy.

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