

Clim. Past Discuss., referee comment RC2
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Comment on cp-2021-99

Anonymous Referee #2

Referee comment on "Canadian forest fires, Icelandic volcanoes and increased local dust observed in six shallow Greenland firn cores" by Helle Astrid Kjær et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2021-99-RC2>, 2021

Review of manuscript cp-2021-99:

"NEEM to EastGRIP Traverse - spatial variability, seasonality, extreme events and trends in common ice core proxies over the past decades" by Helle Astrid Kjær et al.

This study presents new impurity data from six firn cores taken along a spatial transect in North Greenland and measured with a Continuous Flow Analysis system. The data are investigated in regard to their mean seasonal cycle, their temporal trends and their usability for indicating volcanic events and as a forest fire proxy. While the results could be of interest to the ice core and proxy community and hence to the Climate of the Past readers, I rate this paper to not sufficiently well communicate the novelty of the results and its overall presentation quality to be poor. In brief, I recommend the paper to be rejected.

Major comments

Overall structure and writing. In my opinion, the text seems carelessly assembled and is poorly written. Many parts and sections lack a clear structure, most notably the abstract and the various results sections. Especially regarding the latter, there is no clear distinction between the presentation of the study's results and their discussion. While the journal offers the possibility of a combined results and discussion section, I find it unusual that the authors chose to start many sections with some kind of short literature review before they actually present their own new results. Additionally, results are very often stated or mentioned without any clear reference to a figure or table, which makes it

difficult for the reader to retrace and verify a particular result. Regarding the writing, the text suffers from frequent grammatical mistakes and “orphan sentences” which lack a subject or syntactically just peter out.

Figure quality. The figure quality is very poor overall. The resolution is too low, making the graphics grainy already at standard zoom, the labeling is faint and too small, and the line plots are thin and are using color scales that are very hard to distinguish and are even indistinguishable for color-blind people. I would strongly recommend the authors to study how to produce higher-quality graphics from the computer program in use, either by using scalable vector graphics or by using a sufficiently high dpi value for raster graphics. In addition, color scales which are legible for color-blind people and sufficiently distinct both for on-screen viewing as well as printing can be looked up on resources such as <https://colorbrewer2.org>.

Local deposition noise. Local deposition noise, and also the noise from intermittent precipitation, is an important issue but not treated appropriately in this study. It is either mentioned somewhat unmotivated, as is the case for example on P10 Line 29, or only briefly referred to at instances scattered throughout the text. In the recent years quite some literature was published on these topics, both for Greenland and Antarctica, which could be used to put the current data into context. While the available data might be a bit limited for this purpose, one could perform at least some statistical investigations, e.g., looking at the correlations between profiles at seasonal and annual resolution to see if there is any common signal among the cores along the traverse, depending on the impurity species.

Trends (Section 5). In general, it is very difficult to follow from where you derive your results and conclusions about the various trends. Overall, the paper would benefit from showing additionally a plot with the annual mean time series for the individual impurities, maybe even showing only stacked annual mean time series from averaging across the firn cores in favor of a clear presentation. Then, clearly stating the results from linear regressions on the data, including slope uncertainty and p values, might help creating a concise picture on the overall trends. In case of insoluble dust fluxes, you do use annual mean time series, but for unknown reasons they are relegated to the supplement, and the trend results mentioned in the text are hard to verify by looking at Fig. S3. Maybe a logarithmic y axis scaling and adding the trend lines to the plot might help here.

Section 6. Overall, these sections are overly detailed, making it hard for the reader to grasp the main conclusions you want to convey here. One idea could be to put all of the results concerning the determined extreme and volcanic events, and the possible sources thereof, into a table, maybe also giving some indication for how certain you can be on relating a specific event in the records to a known eruption or other source. Then, the text could be significantly shortened to concisely present the main findings and conclusions from this table, which could make it much clearer for the reader how the new data can possibly advance our knowledge on the mentioned topics.

Minor comments

General. Frequently, the term "excess" is used to refer to specific data series, however, what this terminology means is nowhere explained. This is problematic since it is firstly not a common terminology for data series, and secondly it might be confused with the quantity of "deuterium excess" commonly measured on firn and ice cores. From what I understand, your usage of "excess" refers to either the deviations from the mean of the seasonal cycle data (Fig. 3), which more commonly would be referred to as "anomalies", or to the residuals after subtracting a five-year running mean from the data series (e.g., Fig. 4). I would suggest to adopt a more appropriate terminology or to clearly define your usage of the term "excess" in the Methods.

Title. I find the title too long and too general, merely listing key words rather than naming the key essence of the paper. In addition, the title should not have a full stop (I am referring to the pdf version here).

Abstract. In my opinion, the abstract could be significantly shortened to convey only a brief introduction as well as the key messages and results of the study. There are several unnecessary filler sentences, e.g., "The temporal variability of the records is further assessed", "By creating a composite based on excess ammonium compared to the five year running average..." etc.

P2L17. Maybe here a word about possible complications with CFA measurements is appropriate, such as the intrinsic diffusion-like smoothing of the CFA system.

P2L19-23. I find the here-stated motivation for the paper a bit vague, e.g., "constraining proxies analysed by means of CFA" could be understood in a technical sense from a measurement quality point of view, which is I guess not what you have in mind. Could you elaborate more precisely on the main aims of the study?

P4L6. I guess by "acid" you refer to the H^+ measurements here, which is, however, unclear at this point, since you use one or the other term throughout the text, and it is also a bit misleading, since in normal language acid could mean any kind of acid (I guess you refer to the Brønsted–Lowry acid definition here?). Please choose one terminology, introduce it here and then use it consistently throughout the text. The same goes for the other species, which you alternately refer to either by their chemical composition (e.g., NH_4^+) or by the common name (i.e., ammonium). The text would be much easier to follow if you stuck to one option throughout.

P5L1-11. This method description is hard to follow and seems incomplete. What I

understand you do in essence is seasonal layer counting to derive an age-depth relationship for your cores, for which you use the peroxide mainly, and additionally calcium, if the former has not good enough quality. What remains a bit unclear is how you derive the age scale in Fig. 2; I guess you use the age-depth relationship from the peroxide peaks to interpolate your depth series into a time series using the constant accumulation assumption stated in the second paragraph. However, this is not entirely clear since you mention the equal accumulation assumption and formal month definition only in relation to "investigating the seasonality" (Fig. 3). In addition, from the caption of Table 2 it seems that you block-average your depth series data into monthly means following the formal month definition; is that correct? If so, it should be mentioned here.

P5L6-9. But could you maybe give an educated guess for how far off you might be with the constant accumulation assumption from the actual seasonal accumulation variations?

P5L13. "profiles": If I understand your methods correctly, Fig. 2 actually shows monthly mean time series for the individual impurity species and cores. This should be explicitly mentioned/repeated here to ease understanding and to avoid confusion with the original depth series.

P7L5. Do you mean the interannual variability here? Where do I see that the variability is large, and what do you mean with the "concentration variability between sites is masked"?

P7L19-20. How do you derive that conclusion, based on the values in Table 2? Did you perform any statistical test to check whether the null hypothesis of identical mean and/or distribution cannot be rejected?

P8L2-4. Speaking of spatial variability here is misleading, since variability is more commonly understood to mean random variations. I could imagine what you instead observe here is a spatial gradient in concentration due to a gradient in accumulation.

P8L13. Rather use "average seasonality", "average seasonal cycle" or "climatology" for describing these results.

P10L3-4. "The variability is high and unevenly distributed" – again, where can I see this? Can you quantify it, i.e., it is high relative to what? What means unevenly distributed?

P10L14. It is unclear to which species you refer to here. What means "high deviations in adjacent months"? Isn't that in general the case for a seasonal cycle?

Technical comments (by far not exhaustive)

Throughout text. The core names are inconsistently labelled either T2015-A1 or 2015T-A1, and so on. Please use one consistent nomenclature.

P1L24. Change "70's" to "1970s" (more similar instances throughout the text).

P1L25-26. The sentence "After detrending using..." is difficult to understand and should be rephrased.

P2L3. "intricate": I would avoid such an evaluative adjective in a scientific text.

P2L11. Should be changed to "at the deposition site".

P2L5 and L12. Please note the hyphenation needed in phrases such as "large-scale atmospheric circulation patterns" or "high-resolution climatic signals". This is a frequent mistake needing correction throughout the text.

P2L18. "sample decontamination": To my understanding this means cleaning from toxic components or from radioactive radiation. Is this what you actually mean here?

P2L25. "Neem" should be "NEEM"; "May to June" of which year do you mean? You also should explain the various site acronyms at some point in the manuscript (preferably at their first respective instance).

P2L26,27. Please format the site coordinates correctly. Besides, I would welcome giving the coordinates in decimal degrees, since that is easier to handle in a numerical context.

P2L31. A comma is missing between "Greenland" and "and then shipped".

P3L2. Please rephrase to “prior to the CFA measurements”.

Fig. 1 caption. Please mention the information relevant to the study first, i.e., first the firn cores, then afterwards the information on the surface elevation data set.

Table 1 caption. The column of core depths is not mentioned in the caption. Additionally, you write that the core labels go till “2015T-A5”, but there is another core (“2015T-A6”) listed in the table.

P4L4. “in 2017”: this could be mistaken to mean that you only measured the impurity content for the year 2017; I guess instead you mean the CFA measurements took place in 2017; please rephrase.

P4L5. Add a comma before “by adding”.

P4L8. Please change to “were converted into units of concentration”.

P4L9-10.

- Do you mean “A baseline was established”?
- You should explain what “milliq water” means; not every reader might be familiar with the laboratory terminologies.
- What is “eight 55 cm pieces stacked” supposed to mean?
- “Although” is not the correct wording here; I guess you mean something around “In general the baseline was established by... However, for the top 1.65 metres, where the core was fragile [...], the baseline was established...”. Please clarify.

P4L13/15. The firn cannot “suck anything”. Melt water can flow or percolate into the firn driven by capillary forces; please use the correct physical terminology.

P4L15. I don’t understand how excess water can be limited to an amount of 0.5-1 cm; what does this unit mean here? Please bear in mind that not every reader might have worked with a CFA system him- or herself.

P4L18. “response time”: Again, a reader not familiar with the CFA technique will have

problems understanding this; what do you mean by response time and how does this affect the effective depth resolution?

P4L20. Please change to "at a sufficient resolution".

P4L21. Do you mean "which are used to constrain...".

P4L22-22. Please change to "as it is produced by a photochemically-derived".

P4L27. Please change to "this exchange can cause smoothing".

P5L3. Please change "invoked" to "used".

P5L9-11. Why not? If you mention this explicitly here then you should give a reason for not doing it.

Figure 3. It is rather counterintuitive to display the formal months in the reversed temporal order summer – spring – winter – autumn.

P20 L27. "dissolves" is the wrong wording, please use "resolves" instead.

P20L29. As mentioned earlier, you mix up spatial variability (random variations) with spatial gradients or spatial variations. Please be careful to use the appropriate wording throughout the text.

P21L4. Please change to "We thus highlight" and to "of using the same methods".

P21L6. Please change to "in the acid and conductivity profiles".

P21L7. Please change to "an increase over time, especially for the large ...".

P21L9-11. Please change the reference to the standard format; the final sentence is grammatically wrong.