The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC2
https://doi.org/10.5194/tc-2021-190-RC2, 2021

Comment on tc-2021-190

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Referee comment on "Microstructure, micro-inclusions, and mineralogy along the EGRIP (East Greenland Ice Core Project) ice core – Part 2: Implications for palaeo-mineralogy" by Nicolas Stoll et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-190-RC2, 2021

The manuscript presents a series of detailed investigations of cm-scaled sections from the EGRIP ice core, mostly from the Holocene ice core section. The sections are analyzed for cryo-Raman spectra, microstructure, microscopy, and compared to high-resolution dust records. Based on this, the temporal development of the ice core mineralogy is discussed.

The manuscript (MS) is very detailed almost providing a review in some section, figures are generally good, and referencing is satisfactory. The analytical work presented in the paper is impressive and of relevance to the community. I have some comments and concerns in the following.

General comments

Whereas the MS discusses to a great detail how the impurity composition results may relate to the long-term climatic context, I think another important property/sample characteristics is somewhat overlooked, namely the sample seasonality. Because almost all of the impurities in the Greenland ice sheet show some kind of seasonal pattern/variation, I think the season from where your samples are taken may influence their composition just as much as the longer term climate context (eg where in the Holocene the sample is taken). For example concerning dust, we know that today we have a large Asian-derived dust spike in Greenland in spring/summer, whereas the dust in other seasons could be of different origin(s). The detailed sample composition may therefore depend strongly of which season the sample is take from. In Fig. 1 (b)-(l), we see that all of the samples appear to be associated with a dust spike. Does that mean that all samples are from spring/summer? I think that with all of the high resolution profiles that are available for EGRIP, it should be possible to determine the approximate seasonality of the samples? For the Holocene, you may for example compare the CFA profiles to those of (Gfeller et al., 2014).

Likewise, it may be of use to make more comparison to the CFA / DEP / ECM record or to the line scan profile across the sections you have sampled. Are samples with high sulfate associated with high DEP/ECM/Conductivity? Are you in a winter layer with high NaCl? Are the dust concentrations typical? Is here a possibility that one or several samples coincidence with forest fires (NH4), a volcanic eruption (DEP/ECM/Conductivity) or some other atypical feature? One sample is from a cloudy band. Is this a 'typical' cloudy band for the period or is it somehow exceptional? It is stated that in this MS you 'focus on the chemistry', but there is very little chemistry data shown and the comparison between 'chemistry' and the Raman and other results is sparse.

I think the authors need to spend a little more time working with the wording of the text. In every other line, I think there are imprecise statements or the wording is not concise. I gave up making a list of specific places where I think the text could be improved, as I think this is a task of the authors.

Specific comments

Throughout the MS there is reference to 'bags'. Whereas this may be a meaningful notation for those working on ice cores on an everyday basis it may not be the most obvious notation for the reader. I would suggest to replace with '55 cm sample' or similar throughout the MS.

Throughout the MS there is reference to 'a companion paper'. Rather than making the reader start guessing about what paper that might be, I suggestion to cite to the full reference.

In several places there is mentioning of the upstream effects at EGRIP. There is now a paper discussing those effects at EGRIP and it may be discussed how important upstream effects may be for the sampled intervals (Gerber et al., 2021).

For the discussion of the extend of the Greenland ice sheet in earlier periods and possible costal dust sources (l. 422-432), you may refer to (Simonsen et al., 2019).

Figure 1: This is the figure where you put your samples into a climatic context and I have a number of comment/suggestions:

- It is very important that overall climatic context is clear, therefore, it would be very helpful to include to water isotopic profile (d18O) in the figure, eg we need to know exactly where the YD onset and terminations are in relation to the samples and which part of BA your sample are taken from. If the EGRIP isotopes are not released you can show

DEP or ECM or transfer the isotopes from another deep ice core.

- In (a) I do not understand what the black dots represents. How are the depths chosen? Isn't there a continuous dust profile for the Holocene? It seems like the dot density is very irregular? Considering the abrupt change in dust concentration at the YD boundaries by an order of magnitude or more, the smoothing of the dust profile appears somewhat unjustified.

- In all figures it says the x-axis shows dust particles per ml. Are those the >1 micron particles only or what size fractions are included. This should be specified.

- In all of the Greenland dust profiles I know of (Eg (Ruth et al., 2002; Schüpbach et al., 2018)), the Younger Dryas is characterized by a much high (order of magnitude) dust concentration than the Holocene, whereas the BA period has intermediate dust levels. This pattern is not at all reflected in the dust curve shown in (a). The indication of the YD interval appears inconsistent with the depths provided lines 100-103.

- Figures (b)-(l) nicely show the position of the sample in context of the continuous dust profile, but they do not give an impression of the absolute dust level in each sample, which vary by orders of magnitude and may have important implications for the interpretation. I would suggest to either use a common log scale for all the figures or to keep-as-is but then add another column of figures that shows the absolute level at the same detailed depth resolution. The dust level at the sample resolution is a basic parameter that that may fundamentally impact the sample composition, and it is not deducible from (a).

- Caption: please be somewhat more precise in this and other captions: Eg 'Dust data' potentially means 'Number counts of particles larger than 1 micron per ml of melt water'? '55 cm bags' may not make sense to the reader. 'Cloudy band' may not make sense to the reader. Refer to main text if explained elsewhere.

Table 1: Please specify what the depth refers to: top, middle or bottom of sample. If someone wants to compare your results to other records it is important to know the exact sample position. You may consider naming your samples, eg S01, S02, … S11 rather than referring to the sample depth in the text. This may improve the readability of Figure 4 and others. If you do that, this table should include the sample names. You may also include information about what criteria the individual samples are selected from. Furthermore, information about the mean crystal size, fraction of sample covered by crystal boundaries, the mean dust and salt concentrations and the sample average conductivity/DEP/ECM level(s). If possible, information about the season from where the sample is taken could be included as well.

Table 2: You investigate the fraction of impurities that are found in grain boundaries. I think it is relevant in this context also to state the fraction of each sample that is covered by grain boundaries according to your 300 micron definition? For some samples it appears that a quite a large fraction of the analyzed area is covered by boundaries. If you then subtract the area covered by air bubbles, it could be that in the end there is no preference of the impurities to be located in a boundary or not?

Figure 4: Based on the sulfate diversity presented in Fig. 4(b) you conclude that there is a general decrease in the sulfate diversity with depth and in the abstract you mention that there is a change at around 900 m depth that is also discussed at length in the discussion. I think this conclusion is poorly supported by the data. Indeed, the sulfate diversity of the four deepest samples is low, but it is also low for two other samples from above 900 me depth. The two deepest samples are from the last glacial period where many climatic conditions were quite different from the Holocene conditions, so I am not sure those two deeper samples are directly comparable to the younger ones. An alternative interpretation of the figure would be to say that the sample from 1062.65 m depth looks unusual in terms of sulfates, but that all of the other samples are similar, leaving out the two deepest samples that are from a different climatic period. In other words, I think the statistics may not allow for the conclusion you make.

l. 37: 'CFA' is unexplained at this point.

l. 111: 'thin sections' is unexplained at this point.

l. 290-294: This section appears to belong in the conclusions?

l. 344: Does 'the stadial' refer to the Younger Dryas interval in this case?

l. 445: What is Dome Fuji Interstadial ice?

l. 458-465: It seems unnecessary to repeat part of the introduction here.

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