

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-142

Anonymous Referee #1

Referee comment on "Accumulation of legacy fallout radionuclides in cryoconite on Isfallsglaciären (Arctic Sweden) and their downstream spatial distribution" by Caroline C. Clason et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-142-RC1>, 2021

General comments

This manuscript provides an original dataset including gamma-emitting fallout radionuclides activities, geochemical oxide composition/trace element concentrations, and C/N compositions obtained on cryoconite samples (n=14), sediment sources (n=23) and a 38-cm long lacustrine sediment core collected in a 1-km² glaciated catchment of Sweden. The authors discuss the spatial and temporal distributions of these properties in response to glacial processes and sediment transport. They also underline the potential environmental and health deleterious impacts of the redistribution of these potentially harmful substances (e.g. in response to the ongoing global warming and snowmelt processes). Overall, the manuscript is well written, the data is well described and the results are well discussed at the light of those previously published in the literature.

However, in my opinion, the study site should be further contextualized. Furthermore, the maps could be improved and the interpretation of some of the results could be taken further (e.g. relying on part of the data analysed although maybe under-exploited, regarding the particle size and the organic matter composition, in particular for cryoconite samples). The interest of this research for tracing the impacts of snowmelt-induced sediment redistribution could also be underlined (instead of focusing only on the potential harmful impacts of the release of radionuclide substances stored in this glaciated area in response to snowmelt, although I acknowledge this interest of doing so, in particular in Sweden, for the reasons well explained by the authors in the manuscript including the substantial post-Chernobyl fallout in this region and the specificities of the regional food diet). Accordingly, I recommend reconsidering acceptance of the manuscript after major revisions have been performed. Nevertheless, I would like to underline the fact that I enjoyed reading the manuscript, and improving the data presentation /interpretation will definitely further increase the impact of this nicely conducted study. I acknowledge the large quantity of fieldwork (in very likely adverse conditions!) and labwork conducted, and I am thankful of having been given the opportunity to discuss these results with the community!

Detailed comments

Abstract

LL18-20 maybe adding values would be useful for the readers here; not sure whether you only refer to the Chernobyl and Fukushima exclusion zones here?

LL.25-26: as in the general comment above, I would also insist on the interest of analysing these substances as unique tracers to understand the impact of ongoing snowmelt processes on the dispersion of sediment and associated contaminants across catchments in this part of the world.

Introduction

L.42 not sure I would start this sentence with a 'but'?

L.50 could you provide examples of what would be 'anthropogenic organics'?

- 59 please remove the . before the (

L.60 (and elsewhere in the text): Is 'prevalence' the right term to use here? Wouldn't the terms 'persistence' or simply 'occurrence' be more appropriate?

L.62 'environmental fate of the radioactivity' >> fate of the radionuclides?

- 63 unclear what you mean with 'in addition to any potential socio-economic impacts' here? Could you be more specific?

LL.64-65 same remark with 'subsequent dilution in the hydrological system', could you specify what you mean?

LL.67-76; I had the impression that this paragraph could be rewritten to better outline scientific questions instead of listing the analyses made and 'arguing' that FRN activities are higher than those found in other environments?

Study site

In my opinion, this section was pretty short and focused on glacial geomorphology. What about rainfall/snowfall in this catchment? What about the bedrock lithology, the soil characteristics (if this is relevant in this catchment?), etc.

Methods

Overall, in this section, the sampling period should be better defined (in the introduction, the period of 'August 2017' is mentioned, then nothing else is added... How high was the precipitation during the months before sampling? How was it distributed with time? I guess that this is a crucial aspect for supporting the interpretation of the results (e.g. mainly for Be-7 and Pb-210 data).

L.98 the authors refer to 'sources' here, although the reference to sources is no longer used in the interpretation... Were all the potential sources covered by this sampling (or maybe this wasn't the purpose...)?

L.102 could you be more specific on what you mean when referring to the 'proglacial outlets'?

L.106 At 100°C? Isn't it too high for the organic matter composition analyses?

L.107 'due to the limited amount of cryoconite available' >> what did it represent in grams of material (to have an idea of the difficulties encountered)?

L.107 why using a < 75µm sieving threshold (compared to the classical 63 µm threshold for instance?)

L.109 was there a specific preparation protocol implemented before conducting the particle size analyses?

L.115 the article cited here (Wynants et al., 2020) refers to a study conducted in the African Rift Region with limited additional details on the gamma spectrometry analyses: I am not sure this has an added value here, or did I miss something?

L.130 I guess that you used two certified material samples to account for the matrix composition differences between cryoconites (more similar to moss soil?) and other sediment materials (more similar to the 'soil' TEL-2012-03); is it so?

LL.134-147: the section on WD-XRF analyses is well described, except maybe the calibration/validation issue: was it exclusively based on comparing the results obtained with WD-XRF and ICP-OES on a selection of samples, or were certified materials also used for this crucial step?

L.149 wasn't the drying of cryoconites at 100°C a problem for the subsequent stable isotope analyses? Where are the analysed $\delta^{13}\text{C}$ / $\delta^{15}\text{N}$ values of the samples provided? Or did I misunderstand this paragraph and only the TOC/TN were analysed?

L.164: the attribution of the year 1952 or 1954 (or even 1955) may be debated for the lower level of lacustrine sediment in which Cs-137 is detected. This gives at least an idea of the uncertainties associated with core dating (+/- 4 years?). What about the level to which the year 1959 (L.169) is attributed? To which event is it related (e.g. the Tsar bomb fallout took place in 1961)? Or did I miss something in the rationale here?

Results and discussion

L.177 is the title inclusive enough here ('geochemical composition of cryoconite') given the section contents?

LL.183-184/L.185/etc. at some places, some generalities are given on radionuclides, although I wonder whether they are really relevant (e.g. on the solubility of Cs-137 and the long range transport of Chernobyl fallout...?)

LL.193-195 Providing additional information on the lithologies found in the catchment would be very useful to support the interpretations made on the K-40 levels measured in the samples

LL.199-200 maybe I missed it here, but I don't see how Fig. 2C illustrates the influence of organic content on the accumulation of radionuclides; additional elements should be

provided here to better support this statement...

L.203 not sure it is relevant to use 2 decimal digits here for the %C and %N?

L.212-230: to better support the interpretation of Be-7 results here, additional information should be provided on precipitation (snow/rainfall + snowmelt) during the months before the sampling campaign was conducted here. Furthermore, given the short half-life of Be-7 (~53 days), information on the analysis period after sampling is also crucial (as Be-7 could be <MDA in some samples just because some samples were analysed too late, and Be-7 initially present had just decayed to undetectable levels?)

L.220 maybe the following ESSD manuscript (on Be-7 and Pb-210 levels across the globe) could be of interest to the authors here:
<https://essd.copernicus.org/preprints/essd-2021-35/>, similar work must have been published on Cs-137 as well.

L.248 how were these metals selected?

L.253 is the normalization to the upper continental crust the most relevant option here to calculate the enrichment factors? Or did you use a more specific dataset for normalization?

L.275 'it is perhaps unsurprising' > I would consider rephrasing the sentence here?

L.281/283 problem with the notation of Na₂O here (should be a subscript instead of a superscript?)

Discussion in subsection 4.2

LL.293-... Overall, here, I think that the comparison of properties in cryoconite vs. other samples should be supported by the comparison of their respective particle size/organic matter compositions, as an enrichment in fine and organic material in cryoconites vs. other samples is expected to control the higher levels of contaminants measured in these samples and, according to the Materials and Methods section, you did analyse these properties...

LL.299-301 see my remark above on the precipitation before sampling to support the interpretation of the Be-7 results

L.323 see my remark above about referring to the lithological characteristics of the study site to interpret K-40 (and I guess supported) Pb-210 here...?

LL.363-366: not sure if you can go that far in the interpretation regarding Am-241 activities here?

Section 4.4

LL.372-... importantly, here, I would add the implications of these results and the detection of such high FRN activities in material transiting glaciated environments to trace and understand the icemelt/snowmelt-induced redistribution processes in the future?

LL.384-386 'It has been suggested that areas with previous ¹³⁷Cs contamination may augment ¹³⁷Cs transfer following future contamination events due to fixation in soils' >> unclear what you mean here, could you please clarify this statement?

Conclusions

Based on the changes made when revising the manuscript, some conclusions could be revised here (e.g. interpretations related to the organic matter content in cryoconites vs. other samples; interpretations related to Be-7 activities...)

L.412: nuclear incidents >> nuclear accidents? Importantly, the thermonuclear bomb testing supplied most of these FRN (and I am not sure that they can be considered as nuclear incidents or accidents?)

L.434 see the previous comment regarding the use of the 'prevalence' term

Figures

Figure 1: this catchment map actually does not provide catchment delineation (to the best

of my understanding of this map); could this be improved? Furthermore, there is no North arrow/ scale on the inset map of Sweden (I guess this is the map of Sweden?); it is hard to see the river network and the sample symbols are not so easy to see/understand on these maps... This is nice to see the glacier lobes on the image but the other features of interest (sampling locations and types, catchment delineation, river network...) could be presented in a much clearer way in my opinion...

Figure 2: it is not easy to read/infer the FRN activities based on this map (as single values are attributed to the circles), the exact values could maybe be added near the circles on the map in red/blue?

Figure 5: I don't understand why the core samples were split into 4 sections; in my opinion, the core samples should be merged and compared to the potential sources (maybe the continuously supplied FRN such as Pb-210 and Be-7 as they decay with time/with depth in the core and they are therefore not fully relevant for this comparison but some of the geochemical elements/ organic matter properties might be?); I would consider adding the cryoconite properties to the graphs (after normalization to the particle size/organic matter properties?)

Figure 6 is not very easy to read neither, at least the river network should be clearly added to the map?

Figure 7: figure resolution seems not to be optimal, the years attributed to the peaks could be added on the Cs-137 part of the graph?

Appendices

Table A.1 what was the decay-correction date? Not sure that you should provide 2 decimal digits for the Am-241 activities?

Table A.2 I would remain consistent with the number of decimal digits provided in this table... Do the values after +/- refer to the SD? For the 'central forefield' samples (n=2!), this is meaningless to provide a mean/SD and I would provide the range of values instead...?

Adding the particle size/organic matter data to this summary table would be very useful...

Regarding the footnote on Be-7: information on the time between sampling and analysis

would be particularly meaningful here...

Table A.3 were the EF calculated based on the data of the upper continental crust here?