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The Cryosphere Discussions

Interactive comment on "Cryoconite as an efficient monitor for the deposition of radioactive fallout in glacial environments" *by* Giovanni Baccolo et al.

Anonymous Referee #1

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General comments

This study presents high concentrations of radionuclides found in cryoconite collected from two mountain glaciers in European Alps. Cryoconite is organic and inorganic sediment on glacial ice and has been studied chemically and biologically on world-wide glaciers. However, there has been still limited information on radionuclides in cryoconite. The manuscript is well-written and contains interesting analytical results, which were properly discussed in terms of natural and anthropogenic sources of radionuclides. However, I have some concerns on the discussion of the accumulation processes of radionuclides in cryoconite. I would strongly suggest to revise the points indicated below before the publication.

Major points

1. I would strongly suggest to divide the section of "Results and discussion" into two sections: i.e. "Results" and "Discussion", which would present the context of this paper more efficiently.

2. Use carefully the terms of "cryoconite" and "cryoconite granules". "Cryoconite" means bulk sediment on glacier ice, but "cryoconite granules" mean spherical aggregations of the sediment. This difference is particularly important when authors discuss the resident time of substances or elements in cryoconite. In many cases in the text, cryoconite should be replace to the cryoconite granules, please check it throughput the text.

3. High concentrations of 210Pb in the cryoconite is interesting. Authors concluded that it is a result from interaction between ice, meltwater, and cryoconite. However, this could be discussed more carefully with previous works. For example, there has been a quantitative study of accumulation of 210Pb in snow and ice on an alpine glacier in Europe (Gäggeler et al., 1983). The age of ice at the sampling sites in this study seems to be important to explains the high 210Pb concentrations. If available, it would be worth to show the exact locations of samples on the glaciers and age of ice (or estimation based on the glacial ice movement). In terms of role of organic matter or biological activity for 210Pb in cryoconite, there have been many studies on the process of 210Pb (or 210Po) in organics in marine or other environments (e.g. Kim et al., 2012; Fowler et al., 2011) and also on accumulations of heavy metals in snow algal cells (Fjerdingstad, 1973), which would help to understand why the 210Pb was concentrated in cryocontie. Nagatsuka et al. (2010) showed the variations in stable isotopes of Pb in different organic and mineral fractions in cryoconite, which may also be worth to discuss the accumulation process of Pb in cryoconite.

4. The accumulation process of elements in cryoconite should not rely on their radioactivity, but on the chemical or biological properties of each element regardless of radioactive or stable elements. Some statements in the text are misleading. For example, authors say that "cryoconite accumulates radioactivity" in L92, but cryoconite does

not accumulate radioactivity, but may chemically accumulates the elements including radionuclides. Same in many places (e.g. L435-446). Please present it correctly.

5. In conclusion, authors mentioned that cryoconite is a potentially hazardous material, however, I would think that this is an excessive statement and out of the context of this manuscript. There was only one sample that exceeded 10000 Bq kg-1 in this study. Also, the limitation of legislations on the radioactivity in environmental materials should be shown and their potential risk for human health should be quantitatively discussed if authors want to use this statement. I would suggest to state the conclusion more objectively.

Minor comments

1. Title: I would not be sure that cryoconite can be an efficient monitor of radioactive fallout. Use of "monitor" here is very vague. Based on the conclusion, we might detect artificial radioactive elements in cryoconite, but it seems to be difficult to know the time and amounts of their fallout. There might be more proper title for the manuscript.

2. L27 It would be worth to state the specific interaction between cryoconite and the environments.

3. L28 Again, what is "an ideal monitor"? Need specific explanation.

4. L47 Insert "on the ice surface" after "a dispersed material".

5. L53 Insert "granules" after "cryoconite".

6. L63 Insert the year of Meese et al.

7. L82-85 Nagatsuka et al. (2010) could also be worth to be cited here.

8. L92 Please state properly that cryoconite doesn't accumulates radioactivity, but accumulates radioactive elements.

9. L103-116 It would be worth to add more information of the two glaciers in this study,

for example, the reason why the authors selected these two glaciers for this study and difference of mass balance, glacial flow velocity or estimated age of ice at the sampling sites between the glaciers.

10. L127-128 Please show exact locations of the 12 samples for Morteratsch and 10 for Forni Glaciers on the map of Fig.2, and add their coordinates and altitudes in the Table S1. This is important to discuss the resident time of cryoconite on the glaciers. Also, please show the total amounts (dry weight) of cryoconite used in this study.

11. L168 "Pearson's correlation coefficient" instead of "Peason correlation"

12. L179-184 This part, which presents mostly previous works, should not be in Results, but be moved to Introduction or discussion section.

13. L214 Suggest to start a new paragraph here.

14. L228 It is very good to compare the results with those of other environmental samples. But, it would be better to compare with only studies in Europe in order to show whether cryconite accumulates the elements or not. Because the radionuclide activities can vary with geographical locations, i.e. the distance from the source.

15. L254-255 Please clarify that this statement is from previous works (need references) or from this study.

16. L274-278 The difference of the two glaciers is interesting and can be discussed in more detail here or later.

17. L304-305 Specify the time difference between "historic" and "contemporary". It would be worth to mention the age of ice at the sampling site if available.

18. L324-347 and Fig.5 It would be worth to show a map showing the geographical locations of the Caucasus, Svalbard, Chernobyl, Semipalatinsk, and the glaciers of this study.

19. L360-374 Organic carbon contents in cryoconite seems to be significantly different

between the two glaciers. Please explain why.

20. L383-400 It is interesting that the radionuclides differ between the two glaciers. Authors discussed it with only the difference of altitude of the glaciers, but it needs to be discussed more carefully. What is the geology of the bedrock of the two glaciers? There is a significant difference of carbon contents in cryoconite, which could also affect the accumulation of radionuclides? Please discuss also the difference of age of ice of the glaciers.

21. L410 Clarify whether this text means “cryoconite” or “cryoconite graniles”.

22. L420 Again, insert “granules” after cryoconite, and check it throughout this paragraph.

23. L434 What is “absorption”? Explain and clarify it.

24. L447-449 It is likely, but please explain more carefully how the organics incorporate the elements, by microbial metabolism, or by just chemical combination? Also, discuss it with the difference of organic matter contents between the two glaciers.

25. L456 “older” is very vague. What this “old” exactly means? Does it mean the time from deposition on the glacier, or from the formation of cryoconite granules?

26. L481 Again, “makes cryoconite a “sponge” for radioactivity” is misleading expression. It is not a sponge for radioactivity, but might be a sponge for the elements including the radionuclides.

References

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