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The Cryosphere Discussions

Interactive comment on "Discovery and characterization of submarine groundwater discharge in the Siberian Arctic seas: A case study in Buor-Khaya Gulf, Laptev Sea" *by* Alexander N. Charkin et al.

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We thank all three reviewers for their large effort and for providing valuable and very constructive comments, which have been useful in our revisions of the manuscript. Naturally, we are encouraged that all reviewers support our study of submarine groundwater discharge (SGD) in the Bhuor-Khaya Bay, SE Laptev Sea, and the conclusion that it provides a previously largely unexplored vector for transport from land to the East Siberian Arctic shelf, yet complicated by geocryological conditions such as permafrost. Below, each review comment is listed first, followed by our response and a description

of resulting edit. Author comments are marked below as AC.

General comments by anonymous referee 1 (Reviewer 1).

RC: Only since about 20 years ago have ocean scientists fully appreciated the potential for submarine groundwater discharge to supply substantial quantities of nutrients and carbon to the coastal ocean. Here Charkin and co workers provide exciting new data on the potential for SGD to contribute material fluxes to the coastal Arctic Ocean, an ocean basin that is arguably undergoing the most significant changes due to climate shifts. The paper is generally well written and the topic is timely, for the reasons above. I have only one major criticism, and that is the paper is much too qualitative, given that the authors appear to have sufficient data to try and calculate SGD fluxes for this region. Perhaps the authors were rushed in their analysis of the data set in order to meet a deadline for this special issue? In any case, the data are underutilized for reasons that are note fully explained.

AC: Thank you for your appreciation of our work. We were originally hesitant to make too much quantitative calculations because of the limited database, requiring many assumptions. Following the reviewer encouragement, we have now added an estimate of SGD discharge (1.7 x 10 6 m3 d-1) and transit times (3.2 – 1.5 days) around the SGD place, while stating clearly all assumptions. Discharge of the subpermafrost groundwater from Kharaulakh hydrogeological massif through the talik area were calculated on excess 224Ra activities using a Ra mass balance model (Moore 1996; Burnett and Dulaiova 2003; Null et. al., 2012, 2014). In order to calculate the growth of the water mass "radium ages," we used the equation proposed by Moore (2000). As a result, there will be two new chapters in the methods section and one in the discussion section. This results will be shown in our revised text.

Specific comments by Reviewer 1

RC: Abstract line 20: this sentence mentions freshwater then SGD, and we know that SGD often includes only a minor fraction of freshwater. The rest of the manuscript is

good about making this distinction, but the first sentence should be reworked regardless.

AC: Thanks, we reworked this sentence.

RC: p. 3 line 17: The methods here talk about the Ra quartet, but only the short-lived Ra isotope data are presented in Table 1. One 226 and 228 value each are cited on p. 8 lines 23-24, so clearly these data exist, but it's unclear why they're not used the paper or presented in the table. Please use and publish these data!

AC: We would have liked to publish wintertime data for long-lived Ra isotopes, but this is beyond the scope of the present study. Once/if such gamma counting results of long-lived radium isotopes for wintertime will be delivered from our collaborators at the Radium Institute (located in Sankt-Petersburg), it will be included in a future study. So, we have to keep Table 1 with no changes. However, in the final version of the manuscript we will include data on long-lived isotopes in the summertime: Regarding methods for Ra isotopes, this will be included in the revised ms. Briefly, in the shore-based/home laboratory, Ra was leached from the fibre with hot 6N HCl, coprecipitated as BaSO4 and counted with gamma spectroscopy for 226Ra and 228Ra (Moore, W.S., 1984. Radium isotope measurements using germanium detectors. Nuclear Instruments and Methods in Physics Research 223, 407-411). So, we modify Table 1/Suppl materials with the summer data for long-lived Ra isotopes; and move this table to the main text.

RC: p. 5 methods: Where the groundwater samples (and surface water for that matter) filtered or unfiltered? If unfiltered, I am concerned about contamination of the shortlived isotopes from particulate Th isotopes (228 and 227).

AC: All samples were passed over Hytrex cartridges with 1μm nominal pore size. We will add this information to the methods p.5, line 14.

RC: p. 7 results: the radon data are hardly used in the manuscript.

AC: As can be seen from the table 1, we have much less radon data compared to the radium isotopes. This is a reason why the radon data is used less in the manuscript.

RC: p. 8, line 12: sediment diffusion could supply short-lived Ra isotopes to the bottom water. How is it "clear" that SGD can be the only source? Please provide a calculation to support this statement.

AC: We do not have data on the production rate of 224Ra (and 223Ra) within the surface sediment, so we see no way to make a reliable estimate of the diffusive flux of 224Ra out of the sediment. The approach developed by Nozaki and applied by Moore confirms the low ratio of long-lived to short-lived nuclides in the diffusive flux, which we used as argument to separate the role of diffusion and SGD in the summertime cruise. These results will be shown in our revised text.

RC: p. 8, section 3.4; The short lived isotopes can be highly modified by decay in addition to mixing. The linear mixing lines in Figure 11 are deceiving.

AC: Yes, we agree. We will remove the linear mixing lines and add the expected decay lines (for better perception) to the plot.

RC: Fig. 9: axis labels are unreadable as is the legend.

AC: This figure will be modifed accordingly.

RC: Fig. 11: Salinity is the dependent variable; it should be on the x-axis.

AC: You are right. This will be fixed.

Thank you for your valuable comments which help to improve our manuscript.

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