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Interactive comment on "A revised northern soil Hg pool, based on western Siberia permafrost peat Hg and carbon observations" *by* Artem G. Lim et al.

Anonymous Referee #2

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Recent work by Schuster et al. (2018) and Olson et al. (2018) showed that arctic permafrost stores a significant amount of mercury (Hg), environmental toxicant harmful to human health and the environment. Climate change driven permafrost thaw will most likely lead to substantial Hg remobilization to the atmosphere and aquatic systems. In that context, a well constrained Hg budget in arctic permafrost is necessary. The two above-mentioned studies used Hg to carbon (Hg:C) ratios measured in Alaska, together with a northern soil C inventory, to estimate the amount of Hg stored in pan-Arctic northern soils. However, measurements of Hg:C ratios in Siberia are missing, hampering our ability to accurately estimate northern soil Hg pool. In this manuscript, Lim et al. report Hg and C concentrations, and Hg:C ratios, in six peat cores collected

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in the Western Siberian Lowlands (WSL). Using these data, the authors revise the northern soil Hg pool to 557 Gg (0-300 cm), which is three times lower than the previous estimate of ∼1650 Gg by Schuster et al. (2018). Therefore, this manuscript will make an important contribution to the field after the authors address the following comments. Overall, I consider that the manuscript lacks precision in many aspects and the authors should clarify their Methods section.

1. Throughout the manuscript, the authors refer to northern soil Hg pools calculated by Schuster et al. (2018) et Olson et al. (2018) for the upper 1 m: 755 Gg and 184 Gg, respectively. Olson et al. (2018) actually showed that Arctic tundra soils store 184 Gg of Hg while boreal soils store additional 224 Gg. The authors therefore reported a pool of 408 Gg of Hg for northern tundra and boreal soils. Page 1068, Olson et al. say "Our combined estimate for Hg pools of 408 Gg for the top 100 cm of boreal and Arctic soils is about half of what Schuster et al. (2018) estimated was stored within upper soils". If the authors consider that 184 Gg is a better estimate and is a better comparison to the Schuster et al. study, please provide an explicit definition of "northern" soils to provide the readers an easier apple-to-apple comparison.

2. Throughout the manuscript, the authors suggest that according to Olson et al. (2018), the Hg:C ratio in Alaskan organic and mineral horizons ranges from 0.12 to 0.62 Gg/Pg. However, according to Table 1 in Olson et al. (2018), Hg:C ratios range from 0.27 Gg/Pg in organic soils to 0.62 Gg/Pg in mineral soils. Please edit the manuscript accordingly.

3. The authors extrapolate Eurasian soils Hg pool based on six peat cores collected in the WSL but do not discuss horizontal soil heterogeneity nor the need for additional samples in other parts of Siberia. I would appreciate a critical discussion on the soil sampling strategy used in this study. See Perkins et al. (2013) for tips. It is for instance usually recommended to implement a systematic sampling strategy or to combine replicate samples into a "composite sample".

4. According to section 2.2, C pools were multiplied with the respective Hg:C ratios for organic and mineral soils from north America (excluding Alaska) and Eurasia to estimate the northern soil Hg pool. I am not entirely sure what the authors mean by "excluding Alaska". Did they estimate the northern soil Hg pool by applying different Hg:C ratios for Alaska, or by simply assuming Alaska does not exist? Please clarify.

5. Page 14 and Figure 8, the authors suggest that "North American and Eurasian mineral soils Hg:C ratio was lower than Hg:C ratio reported for Alaska". Additionally, "the Hg:C ratio in organic soils was approximately 4 times lower than that in mineral soils of North America and Eurasia". I do not understand which dataset was used here. I would appreciate a table with the list of studies the authors are referring to. In lines 345-346 the authors mention "the literature data compilations of Olson et al. (2018) and Schuster et al. (2018)" but this is to my point of view not enough.

6. Same comment for the Hg:C ratios in various climate zones: which data were used? Again, I would really appreciate a table summarizing the literature used here. This entire section is too confusing as is.

7. The authors compare their 1084 Gg estimate of global Hg soil pool (0-30 cm) to the available literature. However, as mentioned by Outridge et al. (2018) (that should be cited here), most of these studies refer the amount of Hg in the actively recycling soil pool. For instance, the 950 Mg estimate by Outridge et al. (2018) refers to the top 10 cm. Similarly, Selin et al. (2008) refered to a layer $\sim$ 15 cm deep.

Line-by-line comments:

Lines 38-39: "Hg concentrations increase from south to north in all soil horizons, reflecting enhanced net accumulation of atmospheric gaseous Hg by the vegetation Hg pump". As is, this sentence seems to suggest increasing vegetation uptake from south to north. However, as discussed in the manuscript, the Hg concentration increase is actually due to decreasing reemissions from south to north. Please edit this sentence accordingly (misleading as is).

Lines 70-71: see major comment #1.

Line 82: “strong year round net Hg(0) emission”. Please clarify what you mean by “strong”.

Line 91: “GIS” please define acronym.

Line 95: see major comment #2.

Line 126: please replace “atmospheric” by “ambient” and “increases” by “decreases”.

Line 131: referring to the active layer as “unfrozen” soils is somewhat misleading since the active layer thaws during summer but freezes again in winter.

Lines 152-155: see major comment #3.

Lines 166-177: please define acronyms (BCR, MESS, NIST, SRM, ICP-MS).

Lines 187-189: unclear, see major comment #4.

Line 190: typo, “singe” should be “single”.

Line 211 and throughout the manuscript: please use “PI” instead of the full name to make it easier to find the associated figure (same comment applies to all the sites).

Lines 218-224: how does this compare to other studies? Please strengthen the discussion.

Lines 225-229: how does this compare to other studies? Please strengthen the discussion.

Line 301: for consistency please use the same units throughout the manuscript (Gg/Pg).

Line 320: see major comment #2.

Lines 322-323: see major comment #1.

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Lines 328-329: please add units for the medians.

Lines 318-352: I find this entire section confusing because I do not understand which data you are referring to. See major comment #5.

Lines 365-367: Please clarify which studies you are referring to. See major comment #6.

Lines 369-373: See major comment #7.

Figure 3: the caption should be self-explanatory. What do ALT, PF1 and PF2 mean?

References

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