

**Author response to Reviewer comments 2, the reviewers comments are in normal black font and the autor response are in blue bold font.**

Review of Jiskra et al.

This manuscript is well written and represents the work of a strong field and laboratory team focused on mercury deposition to the Arctic. The study is well conceived and presented. It will be of interest to a variety of leadership, particularly because there is an increasing interest in understanding the source and ultimate fate of Hg in permafrost soils. I have some small to moderate comments/recommendations:

**We thank the reviewer for this thorough and constructive comments**

Title: "Insights" is not a strong word for this study. I recommend a far better title. "Mercury stable isotopes reveal XYZ on the terrestrial-atmosphere exchange of Hg(0) in arctic tundra"

**The problem with the suggestion of the reviewer is that we would have to highlight only one major finding and through this we would give the others less attention. We therefore prefer to keep the rather general title.**

This brings me to a question about the conclusions (more later): what does this study say about the seasonal net in versus out of Hg with respect to the snow pack, inferring snow melt, and summer soils? I kept hoping they would provide a seasonal diagram with the Hg % deposited, % re-emitted, and overall fluxes for their site.

**The overall fluxes and how they are distributed over the different seasons were discussed in Obrist et al. 2017. In order to avoid too much overlap between two studies (see comment to reviewer 1) we refer to the refer to the Obrist et al. study for overall mass balance.**

Page 1: 12: in arctic mercury Make sure "Arctic" versus "arctic" are correct You could say "the Arctic mercury cycle" **changed as suggested**

17-18 net emission fluxes based on the AMDEs or over the entire spring there was an overall net loss? **Net re-emission was observed in the entire spring, see discussion in section 3.2. The sentence starts with in spring, we therefore consider this statement to be clear, no changes made.**

32: Hg emission **changed as suggested**

33: such as the Arctic, through **changed as suggested**

36: (AMDEs), leads **changed as suggested**

Page 2: 32: Toolik Lake is on the Arctic Coastal Plain of Alaska. Not the Interior. **changed as suggested**

Page 3: 15: an assembly with two 47mm diameter single stage filters (?) membrane **Filter assembly is the technical term used by the manufacturer and we prefer to keep this terminology in the manuscript, no changes made (see Figure 1B in the SI)**

16: apart **changed as suggested**

18: Since the site visits were every 6-8 weeks: did the filter void spaces fill up? **Soil air lines were positioned under-ground and covered by soil. We did not inspect the filter packs**

during site visits, to minimize disturbance of the sampling system. When the soil was saturated with water we saw a decrease in pressure/flow rate of the sampling system and manually switched off the sampling to minimize the risk of water intrusion. No changes made to the manuscript

20: The 5.7 to 17.7 m3. Is this for the long term or short term deployments? **This information is for both, short and longterm deployments as indicated by the word overall, no changes made**

22: no comma after 22:00 **changed as suggested**

24: what is "sufficient Hg for analysis"? **information added (<2.5 ng)**

26: the soil pore **changed as suggested**

29: no comma after IAC trap **changed as suggested**

30: no comma after oven system **changed as suggested**

Page 4: 11: were determined **changed as suggested**

31: Here Teflon has the registered trademark but not earlier when "Teflon" is written (page 3, line 15) **Trademark sign added to page 3**

Page 5: 5: do you mean sonic sounder? There is little information on the meteorological measurement instrumentation except perhaps here? **Correct, we used a Metek USA-1 sonic anemometer (Metek GmbH, Elmshorn, Germany). The respective information will be added to the revised manuscript.**

Was wind direction measured and analyzed? Any association between MDEs and prior wind from the coast? Any association at all with wind direction and the Hg values measured? **We added HYSPLIT back trajectory analysis to the revised manuscript to track the origin of the air masses.**

Results and Discussion Were there any measurements during snow melt? How/why were the different time intervals selected? They seem arbitrary. Perhaps non-AMDE winter and AMDE conditions instead of winter and spring? The "spring" is actually colder than "winter." **The spring window includes snow-melt conditions, where no AMDE's were observed. We therefore prefer to keep the terminology. The observation of the reviewer is right, in winter 2015/2016 average temperatures were higher than in spring. For atmospheric mercury redox chemistry and atmospheric boundary layer stability the solar radiation is more important than absolute temperature. This situation was very unusual, normally temperatures in winter are colder and around -40°C but in this particular winter temperatures were around the freezing point for a couple of days around new year.**

Where are the data from 5 April to 3 May?

Was snow melt part of the 3 May to 9 Sep timeframe? Or an inundated tundra surface following melt?

Any relationships between summer seasonal thaw and Hg?

**The Snow melt period was included in the spring season discussion (Paragraph 3.2), which was renamed. The systematics of Hg<sup>0</sup> isotope signatures in interstitial snow air during the snow melt**

period are shown in Figure S3. In General it has to be recognized that during snow melt mercury is expected to be emitted to the atmosphere in pulses, which we were able to track through the flux measurements, however our Hg stable isotope sampling scheme had a too course resolution to track such short-term pulses.

30: under the snowpack **changed as suggested**

38: coastal snowpacks **changed as suggested**

Page 6: 4: remove “also” as “possibly” is already in there **changed as suggested**

8 (Figure 3): How were AMDEs defined?

The main text Figure order is 1, 2, 8, 3, 6, 4, 5, 7 Please reorder in numerical order **Figure order was corrected**

16: similar AMDE events **changed as suggested**

8-20: Was there any analysis of the wind back trajectories or the Barrow (now Utqi-  
ag̃vik) based GMDozonetoidentifywhethertheAMDEswereregionaltothecoast? **Good  
suggestion, we will include backward trajectories to the revised manuscript**

Page 7: 8-9: each night, and the strongest, **changed as suggested**

24-28: Here and elsewhere where these types of data are presented. Are the different pools statistically significantly different? Providing the analytical errors is helpful but a statistical analysis of these data is in order. From a visual perspective the standard deviations likely cross over and there is no significant difference. **We agree that statistics have been missing and will add the results of statistical t-test in the revised manuscript.**

Page 8 24: data in Figure 7. Same comment as above about statistical analyses **The results of the statistical tests are provided in the main text (P7, L32 and P8, L23-24 of the Discussion version).**

39: strongly affect **changed as suggested**

Conclusions: I really like the information in this manuscript and how it is presented. There is a lot of work here.

However, the conclusions read like a summary of the results. This study could go far in identifying the seasonal aspects of Hg deposition and re-emission but the authors mostly just summarize. All the way back to the title word “insights” I recommend they go farther.

What can they say about the Hg seasonality of deposition in the Arctic?

In the introduction the authors start with Hg being a pollutant and then introduce AMDEs and talk about snowpack re-emission. A large question there is- what frac- tion of snowpack Hg makes it into runoff and of that how much ends up stored in soils?

They then mention tundra soils can draw down summertime Hg(0). So can they say at all what the overall fluxes are from the soils and vegetation exchange with the atmo- sphere?

From the abstract: in winter. ... Small overall Hg(0) deposition. Is this a net over the winter? i.e. the snowpack at the end of winter has more Hg than earlier in winter? What does this say about snow melt which this study seems to ignore? Are there measurements from the snow melt period? If so, they should be incorporated here so that a total “year round” net Hg deposition can be calculated.

And in spring there were AMDEs and post-AMDE re-emission. But the total net for spring was an overall loss of H(0) from the snowpack? Where did this added snowpack Hg(0) come from to be lost?

Finally, in summer, what was the overall net increase/deposition? And taken in total what were the yearly net fluxes? I feel this set of questions are important because of the still uncertain seasonal loss versus loading calculations folks have been trying to make. This study may have the most up to date information to address this need. They cite the Douglas et al., (2012) review for some mention of this (page 1, 37-38) but that paper provides a wide range of re-emission values.

**In general, we agree with the reviewer about the “summary” character of the conclusion paragraph and in the revised manuscript we will provide a more concise discussion on the implications of our study also in the context of climate change. Concerning most questions raised by the reviewer here we refer to our Obrist et al. 2017, Nature study, where we discuss the ecosystem mass balance including the seasonal variation. We would also like to mention that no runoff was measured in this study, we have therefore a very limited evidence to discuss overall Hg stability in soils with respect to runoff and prefer to focus the scope of this study on terrestrial – atmosphere exchange.**