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Comment on acp-2020-1287

Anonymous Referee #3

Referee comment on "Dynamics of gaseous oxidized mercury at Villum Research Station during the High Arctic summer" by Jakob Boyd Pernov et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-1287-RC1, 2021

The manuscript by Pernov et al. describes the measurement of mercury species and ancillary chemical and meteorological parameters at a site of great importance and interest in the high Arctic at 81°N in Greenland. Unlike many studies which concentrate on Spring when mercury depletion events are common, this study describes two measurement campaigns which were performed in the Summer, which is a relatively less well studied period of the year at these kinds of latitudes.

The manuscript is well written and mostly clear. There is one point however which I think could improve the clarity of the presentation and that is making it more clear when the authors are referring to the free troposphere, the planetary boundary layer or the troposphere in its entirety. As a large part of the discussion revolves around the height of origin and transport of the air masses arriving at the measurement site, it would be useful if the authors were explicit in their descriptions. For instance when they refer to the surface (see for example line 183), does this literally mean the soil or snow, or the surface layer, that is the boundary layer? Still on the same subject, it would be useful for the reader if in the Introduction, the authors could provide a brief description of the typical characteristics of the boundary layer. This would help the reader later on in the Discussion section.

I have a few more specific comments, which are listed below.

L19 does *tropospheric* in this sentence refer to the free troposphere?

L24 I think it should be artisanal rather than *artisan* and in the list of 'natural' emissions, many would include re-emission of legacy mercury, perhaps the authors could make this clear.

L29 Hg(P) could include elemental mercury adsorbed (strongly) to soot particles as well maybe, which could be important in some instances.

L34 references for the specific cases mentioned where rapid oxidation occurs would be better, the Angot et al. paper refers only to polar regions.

L39 my curiosity here, to which type(s) of aerosol are the authors referring?

L42-44 I was very surprised that none of the work by Dibble or Saiz-Lopez and their co-workers was included in the references here. Is there a reason for this? They would seem pertinent to me.

L50 Again, I think the references should be more inclusive here.

L53 Some recent work by Gustin and her co-workers seem to be making progress on this front, see for example, Development of an Understanding of Reactive Mercury in Ambient Air: A Review MS Gustin, SM Dunham-Cheatham, J Huang, S Lindberg, SN Lyman, Atmosphere 12 (1), 73.

L55 The sentence beginning *Recently* would be better at the end of the paragraph, where it is it interrupts the flow

L63 … thus posing a threat to … ?

L154 Here is a point where a little more description of local boundary layer dynamics would help the reader.

L163 to be honest I haven't checked all the references, but Greene 2020 is definitely missing.

L168 In this section would it be possible to have a small summary table with the parameters listed simply as High or Low, when compared to the averages?

L232 The reference list is rather scarce again.

L263-4 Are there not any more recent studies which support or further clarify the results from these studies?

L284 *mixed layer height* which is how high exactly and how does it vary over time, see introductory remarks

L291 the characteristics of the trajectories for 2019 and 2020 seem very comparable, give or take a few hours, I would have emphasised this point, I think.

L312 Could the authors add a reference to Section 3.5 and or just include a short explanation of why fires might be important, otherwise the reader is at a bit of a loss as to why they are mentioned here.

L325 *troposphere*, all of it or just the free troposphere?

L330 This article might be useful in the discussion of free tropospheric Hg dynamics/reactions Weiss-Penzias, P., Amos, H. M., Selin, N. E., Gustin, M. S., Jaffe, D. A., Obrist, D., Sheu, G.-R., and Giang, A.: Use of a global model to understand speciated atmospheric mercury observations at five high-elevation sites, Atmos. Chem. Phys., 15, 1161–1173, https://doi.org/10.5194/acp-15-1161-2015, 2015.

L355 and 358 both parentheses refer to median O3 from August 2010-2018 but the numbers are different, should one be July?

L380 Good point, it is unlikely that small decreases in O3 would be noticed in the FT. But as we seem to be lacking oxidants

(Photochemistry of oxidized Hg(I) and Hg(II) species suggests missing mercury oxidation in the troposphere, Alfonso Saiz-Lopez, Oleg Travnikov, Jeroen E. Sonke, Colin P. Thackray, Daniel J. Jacob, Javier Carmona-García, Antonio Francés-Monerris, Daniel Roca-Sanjuán, A. Ulises Acuña, Juan Z. Dávalos, Carlos A. Cuevas, Martin Jiskra, Feiyue Wang, Johannes Bieser, John M. C. Plane, Joseph S. Francisco, Proceedings of the National Academy of Sciences Dec 2020, 117 (49) 30949-30956; DOI: 10.1073/pnas.1922486117)

Can we really ignore the possibility of O3/OH being an Hg oxidant, maybe through heterogeneous reactions? Just a thought.

L390 common source as in emission source? Or do you mean source region or regions?

L405 *surface level*, is this literally ground level or within the boundary layer?

L411 sources or source regions?

Section 3.6

In this discussion of possible halogen sources it would be useful to understand the dynamics of the mixing between the boundary layer and the free troposphere. The authors mention a number of surface sources and suggest that these are unlikely to play a role given that Hg oxidation seems to be occurring in the free troposphere L487.

However it is then postulated that biogenic halogen compound emissions and cycling on coarse mode aerosols are a potentially widespread source in the Arctic.

I would have thought that the coarse mode aerosol was less likely to reach the free troposphere than gaseous halogen containing compounds.

Some clarification of the reasoning behind the last two paragraphs of this section is required