Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2019-285-RC1, 2019

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Diurnal cycle of iodine and mercury concentrations in Svalbard surface snow" *by* Andrea Spolaor et al.

Henrik Skov (Referee)

hsk@envs.au.dk

Received and published: 17 July 2019

Review

This paper presents an important study of the behavior of mercury and iodine in surface snow. The study is carried out over 3 times 3 days with high time resolution. The study present some new and important results that clearly is of interest for ACP's readers. Therefore, the paper is recommended to be published after mayor corrections. General questions and recommendations The experimental design gives some short comings that need to be included in the interpretation of data: Representativeness Light is penetrating far below 3 cm depth depending on the snow morphology and the properties of the upper 3 cm can vary substantially. A discussion of how these factors affect the

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results has to be included and used in the discussion of the results e.g. can there be a photo-reduction below or can there be a diffusion downwards, how is the “collapse” of snow pack affecting the concentrations.... The 2015 and 2016 experiments were made during spring where atmospheric Mercury depletion episodes (AMDE) are taken place potentially leading to high levels of GOM concentrations and thus followed by large GOM dry depositions (Skov et al. 20061; Brooks et al. 20062) leading to high Hg concentrations in surface snow, which then decreases over the coming days. The situation during the short measurement periods with stable GEM concentrations and relatively low snow concentrations indicates that AMDE does not occur. A discussion of the meteorological and chemical situation before the campaign has to be included As a consequence, it is difficult to judge to what degree the study really represent a seasonal pattern? This has to be further discussed in the paper, see also detailed comments.

Detailed comments Page 1 Line 1; Title: As Bromine is also treated and discussed, I suggest changing title to e.g. “Diurnal cycle of iodine, bromine and mercury concentrations in Svalbard surface snow

Page 3 line 79 and 80: in the list of papers I suggest to add Brooks et al. 20062 and Skov et al. 20061 as they represent to my knowledge the only study where the dry deposition of GOM and reemission of GEM has been determined. Line 85 to 87: the three campaigns are for sure representing different environmental conditions. They are also “only” snapshots and I miss a discussion of the period is typical for the season. The spring values are for sure outside AMDE episodes and thus was there any before the campaigns. The snow concentrations indicate that is not the case as AMDE has lead to high Hg concentrations in snow. The lack of AMDE has also to be used in the discussion of Br dynamics in snow. Page 4 line 115 Add Brooks et al. 2006 should be added. Line 117-118. Very high reemission rates have recently been measured Kamp et al. 2017. Similar situation might affect your results? Page 5 line 170; You have chosen to look on the upper 3 cm of the snow. The sun can penetrate much further

into to the snow pack and there can be diffusion between the upper layer and those below. A discussion how that might affect your study is needed.

Page 6. Line 195. You base your Hg analysis of the analysis on 202Hg other isotopes could have been very interesting but I guess that you have investigated the possibilities for those analyses? Line 206. You look on I and Br, it would have been interesting to see the variation on Cl as well. Page 7 Line 217. The location should be indicated as it is not at the snow sampling site and this is first told in the discussion section and I foresee some problem in the use of GEM data to explain the results as your snow sampling site. Page 8 line 258: You look on four elements therefore you need to change your title line 271 Your measurements are within the period of AMDE but clearly you are not affected directly by an episode as earlier noticed. Therefore, you need to discuss how your "snap shot" campaign fit into the seasonal behavior of GEM.

Page 9 line 312. The reactions of iodine species in high Arctic with NO3 will in general be low as NOx is very low <1 ppbv. It can be relevant close to Arctic cities. Further explanation is thus needed. Page 11 line 365. The deposition of Hg can be either dry or wet. It looks like the authors only consider wet deposition? The balance of dry deposition of GOM and remission of GEM has been determined by Brooks et al. 2006.

Line 382-391. Further discussion of the effect of reemission on the atmospheric GEM concentration needs to be elaborated. The reaction in the snow is not only taken place in the first 3 cm. The concentration of GEM will depend on the emission rate but also on the mixing height of the troposphere. The mixing height may vary even at a snow-covered site between night and day. Page 12. The description of Zeppelin station has to be moved to section 2.5 Line 411-414 I will argue that the Aspmo et al. 20053 paper indicates that very often the measurements at 400 m is not representative for surface GEM concentrations. This statement is even more correct considering the short campaign period. The text needs to be revised. Page 12 last line and page 13 line 428 Br has often been observed to be depleted from snow surfaces. These observations need to be discussed as this illustrates that there is discrepancies in

literature (Simpson et al. 20074). Line 449 In the conclusion indicate the exact period of the campaigns as they are fundamental in order to understand the conclusion Page 14. Line 464 to 465 Boundary layer height needs to be included here. Line 472 -473 The chemistry in the snow is not necessary comparable with alpine regions. Though at high altitudes, the NOx and VOC levels are most likely higher than in the Arctic and how will they affect the snow chemistry, further discussion is needed?

Page 17. Figure 2 and 3. The colors are very difficult to distinguish. I needed to have assistance in order to separate out the different variables. Redraw the figures and call them sub-figures a,b,c. . .

Page 19 Figure captions. Add; "The figure is based on the same data as Figure 3. . .."

List of suggested papers: 1. Skov, H.; Brooks, S.; Goodsite, M. E.; Lindberg, S. E.; Meyers, T. P.; Landis, M.; Larsen, M. R. B.; Jensen, B.; McConville, G.; Chung, K. H.; Christensen, J., The fluxes of Reactive Gaseous mercury measured with a newly developed method using relaxed eddy accumulation. Atmos. Environ. 2006, 40, 5452-5463. 2. Brooks, S.; Saiz-Lopez, A.; Skov, H.; Lindberg, S.; Plane, J. M. C.; Goodsite, M. E., The mass balance of mercury in the springtime polar environment. Geophys. Res. Lett. 2006, 33, L13812. 3. Aspmo, K.; Gauchard, P. A.; Steffen, A.; Temme, C.; Berg, T.; Bahlmann, E.; Banic, C.; Dommergue A; Ebinghaus, R.; Ferrari, C.; Pirrone, N.; Sprovieri, F.; Wibetoe, G., Measurements of atmospheric mercury species during an international study of mercury depletion events at Ny-Alesund, Svalbard, spring 2003. How reproducible are our present methods? Atmos. Environ. 2005, 39 (39), 7607-7619. 4. Simpson, W. R.; von Glasow, R.; Riedel, K.; Anderson, P.; Ariya, P.; Bottenheim, J.; Burrows, J.; Carpenter, L. J.; Friess, U.; Goodsite, M. E.; Heard, D.; Hutterli, M.; Jacobi, H. W.; Kaleschke, L.; Neff, B.; Plane, J.; Platt, U.; Richter, A.; Roscoe, H.; Sander, R.; Shepson, P.; Sodeau, J.; Steffen, A.; Wagner, T.; Wolff, E., Halogens and their role in polar boundary-layer ozone depletion. Atmos. Chem. Phys. 2007, 7 (16), 4375-4418.

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