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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Size resolved airborne particulate polysaccharides in summer high Arctic" *by* C. Leck et al.

Anonymous Referee #2

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General Comments:

This paper is an interesting study of the monosaccharide composition of Arctic aerosol particles. The authors compare measurements of ambient particles and particles generated in open leads to confirm the source of monosaccharides in the Arctic. It will be a good contribution to the understanding of the composition and sources of organic Arctic aerosol particles.

The focus of this study, based on the title and abstract, appears to be on polysaccharides in Arctic aerosol. The actual measurements that were made were of monosaccharides. More explanation needs to be given as to why the measured monosaccharides are assumed to be in their combined form as polysaccharides. This is not

clearly stated and is necessary, based on the title. This is especially important because the dissolved organic mass in the ocean could include monosaccharides, as well as polysaccharides. The paper goes back and forth between discussing monosaccharides and polysaccharides, which is not ideal.

While this paper has some very interesting points, it would benefit from some restructuring to better highlight those points. It would be helpful if the authors included some context on why these findings are important. The conclusions need to emphasize the main points and why they are relevant and interesting. Additionally, this paper provides a lot of background information, which distracts from the main point of the paper. A lot of the discussion of meteorological conditions (temperatures, backtrajectories, etc.) could be shortened or moved to the Supplementary Material, especially the parts that have been previously published. There is a lot of information that is introduced in the beginning that is not tied back in during the concluding paragraphs (for example: Arctic low level clouds). Also, the authors should check the grammar and writing style, as well as check for typos. There are some instances where poor sentence structure makes it difficult to understand the main point.

The comparison between the ambient particle and the generated particle composition is interesting. The bubbling experiment provides support for assigning the source of monosaccharides in the Arctic. This section should be expanded and should clearly state the results and implications. Also, the authors should discuss other potential sources of organic mass in the Arctic, such as frost flowers.

Specific Comments:

Title: The word “airborne” could be better replaced with “atmospheric”.

P. 9802, L. 23: Be clearer about how the particles were created in the leads. What does “experimentally” mean? By bubbling air in the leads?

P. 9802, L. 23-25: Where does the air come from that creates the bubbles in the leads?

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Also, can leads be considered “sea” in the air-sea interface? Did you look at different sizes of leads?

P. 9803, L. 6: Expand on what is meant by “most of the time”. Or change to “Arctic low-level clouds mainly warm the surface”. Does the warming depend on season?

P. 9804, L. 5-8: Include the size range of aerosol particles produced from these production mechanisms (film and jet drops) for reference. Line 10 mentions that the particles produced are “in CCN sizes”. Is that true for both the film and the jet drops?

P. 9804, L. 10: Be more specific as what is meant by “debris”.

P. 9804, L. 13: It has been determined that submicron marine aerosol particles, which are produced by bubble bursting film drops, are not composed of only sea salt but also have organic fractions too. This sentence needs to be re-written to emphasize that it is an old, disproven assumption, a simplified assumption used in some models, or that sea salt is a fraction of marine aerosol in general. Blanchard and Woodcock (1957) suggested that marine aerosol particles produced from bubble bursting also contain surface-active OM.

P. 9804, L. 15: It would be helpful to add a reference for the wind speed needed for breaking waves, in addition to the typical size (length and width) of leads in the Arctic.

P. 9804, L. 20: How likely is it that the surface heat flux is the source of bubbles? Does it produce the same number and size of bubbles as air entrained from wave breaking?

P. 9805, L. 7: Does the size of jet drops influence their ability to act as CCN?

P. 9806, L. 3: What is the immunological technique?

P. 9808, L. 6: Was the mast facing upwind “to maximize sampling time” or to prevent the inlet from sampling particles from the ship exhaust? Was the ship always pointing in to the wind, or could the inlet be rotated in to the wind?

P. 9809, L. 17-20: How was the depth of the frits chosen? How do you think the

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bubbles and resulting aerosol would change with a different bubble production depth? How was the flow rate of the bubble chosen? Did the bubbles persist at the surface and form rafts, dissipate, or burst immediately?

P. 9809, L. 22: What do you think is the influence of ambient gases and aerosols during this collection process? How much of the aerosol that was produced was collected?

P. 9810, L. 7-9: How were these 7 monosaccharides chosen? What is their significance?

P. 9810, L 25: Because glucose and mannose were quantified together as a sum of the sugars, they cannot be reported separately.

P. 9811, L. 12: This is discussing polysaccharides, but earlier only monosaccharides were listed.

P. 9811, L. 25: Is 100 m3 an example of an actual sampled volume? It is better to use a relevant range than an assumed volume.

P. 9812, L. 22: Based on these uncertainties in backtrajectories, how certain is the calculated DOI? How precise are the origins of the backtrajectoreies? Why was an arrival height of 100m chosen? Were heights other than 100m considered and compared?

P. 9813, L. 10-21: This description could be shortened, since it is described by Tjernstrom et al. (2012), as stated. There seems to be a lot of description of meteorology, which needs to be shortened or better tied in to the main point of the paper.

P. 9813, L. 8: What method was used to split these backtrajectories in to clusters? Was the shape of the trajectory and the time spent over other regions considered or only the origin?

P. 9813, L. 16-18: How is a “subsiding pathway from the free troposphere” shown in Figure 3d? The heights of the backtrajectories are not shown in the figure. How was this determined? Overall, this sentence is unclear and/or this statement needs more

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explanation.

P. 9817, L. 9: Expand on how much pack ice remains left to melt August. How much of the nutrients are available to be released from winter storage? Were some of the nutrients released in the spring season?

P. 9817, L. 26 to P. 9818, L. 10: This group of sentences seems like a discussion of Gao et al. (2012). It needs to be clear here what was determined by Gao et al. (2012) and what are new ideas based on the previous work.

P. 9819, L. 16-29: The main point needs to be better emphasized so that it stands out. This may be included later, but why is this interesting or important?

P. 9820, L. 28: Instead of using "stage", it would be more helpful to the reader to include the size range related to that stage.

P. 9821, L. 19: Is this the basis for the polysaccharide measurements? All of the measurements discussed have been monosaccharides, so some explanation is required before it can be inferred that the measured monosaccharides make up polysaccharides.

P. 9822, L. 3: Same comment as before – how do you know that the monosaccharides that were measured are polysaccharides or "monosaccharides in combined form"?

P. 9822, L. 9-11: This comparison to amino acids should be excluded. Or it should be rephrased. Multiple assumptions must be made to go from relative levels of amino acids and carbohydrates in DOM in the ocean to those in marine aerosol particles. This is not fully explained here. It will take more effort to explain why they can be compared than is worth the comparison.

P. 9823, L. 13: It would be helpful to state the ratio of Cl to Na in seawater here and why a ratio of 1 shows that there is little Cl depletion and thus a recent emission. Also, why are the salt particles produced specifically from jet drops in this case? And with the time spent over the ice, is it possible that the organics are coming from frost flowers

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or that the ratio of Cl to Na would be different in sea ice melt than in bulk seawater?

P. 9825, L. 1-6: Explain why a larger fraction of glucose + mannose would imply that the particles were from combustion sources. Glucose can be found both in seawater and in plant material, also.

P. 9827, L. 17-18: Were polysaccharides actually measured? Or were measurements of monosaccharides combined to imply polysaccharides? If the monosaccharides were measured, how was it determined that they were in the form of polysaccharides?

P. 9828, L. 1-3: This is an interesting result that should be explained more clearly. The lowest concentrations of monosaccharides were found in the air masses that spent more than 5 days over the pack ice. This implies that the open ocean produces more monosaccharides than sources over pack ice. Is this just because open leads make up a small fraction of pack ice compared to the same area of open ocean? Is there less bubble-bursting in open leads? Is the concentration of aerosol the same and just the fraction of monosaccharides lower?

P. 9828, L. 7-11: Explain why this is an interesting and relevant result.

Figure 1: The caption does not discuss the dark blue dashed line.

Figure 3: Why was Cluster 4 split in to two sub-clusters?

Figure 4: The way the lines connect the points in the figure is distracting. The curvature of the lines make it look like a single line was fit through all of the points, instead of just connecting the lines between the points. Because the emphasis is not on the connection between the values, a bar graph could also be used.

Figure 5: This figure could be compressed to contain less panels and more easily portray information, depending on the focus. To emphasize the differences between the monosaccharides for one sampling location, all of the PI-Drifts, etc. could be merged. If the emphasis is instead to show the difference in sampling location on a monosaccharide distribution, then the plots with the same monosaccharides could be combined.

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As the figure is, there is a lot of empty space and repeated information that could be removed.

Figure 8: Include the relevance of DOY 242. Where was this taken?

Table 2: Some of this information would be better presented as a figure. The monosaccharide composition could easily be made in to a bar graph since the values are all percentages of the total monosaccharide concentration.

Technical Corrections:

P. 9802, L. 2: Replace “determination” with “identification”

P. 9802, L. 7: Replace “sizes” with “particle sizes”

P. 9803, L. 9: Change to: “controlled by the fraction of aerosol particles capable”

P. 9803, L. 13: Is this “open-water” referring to “leads”?

P. 9803, L. 13: Change “low-lewel” to “low-level”.

P. 9803, L. 14-17: This sentence is unclear. Try removing “apparently thus” and replacing “To be able to” with “The ability”.

P. 9803, L. 18: Does this refer to any water or seawater or open leads specifically?

P. 9804, L. 7: Remove the space in “upward- moving”.

P. 9804, L. 6: Replace “thrown” with “emitted” or “injected”.

P. 9805, L. 1-6: Rephrase these two sentences for clarity.

P. 9806, L. 5: Change “To further strengthen” to “Strengthening”.

P. 9806, L. 22: Change “Determinations” to “Identification” or “Measurements”.

P. 9808, L. 17: Replace “determination” with “analysis” or “measurement”.

P. 9809, L. 16: “frit” should be “frits”

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P. 9810, L. 24: “baselined”

P. 9812, L. 2-5: Rephrase to be similar to: “To our knowledge, using LC/MS/MS to measure natural occurring monosaccharides. . .”.

P. 9815, L. 1: Change “would allow” to “allows”

P. 9815, L. 4: Need a “(“ before “2)”.

P. 9816, L. 19-21: Rephrase this sentence to read similar to: “In order to fully understand the characteristics of the gel-particles derived from bubbles bursting at the seawater surface, the biological activity of the SML and its connection to the presence of the gel-particles needs to be understood.”

P. 9819, L. 27: “pentose”

P. 9821, L. 15: “relative” is used twice.

P. 9823, L. 4: Replace “is” with “are”.

P. 9823, L. 4-28: This paragraph makes multiple points and would be easier to read if it was further split in to multiple paragraphs.

P. 9823, L. 14: Why is “ca.” used here?

P. 9824, L. 26-27: Change “is distinguishable in terms of” to “can be distinguished by”.

P. 9824, L. 28: Insert a period after “Fig. 8c”.

P. 9825, L. 20-21: This line states “three categories”, but the list either includes four or the commas should be redistributed.

P. 9825, L. 26: “increase”

P. 9826, L. 25: Remove “the”

P. 9827, L. 13-14: This sentence should be rewritten.

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P. 9827, L. 15: Remove “for determination”.

P. 9828, L. 1: Rephrase: “It is hoped that”.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 9801, 2013.