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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Wintertime Arctic Ocean sea water properties and primary marine aerosol concentrations" *by* J. Zábori et al.

Anonymous Referee #1

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General comments

The paper describes laboratory experiments aiming to investigate the effects of Arctic seawater properties, such as water temperature (range -1 °C to 9 °C), salinity (26-36 psu), and oxygen saturation (72%-83%), on microphysical properties of sea spray aerosol (SSA) such as number concentration and number size distribution (i.e., the magnitude and shape of the sea spray source function). Different types of seawater were sampled/collected in wintertime (late Feb-early Mar) from different locations around Ny-Ålesund, Svalbard, to ensure different properties (e.g., salinity and organic content). Measurements were made immediately after collecting the seawater samples and after some storage time at air temperature of 4 °C. The range of seawater temperature was obtained by warming and cooling the seawater samples to ambient indoor and outdoor air temperatures. The range of salinity was extended from that of the collected samples by formation of ice slush and by adding glacier ice. The bubbles that produced SSA were generated with a water jet in effort to obtain bubble size distributions similar to those observed in the field. Wide range of SSA sizes was measured, dry diameter Dp from 0.01 micrometers to 32 micrometers, with two types of particle counters. The authors report strong influence of the seawater temperature on the magnitude of SSA production, and small or no change in the shape of the size distributions. Changes of salinity and oxygen saturation affected only weakly, if at all, the magnitude and shape of the size distributions. The overall goal of the experiments is to infer possible changes in SSA production in Arctic Ocean as the ice extent decreases with the observed changes in polar climate and more open water becomes available for production of SSA.

The subject of the paper is timely and relevant as polar amplification causes fast changes in the Arctic. Similar microphysical SSA properties and influences of environmental variables on them have been measured before in the lab and in the field. The novelty of this study is inferring the implication of this kind of measurements in the context of warming Arctic conditions which change the forcing variables in the region. In this sense, the new data for SSA production are useful and will add to the existing data sets needed to investigate the direct and indirect effects of SSA on the climate system. The conclusion about the robust shape of the size distributions is also quite intriguing, especially in the light of the suggestion by de Leeuw et al. (2011) that both the magnitude and the shape of the size distribution could be affected by wind and many other factors. The paper is also useful with the lessons learned so that future similar experiments are better planned, namely that larger bubble sizes (Db > 2 mm) need to be also measured; wider range of salinity needs to be investigated; oxygen saturation should not be the only variable quantifying organics in the seawater samples. The paper is well organized and written. I thus recommend the manuscript for publication in ACP with only minor revisions for clarity and completeness and some technical corrections as listed below.

Scientific questions/comments

1. The seawater properties which the authors want to investigate are water temperature, salinity, and organic content (lines 12-14, p. 16089). Oxygen saturation is chosen as a marker for the organic content (line 27, p. 16089), but no connection between the two is established. Need to add couple of sentences and references showing that oxygen saturation is a reasonable proxy for the organic content in the seawater. Should mention that there are other such proxies, and why the authors have chosen oxygen saturation versus the others.

2. This is a study of SSA production from Arctic seawater samples collected in wintertime conditions. The importance of sampling Arctic seawater is understandable; the Introduction gives a good account of the Arctic amplification in terms of the possible feedbacks that cause it. But the emphasis on wintertime sampling (the title and line 3, p. 16090) versus samples collected at any other time of the year is not clear. One can ask why not sampling Arctic seawater during summer when the maximum warming occurs (lines 29, p. 16088) and represent the future conditions for which the authors want to get implications? If the reason behind the sampling in wintertime is the seasonal delay of the impact of the summer warming on the polar climate (due to the large heat capacity of the ocean, e.g., Miller et al. (2010) in the refs), then this should be clarified for the readers. If not, then this should be made clear too.

3. The authors have chosen to work with median as a statistical characteristic instead of average value. Some justification for this choice is necessary. This choice is similar to that used by Hultin et al. (2010), a paper involving most of the co-authors in this manuscript. Figure 3 in Hultin et al. compare average and median size distributions, but, again, the differences and the choice to use median are not discussed. Here the authors have the possibility to make their case. Perhaps additional panel in Figure 3 can show median and average size distributions, and the differences can be quantified (e.g., as percent difference) and used to rationalize the choice to work with the median.

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Interactive Comment

4. Types of experiments are described in section 3.2 (p. 16097) and elsewhere. Often "single" experiment is mentioned. Only in the end (lines 23-24, 16107) the definition of a "single" experiment is clearly given. Suggest moving the definition "with water sampled…" much earlier, say in section 2.5. Clarify "single" versus what other type of experiments–"double"? "multiple"? In other words, consider introducing names and definitions for each experiment and what is expected to get from each experiment as early as possible, and then use these names consistently throughout the text.

5. The solubility of oxygen depends on the water temperature. Can the experiments reported here separate the effects of water temperature and oxygen saturation?

6. Regarding "hypothesis" in Line 12 (16108)–it would be beneficial for the discussion to formulate this hypothesis early in the text, say in the end of the Introduction. How the current average seawater properties are expected to change as Arctic conditions evolve toward warmer state, e.g., in future warmer conditions on average the seawater temperature would increase, the salinity would decrease, and the organic content would increase. How these new average properties would affect the sea spray production? Then in the discussion show if your results confirm or repudiate your hypothesis for each of the considered variables.

7. In section 5 the authors establish the seawater temperature as the most influential variable when wind speed as a forcing factor is absent. But when inferring the implications of this result for SSA production in future Arctic conditions, one needs to consider ice coverage and water temperature drivers together with the wind speed. To claim the water temperature as the most influential factor, one needs to assume that the change of Arctic conditions to warmer state will not change the average wind speed. If this assumption doesn't hold, the discussion could be extended to consider/conjecture whether the effects of ice shirking (more open water) and warmer waters can compensate for possible decrease of average wind speed over warmer Arctic. Or masking of the water temperature effect if the average wind increases. What would be the net result of the interplay of these three forcing factors–increased or decreased SSA pro-

duction? The experiments reported here can't give full answers to such questions, but the questions can be posed.

Technical corrections

1. All cases of "water temperature, salinity and oxygen saturation" and similar need coma after "salinity": line 7 (p. 16086), lines 5 and 9 (16088), 14 and 27 (16089), 22 (16093), 6 (16095), 18 (16109). (Rule 1 here http://www.grammarbook.com/punctuation/commas.asp)

2. Suggest adding "dry diameter" before Dp in line 12 (p. 16086).

3. Introduce acronym "CCN" on first appearance in line 2 (16087), not in line 13 on the same page. Use the acronym in lines 5-6 and 13.

4. Check all cases of "e.g." and "i.e." to have comma before AND after them. See lines 13 (p. 16089), 20 (p. 16092), 1 (16094), 24 (16099), 7 (16101), 21 (16109). (Rule 21 here http://www.grammarbook.com/punctuation/commas.asp)

5. Add comma after weak clause in the beginning of a sentence: line 16 (p. 16094, after "experiments"); line 13 (16101, after "+2oC"); line 18 (16102, after "35 o/oo"). (Rule 9 here http://www.grammarbook.com/punctuation/commas.asp)

6. Line 14 (16099)–change "wether" to "whether"

7. Line 16 (16102)–in the title of section 3.4 add "on" before "oxygen"

8. Line 16 (16105)–opening parenthesis before "1992", not before "Thorpe". Remove comma after "et al."

9. Line 22 (16105)–remove "a" before "radii"

10. Line 8 (16106)–suggest end of sentence after "Ocean", new sentence for "Hultin et al. (2011)...".

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 16085, 2012.