We thank referee #3 for their helpful review and address the comments below.

Reply to comments by Anonymous Referee #3

This manuscript describes model-measurement comparison between GEOS-Chem with various sea-salt aerosol (SSA) sources and measurements from circum-Arctic field sites and a research ship cruise. The manuscript compares three models of SSA sources, open ocean, blowing snow, and frost flowers. Through the improved agreement between the model using the ocean + blowing snow model, the authors conclude that blowing snow is the dominant wintertime SSA source. The model using frost flowers is unable to match the observed seasonal cycles, and thus is indicated to be incorrect, and the model using only open ocean sources underpredicts SSA. The writing and logic of the manuscript are good, and the metrics for comparison are well defined and appropriate. Therefore, I support publication in ACP, with minor revisions.

General Comments:

1) The modeling in this manuscript uses a simple model for blowing snow based upon purely windspeed. However, experimental evidence (e.g. Sturm and Stuefer, 2013) shows that winds speed (alone) is insufficient to explain blowing snow fluxes fully.

Sturm, M. and Stuefer, S.: Wind-blown flux rates derived from drifts at arctic snow fences, J. Glaciol., 59, 21–34, doi: 10.3189/2013JoG12J110, 2013.

This experimental observation could be a partial explanation of deviations between the model and high time resolution data shown in Figure 2. However that citation also is not able to give a simple single equation for blowing snow, so is not a solution to this challenge, and the approach adopted by the authors is reasonable given the complexity.

-We agree with the referee that other factors, in addition to windspeed, are likely to affect the blowing snow flux. We choose to use the Yang et al. (2008) parameterization, which itself is based on the blowing snow sublimation parameterization of Déry and Yau (2001), as this seems to be a well-established formulation.

2) The manuscript uses mass concentration data of SSA as the metric for model-measurement comparison. However, it would be useful to describe the rough size distribution of the modeled SSA and potentially some comparison between the model and observations. Table 1 shows this information, but it is only briefly discussed and it would be valuable to enhance the discussion. In addition, because SSA could be a source of cloud condensation nuclei, conversions of these numbers to number densities would also be valuable.

- We have added the following discussion in p5, L20:
"Our simulation yields blowing snow SSA emissions with 38% of SSA mass in the submicron range (0.01−0.5 μm) and 62% in the supermicron range (0.01−0.5 μm) for the Arctic. As we assume a lower salinity in the Antarctic, more of the blowing snow emissions are in the submicron range (60%) in that region."

As we do not track number concentrations in the model, we cannot comment on the resulting CCN concentrations. Based on this referee's comment and the other referees as well we have added more discussion on the potential role of SSA as ice nuclei.

Page 1, line 18: The manuscript later defines "Over the Arctic..." as >60 degrees. these statements (in the abstract) should also include the definition.

-We have made the change in the manuscript.

Page 2, line 2: I would say "waters are mostly covered by sea ice."

-We have made the change in the manuscript.

Page 2, line 11: It would be more accurate here to describe studies that support SSA formation from frost flowers, as well as ones that don't support frost-flower SSA. The section later (at the bottom of this page and top of next) contains the references that are relevant.

- Good point. We have moved the paragraph describing studies that don't support SSA formation from frost flowers higher up.

Page 4, line 28: I believe that other measurements of Arctic surface snow could be compared to the 0.1 PSU concentration. Toom-Sauntry and Barrie (2002) measured fresh snowfall, and Krnavek et al. (2012) have fairly extensive data sets.

Toom-Sauntry, D. and Barrie, L. A.: Chemical composition of snowfall in the high Arctic: 1990 – 1994, Atmos. Environ., 36, 2683–2693, doi:10.1016/S1352-2310(02)00115-2, 2002.

Krnavek, L., Simpson, W. R., Carlson, D., Domine, F., Douglas, T. A., and Sturm, M.: The chemical composition of surface snow in the Arctic: Examining marine, terrestrial, and atmospheric influences, Atmos. Environ., 50, 349–359, 2012.

-We thank this referee to pointing out these studies. We have added a discussion of these measurements in the revised manuscript.

"This profile is consistent with a salinity source from the underlying sea ice and little influence from atmospheric deposition. Toom-Sauntry and Barrie (2002) find that freshly fallen snow itself tends to have low salinity (<0.01 psu). For simplicity, we assume the same salinity for surface snow on first-year and multi-year sea ice, although we recognize that in reality the surface snow may be less salty on multi-year sea ice due to less efficient upward transport of brine. Indeed, Krnavek et al. (2012) reported that the ion concentrations of surface snow sampled in the Alaskan Arctic display large variability depending on sea ice type: 0.01 psu for snow on multiyear sea ice, 0.1 psu for snow on thick first year sea ice and 0.8 psu for snow on thin first year sea ice. "

Page 5, line 9: "ease" instead of "easiness"

-We have made the change in the manuscript.

Page 7, around line 12: It would be useful to mention that modeled spatial maps will be presented later.

-We have made the change in the manuscript.

Page 8, line 30: The wording here is a bit confusing, because the normal conditions used for modeling frost flower formation include open water and cold temperatures. In this work, page 5, line 26 indicates that frost flowers are suppressed by the high winds (or are covered by drifting snow), which is the origin of the statement. Please reword this section to indicate clearly that the high winds (rather than open water and cold temperatures) are the reason for "inhibition of frost flowers".

-We have removed this statement from our manuscript, as based on referee #1's comments we now use a frost flower simulation with no wind inhibition. The wind inhibition simulation is included in the supplementary material.

Reference

Déry, S. J. and Yau, M. K.: Simulation of blowing snow in the Cana- dian Arctic using a double-moment model, Bound.-Lay. Meteo- rol., 99, 297–316, 2001.

Krnavek, L., Simpson, W. R., Carlson, D., Domine, F., Douglas, T. A., and Sturm, M.: The chemical composition of surface snow in the Arctic: Examining marine, terrestrial, and atmospheric influences, Atmos. Environ., 50, 349–359, 2012.

Toom-Sauntry, D. and Barrie, L. A.: Chemical composition of snowfall in the high Arctic: 1990 – 1994, Atmos. Environ., 36, 2683–2693, doi:10.1016/S1352-2310(02)00115-2, 2002.

Yang, X., Pyle, J. A., and Cox, R. A.: Sea salt aerosol production and bromine release: Role of snow on sea ice, Geophys. Res. Lett., 35, L16815, doi:10.1029/2008GL034536, 2008.