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Atmospheric Chemistry and Physics Discussions

Interactive comment on "How important are future marine and shipping aerosol emissions in warming Arctic summer and autumn?" *by* Anina Gilgen et al.

Anonymous Referee #2

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This paper investigates the impacts of changes in natural and anthropogenic aerosol emissions in a warmer future climate with less Arctic sea ice, delineating the contributions from aerosol radiative forcing, aerosol-cloud interactions, and cloud radiative effects. The topic is timely and results are interesting, both for the broader scientific community, as well as from a mitigation perspective. The quality is generally good, but some improvements are needed before publication. See comments below.

Comments:

On several occasions, results are presented and discussed without actual numbers, sometimes also without showing figures. Adding values would improve the quality and

readability. Furthermore, more information about the baseline state of the conditions in the model would be helpful. See also specific comments below.

Several different spatial and temporal regions are used (e.g., JJA/August, early fall, Sept/Oct, 70-90N, 75-90N, 60-90N). This makes it a bit hard to follow and the authors should consider if it is possible to be more consistent.

I'm missing a bit of broader context; e.g., do the results from this study point to future research needs, how do the impact of shipping emissions from the present study compare with previous work, what are the most important caveats/limitations.

Abstract: consider adding some quantitative information.

Page 1: cite Melia et al. 2016? (Melia, N., K. Haines, and E. Hawkins (2016), Sea ice decline and 21st century trans-Arctic shipping routes, Geophys. Res. Lett., 43, 9720–9728, doi:10.1002/2016GL069315.)

Page 3, line 18: "re-emission" – suggest rephrasing.

Page 4, line 8-15: I think the motivation and objective for this study needs a couple of additional lines, e.g., to summarize what the bulk of the literature described above show about the importance of combining all the processes and what is new/unique about the present study.

Page 4, line 11: I don't see that this goal is sufficiently addressed in the paper. The model is run with fixed SSTs and no quantification of temperature responses. As far as I can tell, Fig.1 shows arrows only from temperature changes to radiative changes. If you want to maintain this as a main objective, you need to come back to it later in the manuscript in a better way. However, I think that disentangling the aerosol-radiation-cloud interactions is a sufficient objective in itself.

Fig. 1: I like the figure, but find the colors a bit confusing. E.g., use of blue from less sea ice to more aerosols. Perhaps use red for increases and blue for decreases? Or add colors.

Page 5, line 8: “simplistic treatment”: please specify.

Page 5, line 12: changing CDNC - does that affect the global radiative balance?

Page 5, line 12: is this based on observational constraints?

Section 2.1.2: to make the methods section easier to follow, I recommend combining all description of emissions into one paragraph. This will also reduce the need to refer to following paragraphs, which makes this section a bit hard to follow. Furthermore, are marine organic aerosol emissions included?

Page 6, line 18: all BC particles? Only hydrophobic? And only ship, or also other anthropogenic particles? Please specify

Section 2.2: Arctic_2050 vs Arctic_2050_shipping: the difference is a bit unclear. Does the former have Peters et al. 2050 ship emissions, but without the x10? Shipping emission factors are described as being lower due to regulations, which is why I wonder. If so, comparing these two does not give the total effect of changes in ship emissions, but the effect the x10 increase? Please clarify.

Table 1: would be useful to add references for the emissions as well.

Page 8, lines 20-22: I think these two sentences are excessively detailed.

Page 9, line 26: first you justify the increase, then you say it is probably too high? Consider revising for clarity.

Page 9, line 27: is it possible to add a reference?

Page 10, line 14: “naïve stipling approach” is not good language. Does this refer to a standard student’s t-test? Please clarify/change.

Page 11, line 1: figures show, not “will show”. Consider changing the language.

Page 11, line 17: consider providing numbers or showing results in a supplementary material.

Page 11, line 18: perhaps I misunderstand the language, but isn’t the increase in wind speed following the reduced SIC the main reason for the increased DMS and sea salt emissions, and hence for the burden increase? Or are there other mechanisms, related to e.g., scavenging due to lower SIC that dominate the burden change? Please clarify.

Page 11, line 26: caused by what?

Page 11, line 32: JJA/August – do you consider a different period here? Please clarify.

Page 12, line 1: at some point it would be good to show/describe in detail the changes in variables such as SIC between 2004 and 2050. Could be added in a supplementary material.

Page 12, line 4: absolute emissions in 2004 or absolute emission changes? Please clarify.

Section 3.1.2: are the same general features seen during summer?

Page 16, line 13: again, it would be helpful to have the actual numbers.

Page 17, line 4: perhaps instead say “a strengthening of the direct aerosol effect” since it is in fact much stronger in 2100?

Page 17, line 5-7: I’m not convinced it makes sense to compare these numbers since the foundation and model experiments are so different. Unless you’re able to disentangle effects of experimental differences in more detail, I don’t see that this section add much information of value and it could be left out.

Figure 5: very hard to distinguish statistically significant areas.

Page 17, line 8: please add numbers or relative change.

Page 17, line 9: if I follow correctly, these results are still without any changes in anthropogenic aerosol emissions, so a small effect due to changes in BC deposition is to be expected, unless there are large changes in the scavenging. Could be useful to

remind the readers of this. In fact, even under RCP8.5, anthropogenic aerosol emissions decline strongly through the century, which could perhaps reduce this forcing altogether.

Page 22, line 7: A comparison with previous work using the Peters et al. inventory (without the x10 enhancement) could be useful, e.g., Ødemark et al. 2012; Dalsøren et al. 2013.

Dalsøren, S. B., Samset, B. H., Myhre, G., Corbett, J. J., Minjares, R., Lack, D., and Fuglestvedt, J. S.: Environmental impacts of shipping in 2030 with a particular focus on the Arctic region, Atmos. Chem. Phys., 13, 1941-1955, https://doi.org/10.5194/acp-13-1941-2013, 2013. Ødemark, K., Dalsøren, S. B., Samset, B. H., Berntsen, T. K., Fuglestvedt, J. S., and Myhre, G.: Short-lived climate forcers from current shipping and petroleum activities in the Arctic, Atmos. Chem. Phys., 12, 1979-1993, https://doi.org/10.5194/acp-12-1979-2012, 2012.

Page 22, line 8: the maximum changes occur at the same location as the emissions; however, there are statistically significant increases over much larger areas. Should be specified.

Page 22, line 11-17: are these shifts large enough to have notable implications, e.g., for forcing? Possible to discuss to add some context?

Page 25, line 18-19: actual magnitudes would be useful.

Section 3.2.3: this section is missing a discussion of and connection to studies of the radiative forcing of shipping, both in the Arctic and overall to global impacts. This is important given that main conclusion of the study concern the negligible impact of shipping aerosol emissions. In particular, a discussion of the impact of shipping found in studies that do include explicit treatment of aerosol-cloud interactions and/or offline radiative transfer calculations could be important.

Page 32, line 20-25: be careful about the phrasing of this conclusion, as it does not

cover other effects of shipping emissions, such as NOx-induced ozone changes and CO2.

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