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 #1

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General comments: The topic of the paper is timely and of interest to both the research community, to policy makers and to the general public as we move towards sea ice free Arctic summers/autumns. The methods applied hold high scientific quality. However, the overall impression of the work is that it is a bit unfinished and rough. The discussions lack precision and results are presented in a somewhat confusing manner. The research quality is good, but modifications to how it is presented is needed before publication.

Specific comments:

- In general, a lot of the discussion concerning specific results does not include the

numbers in question and not references to where to find these numbers in the text (if present). This makes the discussion only qualitative. This is a shame, when the numbers are clearly available from the model results. Also, the reader ends up flipping back and forth looking for the numbers to back the discussion. Below, I will list some places in the text where this should be addressed.

- The reader lacks some of the basic information about the set up and the control simulation to be able to understand the results. There should, for instance, be a plot of the sea ice concentration at annual minimum or averaged over each season available for both periods, at least in the supplementary.

- A lot of the changes that occur between 2004 and 2050 are discussed, but not shown. This goes for example for temperature and precipitation. Make sure to label when the results you are referring to are not shown (see comments below) and please consider to show more of the changes that you use in your explanations, at least in the supplementary.

- For some figures, you average from 70-90N, for the tables you use either 60-90N or 75-90N. It would be more consistent if your figures and tables matched and one could follow the impacts of interest from figure to tables etc. Please consider changing this.

- Parts of the text is very oral and parts are too elaborate. Below I make both comments on things that should be changed and comments about how the text itself can be improved.

o P2, L17: Remove "where some (. . .) are labelled"

o P2,L20: Replace "until" with "before"

o P2, L22: Remove "(cruise ships)"

o P2, L24: "Nowadays" is very oral. Please rewrite. Also include " (. . .) pristine compared to other regions (. . .)" The use of depleted here make it sound like the aerosols have been removed. Please rewrite.

o P2, L28: Remove "and can (...) (Vali, 1985)" It is of no relevance here and only distracts the reader.

o P2, L32: Make part of the previous paragraph.

o P2, L32-P3,L8: May be a bit hard to follow because the indirect effects are described before the general radiative effects of clouds. Consider a rewrite to change the order.

o P3, L1: Perhaps mention why smaller droplets increase the cooling effect of clouds?

o P3, L18: "Re-emission of SW"? Please rewrite!

o P3, L23-27: Suggest to use the same terms for SW and LW description. For LW, the emissivity includes the water path and the temperature is height dependent. I suggest to make the definitions a bit more tidy.

o P3, L31: Suggest new paragraph before "How Arctic clouds (...)"

o P4, L11: a bit confusing to have figure references in a listing of the main goals of the paper. Suggest to move this.

o Figure 1: A bit confusing. Why not use red for increase and blue for decrease?

o P4, L22: Suggest to remove: "HAM2 (...) modes." and move "To link (...) implemented (...)" to the end of the next paragraph, after "(...) sedimentation".

o P5, L12: Does lowering the CDNC threshold affect the global radiative balance?

o P6, L13: Suggested rewrite: "(..), we used an inventory described in (...)"

o P6,L19: Remove "more equations can be found therein"

o P8,L10: Define the abbreviations COADS and AMVER.

o P8,L15: Remove "in addition". It is a bit confusing

o P8, L19: Please replace the word "exploit"

o P8, L21: Consider removing the sentence "We processed (...)". Too detailed information in my opinion.

o P9, L10: Suggest to remove "(non- (...) control)".

o P9, paragraph starting on line 18: I find this very confusing and suggest a clarification of what you mean in this paragraph. Do not see the link between these two sentences. The reasoning therefore fails.

o P9, L25: Please rewrite to "(...) can be considered as a realistic (...)"

o P9 General comment to the justification of a tenfold increase of the ship emissions. I suggest a rewrite of this discussion. You increase emissions so as to see a signal and try to justify it afterwards, while at the very end of the paragraph state that the emissions are now "probably too high". Increasing your emissions to get a signal is fine. To discuss that emission estimates may be too low is fine. Your emissions may well be an upper estimate. However, the discussion is long, a bit vague and a bit on the defensive side and makes the reader question whether the authors question their own reasoning here.

o P9, L30: Please define your abbreviations and give references to the models used. Did you use RCp8.5 for future simulations here? Please specify.

o P10, L9: The results would have appeared more robust if the sic and SSTs used were an average taken over eg a ten year time period centered at 2004 and 2050. Using one year (2003) and one ensemble (2050) to test the robustness of your choice of sic and sst is too week.

o P11, L3: suggest to remove "(eg. SW radiation, temperature)". It is not necessary.

o P11,L3: Rewrite to "change considerably"

o P11,L9: Rewrite to "deviate considerably"

o P11,L10: reference needed after statement "Furthermore, most models (...) preva-

lent in the Arctic".

o P11, L17: Rewrite "in the vicinity". Suggest "Over the arctic ocean"

o P11,L17: When you say "significantly" here is there a statistically significant change? Please specify.

o P11,L18: How much does the SIC decrease? Please specify.

o P12,L3: "(...) modified (...)" What does modified mean here? Consider removing.

o P13,L3: Please insert the "(...) increases in the future (...)"

o P13,L5: Is it only the change in CCN concentration that affects CDNC? Not moisture availability? At what supersaturation do you calculate your CCN concentration? Does the average supersaturation change between the runs?

o P13,L8: "averaging over cloudy and non-cloudy conditions". This is a bit confusing. Are you writing about allsky conditions? Also, please replace increases with increased.

o P13, L22: Please explain why the increase in ICNC near the surface is due to the increase in CDNC.

o P13,L25: insert (not shown) after (near Svalbard).

o P16,L2: ((...) except over the Arctic Ocean (...)" This is over the sea ice?! This should most definitely be specified.

o P16,L6: "since the clouds (...), more SW radiation can be absorbed (...)". Consider rewriting this for clarity.

o P16,L10: cooling effect vs warming effect. Please specify the actual numbers here.

o P16;L13: What does the optical thickness change from and to? If you do not give the numbers you need to specify that it is not shown.

o P16,L14: Consider replacing disentangle by "distinguish between"

o P17,24: Please insert "(not shown)" after "temperature".

o Table 2: Please include the values from the control run to get the relative importance.

o P22,L7-8: Please insert "(not shown)" after "late summer" and after "significant for OC".

o P22,L12: Please remove "using the hypsometric equation". Redundant.

o P22,14: Please move your reference to figure 9b to directly after "800 hpa" to avoid confusion.

o P22, section 3.2.1 general comment: Your hypothesis is very likely, but can you verify in your model that this is the case? Perhaps you could perform some sensitivity test? Right now this section is not very strong as it just lists model results without any proper discussion. It would also be good to include a vertical cross section of the aerosol change. This would be beneficial for the next section as well when discussing freezing.

o P22,L29: How much does the Liquid water path /mass increase?

o P23,L2: Please include the numbers you are describing in the text.

o P25,L21: How much does the optical thickness change. You should strengthen your discussion by describing the actual model results.

o P25,L27: "(...) under clear-sky conditions." Insert "(not shown)" here.

o P25,L32: The significant areas are not large and looking at the figures it looks like the numbers you are giving here are averaged over the whole region. If so, please make it clear that this number is not only including significant changes.

o P25,L32: The figure reference should be to figure 13(f)?

o P27,L4: please consider changing the numbers here to (-2 to -20 Wm-2)

o P27,L5: please insert "(not shown)" after "correlated with ship emissions".

o P27,L8: "While the CRE (. . .)" is it not the change in CRE? Same goes for line 7 and the figure text to figure 14.

o P27,L9: The change in optical thickness is significant in very small regions. This should be mentioned. Also when the average numbers are given in the following sentence, make clear that these numbers are not significant.

o P27, L14: Are these numbers significant?

o P27,L16: Please insert "very": "(. . .),ship emissions lead to a significant, but very weak (. . .)"

o P27,L20: Suggest to add "in limited regions" or something similar after "(. . .) and lead to significant net cooling"

o P32,L16: Insert "a very small" in front of "local warming".

Technical corrections: - Polarstereographic maps: Please insert a few more latitude lines, perhaps at the boarders for averages that you use: 70N and 75N.

- All figures: Move (a), (b) etc above figures.

- Figures using a blue to red color scale: The lightest colors are impossible to separate in printed figures. You need to improve this color scale. At the same time, consider to use a white color surrounding zero so that values at this separation (zero values) do not come out in color.

- Figure 7: Suggest to use different color scales for positive and negative values in (a) and (d).