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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 #3

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Gilgen et al present a set of sensitivity studies with the atmospheric GCM ECHAM-HAM. The control simulation is driven by conditions approximately representative for present-day, three sets of differing boundary conditions are then computed: (a) increased sea surface temperatures and decreased sea ice cover, (b), in addition, changed aerosol emissions, and (c) in addition, further ship emissions. Each of the simulations is run for a short period of ten years. A large set of results is presented.

The study is to a large extent based solely on the results of the one model and thus the hypotheses developed are strongly dependent on the chosen parameterisations. Very little comparison to data (for the control simulation) is presented. In one paragraph, the

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Discussion paper

cloud radiative effects are compared to SHEBA data – from this it seems that the model has a very large bias. I believe it would be necessary for an improved paper to at least show some evidence that the model performs satisfactorily in the Arctic in comparisons to observations, before the results from the sensitivity studies can be considered meaningful. At two instances, the results are compared to previously-published results for similar scenarios. It is astonishing how different the results are. A key hypothesis is that sea salt emissions may substantially increase with decreasing sea ice coverage. Fundamentally, this is no surprise, so the question is how large this could be quantitatively. Unfortunately the two other model studies reported are much more different from the model presented here than the change due to sea ice retreat (one model has a factor of 3 more, the other, a factor of 1000 less emission flux in present-day conditions). Also the radiative forcing due to aerosol-radiation interactions is very different between models – the model presented here has a substantially positive forcing, the other model, a negative one. Since such results are easily available from multi-model ensembles (CMIP5 or AEROCOM), it would be easy to put the model the authors use into context, much beyond the two studies cited.

When it comes to the interpretation of the results, much is left for speculation. If the authors choose to have a pure modelling study, why don't they at least precisely clarify the processes that change? Why not budgets for changes of CCN, INP? A table that lists all relevant numbers (e.g. for the entire region, and split for open ocean and sea ice surfaces) as simulated for the different scenarios would be useful (emission fluxes, CCN, INP, cloud particle concentrations, LWP, IWP).

Specific comments:

p3 l30 – this is not "generally" true, e.g. not in summer (as the following sentence correctly acknowledges)

p3 l32 – but it is likely a small effect (Pithan and Mauritsen). What is the reference for the following sentence ("generally...")?

P5 l12 – it would be good to report already here whether this threshold is hit, and, if so, how often. It would further be good to analyse whether indeed the lack of nitrate or organics is a major problem of this model for the Arctic.

P6 l1 – it would be good to comment on the results of Eckhardt et al. (ACP 2015)

p8 l6 – 10 years seem very little for small forcings

p12 top paragraph – what do these discrepancies by a factor of about 3000 imply for the fidelity of the results in terms of sea salt emission changes?

P13 l8 increased p13 l22 – i.e. homogeneous freezing of droplets? P13 l23 – at constant ICNC? L13 l27 – indeed surface fluxes? Or rather simply moist adiabat changes?

P16 l2 – it would be important to clarify whether this section refers to the radiative forcing by aerosol-radiation interactions only, or to the effective radiative forcing due to aerosol-radiation interactions, or whether it includes aerosol-cloud interactions. P16 l4 – what are the absorbing components, and why is the positive forcing so large? P16 l6 – it would be useful to demonstrate this at least in the supplementary material (since the authors write “not shown” it seems hey have the analysis at hand)

p17 l5 – how is the coincidence of approximately the same reduction by 0.2 Wm-2 explained? Is the same thing happening in both models?

P18 l13 – i.e. the effect is twice as large as observed? The authors should report this analysis as a table or similar.

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