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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Short lived climate forcers from current shipping and petroleum activities in the Arctic" *by* K. Ødemark et al.

Anonymous Referee #2

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The authors present a modeling study on the impact of emissions from Arctic shipping and petroleum activities on the column amount of atmospheric aerosols and radiative forcing of climate relevant trace gases and particulate matter. The manuscript is generally well written but I have a few concerns about the method used to estimate the indirect aerosol effect and I think this deserves a more thoroughly discussion. I would also like to see a more detailed discussion in the conclusions section and a more quantitative uncertainty analysis. I suggest publishing in Atmospheric Chemistry and Physics after addressing the comments and suggestions given below.

General comments

- The indirect aerosol effect is estimated from a relation between cloud droplet number and aerosol optical depth following the work of Quaas et al. More recent studies show

that this approach is not appropriate and underestimates the indirect aerosol effect. For instance Penner et al. (PNAS, in press) show that CCN do not scale with AOD: "empirical relations for ln(Nc) versus ln(AOD) derived from present-day results do not represent the atmospheric perturbation caused by the addition of anthropogenic aerosols to the pre-industrial atmosphere.". Since the Arctic is a relatively clean region, this finding should apply to this study as well. I think this should be discussed and needs to be taken into account when assessing the impact of ship emissions on RF.

- The indirect aerosol effect is only estimated for water clouds (no mixed phase or ice clouds) (p. 21574, l. 9). It seems that in the Arctic, pure water clouds are not the dominant cloud type. I rather expect mixed phase clouds to dominate in the Arctic. This is a major point and needs to be discussed in more detail, for example, can additional clouds droplets freeze or have any other impact on the ice phase? The limitations of this approach should be named and discussed.

- The emissions should be described in more detail. For example, what are the aerosol-size distributions used? How does the seasonal cycle look like? It also remains unclear to me from table 1 whether the emission totals are given in kt(species) or kt(S), kt(N), kt(C), etc. A figure showing the geographical distribution of, for instance, NOx and SO2 would be good. Furthermore, I think the Arctic ship emissions / emissions from petroleum activities should be put into perspective with the total (global) ship emissions.

- The discussion of the uncertainties (section 4.1) is too short. The main uncertainties should be discussed in more detail and numbers should be given instead of describing everything only qualitatively. I also would like to see the conclusions section to be extended. I am missing some explanations. For example, why is "BC in snow" so different for shipping and petroleum activities? If the NRF for OC is not as strong in the Artic than it is in other regions, then what about SO4? If the reason is the high surface albedo (Why? If sea ice permits shipping I presume the shipping lanes are open?) shouldn't this also be the case for the direct and indirect effect of SO4?

Specific comments

- p. 21571, l.6, "... direct global warming from the GHGs": I don't like this term as I think it might be misleading. I propose to delete "direct" and simply refer to "global warming from the GHGs".

- p. 21571, l. 23, "... due to feedbacks occurring at these high latitudes.": This should be expanded by giving examples and adding references.

- p. 21572, l. 21, l.25: No references are given for the OsloCTM2 and the chemistry scheme used.

- p. 21572, l. 23: Please be more specific which data and variables from the IFS model are used to drive OsloCTM2.

- p. 21573, l. 11, "... with a more advanced BC scheme better reproducing BC measurements at high latitudes": Please give some more details here.

- p. 21573, l. 12, "This scheme also includes uptake of BC on snow and ice covered surfaces.": Do you mean deposition of BC on snow/ice and corresponding changes in albedo? How is sea ice and sea ice albedo handled in the model? Are they prescribed from observations? Is there an effect of BC on sea ice as well?

- p. 21576, l. 12, "4.19 Wm-2" → "4.19 mWm-2"

- p. 21576, l. 19, "The current methane emissions from Arctic oil and gas activity are also small in such a context. We therefore expect the radiative forcing due to direct methane emissions to be small.": Isn't this the case for the other emissions from gas and oil activities as well? Please explain.

- p. 21577, l. 6, "and stratospheric water vapor RF of -0.09 mWm-2": Is a 1-year integration enough for assessing changes in the stratosphere? Because of the longer time scales involved, the stratosphere might not have reached equilibrium yet and the numbers are thus not representative. Please explain.

- p. 21578, l. 10, "... the radiative balance from reflective aerosols over bright surfaces is small.": What about sea ice and changes in sea ice coverage that make shipping in this region possible in the first place? At least the open shipping lanes should have a low albedo. Please comment.

- p. 21579, l. 1, "The indirect aerosol effect dominates shipping contribution, ...": What about changes in water vapor (as a results of changes in cloud properties) and CO2 (even though CO2 is not short-lived). It would be helpful to put things into perspective. It should be stressed that this statement takes only short-lived species into account.

- p. 21580, l. 7: Add "of aerosols" after "water uptake"

- p. 21580, l. 7, "Sulphate from petroleum are...": "are" → "is"

- p. 21581, l. 14, "Sulphate values are about 2 times stronger in Fuglestvedt et al. (2010) than here, due to the prevailing Arctic conditions.": This should be explained in more detail and might not necessarily be true as the method applied to estimate the indirect aerosol effect might simply underestimate the aerosol effect (see general comments).

- p. 21582, l. 7: "leads" → "lead"

- p. 21582, l. 9: "exert" → "exerts"

- p. 21582, l. 19: insert "a" before "different"

- p. 21582, l. 21: "show" → "shows"

- p. 21582, l. 26: "are stronger" → e.g. "has a stronger GWP"

- p. 21583, l. 1: "GWP" → "GWPs"

- p. 21589, caption of table 1: Insert "in the Arctic" after "activity"

- p. 21590, table 2: The values for "BC snow" are missing. I presume this would be the amount of BC deposited on snow in the year 2004?

- p. 21592, caption of table 4, "Sulphate are" → "Sulphate is".

- p. 21592, table 4: Are the emissions assumed to be constant over the years? Please clarify.

- p. 21597, figure 5: Shouldn't the lower limit of the color scales be zero?

- p. 21598, figure 6: Is this the change in net cloud forcing or in shortwave cloud forcing only?

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 21569, 2011.