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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Effects of Black Carbon Mitigation on Arctic Climate" *by* Thomas Kühn et al.

Anonymous Referee #1

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The manuscript submitted by Kuhn et al. assesses how different black carbon mitigation measures in regions expanding from the eight Arctic Council member states to the entire globe influences the Arctic. They find that 60% of the total effect of global mitigations on BC deposition in the Arctic can be achieved by focusing on local measures. While the direct forcing scales with the total amount of BC emission reduction, the effective radiative forcing, influenced by indirect aerosol effects, is much smaller in magnitude, due to cloud effects that balance the direct forcing. They also include an assessment of Arctic health benefits to aerosol reductions, and find that the amount of premature deaths is strongly reduced if also the observer states in addition to the Arctic Council member states reduce their emissions.

General comments:

- Section 3.1 is a bit confusing – some clarifications in the text will do much to improve this section

- The discussions of how BC and OC influence clouds are solely focused on indirect aerosol effects. Firstly, a short discussion of how BC and OC particles are thought to act as cloud condensation nuclei would improve these discussions. My impression is that while BC particles can act as CCN when duly coated, it is not thought to be as efficient a CCN as OC, which is hygroscopic to begin with. Even so, certain models have been shown to have very strong indirect aerosol effects from BC. A comment of the validity of such model results could be added here. Secondly, numerous studies have shown that BC potentially cause strong rapid adjustments in clouds, but perhaps more importantly due to its influence on the vertical temperature profile and water vapor levels (semidirect effects) than due to the indirect aerosol effects. This should also be discussed in the paper.

Specific comments:

- P1 L19: This important information is difficult to assess in absolute numbers, as we do not have any reference points. Is it possible to rather give the % change in premature deaths?

- P2 L7: Several studies have pointed to the fact that the direct radiative heating effect of BC is in fact offset by rapid adjustments in clouds. Perhaps consider adding some of these references here, and also mention that semidirect effects may be just as or more important than indirect effects in this regard.

- P2 L14: Please add references after "gas industry".

- P6 L21: Please add "2010 – 2030" before "emission reduction", to be entirely clear that the reader is to look at changes along the x axis in Fig. 2 at this point. The statement that OC and BC emissions are mostly unchanged is also not obvious from Fig. 2 – a change of about 1 Tg/yr in BC from 7.2 or so in 2010 to 6.2 or so in 2030

is after all 10-15%, which is definitely a change. SU seems to change by about 100 to about 80 over the same period, which is around 20%, so in other words relatively comparable to the BC change? I realize that I may be misunderstanding here, but if so that just underlines the need for some clarifying comments in the text.

- P6 L22: Please specify in the text that no information on CO2 can be found in Fig. 2.

- P7 L1: See two comments up – this information is excellent, but it would help the reader to provide it further up in the text. Please also give percentage changes for BC and OC emission reductions, for instance for CLE and GLOB, respectively?

- P12 L31: Somewhere in this section, it would be good to see a discussion of how well SU, BC and OC function as CCN in the ECHAM model.

- P14 L8: "the warming effect of SU reductions" → "the direct warming effects of SU reductions", or "the SU warming effects due to aerosol-radiation interactions"

- P14 L16: Please point the reader to where in the vertical profiles we see signs of that upward shift. Also, are we sure that the temperature profile doesn't shift too? If so, there's not necessarily more ice clouds, just liquid clouds higher up. Please comment on this. Here, it would also be nice to mention that, as seen in Fig. 6a moving from CLE to AC – the most local mitigations, which cause strong changes in lower-atmosphere but little changes in upper-atmosphere BC concentrations (Fig. 4), has a very little influence on the direct forcing, presumably due to the low aerosol absorption efficiency at low altitudes.

- P14 L29: This is a good point, concerning the increased aerosol absorption efficiency of BC with height. The literature on this is extensive, so a reference here would be good!

- P14 L30: "the BC mitigation scenarios" is a term not used before – is this equivalent to "SLCF scenarios". If so, make this clear to avoid confusing the reader.

- P14 L30: "Compared to the sRFA values of the BC mitigation scenarios, the sRFA

that is caused by the reductions in SU emissions in the CLE scenario is much smaller in magnitude" Please point the reader to where this small(er) reduction in sRFa can be seen – from Fig. 6a, the sRFa increases from 2010 to 2030, and is reduced in 2050. Which, if any, of these are you referring to?

- P15 L1: "systematically" is perhaps a bit strong – it does not seem that sRFa for CLE and AC follow the BC emissions in the same way as the other scenarios

- P15 L6: Here, on the other hand, I don't agree that there is no visible systematic response in sRFtot to BC/OC reductions: The further away from the Arctic emissions are reduced, the weaker this warming effect in 2030. If I understand correctly, the direct aerosol effect will be included in this tot effect, and as you saw in panel a, this component is more strongly negative moving from AC towards GLOB. Thus, any positive radiative forcing effect is offset the most in GLOB, which causes the weakest positive sRFtot values here.

- P16 L1: "Here the effect of both SU reduction in the CLE scenario and BC and OC reduction in the SLCF scenarios are clearly visible." Could it possibly be also that the small (in relative terms, but perhaps noticeable in absolute terms) reduction in SU between the CLE and the other scenarios is also contributing do this change in CDNC?

- P16 L12: While the CDNC explanation for the increase in sRFtot is plausible, BC have also been shown to have a strong influence on clouds (rapid adjustments / semidirect effects) via the influence on atmospheric heating. Although this element is not included in the analyses, I think the authors should discuss how it could also contribute to explain the findings.

- P16 L13: By "cloud time" in this section – do you mean "cloud lifetime"?

- P16 L28: Here it would be good to mention that this supports earlier findings of BC climate effects – that rapid adjustments in clouds tend to balance out the direct effect.

- P18 L1: here you could add ", which cause lower-level changes in BC, " or something

similar behind “the Arctic Council member states”

Figure 5: Just a simple edit: could you perhaps change the unit of the cloud cover to %? I believe the units on the x axis would be the same, so that you could just change “x10-2” to “(%)”.

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