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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Arctic climate response to forcing from light-absorbing particles in snow and sea ice in CESM" *by* N. Goldenson et al.

Anonymous Referee #2

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Review of "Arctic climate response to forcing from light-absorbing particles in snow and sea ice in CESM" by Goldenson *et al.*, submitted to *Atmos. Chem. Phys.*

The manuscript describes numerical simulations of the climate response to black carbon and mineral dust absorption in snow and ice. Results show that in spite of the weak global forcing exerted through that mechanism, climate response in the Arctic can be large, especially when sea-ice cover and thickness are considered. The authors have made a comprehensive set of simulations, looking at the impact of BC or dust deposition only, of land-based deposition only, and of the background climate.

I recommend presenting the results differently in order to focus on 1850–2000 changes; documenting better the climate forcing and response in the 2xCO2 simulation in order to better compare with the surface albedo mechanism; and documenting the dust de-

position fluxes.

1 Main comments

- Section 4.1.1: Forcing and climate response are computed in the paper with respect to a simulation with no change in surface albedo. I recommend to use the simulation with 1850 deposition fluxes as a reference instead. The analysis would then identify clearly the contribution of 1850-2000 changes in aerosol deposition to climate forcing and response, and allow a direct comparison to 2xCO2 forcing and response, but also to the forcing and response for aerosol direct and indirect radiative effects cited in IPCC reports.
- In addition, it would be interesting to also show on Figures 6, 9, and 11 the distributions of changes in snow, near-surface temperature, and ice thickness due to 2xCO2. That would greatly help in the analysis of the efficacy, and in addressing the important question of the relative impacts of CO2- and albedo-driven changes in the Arctic.
- Figure 5: The early start of snow melt when aerosol absorption is included is expected, but why are snow melt rates similar in JJA? Since more snow has melted in the Spring, one would expect less snow to be available for melting in the summer.
- Section 4.2.1 and Figure 11: How can the authors explain the larger sea-ice response to 1850 deposition fluxes compared to 2000 fluxes? Is it due to the different relative contributions of BC and dust to total deposition? Speaking of which, figure 1 must also show the mineral dust deposition fluxes. Currently, nothing is known of the prescribed mineral dust deposition fields.

- Sections 2.2 and 2.3 do not read well and would benefit for a better organisation of paragraphs and a removal of redundant statements. For example, brown carbon absorption is discussed in three distinct places within section 2.2, with unrelated paragraphs in between. Parts of section 2.3 clearly belong to the introduction.

2 Other comments

- Page 5344, lines 5–7: I do not understand this sentence.
- Page 5344, line 19: What concentration?
- Page 5347, line 22: It would be helpful to give the value of the mass absorption cross-section that is recommended.
- Page 5347, line 26: Does the sulphate coating survive the immersion of the aerosol into snow or ice? In other words, does hydrophilic black-carbon really have the same optical properties in both the atmosphere and cryosphere?
- Page 5351, line 18: How did you obtain the standard deviation? What is its value?
- Page 5352, lines 1 and 4: It is surprising to prescribe ocean heat flux from a pre-industrial simulation while setting CO2 at its year-2000 level. Any reason for this choice?
- Page 5352, line 17: "most *anthropogenic* aerosol emissions".
- Page 5352, line 24: By alpine, do you mean the Alps specifically, or any mountain glacier?

- Page 5353, line 18: The dataset by McConnell [2010] is a useful source of observational data here – even the 1850 deposition fluxes can be compared.
- Page 5354, line 16: The authors can be more assertive than the current "may have been altered". A control simulation must exist that can show whether the presence of impurities affect the snow cover even when no albedo changes happen.
- Page 5354, line 18: Typo "estimate".
- Page 5358, line 17: Why is the fact that dust represents half of the response in sea thickness surprising?
- Caption of Figure 6: State clearly what the "two runs" are.

3 References

McConnell, J.R. New directions: historical black carbon and other ice core aerosol records in the Arctic for GCM evaluation. *Atmos. Environ.*, **44**, 2665–2666, 2010.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 5341, 2012.