

Atmos. Chem. Phys. Discuss., referee comment RC1
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Comment on acp-2022-288

Anonymous Referee #1

Referee comment on "Mapping the dependence of black carbon radiative forcing on emission region and season" by Petri Räisänen et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2022-288-RC1>, 2022

Review of "Mapping the dependence of BC radiative forcing on emission region and season".

Summary

This paper uses a large set of simulations with the NorESM1-Happi aerosol scheme in an offline mode (i.e., aerosols do not effect climate) to quantify the BC radiative forcing (direct and snow/ice) in response to BC emissions perturbations in 192 grid boxes. Seasonally uniform emissions, as well as emissions in each season are separately evaluated. The authors find the BC RFs significantly vary as a function of emission location (spatially) and season. When normalized by emissions, the direct specific BC RF varies by up to a factor of 10 (even larger for the corresponding snow/ice RF). The authors also discuss reasons for the spatial variability (e.g., enhanced lofting in tropical convective regions, which enhances the BC lifetime and the corresponding RF). The authors also show that for present-day BC emissions, the RF is nearly additive across regions/seasons (within ~10%); however, the indirect BC RF is not.

Overall, this is a well written paper that presents comprehensive model simulations and interesting results relevant for SLCF mitigation. The main novelty here is the use of much smaller emission regions (5x5 grid boxes, as opposed to continental scale). This is more relevant to BC mitigation. This in turn leads to the conclusion that the BC specific RF (spatially/seasonally) varies more than previously recognized.

Limitations of the present study (which are discussed in Section 6.2) include the fact the authors are not able to quantify the rapid adjustments, which have been shown to be very important for the climate impacts (e.g., Stjern et al. 2017). See also:

Smith, C. J., Kramer, R. J., Myhre, G., Forster, P. M., Soden, B. J., Andrews, T., et al. (2018). Understanding rapid adjustments to diverse forcing agents. *Geophysical Research Letters*, 45, 12,023– 12,031. <https://doi.org/10.1029/2018GL079826>

Specific Comments

L130 “the semidirect effect of BC cannot be included”. Shouldn’t this be more general, i.e., rapid adjustments cannot be included? Semi-direct effects traditionally refer to clouds alone, but there are several rapid adjustments including those associated with the clouds.

Section 2.3 In the context of BC emissions, the two main sources are fossil fuel and biomass burning. In contrast to fossil fuel BC emissions, biomass burning BC emissions are likely less easily controlled to mitigation policies. Is there any utility in separating the two? Probably beyond the scope of this work, but perhaps the authors could comment.

L200. In the context of convective lofting, see also:

Park, S., and Allen, R. J. (2015), Understanding influences of convective transport and removal processes on aerosol vertical distribution, *Geophys. Res. Lett.*, 42, 10,438–10,444, doi:10.1002/2015GL066175.