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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Surface temperature response to regional Black Carbon emissions: Do location and magnitude matter?" *by* Maria Sand et al.

Anonymous Referee #3

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Review of "Surface temperature response to regional black carbon emissions: Do location and magnitude matter?" by Sand et al., submitted to Atmospheric Chemistry and Physics.

This paper discusses the impacts of regional emissions of black carbon on global and regional temperatures. Scenarios are examined with different levels of emissions. One conclusion is that a higher emission rate results in lower temperature change per unit emissions, except in the Arctic. Impacts of emissions from North America and Europe are found to be similar to each other but different from emissions from East Asia.

Overall, the paper contributes to our understanding of the impacts of black carbon.

However, the paper can be improved if the model is described more completely and if previous understanding of black carbon climate effects were discussed more completely. Also, the authors do not discuss the physical processes they are not including that could affect results. Finally, there is no evaluation of the model. Below are more specific comments.

With respect to the model, there should be some validation of baseline cloud fields and aerosol optical depth and aerosol absorption optical depth against satellite and/or in situ data. Some validation is required in virtually all papers.

Abstract. "BC emissions are increase by a rate of 10 and 20. . ." 10 and 20 what? A factor of 10 and 20? 10 and 20%? Please clarify.

Introduction. "There has been a growing interest for reducing black carbon emissions to slow global warming emissions and improve air quality." This was proposed at least as far back as 2002 in Jacobson (2002), which states in the abstract, "Reducing BC + OM will not only slow global warming but also improve human health." Please include this information.

Introduction. "BC absorbs solar radiation and therefore rapidly influence heating rates, humidity and clouds in the atmosphere." That feedback, along with 11 other feedbacks of black carbon to climate, is discussed Jacobson (2002), Sections 3.1-3.12. Please discuss.

NorESM. Please state explicitly how, in your model, "aerosols can act as CCN based on their size and composition." Is it an empirical parameterization? Do cloud drops of different size and composition grow physically in time, or do you assume an equilibrium cloud drop size distribution.

Please state explicitly in the text whether you include Cloud Absorption Effects I and II of black carbon (Jacobson, 2012). CAE I is cloud burnoff due to absorption by black carbon inclusions within individual cloud drops and CAE II is cloud burnoff due the

hydration of BC-containing aerosol particles between cloud drop at the ∼100% relative humidity of the cloud, and the resulting enhanced absorption and heating of the cloud due to optical focusing. If you do not include it, please discuss briefly the potential impacts of not including this treatment.

Please state explicitly how "The BC on snow effect is included in the model." Do you model the size-resolved deposition of BC (through wet and dry deposition) to the surface. How is radiative transfer solved through the snow if it is? If it is not, please state so explicitly.

What is the mixing state of BC aerosol components in the model? Externally mixed, well-internally mixed, or something in between?

Abstract. "For these regional BC emissions perturbations, we find that the effective radiative forcing is not a good measure of the climate response." Although it is not clear if your model includes this, one explanation may be that "when absorbing aerosols exist in clouds, instantaneous direct radiative forcing (DRF) and surface temperature change are anticorrelated because when absorbing aerosol burns off a cloud, the aerosol DRF decreases due to a decrease in optical focusing, yet surface temperature escalates rapidly due to the pouring in of sunlight to the surface." (Jacobson, 2014). Please discuss.

Figure 5. Change figure captions to "Delta TOA" rather than just "TOA" Are these "net downward minus upward" irradiances with versus without black carbon emissions? If so, please clarify.

The text mentions that the Indian Monsoon was displaced. How was it displaced? In what direction and what was the magnitude in wind speed change? Were Monsoon wind speeds decreased due to black carbon? Were globally or regionally averaged wind speeds decreased as might be expected (Jacobson and Kaufman, 2006).

References

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Jacobson, M.Z., and Y.J. Kaufmann, Wind reduction by aerosol particles, Geophys. Res. Lett., 33, L24814, doi:10.1029/2006GL027838, 2006.

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