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In terms of radiative forcing, not all BC emissions are equal

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The development of robust emission metrics to guide climate policy is more complicated for short-lived climate forcers like black carbon (BC) than for long-lived greenhouse gases like CO_2. The challenge is that for short-lived climate forcers, the atmospheric concentrations, the radiative forcing (RF), and ultimately, effects on climate, depend on the location and timing of the emissions. In the present work, the impact of emission location and season on the RF resulting from emissions of BC is studied using the NorESM1 climate model. NorESM1 is run in a configuration in which the distribution of aerosols is simulated using a state-of-the-art aerosol scheme, but the interactive aerosols are not allowed to influence the simulated meteorological conditions. Consequently, the patterns of weather are repeated identically irrespective of the assumed aerosol emissions. This allows for an essentially noise-free evaluation of the radiative forcing associated with changes in aerosol emissions, irrespective of the magnitude and spatiotemporal extent of the emission changes.

We employ the model to systematically evaluate the radiative forcing efficiency (i.e., global-mean RF divided by the emissions) of BC emissions, for various assumptions about the latitude, longitude and season of the emissions. The BC direct effect and the effect of BC on snow albedo are considered. Preliminary results from tests focusing on BC emissions in the subarctic region (60-70°N) indicate the RF efficiency depends strongly both on the timing and longitude of the emissions. The RF efficiency of emissions in spring and summer is much larger than that of emissions in fall and winter, mainly due to the stronger insolation. Furthermore, emissions in the Siberian and North American sectors have higher RF efficiency than emissions in the Atlantic and European sectors. This is largely because emissions from subarctic Siberia and North America preferentially increase the atmospheric BC burden and BC deposition in regions with seasonal snow cover persisting into late spring / early summer. This acts to increase both the BC direct RF and the RF due to BC in snow. Furthermore, long atmospheric residence times act to increase the direct RF associated with Siberian BC emissions in summer.

An implication is that the use of large-scale mean (e.g., subarctic average) emission metrics may mispresent the role of BC emissions from smaller regions like individual countries.