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The sensitivity of the Arctic climate to within-Arctic emissions of black carbon

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Black carbon (BC) aerosols in the Arctic originate mostly from source areas outside the Arctic and are a result of a long-range transport from lower latitudes. The high static stability in the Arctic boundary layer suppresses the mixing of pollution in the free troposphere down to the boundary layer, and pollution reaching the Arctic from lower latitudes is not easily deposited on the Arctic surface. BC sources within-Arctic, however, are more likely to have a surface warming due to the near surface solar heating and the greater likelihood of BC deposition events.

We present a set of experiments using the fully-coupled climate model NorESM to investigate the sensitivity of the Arctic climate to emissions of BC aerosols within-Arctic and compare this with the response to emissions of BC aerosols from lower latitudes. The climate model includes a snow model, SNICAR, to simulate the climate effect of BC deposited on snow and sea-ice.

We find that the Arctic climate have a significantly larger sensitivity (per unit of emissions) to BC emitted with-in the Arctic compared to lower latitudes. Especially during winter emissions from North-Eurasia can be transported into the high Arctic at low altitudes and become trapped within the boundary layer. A large fraction of the forcing from BC is due to deposition on snow. We find that in total the emissions from lower latitudes have higher impact on the Arctic surface temperatures, despite that the BC reaching the Arctic at higher altitudes has a small or even negative impact on the surface temperatures.

Today there are few within-Arctic sources of BC, but the emissions are expected to grow due to new developments in the Arctic. Special care should be taken as the Arctic have a different sensitivity to emissions than lower latitudes.