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Aerosols in the future Arctic and their impacts on climate, as investigated with an earth-system model

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With global warming and increasing sea ice melt in the Arctic during summer, increased aerosol emissions are expected in these remote regions. Local sources are expected from the exposed sea surface as well as increased ship traffic in the area. With the low level of background aerosol concentrations under present day conditions, these increased local emissions have the potential to influence the climate through direct radiative effects, aerosol-cloud interactions, and feedbacks with the sea ice. Previous studies using atmosphere-only models have found, in particular, limited impact of future Arctic ship emissions on the climate. However, one important aspect of the Arctic environment is the presence of sea ice, whose coverage or absence of it can significantly alter the radiative balance. The potential influence of aerosols on the sea ice cover should therefore not be neglected when examining their influence on climate. Thus in this study, we investigate the role of aerosols on the future Arctic climate using an earth system model with a full ocean model and a complex aerosol module (MPI-ESM-HAM). Aside from the impact of local ship emissions, the role of aerosols from natural sources is also examined. In particular, the increasingly exposed sea surface in the Arctic can lead to emissions of marine organic aerosols, which can act as ice nucleating particles and alter the phase and lifetime of mixed-phase clouds. The relative importance of changes in these various aerosol processes is investigated in this study.