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Scavenging processes control CCN in a sea-ice free Arctic

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The effects of climate change are amplified in the Arctic, manifested in the rapid decline in late summer sea-ice extent over the past few decades. The accelerated loss of perennial Arctic sea-ice predicts future ice-free summers with numerous ramifications for the regional and global climate. It has been suggested that this reduction in Arctic sea-ice is likely to increase cloud condensation nuclei (CCN) number concentrations by increasing sea-spray and dimethylsulphide (DMS) emissions in the central Arctic ocean. An increase in CCN number will increase Arctic cloud albedo, a negative climate feedback, which may mitigate the strong positive ice-albedo feedback.

Here we use a global size-resolving aerosol microphysics model to examine the effect of removing sea-ice cover from July to September on Arctic CCN concentrations. In our simulations, the removal of sea-ice has increased average sea-spray emissions by a factor $\sim$9 and average surface DMS concentrations by a factor $\sim$3. However the effect on Arctic CCN concentrations is rather inhomogeneous with median CCN in the marginal Arctic (70º-80ºN) increasing by 30% while median CCN concentrations north of 80ºN decrease by 4%.

Analysis of deposition rates indicate the average sulphate and sea-salt aerosol nucleation scavenging rate north of 80º has increased by 50% and 930%, respectively in the sea-ice free Arctic. We show that aerosol scavenging in stratocumulus clouds in the ice-free simulations is a key process controlling the response of CCN to increasing aerosol and precursor fluxes. Complete suppression of the clouds results in CCN number concentrations north of 80º increasing by 12%.

Our results suggest that while sea-salt and DMS emissions north of 80º increase in sea-ice free simulations, the scavenging flux (particularly of sea-spray) increases at an equivalent rate. Therefore, particles of sufficient size to act as CCN are scavenged too quickly to significantly affect modelled CCN number. Due to the diversity of predictions of both future Arctic DMS and sea-spray emissions this result is uncertain. However, model sensitivity studies suggest that the significance of this mechanism as a negative Arctic climate feedback is strongly dependent on future scavenging rates in the Arctic.