The complex response of Arctic CCN to sea-ice retreat

J. Browse [1], K. S. Carslaw[1], G. Mann[1], C. Birch[1], S. R. Arnold[1] and C. Leck[2]

1. Institute for Climate and Atmospheric Science, University of Leeds, Leeds,UK.
2. Department of Meteorology, Stockholm University, 10691, Stockholm, Sweden

Loss of summertime Arctic sea ice in a future climate will lead to a large increase in aerosol emissions in a region with currently limited local sources. Increased aerosol could constitute an important climate feedback through changes in cloud drop concentrations and radiative properties. In response to a complete loss of Arctic summer ice, our global aerosol microphysics model predicts a factor of 10 increase in the source strength of sea spray particles and an increase in the sea-air flux of dimethyl sulfide (a natural sulphate aerosol precursor) of a factor of 15. However, the predicted response of cloud condensation nuclei (CCN) concentrations is weak, with negative changes over the central Arctic. The weak response is due to the efficient scavenging of aerosol by extensive drizzling stratocumulus clouds. In the scavenging-dominated Arctic environment, the production of condensable vapour from the oxidation of dimethyl sulphide grows aerosol particles to sizes where they can be scavenged, thereby reducing CCN concentrations in regions with limited particle formation from boundary layer nucleation. In addition, condensation growth of primary particles also decreases H2SO4 concentrations, suppressing boundary layer nucleation and further decreasing CCN. However, if the increase in aerosol suppresses drizzle scavenging, then CCN increases are predicted. This study highlights the complex and inter-related processes controlling the Arctic summer aerosol size distribution and CCN load. Our results indicate that small changes to model processes can significantly alter the CCN response to sea-ice loss. Thus, we suggest that for aerosol-climate feedbacks in the Arctic to be predicted we must first address the significant gap in our understanding of polar aerosol and cloud processes.

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Presenter: Graham Mann [gmann@env.leeds.ac.uk]
Lead Author: Jo Browse [eejb@leeds.ac.uk]