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Investigating the Microphysics of Arctic Mixed-Phase Clouds using Large Eddy Simulations: The Importance of Liquid-Dependent Ice Nucleation

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Our ability to comprehend and accurately model the Arctic climate is currently hindered by a lack of observations of the atmospheric processes unique to this region. A significant source of uncertainty in such models may be found in our representation of aerosol-cloud interactions [1]: for example, there are unanswered questions concerning the relationship between the ice-nucleating Arctic aerosol and the unique cloud microphysics observed in this region [2].

In an effort to address this issue, the Aerosol-Cloud Coupling and Climate Interactions in the Arctic (ACCACIA) campaign of 2013 was conducted in the vicinity of the Svalbard archipelago, carrying out in-situ airborne observations of the mixed-phase clouds in this region. This campaign was split into two segments - one in spring, the other in summer - with airborne- and surface-based measurement platforms utilised in each. During the spring campaign, a range of microphysics and remote-sensing instruments were active on board the Facility for Airborne Atmospheric Measurements' (FAAM) BAe146 aircraft to produce a detailed record of the observed Arctic atmosphere. These data were used to conduct a modelling investigation with a focus on ice nucleation: the Large Eddy Model (LEM) - a cloud-resolving model developed by the UK Met Office - was initialised from these observations and simulations were performed to allow the resultant cloud evolution, structure and microphysics to be examined.

Models on various scales notoriously have issues with reproducing persistent, mixed-phase Arctic clouds [2,3] and, upon first inspection, the LEM was no different: the modelled cloud dissipated quickly, thus inaccurately replicating the long-lived, mixed-phase clouds observed. However, by considering the discrepancies between the model output and aircraft observations, the treatment of cloud microphysics within the LEM has been developed to improve the simulation of the observed clouds. A long-lived, mixed-phase cloud of similar microphysical properties to those observed is achieved, providing an indication that the realistic simulation of Arctic clouds is strongly dependent on the ice nucleus parameterisation used.

References:

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[3] Morrison, H. et al., 2012. Resilience of persistent Arctic mixed-phase clouds. Nature Geoscience, 5, 11-17.