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Arctic Mixed-Phase Clouds Sometimes Dissipate Due to Insufficient Aerosol - Evidence from Idealized Large Eddy Simulations

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Aerosol concentrations in the Arctic can get quite low, and recent work has shown that low aerosol concentrations could affect Arctic cloud formation and structure. Arctic mixed-phase clouds have been observed to persist for days at a time and dissipate suddenly, and it has been hypothesized that some instances of cloud dissipation are caused by aerosol concentrations falling below some critical value required to sustain the cloud.

We found three cases - from a Department of Energy ARM site on the north slope of Alaska, the ICECAPS-ACE project at the NSF Summit Station in Greenland, and the ASCOS field campaign - where clouds are observed to dissipate coincidentally with a drop of surface aerosol concentration. These cases were used to initialize idealized large eddy simulations in which aerosol concentrations were held constant at observed values before being immediately removed. The resulting simulations are considered to be the fastest possible aerosol-limited dissipation. Comparing simulated liquid water path (LWP) to observations, we find that the ARM case dissipated much faster than our simulations, indicating that the observed dissipation was not driven by lack of available aerosol. The Summit Station and ASCOS simulations dissipate (with respect to LWP) at approximately the same rate as observations, which suggests aerosol-limited dissipation may indeed be occurring in these cases.

Furthermore, we find that the microphysical response to aerosol removal varies between the specific cases we simulate. Simulations where the cloud produces constant liquid drizzle dissipate, within 3-4 hours, via an acceleration of precipitation once aerosols are removed. Conversely, the case with a non-precipitating liquid layer dissipates more quickly (< 2 hours), possibly by glaciation via the Wegener-Bergeron-Findeisen (WBF) in which ice grows and precipitates at the expense of liquid droplets. The simulations suggest that aerosol-limited dissipation in the Arctic is plausible, and we present two microphysical pathways by which this dissipation can occur.