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Stability dependent increases in liquid water with droplet number in the Arctic

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The response of cloud properties to aerosol perturbations is one of the greatest uncertainties associated with anthropogenic climate forcing. Clouds play a central role in the Arctic surface energy budget, so understanding how aerosols influence their radiative properties is important for projecting future changes in the region. This is especially relevant as increases in temperature and reductions in sea ice extent allow for more industrial activity in the region, thereby introducing fresh sources of aerosol.

As it is difficult to retrieve reliable satellite observations in polar regions due to issues such as high solar zenith angles, the impact of aerosols on Arctic clouds is particularly uncertain. However, by carefully filtering the satellite data to remove cases associated with retrieval biases, this work uses multiple satellite and reanalysis datasets to develop new constraints for the influence of aerosols on cloud properties.

The factors which influence the droplet number concentration-liquid water path (N_d-LWP) relationship, a key component of the aerosol-liquid water path relationship, are investigated. The N_d-LWP relationship varies significantly geographically, with increases in LWP with N_d observed at high latitudes. A range of meteorological factors are investigated, and it is shown that the lower tropospheric stability (LTS) is the driving force behind the variability in the N_d-LWP relationship in the Arctic. At high stability, the relationship is significantly more positive, producing LWP increases in more polluted environments, in contrast to the response of clouds to aerosol perturbations seen at lower latitudes.

As the Arctic warms, the boundary layer stability is projected to decrease. Additionally, industrial activity is expected to increase in the region, which may increase the aerosol burden. When considered individually, these two effects would lead to increases in LWP in marine Arctic clouds. However, when working together they may produce clouds with lower water paths, leading to a weaker negative cloud feedback in a more polluted environment.