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Cloud ice processes enhance spatial scales of organization in Arctic stratocumulus

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Around the globe, clouds tend to organize into cellular patterns. This phenomenon has gained growing attention in recent years, mainly due to albedo changes associated with different cloud regimes. Transitions between cloud regimes can be impacted by environmental factors such as tropospheric moisture content, large-scale subsidence, surface temperature and the ambient aerosol concentration or, more locally, precipitation formation, turbulence and boundary layer characteristics. It has been suggested that cold pool formation caused by evaporative cooling of precipitation can induce small-scale overturning circulations that promote cloud cell growth in open-cell stratocumulus clouds.

Cloud organization has so far been primarily studied for the subtropical trade wind region or deep convective clouds. In the mid and high latitudes organized cloud structures have been attributed to frontal systems in low pressure systems or cold air outbreaks. However, cloud patterns are also observed away from these large-scale phenomena in the higher latitudes. As low-level clouds in the high latitudes are mostly mixed-phase, various processes can shape cloud formation, occurrence and breakup. Processes related to the ice phase remain poorly understood and especially with regard to cloud organization remain completely unexplored.

In cloud-resolving model simulations using COSMO-LES we investigate the processes driving organization in open-cell mixed-phase stratocumuli. Similar to warm-phase clouds, MPCs develop a sub-cloud circulation caused by evaporated/sublimated precipitation, cold pool formation, and consecutive updrafts driving new convective cells. For a larger ice to liquid water ratio, we find locally stronger precipitation and larger cloud cells. Hence, a higher concentration of ice nucleating particles can induce a breakup of the stratocumulus organization, with implications for the radiative balance at the surface. A decrease in cloud condensation nuclei concentration is also found to intensify precipitation and impact cloud organization.