Aggregation in Arctic shallow mixed-phase clouds is enhanced by dendritic growth and absent close to the melting level: evidence from long-term remote sensing observations in Ny-Ålesund

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Shallow mixed-phase clouds (SMPCs) are ubiquitous in the Arctic, and are known to significantly impact the surface energy budget. However, our incomplete understanding of how they develop precipitation is likely to affect our ability to accurately simulate them. The significance of different precipitation formation processes for Arctic SMPCs has been in fact widely overlooked.

We statistically assess the significance of aggregation for the formation of precipitation in Arctic SMPCs, employing a 3-year dataset of ground-based remote sensing observations taken in Ny-Ålesund, Svalbard. Dual-wavelength ratio (DWR) is obtained from two vertically-pointing Doppler radar systems, a K-band precipitation radar, the MRR-2, and a W-band cloud radar. DWR is used as a proxy for the characteristic size of the particle population, and matched with Doppler velocity and temperature retrievals to identify situations when the ice growth is dominated by aggregation.

High DWR signals are predominantly observed when temperatures compatible with dendritic growth, especially in the -15 to -10°C range, are found above the liquid base of the cloud. Low fall speeds strongly suggests that these high-DWR particles are due to aggregation of dendritic particles. The occurrence of high DWR signatures is observed in limited regions in the cloud deck, suggesting that dynamical processes might be needed to fully explain these signatures.

Surprisingly, we find no evidence of enhanced aggregation at temperatures above -5°C in Arctic SMPCs. This is typically observed in mid-latitude clouds, and in deeper cloud systems in Ny-Ålesund as well. We hypothesize that ice particles sedimenting from higher levels might be an essential component needed to trigger enhanced aggregation above -5°C.