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The impact of Secondary Ice Processes on Arctic stratocumulus

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Mixed-phase clouds and their effects constitute one of the largest sources of uncertainty in predictions of the Arctic climate. At the heart of this uncertainty is an ice formation “paradox”, where the number concentration of ice crystals (ICNC) frequently exceeds the concentration of precursor ice nuclei (IN) by orders of magnitude. Secondary Ice Processes (SIP), which cause multiplication of the few primary ice crystals (formed from IN), have been suggested as the cause. However, the exact mechanisms and their relative importance remain unknown. In this study, we investigate the impact of SIP on stratocumulus clouds observed during the Aerosol-Cloud Coupling And Climate Interactions campaign, using a Large Eddy Simulation and a Lagrangian Parcel Model. The role of three mechanisms: (i) rime-splintering, (ii) mechanical break-up upon collision of two ice crystals and (iii) droplet shattering, and their sensitivity to the available Cloud Condensation Nuclei and IN, are examined. When activating both rime-splintering and collisional break-up mechanisms, ICNC is enhanced by an order of magnitude, resulting in reduced discrepancies between the modeled and the observed cloud ice content. Our findings indicate that ice multiplication processes play a potentially important role for the Arctic cloud life-cycle and that including these processes in atmospheric models may be critical for the accurate representation of the Arctic Climate.