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What is triggering ice in mixed-phase clouds: A process analysison the importance of ice nucleation and sedimentation with ECHAM-HAM

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Mixed-phase clouds can be found at temperatures between 0 and -40°C and consist of supercooled cloud droplets and ice crystals. Their formation is triggered by different processes forming or introducing ice crystals in a supercooled cloud. Once ice crystals are present they grow at the expense of the cloud droplets due to the Wegener-Bergeron-Findeisen process, which causes a partial or complete glaciation of the cloud. Secondary ice processes can accelerate the glaciation.

In the global climate model ECHAM-HAM there are three different trigger processes, which introduce initial ice crystals into a supercooled cloud: heterogeneous ice nucleation, sedimentation of ice crystals from upper cloud layers, e.g. cirrus clouds, and vertical transport (vertical diffusion) of ice crystals. The aim of our study is to analyze the importance of each process in ECHAM-HAM. We investigated the role of all processes by conducting an ensemble of simulations where individual or combinations of processes are turned on or off. The outcome was analyzed with the factorial method using the supercooled liquid fraction of a mixed-phase cloud as a tracer for the microphysical structure. The analysis shows that sedimentation of ice crystals is crucial for mixed-phase clouds in ECHAM-HAM. Ice nucleation seems only to be an important trigger process if there are no ice crystals sedimented from above. However, even then sedimentation is important to distribute the freshly nucleated ice crystals within the supercooled cloud.