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Large-scale simulations and in-situ observations of mid-latitude and Arctic cirrus clouds

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Cirrus clouds play an important role by influencing the Earth's radiation budget and the global climate (Heintzenberg and Charlson, 2009). The formation and further evolution of cirrus clouds is determined by the interplay of temperature, ice nuclei (IN) properties, relative humidity, cooling rates and ice crystal sedimentation. Thus, for a realistic simulation of cirrus clouds, a Lagrangian approach using meteorological wind fields is the best way to represent complete cirrus systems as e.g. frontal cirrus. To this end, we coupled the two moment microphysical ice model of Spichtinger and Gierens (2009) with the 3D Lagrangian model CLaMS (McKenna et al., 2002).

The new CLaMS-Ice module simulates cirrus formation by including heterogeneous and homogeneous freezing as well as ice crystal sedimentation. The boxmodel is operated along CLaMS trajectories and individually initialized with the ECMWF meteorological fields. From the CLaMS-Ice three dimensional large scale cirrus simulations, we are able to assign the formation mechanism - either heterogeneous or homogeneous freezing - to specific combinations of temperatures and ice water contents.

First, we compare a large mid-latitude dataset of in-situ measured cirrus microphysical properties compiled from the ML-Cirrus aircraft campaign in 2014 to ClaMS-Ice model simulations. We investigate the number of ice crystals and the ice water content with respect to temperature in a climatological way and found a good and consistent agreement between measurement and simulations. We also found that most (67 %) of the cirrus cloud cover in mid-latitude is dominated by heterogeneously formed ice crystals.
Second, CLaMS-Ice model simulations in the Arctic/Polar region are performed during the POLSTRACC aircraft campaign in 2016. Higher ice crystal number concentrations are found more frequently in the Arctic region in comparison to the mid-latitude dataset. This is caused by enhanced gravity wave activity over the mountainous terrain.

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