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Towards a new parameterization of ice particles growth

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Ice particles are the main component of polar clouds, unlike in warmer regions. That is why correct representation of ice particle formation and growth in NWP and other numerical atmospheric models is crucial for understanding of the whole chain of water transformation, including precipitation formation and its further deposition as snow in polar glaciers. Currently, parameterization of ice in atmospheric models is among the most difficult challenges. In the presented research, we present a renewed theoretical analysis of the evolution of mixed cloud or cold fog from the moment of ice nuclei activation until complete crystallization. The simplified model is proposed that includes both supercooled cloud droplets and initially uniform particles of ice, as well as water vapor. We obtain independent dimensionless input parameters of a cloud, and find main scenarios and stages of evolution of the microphysical state of the cloud. The characteristic times and particle sizes have been found, as well as the peculiarities of microphysical processes at each stage of evolution. In the future, the proposed original and physically grounded approximations may serve as a basis for a new scientifically substantiated and numerically efficient parameterizations of microphysical processes in mixed clouds for modern atmospheric models. The relevance of theoretical analysis is confirmed by numerical modeling for a wide range of combinations of possible conditions in the atmosphere, including cold polar regions. The main conclusion of the research is that until complete disappearance of cloud droplets, the growth of ice particles occurs at a practically constant humidity corresponding to the saturated humidity over water, regardless to all other parameters of a cloud. This process can be described by the one differential equation of the first order. Moreover, a dimensionless parameter has been proposed as a quantitative criterion of a transition from dominant depositional to intense collectional growth of ice particles; it could be used in models with bulk parameterization of cloud and precipitation formation processes.