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The influence of aerosol properties and drop freezing modes on convective clouds: Numerical simulations.

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Ice formation in the troposphere is mainly initiated by heterogeneous freezing, i.e. by particles containing an insoluble residue. The ice nucleation ability of this insoluble material determines the temperature of ice initiation. The formation of ice in a cloud affects its vertical dynamics by the release of latent heat so that a mixed phase cloud may reach higher altitudes with lower temperatures which further advance ice formation. Sensitivity studies were undertaken by varying the insoluble particle types as well as the soluble fraction of the aerosol particles to show the effects of these parameters on ice formation and, thus, on the vertical cloud dynamics. An air parcel model with a sectional two-dimensional description of the cloud microphysics was employed for a convective situation. Ice formation was allowed by drop freezing in immersion and contact modes. The results indicate that the soluble fraction decides whether immersion or contact freezing will be the major process. For a high soluble fraction, immersion freezing is dominant. In such cases the freezing process is strongly temperature dependant and the ice nucleation efficiency of the insoluble particle types becomes important for efficient freezing, i.e. for lower cloud temperatures and higher altitudes. Glaciation of the cloud propagates by increasing numbers of ice particles. The freezing point depression can be neglected even for cases of a high soluble fraction because of the preferential freezing of large drops. Contact freezing is the major process in cases of a lower soluble fraction. There temperature and the aerosol particle ice nucleation efficiency are less important, but the soluble fraction of the aerosol particles determines the efficiency of the freezing process and, thus, cloud temperature and altitude. The glaciation of the cloud proceeds by the growth of a lower number of ice particles which reach larger sizes than in the case of efficient immersion freezing.