Impact of heterogeneous nucleation on cirrus clouds in high-velocity regimes

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For cirrus clouds in the cold temperature regime it is always assumed that homogeneous freezing of aqueous solution droplets acts as main formation mechanism for ice crystals. Additionally, heterogeneous nucleation should only (slightly) modify homogeneous freezing because of few available ice nuclei in the upper troposphere. The modification is depending on local vertical motion and it is assumed that in the high vertical velocity regime (i.e. $w>0.5$ m/s) the role of heterogeneous nucleation is only marginal. However, these estimations were derived from box model simulations and parcel concepts neglecting the complicated vertical structure of cirrus clouds, the impact of sedimentation and other two- or three-dimensional effects. Therefore, we investigate the impact of heterogeneous nucleation on cirrus cloud formation and evolution for high-velocity regimes using two-dimensional idealized simulations with the EULAG model containing a state-of-the-art bulk ice microphysics scheme. For calculating the radiative impact of cirrus clouds in these simulations we use an offline radiative transfer model. We investigate two different idealized situations. First, as a purely dynamically driven regime we investigate orographic waves and their impact on cirrus cloud formation. Second, we investigate shallow convection inside cirrus cloud layers as driven by potentially unstable layers in the tropopause region. The latter regime is more complicated since there is a feedback between thermodynamics and dynamics. However, in both cases we can show that heterogeneous nucleation is still important and can change the structure of the clouds as well as their radiative budget.