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How much variability in upper tropospheric cloud-radiative heating can be attributed to ice microphysics?

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While large-domain simulations without convective parameterization are now computationally feasible, microphysics, particularly that of the ice phase, remains a persistent problem for high-resolution models. In 2.5-km equivalent resolution simulations with the ICON model, we find that switching between one- and two-moment ice microphysics can alter cloud top cooling by a factor of ten and in-cloud heating by a factor of four above 350 hPa. A consistent ice crystal effective radius between microphysics and radiation increases the cloud-radiative heating another two-fold, while inclusion of aerosol-cloud interactions reduces it at lower levels between 400 and 500 hPa. We also generate 60-hour trajectories from ICON within ice clouds and use them to force a detailed ice microphysics box model, the Chemical Lagrangian Model of the Stratosphere (ClaMs-ice). We compare the ice mass and number tendencies, as well as the sedimentation fluxes, between ICON and CLaMS-ice. These offline simulations also allow us to quantify the strength of microphysical-radiative feedbacks and investigate the impact on heating of particular ice microphysical factors, including gravity wave parameterization, ice-nucleating particle concentrations, and the number concentration of solution droplets.