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Impact of H_2SO_4/H_2O coating and ice crystal size on radiative properties of sub-visible cirrus

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Abstract. Recent laboratory experiments showed that at conditions resembling those near the tropopause region, small ice particles can be coated by a liquid H_2SO_4/H_2O over-layer formed after the freezing of diluted sulfuric acid/water aerosol drops. Here, idealized radiative transfer tests are conducted to evaluate the impact that such an over-layer would have on the radiative effects produced by sub-visible cirrus clouds (SVCs). Spherical particle shape is assumed to keep the problem tractable. The calculations show that the over-layer increases both the shortwave (SW) and longwave (LW) cloud radiative effects (CRE), but the impact is small: ~0.02 W m^{-2}, or even less, for the total (LW+SW) CRE at the top of the atmosphere. For the smallest ice particles, for which the over-layer is thickest, the fractional change in CRE can, however, reach ~20% for the SW CRE and over 50% for the LW CRE. The dependence of LW and SW CRE on particle size is also studied in the paper. Calculations for spherical and spheroidal uncoated ice particles show that even for high, optically thin cirrus, the total CRE can be negative, if the diameter of the particles is smaller than about 3–4 μm. Apart from the SVCs, this result could be relevant for contrail cirrus clouds, which are believed to consist of large numbers of very small ice particles.

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