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Properties of subvisible cirrus clouds formed by homogeneous freezing

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Abstract. Number concentrations and mean sizes of ice crystals and derived microphysical and optical properties of subvisible cirrus clouds (SVCs) formed by homogeneous freezing of supercooled aerosols are investigated as a function of temperature and updraft speed of adiabatically ascending air parcels. The properties of such clouds are insensitive to variations of the aerosol number and size distribution. Based on criteria constraining the optical extinction, sedimentation time, and existence time of SVCs, longer-lived (>10min) clouds, capable of exerting a measurable radiative or chemical impact, are generated within a narrow range of updraft speeds below 1-2cm s^{-1} at temperatures below about 215K, with concentrations of ice crystals not exceeding 0.1cm^{-3}. The clouds do not reach an equilibrium state because the ice crystals sediment out of the formation layer typically before the supersaturation is removed. Two important conclusions emerge from this work. First, the above characteristics of SVCs may provide an explanation for why SVCs are more common in the cold tropical than in the warmer midlatitude tropopause region. Second, it seems likely that a limited number (<0.1cm^{-3}) of effective heterogeneous freezing nuclei that nucleate ice below the homogeneous freezing threshold can control the formation and properties of SVCs, although homogeneous freezing nuclei are far more abundant.

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