Formation of high ice concentration cirrus in the Tropical Tropopause Layer observed by ATTREX 2011

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Stratospheric water vapor is important to the decadal variation of global surface temperature (Solomon et al. 2010). Dehydration processes in the Tropical Tropopause Layer (TTL) strongly control stratospheric water vapor through cirrus formation. In addition to the frequently observed cirrus with the ice concentration (Nc_i) extremely low (< 10^2 L^{-1}), vertically thin cirrus layers with high Nc_i (10^4 L^{-1}) have been observed in Airborne Tropical TRopopause Experiment (ATTREX) 2011. The lack of aerosol physical state and upwind gravity-wave measurements prevents clear explanation for its formation process (Jensen et al. 2013). Because of the thin structure and small particle size, we could assume that the thin layer is pristine, and the effect of sedimentation, mixing and diffusion can be neglected. These features are the advantage to investigate their formation processes. In this study, cloud microphysical conditions, necessary for the formation of high Nc_i cirrus, are investigated by using a box model with detailed cloud microphysics. The model is designed by Maruwaka and Sakurai (Nagoya Univ.) by referring to Jensen and Pfister (2004). Ice nucleation is calculated by using homogeneous nucleation (Koop et al., 2000). For simplicity, the cooling rate is kept constant, while the pressure is changed to conserve potential temperature. A series of parameter sweep experiments are conducted by changing the cooling rate, aerosol particle size and initial water vapor mixing ratio. The results indicate that Nc_i becomes lower as initial water vapor mixing ratio is higher. The cooling rate, corresponding to the large-scale updraft in the TTL, is too weak to explain high Nc_i such as 10^4 L^{-1} observed in the thin TTL cirrus. Conditions necessary for the formation of high Nc_i cirrus will be discussed.

Key words: TTL dehydration, Cloud microphysics, Ice nucleation process

References

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