

Interactive comment on “Ice nucleation and cloud microphysical properties in tropical tropopause layer cirrus” by E. J. Jensen et al.

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Received and published: 13 October 2009

Jensen et al. present an interesting analysis that exposes a fundamental disconnect between cloud modeling and observations of vertical velocities and cirrus cloud properties in the TTL. They demonstrate that parcel models that contain only homogeneous freezing of aqueous aerosols, the common process assumed for ice generation in the upper troposphere, are inconsistent with both the aircraft observations and lidar observations. Recent aircraft data show the ubiquitous presence of gravity waves, and cirrus with broad ice crystal size distributions and small ice crystal number concentrations. Their modeling experiments with gravity waves and homogeneous freezing alone produce large numbers of ice crystals with a narrow size distribution. They also provide a detailed comparison of extinction from CALIPSO to help solidify their case

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for a model-observational discrepancy.

Although Jensen et al. articulate a number of potential explanations for the described discrepancy, they introduce the explanation that solid ammonium sulfate aerosols may serve as heterogeneous freezing nuclei at very cold temperatures, and that homogeneous nucleation is not the dominant freezing mechanism. Their ammonium sulfate heterogeneous freezing mechanism is enabled only at low temperatures, at which the combined presence of high relative humidity with respect to ice and humidities below the deliquescence point of solid ammonium sulfate particles co-exist. Jensen et al. demonstrate that the potential for the existence of this freezing mechanism by looking at temperature trajectories, but do not provide modeling simulations that demonstrate it as a viable explanation for the discrepancy. Additional support is provided by the observation that ice crystal residuals appear to have compositions similar to the ambient aerosol population.

I found the results and analysis interesting. The paper is stimulating and well written. While additional ice nucleation trajectory modeling is needed to demonstrate that the ammonium sulfate heterogeneous freezing mechanism can reconcile modeling and observations, I think there is sufficient work done here and new ideas to promote future research. Provided the other reviewers and any additional comments support my assessment, I recommend publication in ACP.

Minor comments

Page 20633: 'In addition, given there' to 'In addition, given their'

Page 20634: Is aggregation a common process in the TTL?

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 20631, 2009.

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