Geophysical Research Abstracts,
Vol. 10, EGU2008-A-06053, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-06053
EGU General Assembly 2008

Comparisons of aerosol and cloud particle size distributions in the tropical tropopause layer measured by optical particle counters and a lidar with those computed by a parcel model

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We will show observational results of cirrus clouds in the tropical tropopause layer, hereafter TTL cloud, measured by a lidar and balloon-borne optical particle counters (OPCs). We launched 11 OPCs in Thailand (17.9 ^{o}N, 99.5 ^{o}E); cirrus clouds, such as anvil clouds, were detected at 10-15 km high on 7 occasions, TTL clouds in 6 cases, and simultaneous measurements of TTL clouds with the OPC and the lidar were made on two occasions. We will also show the comparisons of the observations and theoretical results with a parcel model.

Comparisons of the simultaneous lidar and OPC measurements reveal that the height of TTL cloud varies by several hundred meters over distances of tens kilometers; hence the height of TTL cloud is not horizontally uniform, and the mode radii of the cloud particles are estimated to be less than approximately 10 μm. We also find that TTL clouds have two common features that cirrus clouds below 15 km do not have:

(1) the enhancement in the particle size distribution at radii greater than 0.9 μm and (2) the peak at around 0.8 μm in the ratio of the standard deviation of count values, raw data, to that of the Poisson distribution of count values, where the ratio shows the vertical homogeneity of the particle number. These typical features suggest that the transition from liquid, sulfuric acid aerosol, to ice is more observable in the TTL.

We also calculate TTL cloud nucleation processes by using a parcel model where we assume the homogeneous nucleation whose freezing rate is Koop et al. (2000, Nature), aerosol particles are H_2SO_4, vertical wind speed, and initial temperature and relative humidity. Without the heterogeneous nucleation, computed number of aerosol particles whose radii are 0.7 - 1 μm becomes much fewer than that of OPC measurements when the parcel updraft speed is 5 cm/s or more; hence, the averaged updraft speed must be slower than 5 cm/s.