INVESTIGATION OF CIRRUS CLOUDS USING THE CALIPSO LIDAR DATA

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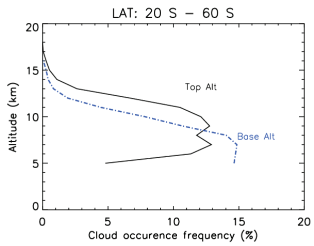
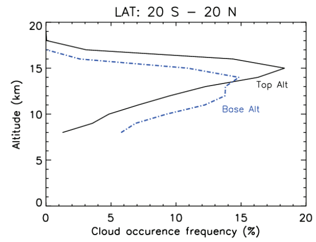
1. INTRODUCTION

Cirrus clouds normally exist in the upper troposphere and sometimes extend into the stratosphere. Unlike many low altitude clouds that have a cooling effect on solar radiation through scattering, high thin cirrus clouds scatter only a small amount of solar radiation and prevent a large quantity of long-wave radiation from leaving the earth–atmosphere system. Cirrus clouds are globally distributed and are composed almost exclusively of non-spherical ice crystals. Maxima in thin, near-tropopause cirrus tend to occur over regions of intense convective activity like equatorial Africa and South America, both of which are sites for vigorous continental convection, and the western Pacific, which is a site of significant oceanic convection. The increase of high clouds is partially correlated to the formation of contrails produced by jet airplanes. Few instruments can deduce the global presence of cirrus clouds, especially subvisual clouds and those of low optical thickness. However, a global characterization of cirrus cloud properties is critical to understanding feedback processes that regulate or modulate the climate response to forcing. The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite mission provides comprehensive observations of cloud vertical structure on a near-global scale.

2. BACKGROUND INFORMATION ON THE INSTRUMENT

Several instruments have been used to investigate cirrus clouds, but in this study we are mainly going to focus on the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO). CALIPSO is part of the “A-Train” constellation of Earth Observing Satellites. The CALIPSO satellite employs an active lidar to provide vertical profiles of aerosols and clouds, and allows vital progress in our understanding of the links between aerosols, clouds, and radiation necessary to more accurately assess future climate change. CALIPSO measures clouds





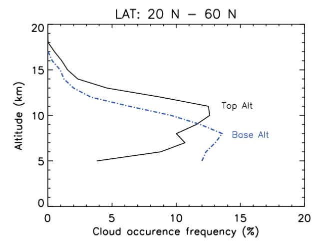
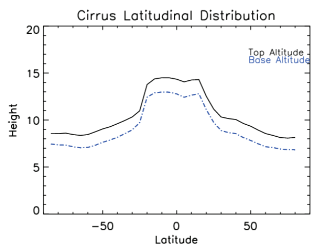


Figure A. Figure B. Figure C.



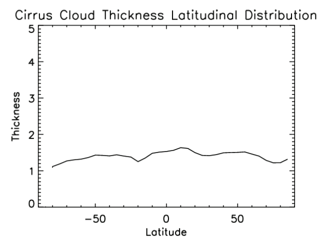


Figure D. Figure E.

with an unprecedented vertical and horizontal resolution, especially high clouds. The CALIPSO lidar provides information on thin clouds and their structure using backscatter measurements in three channels; 1064 nm and 532 nm wavelengths, and a depolarization channel at 532 nm. CALIPSO payload consists of three nadir-viewing instruments: the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), the French-built Imaging Infrared Radiometer (IIR) and the Wide Field Camera (WFC). The CALIOP data products are archived with a vertical resolution of 30 m from 0 to 8 km, and 60 m from 8 to 20 km. We use the CALIOP data to characterize cirrus clouds. The vertical distribution of cirrus clouds occurrence frequencies are presented at different latitude bands. We also study the zonal mean distribution of the cirrus cloud thickness measured by CALIOP as a function of latitude.

3. CLASSIFYING CIRRUS CLOUDS

We examine cirrus clouds using the 5-km (horizontal resolution) cloud layer data product from CALIPSO during October 1 to November 18, 2006. We use certain threshold values to investigate high level ice clouds, which can be considered typical for cirrus clouds. We study clouds with Cloud Layer Base altitude higher than 8 km near the tropics (20° S - 20° N) and higher than 5 km in the 20° - 85° S and 20° - 85° N latitude bands. The thickness of the clouds under consideration is less than 8 km and the optical depth is less than 3.

4. VERTICAL DISTRIBUTION OF CIRRUS CLOUDS

With the previous requirements we evaluate the vertical distribution of cirrus clouds for different latitude bands. We define the cloud occurrence frequency as the ratio of the number of retrieved cloud layers to total number of observations by CALIPSO. The figures A, B, and C show the vertical distribution of the frequency of cirrus top altitudes (black solid line) and cirrus base altitudes (blue dashed line) from CALIPSO from October 1 to November 18, 2006.

5. ZONAL MEAN DISTRIBUTION

We examined height-latitude distribution and thickness-latitude distribution of cirrus clouds from CALIPSO from October 1 to November 18, 2006. We examined the zonal mean distribution of the cirrus cloud layer top altitudes and layer base altitudes measured by CALIPSO for each 5° latitude bin. In figure D the cirrus cloud layer top is shown with the black solid line and the cirrus cloud layer base is shown with the blue dashed line. The zonal mean distribution of cirrus cloud thickness was based on the difference between cirrus cloud top altitude and cirrus cloud base altitude. Figure E shows the thickness-latitude distribution of cirrus clouds.

6. REFERENCES

[1] Eguchi, N., Yokota, T., and Inoue, G. (2007), “Characteristics of cirrus clouds from ICESat/GLAS observations,” Geophys. Res. Lett., 34, L09810, doi:10.1029/2007GL029529.