CALIPSO/CloudSat Science Workshop
28 - 31 July 2009

Characterization of cirrus clouds using CALIPSO data

Hovakim Nazaryan and M. Patrick McCormick

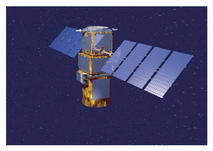
CAS, Hampton University, Hampton, VA, 23668

Corresponding Author: hovakim.nazaryan@hamptonu.edu

Abstract

A global and temporal distribution of cirrus clouds is presented herein based on measurements made by the lidar aboard the Earth-orbiting Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite launched in April 2006. CALIPSO measures clouds with an unprecedented vertical and horizontal resolution, especially high clouds. Few instruments can deduce the global presence of cirrus clouds, especially sub-visual clouds and those of low optical thickness. Cirrus clouds are one of the most important and yet uncertain components in weather and climate studies. In order to place the relevance and importance of cirrus composition, structure, and radiative properties into a global perspective, statistical distributions of fundamental cirrus cloud properties are required. The latitude-longitude distribution of the CALIPSO cirrus cloud occurrence frequency from June 2006 to May 2009 is presented. Our investigation of multi-layer cirrus clouds shows maximum occurrence frequencies of up to 93.5% near the tropics over the 100° - 180° E longitude band. We also study the differences between the occurrence frequencies of cirrus clouds measured by CALIPSO during daytime and nighttime. The zonal mean distributions of the cirrus cloud layer top altitudes and base altitudes for nighttime and daytime are calculated. We obtain that cloud top altitudes from the nighttime data were higher than the daytime top altitudes on average by 0.6 km. These differences may be caused by larger noise levels in the daytime data. The altitude-longitude distributions of the CALIPSO cirrus cloud occurrence frequency at different latitudes from June 2006 to May 2009 are also presented. There are some hemispheric differences in altitude-longitude distributions of cirrus cloud frequency. These differences are more pronounced near the Polar Regions.

1. Description of the Instrument



- The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) is developed within the framework of collaboration between NASA, France's Centre National d'Etudes Spatiales (CNES), and Hampton University.
- CALIPSO was launched on April 28, 2006 and is in a sun-synchronous 705-km circular polar orbit with an ascending node equatorial crossing time of 13:30 local time.
- CALIPSO flies in formation with the EOS Aqua satellite as part of the Aqua constellation, which consists of the Aqua (with MODIS onboard), Aura, CALIPSO, CloudSat, and PARASOL satellites.
- The 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).
- CALIOP is a three-channel lidar system (1064 nm and 532 nm parallel and perpendicular) with a 1 m receiving telescope.
- The CALIOP data products are are archived with a vertical resolution of 30 m from 0 to 8 km, and 60 m from 8 to 20 km.

2. Cirrus Clouds

- We examine clouds with Cloud Layer Base (CLB) altitude higher than 8 km in the tropics (15° S - 15° N) and higher than 5 km in the 15° - 85° S and 15° - 85° N latitude bands.
- The thickness of the clouds under consideration is less than 8 km.
- Integrated Volume Depolarization Ratio is greater than 0.2 (greater than 20%).
- In our study we employ the 5-km (horizontal resolution) cloud layer data product from CALIPSO.
- We take into account only those clouds for which either the surface or a lower cloud layer is detected.

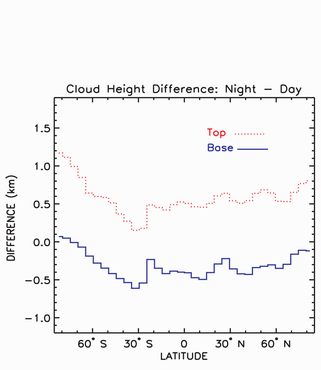


Figure 1. Zonal mean distribution of the (night - day) differences of the cirrus cloud layer heights retrieved by CALIOP from June 2006 to May 2009.

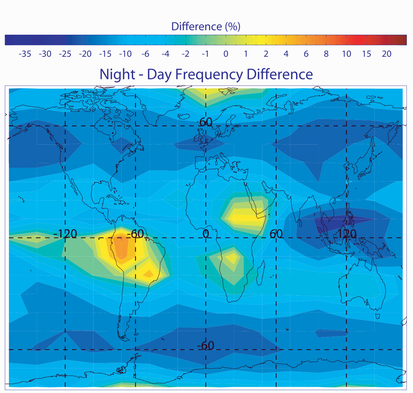


Figure 2. Latitude-Longitude distribution of the differences between the occurrence frequencies of cirrus clouds measured by CALIOP during day and night over the period June 2006 to May 2009.

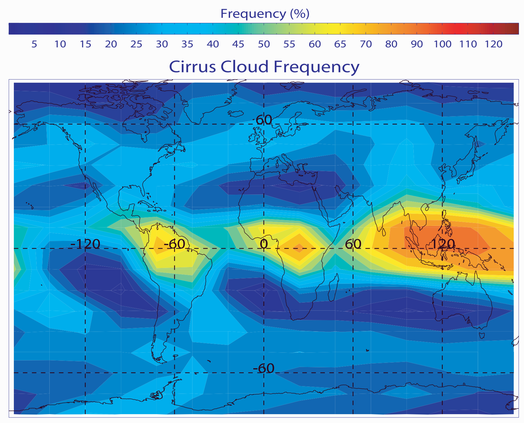


Figure 3. Latitude-Longitude distribution of the CALIOP cirrus cloud occurrence frequency from June 2006 to May 2009.

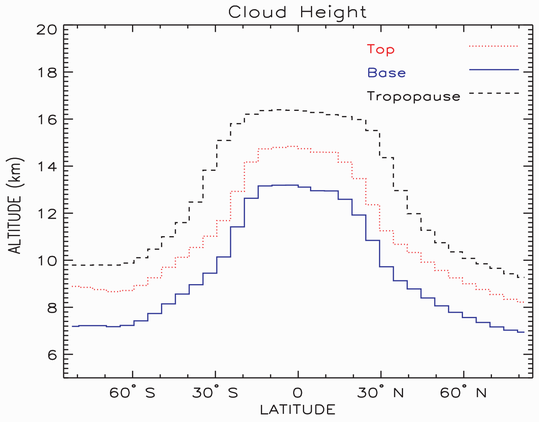


Figure 4. Zonal mean distribution of the cirrus cloud layer top altitudes (red dotted line) and layer base altitudes (blue solid line) measured by CALIOP as a function of latitude from June 2006 to May 2009. The dashed line is the average height of the tropopause.

3. Global and Temporal Distributions of Cirrus Clouds

- To investigate the zonal variability to cloud occurrence frequency, the the CALIOP measurements are grouped into 10° latitude by 24° longitude bins.
- We obtain the cirrus cloud occurrence frequency employing the following formula:

$$Occurrence\ Frequency = \frac{N_M}{N_T} \cdot 100\% ,$$

  where N_M is the number of all retrieved cirrus clouds, and N_T is the number of total observations.
- The mean (night-day) differences between the occurrence frequencies of cirrus clouds measured by CALIOP during night and day are calculated over all latitude and longitude bins.
- We examine the zonal mean distribution of the cirrus cloud layer top altitudes and layer base altitudes measured by CALIOP for each 5° latitude bin.
- The monthly averages of the CALIOP cirrus cloud occurrence frequency are calculated from June 2006 to May 2009.

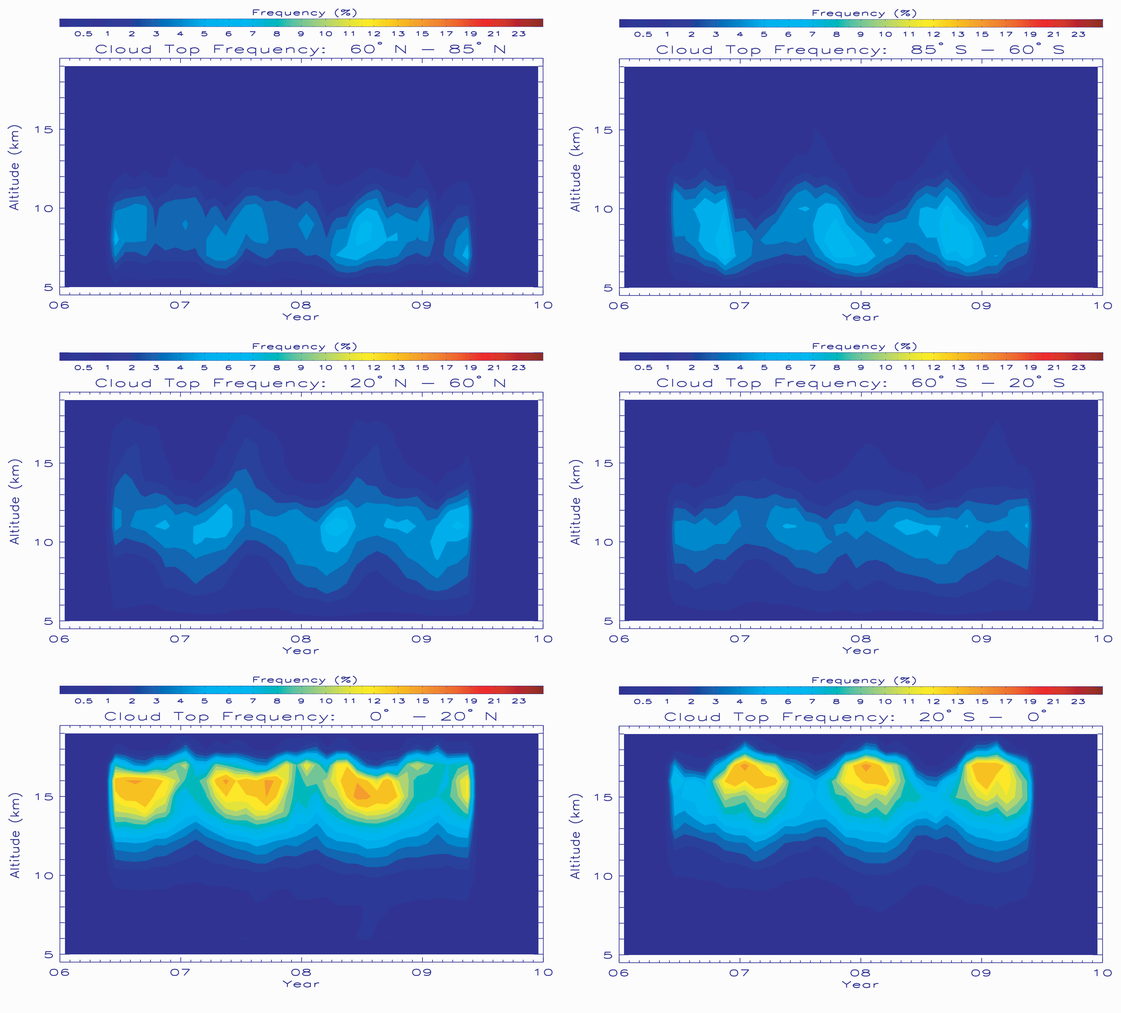


Figure 5. Time series of the CALIOP cirrus cloud occurrence frequency at different latitudes from June 2006 to May 2009.

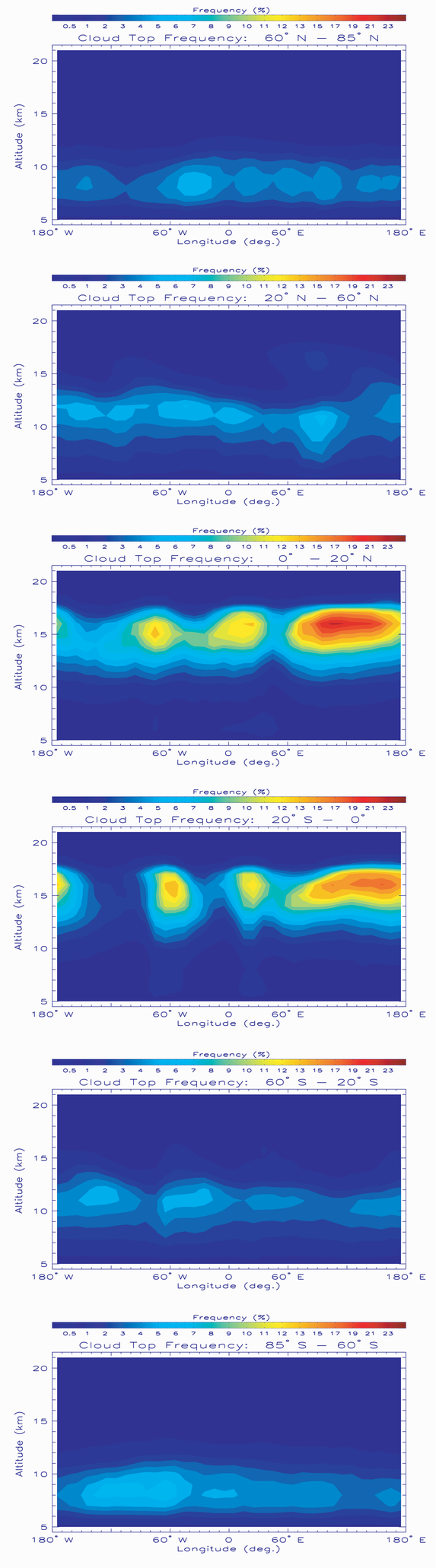


Figure 6. Altitude-Longitude distributions of the CALIOP cirrus cloud occurrence frequency at different latitudes from June 2006 to May 2009.