3D Ice Cloud Climatology from 10+ years of CALIOP Observations

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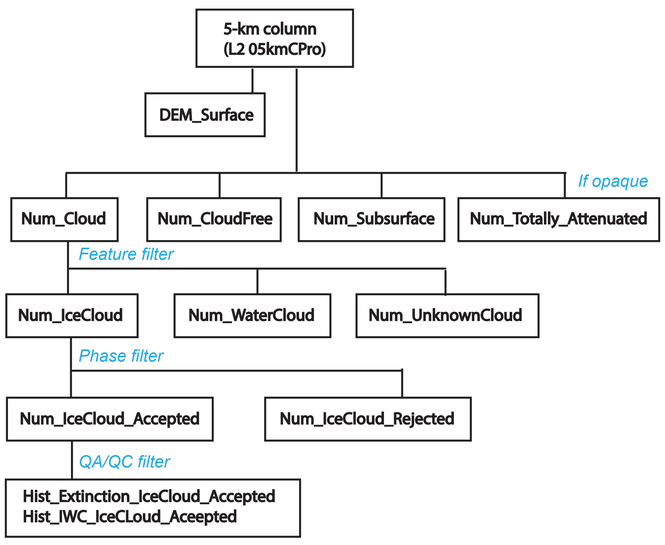
Abstract

A comprehensive understanding of the spatial and temporal distributions of clouds on a global scale can be best achieved when the vertical distributions and multi-layer occurrence frequencies obtained from active remote sensors are fully integrated with the horizontal distributions currently provided by passive sensors. The Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) satellite lidar onboard the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) spacecraft was specially designed to acquire aerosol and cloud profiles with unprecedented high vertical resolution and accuracy. As a part of the A-Train satellite constellation, CALIPSO has been operating routinely for more than 10 years and continues to provide a wealth of cloud observations to describe the mean state and inter-annual variability. Recently a suite of level 3 (L3) cloud products has been under development by the CALIPSO lidar science working group at the NASA Langley Research Center. These products describe 3-dimensional (3D) cloud occurrence and 3D ice cloud extinction coefficients and ice water content. Future evolution of the products will add observations from the Imaging Infrared Radiometer onboard CALIPSO. Here we present a brief introduction and provide results from a product prototype. We will characterize the inter-annual vertical variability of zonal cloud occurrence and ice water content during the last 10 years. Suggestions and comments are welcome to help us design and provide better cloud climatology products using CALIOP observations for our cloud community.

CALIPSO ice cloud properties product



Resolution and filters

- **Temporal coverage:** AM, PM, AM+PM
- **Spatial coverage:** longitude -180º ~ 180º, latitude -85º ~ 85º, altitude -0.5 km ~ 20.2 km
- **Spatial resultion:** longitude 2.5º, latitude 2º, altitude 120 m
- **Missing value:** -9999
- **Valid *Extinction_Coefficient_532* and *IWC* ranges:**
  - Extinction_Coefficient_532: -0.1 km^{-1} ~ 10 km^{-1}
  - *IWC: -0.01 g m^{-3} ~ 1 g m^{-3}*
- **QA/QC filters for ice clouds:**
  - QA filters: hight confidence feature, high confidence phase random-oriented ice clouds
  - QC filters: valid extinction retrieval (*Extinction_QC_Flag_532* = 0, 1, 2, 16, 18; *ExtinctionQC_Uncertainty* ≠ 99 km^{-1}), valid lidar ratio [10, 50), OverlyingOD ≤ 2

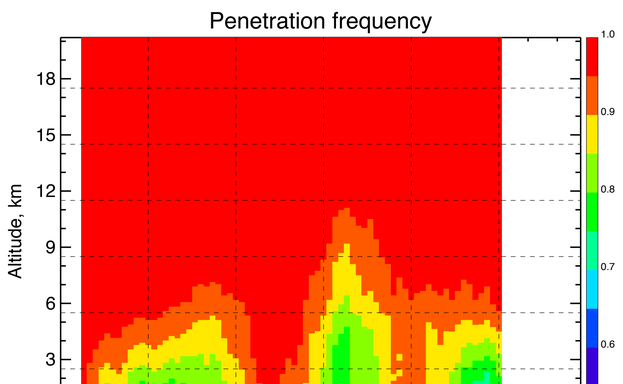
Scientific data set (SDS)

- **Spatial cooridinates**
  - *Latitude_Midpoint*, *Longitutde_Midpoint*, *Altitude_Midpoint*
- **Bin informatin of *Extinction_Coefficient_532* and *IWC* histograms**
  - *Histogram_Bin_Extinction*, *Histogram_Bin_IWC*
- **Meteorological data**
  - *Temperature*, *Pressure*, *Relative_Humidity, Tropopause_Height*
- **Numbers of granules**
  - *Num_Granules_Processed, Day_of_Month_Observed*
- **Numbers of samples**
  - *Num_Subsurface, Num_Totally_Attenuated, Num_CloudFree, Num_Cloud*
  - *Num_IceCloud, Num_WaterCloud, Num_UnknownCloud*
  - *Num_IceCloud_Accepted, Num_IceCloud_Rejected*
- **Histograms of *Extinction_Coefficient_532* and IWC**
  - *Hist_Extinction_IceCloud_Accepted, Hist_IWC_IceCloud_Accepted*
  - *Median_Extinction_IceCloud_Accepted, Median_IWC_IceCloud_Accepted*

Monthly statistics - Night, July 2008

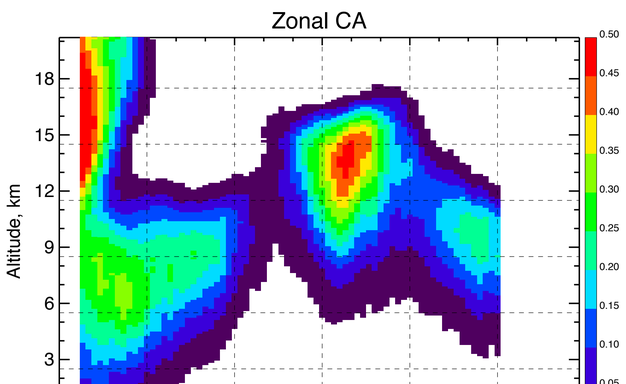
Penetration frequency

(Num_Cloud+Num_CloudFree) /
(Num_Cloud+Num_CloudFree+Num_Totally_Atten)



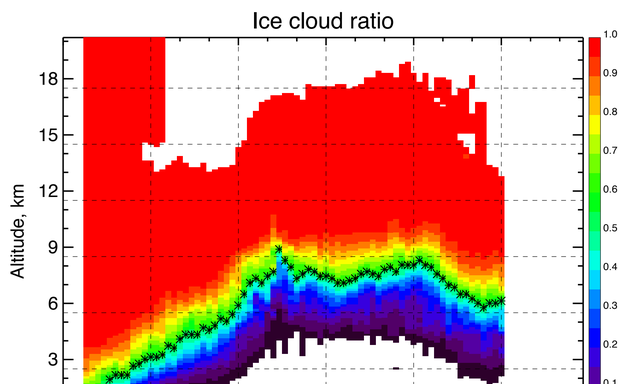
Ice cloud fraction

Num_IceCloud /(Num_Cloud+Num_CloudFree)



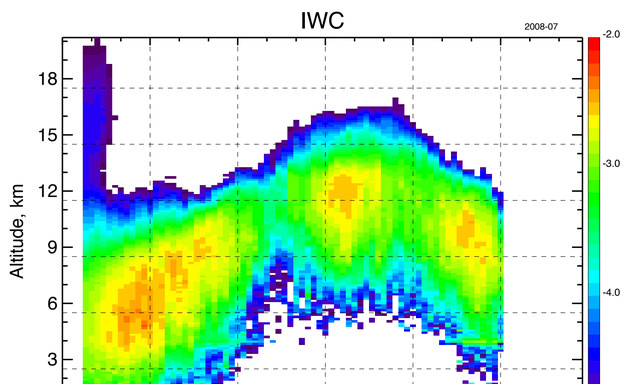
Ice cloud ratio

Num_IceCloud /(Num_IceCloud+Num_WaterCloud)

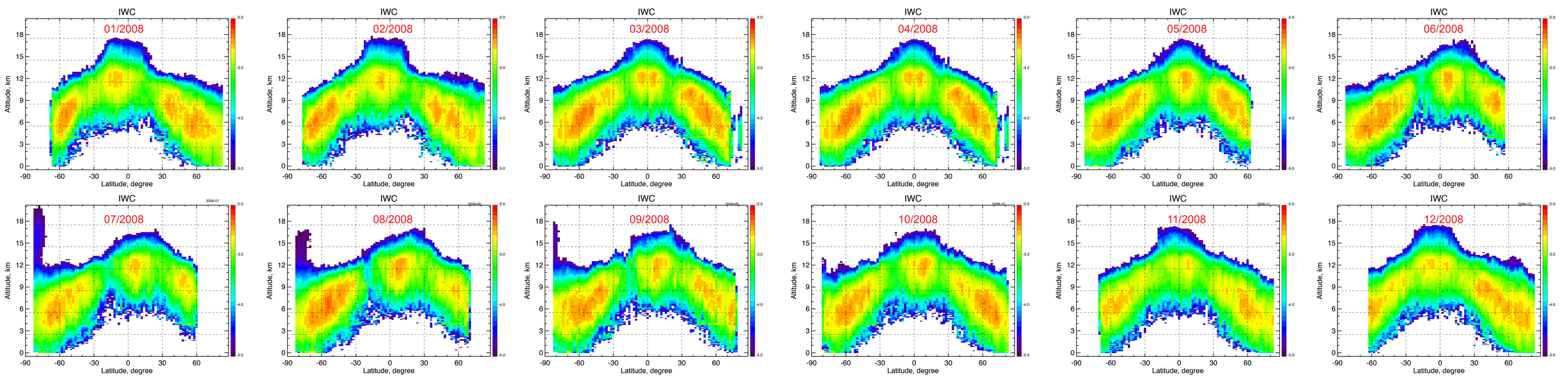


Mean IWC

Estimated from Hist_IWC_IceCloud_Accepted



Annual Cycle of Mean IWC in 2008 - Night



Inter-annual Variability of Mean IWC - Night, July