Initial Comparison of CALIPSO 1064nm Calibration Clouds with Coincident CloudSat Measurements

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Overview

The purpose of the following is to compare those clouds selected by CALIPSO to calibrate the 1064 nm measurements with coincident CloudSat observations. The primary reason for this is to assess the effectiveness of the CALIOP cloud selection criteria, which were formulated specifically to identify cirrus clouds containing large particles. Enforcing this large particle requirement should ensure that the cloud backscatter and extinction coefficients are spectrally independent. The "calibration quality" clouds identified by the CALIOP selection algorithm must meet two conditions: (1) the cloud must lie in the altitude range between 17-km and 8.2-km; and (2) somewhere within this range, the 532 nm attenuated scattering ratios must exceed 50 for 3 or more consecutive range bins. Presumably these selection criteria will most often identify clouds which have particles large enough for the CloudSat radar to detect.
Comparisons are made between calibration clouds found within the CALIOP Lidar Level 1 data files (version 2.01) and the CloudSat Cloud mask and radar reflectivity (2B-GEOPROF) files. Analysis will focus only on February of 2007.

Phase Determination

Used the new ice/water phase algorithm to determine the phase of the calibration clouds selected. Isolated those clouds with simultaneous measurements (~95,000 clouds for the entire month) and derived a distribution of each phase type. Majority of clouds contain randomly oriented ice (ROI=3). Surprisingly a large number of clouds, nearly 15% of the samples, have been characterized as water clouds (WATER=1).

1	Water	14%
3	ROI	55%
4	ROI (low QA)	5%
5	HOI	2%
6	HOI (low QA)	24%

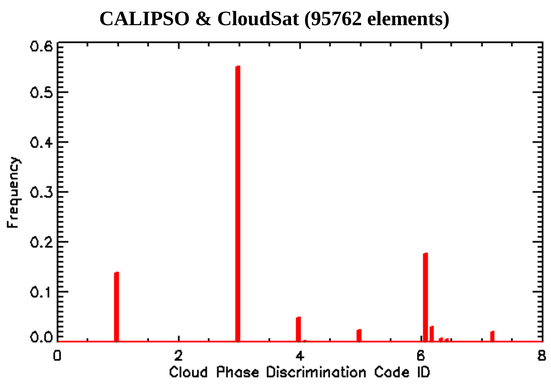


Figure 1: Ice/Water Phase for all simultaneous measurements.

Coincidence Determination

A set of criteria were used to determine a CloudSat detection of a CALIPSO calibration cloud. This was accomplished, on a per calibration cloud basis, by first isolating all CloudSat measurements within a 1-minute window of the calibration cloud. From these measurements a "coincident cloud" is designated if the CloudSat cloud:

- Has a cloud mask value between 20 (weak echo) and 40 (strong echo).
- Find the minimum distance between CALIPSO and CloudSat (using great circle distance algorithm). Is this minimum horizontal distance less than 20km.
- Is within a vertical distance of 500 meters from the top/base of the calibration cloud.

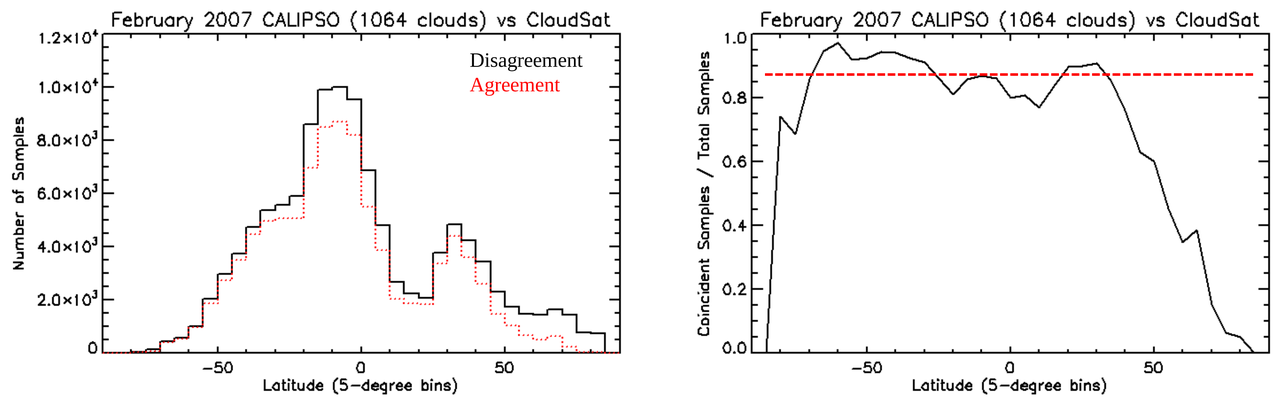


Figure 1: Zonal distribution of coincident clouds; number of samples (left), fraction of coincident samples as a function of all samples (right).

Figure 2 shows the degree of coincidence between CALIPSO and CloudSat. Excluding high latitude clouds, due mostly to stratospheric clouds used for calibration, CloudSat does not see roughly 15-20% of the calibration clouds.

"Potential" Reasons for Non-Coincidence (Why does CloudSat Not See?)

There may be several reasons for non-coincidence occurrences. These include:

1. Incorrectly isolating CloudSat observations. Instead of using the closest CloudSat measurement (in terms of latitude and longitude) there may need to be some accumulation of samples.
2. Cloud structure not favorable to coincidence. Figure 3 shows the affects of an edge affect, where a hard border isolates a homogenous cloud layer with a region of interspersed clouds.
3. Using low altitude altocumulus clouds (super-cooled water clouds). An example can be see in figure 4, where a low altitude water cloud (~8.25km) beneath a lower of thin cirrus was observed. Detected layer contains high backscatter (>0.11). Temperature of the layer is around -18 C.
4. Some high altitude cirrus clouds (ice) not seen. Figure 5 shows high altitude cirrus (ice) cloud layer deck above a layer of attenuating clouds, centered around 20 S latitude.

Water Cloud Undetected?

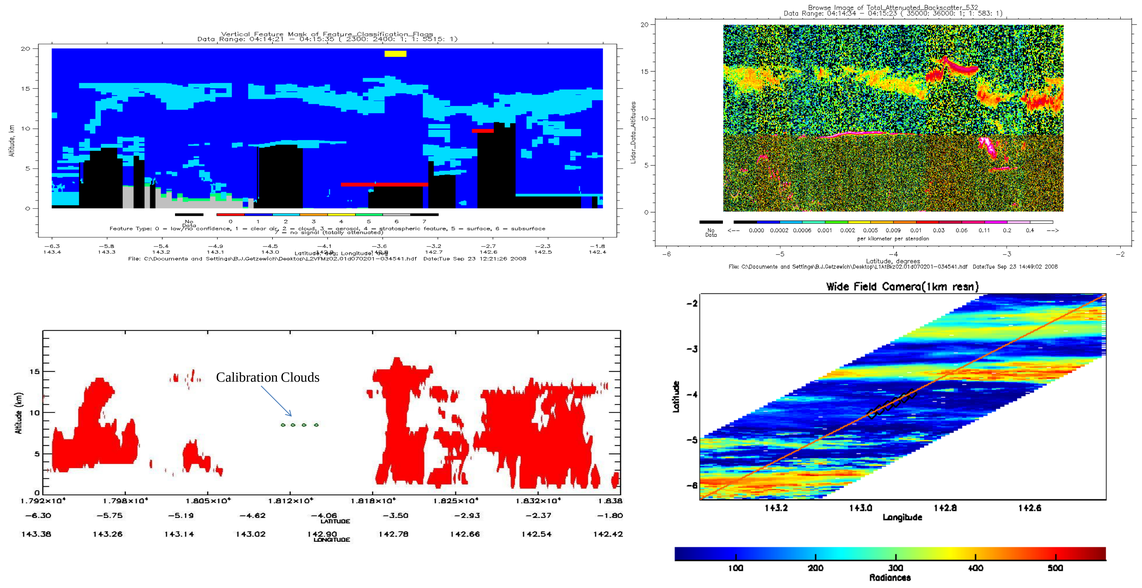
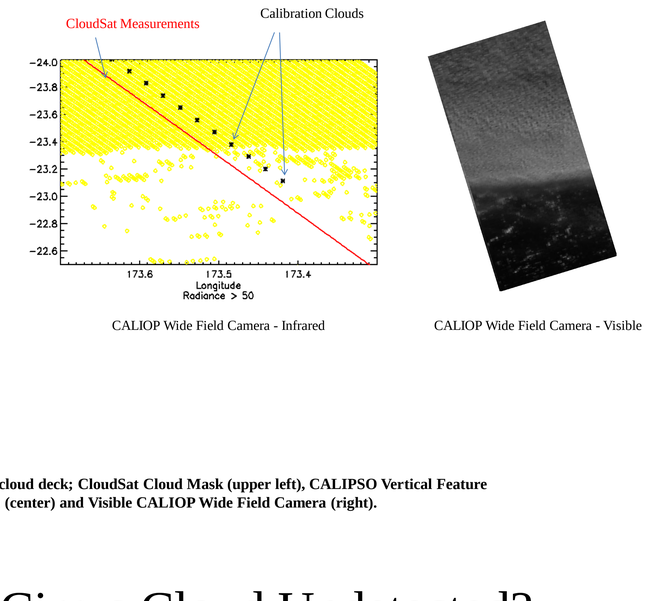


Figure 3: Calibration clouds identified at the edge of a homogenous cloud deck; CloudSat Cloud Mask (upper left), CALIPSO Vertical Feature Mask (lower left), I/R CALIOP Wide Field Camera (center) and Visible CALIOP Wide Field Camera (right).

Cloud Structure Limitation

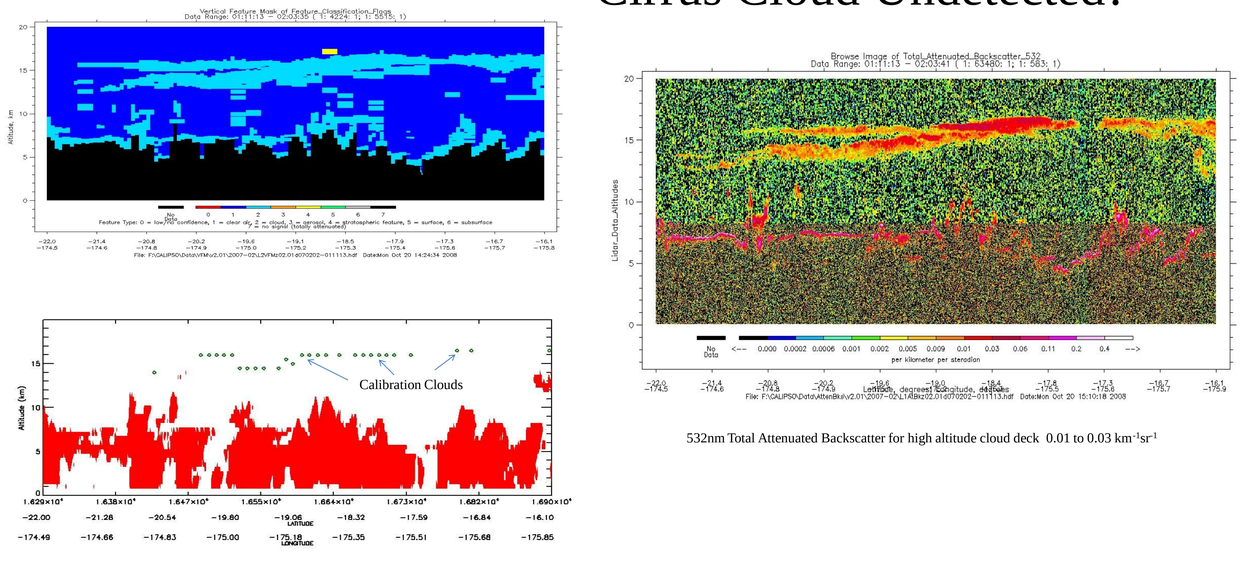


CALIOP Wide Field Camera - Infrared

CALIOP Wide Field Camera - Visible

Figure 4: Calibration clouds identified as high altitude super-cooled water clouds (-18 C) beneath a cirrus layer; CALIPSO Vertical Feature Mask (upper left), CloudSat Cloud Mask (lower left), 532nm Total Attenuated Backscatter (upper right) and Wide Field Camera I/R Radiances (lower right).

Cirrus Cloud Undetected?



532nm Total Attenuated Backscatter for high altitude cloud deck 0.01 to 0.03 $km^{-1}sr^{-1}$

Figure 5: Calibration clouds identified as high altitude cirrus clouds; CALIPSO Vertical Feature Mask (upper left), CloudSat Cloud Mask (lower left) and 532nm Total Attenuated Backscatter (right).

Concluding Remarks

Have been able to detect a large number of simultaneous measurements of clouds between CloudSat and the 1064nm CALIPSO calibration clouds (85% agreement), which will be helpful in the future to further characterize the clouds from which 1064nm measurements are calibrated from. There are instances when there are disagreements between platforms, with examples being shown.