

CloudSat 2B GEOPROF Quality Statement: January 2007 (Version R03)

The primary purpose of the 2B GEOPROF product is to identify those levels in the vertical column sampled by CloudSat that contain significant radar echo from hydrometeors and to provide an estimate of the radar reflectivity factor for each of these volumes. Details on the GEOPROF algorithms and structure of the NetCDF output files are provided in the **Level 2 GEOPROF Product Process Description and Interface Control Document**.

<http://www.cloudsat.cira.colostate.edu/dataICDlist.php?go=list&path=/2B-GEOPROF>

The significant echo mask is stored under the variable name “CPR_Cloud_Mask”, and contains a value between 0 and 40 for each range bin with values greater than 5 indicating the location of likely hydrometeors. Increasing values of the “CPR_Cloud_Mask” variable indicate a reduced probability of a false detection, as summarized in Table 1.

| Mask Value | Meaning | % False Detections Goal | Estimated % False Detection via CALIPSO comparison |
|-------------------|--|--------------------------------|---|
| -9 | Bad or missing radar data | | |
| 5 | Significant return power but likely surface clutter | | |
| 6-10 | Very weak echo (detected using along-track averaging) | < 50 % | 44 % |
| 20 | Weak echo (detection may be artifact of spatial correlation) | < 16% | 5 % |
| 30 | Good echo | < 2 % | 4.3 % |
| 40 | Strong echo | < 0.2 % | 0.6 % |

Table 1 – Description of CloudSat cloud mask values, false detection rates, and percentage of false detections. The percent of false detection is given by 100 times the number of false detections divided by the total number of detections for the specified cloud mask value.

Users are cautioned that radar detections with cloud mask values between 6-10 contain large numbers of false detection. These possible detections represent hydrometeors whose radar-reflectivity is below the single column sensitivity limit of the radar (about – 30 dBZe), and have only been identified as a result of an aggressive along track averaging algorithm. For most applications, users should consider using cloud-mask values of 30 to 40, which are high-confidence detections.

In addition to the cloud mask, this product contains the radar reflectivity (i.e., the calibrated measured return power in units of dBZe = dB(mm⁶/m³)), an estimate of gaseous absorption loss of the observed reflectivity, and several quality indicator flags. Unlike typical weather radars, which operate at much longer wavelengths and are primarily designed to detect rain rather than clouds, the effect of water vapor on CloudSat observed reflectivity can be significant. Two-way attenuation from the surface to the satellite of more than 5 dBZ is not unusual in the tropics.

No estimate of loss in reflectivity due to absorption or scattering by hydrometeors is included in the GEOPROF, and users are cautioned that losses of 10 dB/km or higher are possible with large liquid water contents. At times, the CloudSat radar is fully attenuated, or attenuated to the point where multiple-scattering dominates the measured return power – though this is not common. As a result of a bug in the algorithm, when the surface is obscured, gaseous attenuation is not generally calculated. (This problem will be removed in the next reprocessing of the data R04).

The cloud mask, reflectivity-field, and gaseous absorption are all provided on a height grid with 125 vertical range bins, where the CloudSat range bin closest to mean sea level has been placed in vertical bin 105. The location of the range bin that is closest to the actual surface location is also provided.

Overall, the most significant difficulty with the CloudSat data is that surface clutter effectively reduces the radar sensitivity near the surface. Figure 1, below, shows the estimated radar return power during clear sky conditions. As a result of the surface contamination, all cloud mask detections below roughly the 99th percentile of the clear-sky return (dashed lines in Figure 7) are currently being set to a value of 5, to indicate there is return power above the radar noise floor but the signal is indistinguishable from surface clutter. While this conservative threshold should keep the false detection rate (by volume) below 1%, it also means that typically only rain and heavy drizzle can be detected in the third bin above the surface (~ 720 m) and moderate drizzle in the fourth bin (~ 860 m).

Subtracting an estimate of the surface clutter from the total measured return power in the second through fourth range bins above the surface is currently being investigated. Preliminary assessment of such a clutter rejection algorithm shows reductions in clutter of 10-20 dB over ocean surfaces. This technique also retrieves the position of the surface to a sub-range-bin scale. We hope to implement such a scheme by the next major reprocessing of CloudSat data, currently schedule to start in June 2007, about 1 year after launch.

Finally, the CloudSat orbit follows closely the orbit of the AQUA satellite on which a number of advanced passive remote sensors observe the earth. The GEOPPROF data files include the Moderate-Resolution Imaging Spectroradiometer (MODIS) cloud fraction (from the MOD35 product) integrated over the CloudSat footprint, as well as a cloud scene classification (based on MOD35 cloud detection bit tests). Details of these

parameters are given in the **Level 2 GEOPROF Product Process Description and Interface Control Document**.

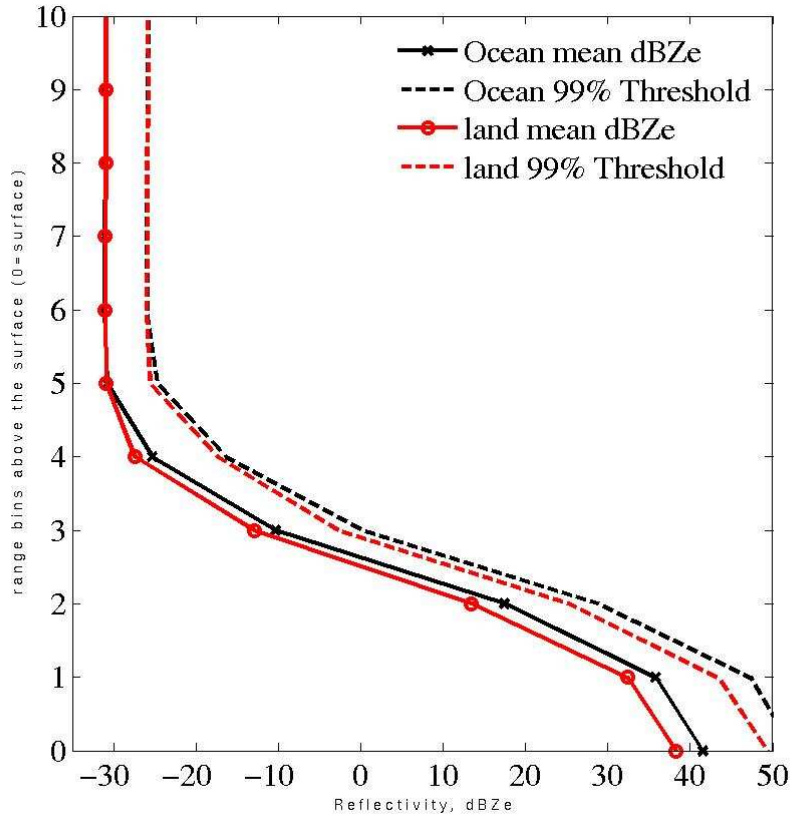


Figure 1 - Estimate of the clear-sky observed return power. At the beginning of the CloudSat mission, the radar was unknowingly pointed 1.7 degrees off nadir. This was corrected starting with orbit 1023, and the radar pointed directly towards nadir. However, it was found that pointing directly at nadir increased the surface reflectance and the effect of surface clutter approximately 10 dB due to specular reflection. Thus, starting with orbit 1595 (August 15 at 20 UTC) the instrument was set to point 0.16 degrees of nadir. This angle put the specular reflection in the first antenna null and reduced the surface clutter to previous levels. Data from these time periods is referred to as epic "E" 00, 01, and 02 (given in each file name), respectively. Data shown here is "typical" for data in epic 00 and that now being collected, epic 02.