CloudSat Project

A NASA Earth System Pathfinder Mission

2D-CloudSat-TRMM Product Description

Version 1.0

Date: May 21st, 2008

Questions concerning this product may be addressed to:

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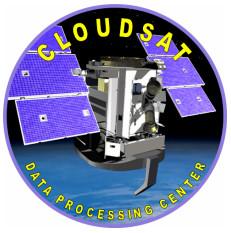

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1 Main Data Specs

A more comprehensive set of interface specifications for this product can be found via the "2D-GEOPROF-TRMM" link on the CloudSat Data Product Documentation page - http://www.cloudsat.cira.colostate.edu/dataSpecs.php

The provided data files are in HDF4 format. A few data fields of interest in this product follow:

Data	Location	Data Type	Data Origin
CPR Height	SDS	INT16	CS GEOPROF (Height, SDS)
CPR Latitude	SDS	FLOAT32	CS GEOPROF (Latitude, Vdata)
CPR Longitude	SDS	FLOAT32	CS GEOPROF (Longitude, Vdata)
CPR Time	SDS	FLOAT32	CS GEOPROF (Profile_time, Vdata)
CPR Reflectivity (GEOPROF)	SDS	INT16	CS GEOPROF (Radar_Reflectivity, SDS)
PR Curtain and Block Latitude	SDS	FLOAT32	TRMM 1C21[1]
PR Curtain and Block Longitude	SDS	FLOAT32	TRMM 1C21[2]
PR Curtain and Block Time	SDS	FLOAT32	TRMM 1C21 (scan_time, Vdata)[3]
PR Reflectivity Curtain/Block (1C21)	SDS	INT16	TRMM 1C21 (normalSample, SDS)
PR Corrected Z Curtain/Block (2A25)	SDS	INT16	TRMM 2A25 (correctZFactor, SDS)
PR Rain Rate Curtain/Block (2A25)	SDS	INT16	TRMM 2A25 (rain, SDS)
PR Curtain Scan Indices	SDS	INT16	N/A
PR Ray Scan Indices	SDS	INT16	N/A

For the SDS HDF4 content not listed in this table, the CloudSat data names have their original names from the 2B-GEOPROF data files with a "CPR " prefix while all TRMM data names have "PR " as a prefix. The TRMM data also has a suffix associated which indicates the original TRMM data set it was extracted from, currently one of "(1C21)", "(2A25)" or "(2A23)". 1C21 provides TRMM PR radar reflectivity, 2A25 provides PR attenuation corrected reflectivities and rain rate profiles, and 2A23 provides rain characteristics. See the TRMM documentation (http://daac.gsfc.nasa.gov/precipitation/TRMM_README/) for detailed information on the included TRMM data sets.

2 CloudSat Data

CloudSat data are copied directly from the 2B-GEOPROF HDF files with no alteration beyond limiting the included scans to the region surrounding the intersection with TRMM PR's path.

2.1 Data Modifications

The CloudSat data range extends 50 scans to either end of the intersection curtain in order to provide context. The first and last 50 CloudSat scans in each file do not have matching TRMM information. Therefore the *TRMM Curtain* data correspond with the portion of the CloudSat curtain left with these end scans eliminated.

3 TRMM Data

TRMM data is available in two components:

[1] Extracted from geolocation SDS
[2] Extracted from geolocation SDS
[3] The TRMM time values have been adjusted to be directly comparable to the CloudSat time values

- Curtain data, which contain a basic nearest-neighbor interpolation of the TRMM data on to the CloudSat data's along track resolution. No height interpolation is performed. The latitude and longitude values provided reference the original latitude and longitude from which the interpolated data originates so it will not generally match up directly with the matching CloudSat curtain scan.
- Block data, which is the full TRMM scan swath which encloses the CloudSat - TRMM intersect curtain. The block data is pulled directly from the TRMM source file with no spatial interpolation and is always 59 scans in along track length.

3.1 Data Modifications

Two TRMM data sets are modified from their original form. First, the TRMM time representation as provided by TSDIS is different from that used in the CloudSat data sets. The TRMM times are adjusted to line up with the CloudSat time information. Any TRMM times which fall before the 0 time in the matching CloudSat granule are represented as negative numbers. The second are the TRMM geolocation data which are simply split in to individual *Latitude* and *Longitude* components rather than being in (lat, lon) pairings within a single SDS as in the original TRMM HDF files.

3.1.1 PR Curtain Interpolation

TRMM curtain data provides a simple nearest neighbor interpolation of the TRMM rays to the CloudSat intersect along-track resolution. For each CloudSat scan, the interpolation routine simply finds the nearest TRMM ray and makes a copy of the matching data.

The *PR Curtain Scan Indices* and *PR Curtain Ray Indices* data sets provide the indices for the block data which correspond to each of the interpolated curtain scans. These indices are provided to allow straightforward access to the intersect curtain in the block data.

4 File Name Description

Each HDF's file name provides a brief overview of the contents of the file. The file names are structured as follows:

yyyydddhhmmss_dt(C|T)_yy(N|S)_xxx(E|W)_nnnnn_ccccc_CS_ttttt_PR.hdf

- yyyy - Year
- ddd - Day of year
- hhmmss - Time of day (GMT)
- dt - Time delta between CloudSat and TRMM in minutes, with an indicator of (C)loudSat or (T)RMM passing over first. Intersection files are only produced for dt values of 50 minutes or less.
- yy - Latitude in integer degrees (N)orth or (S)outh
- xxx - Longitude in integer degrees (E)ast or (W)est
- nnnnn - A five character string which provides a brief indication of the properties of the intersect curtain data included in the file. Each character in the string provides information on a different data characteristic. In order they are:
  - Rain coverage - How many scans in the intersect curtain show rain according to TRMM PR. Values range from "0" for no rain, "1" indicates 5% or fewer scans show rainfall, "2" indicates 10% or fewer scans show rainfall, up through "9" for 45% or fewer scans showing rainfall. "a" indicates 45% or more of the intersection scans have rainfall according to PR 2A25.

  - TRMM PR's maximum seen rainfall value - Maximum rain rate seen by PR 2A25 in the intersect curtain in mm/hour. Values range from "0" for no rain anywhere in the curtain, "1" for less than 5mm/hour rain rate, "2" for less than 10mm/hour rain rate, up through "9" for even increments up to 45mm/hour rain rate, and "a" which indicates a maximum rain rate of 45mm/hour or greater.
  - CloudSat CPR's maximum reflectivity value - Maximum reflectivity seen by CPR in the intersection curtain. Values range from from "0" for values less than -40dBZe, "1" for values less than -30dBZe and so on with 10dBZe increments up to "9" for values greater than 40dBZe.
  - TRMM PR's maximum corrected reflectivity value - Maximum reflectivity seen by PR according to the 2A25 corrected Z data. Values range from "0" indicating no signal greater than 0dBZ, "1" indicating a maximum signal of 8dBZ or less, "2" indicating a maximum signal of 16dBZ or less, with even increments up to "a" indicating a signal of 80dBZ or greater.
  - Intersection curtain cloudiness - The percentage of scans along the intersection which show cloud cover according to the MODIS cloud fraction data provided in the CloudSat 2B-GEOPROF HDF files. Values range from "0" for no cloud cover, with even increments up to "a" indicating complete cloud cover over the entire intersection length.

- ccccc - Source CloudSat granule number
- ttttt - Source TRMM granule number

The lat/lon information refers to the location where CloudSat crosses TRMM's nadir view (PR's across-track ray 25 of 49).

5 Intersect selection method

5.1 Intersect definition

In this document, an intersect is defined as both TRMM and CloudSat observing the same geographic location on the planet with some time difference between the overpasses. "Block data" are PR data which include the full 3D set of PR across- and along-track swath, while "curtain data" are PR and CPR data with a single 2D set of vertical profiles.

5.2 Selection criteria

Due to their similar orbital periods and different orbital trajectories, the CloudSat and TRMM satellites surface views intersect approximately 30 times per day. The time differences between the satellite overpasses for these intersections range from less than one minute to approximately 50 minutes. An HDF file is only generated for intersects with an overpass time difference of 50 minutes or less.

5.3 Data selection and extraction

Each PR granule has 49 across-track rays. The CPR track is checked against each PR ray track independently for an intersection. The center ray (ray number 25 of 49) is considered to be the center of the intersection.

First, the CPR scans are sorted by longitude. Any CPR scans outside of 40°N to 40°S are discarded for this comparison. Each PR ray then has its scans sorted by longitude. A linear search is performed from west to east along the CPR track and each of the 49 PR ray tracks to find any points of intersection. Distances between CPR and PR geolocations are calculated as great circle distances between lat/lon pairs assuming a fixed Earth radius. Ground geolocations are used for the intersection generation process. In order for an intersection to be considered valid the CPR track must intersect with all 49 PR ray tracks.

Once the area of intersection has been determined, two data subsets are extracted.

1. PR block data

    - These data entries include the entire PR scan swath from 10 scans before and 10 scans beyond the region of intersection and provide contextual information for the specific region of intersection.

2. PR curtain data

    - These data entries come from the PR block data and are interpolated using a simple nearest-neighbor approach to match the CPR horizontal resolution. No vertical resolution matching is performed, nor are any adjustments made for the scan angles of PR's 49 across-track scans. In addition, the vertical resolutions of the CPR and PR data are different. CPR 2B-GEOPROF data use ~240m height bins, while the included PR data sets use 250m height bins. For these reasons, the PR curtain data fields in their raw form are meant primarily for quick access and qualitative analysis.

3. PR curtain scan and ray indices

    - These indices indicate the PR block data which correspond with the vertical profiles included in the PR curtain data.

4. CPR curtain data

    - These data include the CPR track data from 2B-GEOPROF from 50 scans before the region of intersection to 50 scans beyond the region of intersection.

6 Known issues and planned changes

- CPR and PR data subsets should have some form of reference to their location in the source files. They do not, beyond their geolocation information. Offset indices from the source data products will be provided in a future revision of 2D-GEOPROF-TRMM
- The PR curtain data are not adjusted for each PR ray's scan angle. This may be accounted for in a future product, but for now the best approach for quantitative analysis and comparison will be to use the PR block data and make the appropriate location adjustments.
- In order to avoid name clashes, data extracted from each source product has a prefix added to the original field's name. In a future revision of this data product the name prefix will be removed and the data will instead be sorted in to separate Vgroups.
- The five character data descriptor in the 2D-GEOPROF-TRMM file names may change as more data are generated and more appropriate scales are determined.
- Due to the requirement that the CPR track intersect all 49 PR rays to form a valid intersection, intersections which occur at a granule start or finish are not included at this point in time. These intersections appear to make up somewhere between 3% and 7% of the total number of possible intersections. These missing intersections will be included in a later revision of this data product.

7 Example intersection image

Figures 1, 2 and 3 show an example intersection curtain. CPR reflectivities are plotted from -26dBZe through 30dBZe included, with others masked out. PR reflectivities are plotted from 15dBZ through 60dBZ included, with others masked out. Displayed PR data in figure 3 have been adjusted to match closely with the CPR heights, but no correction has been made for the PR across-track ray angles. Figures 1 and 3 include the entire CPR curtain length, so there are 50 CPR scans before and 50 CPR scans after the region of PR intersection.

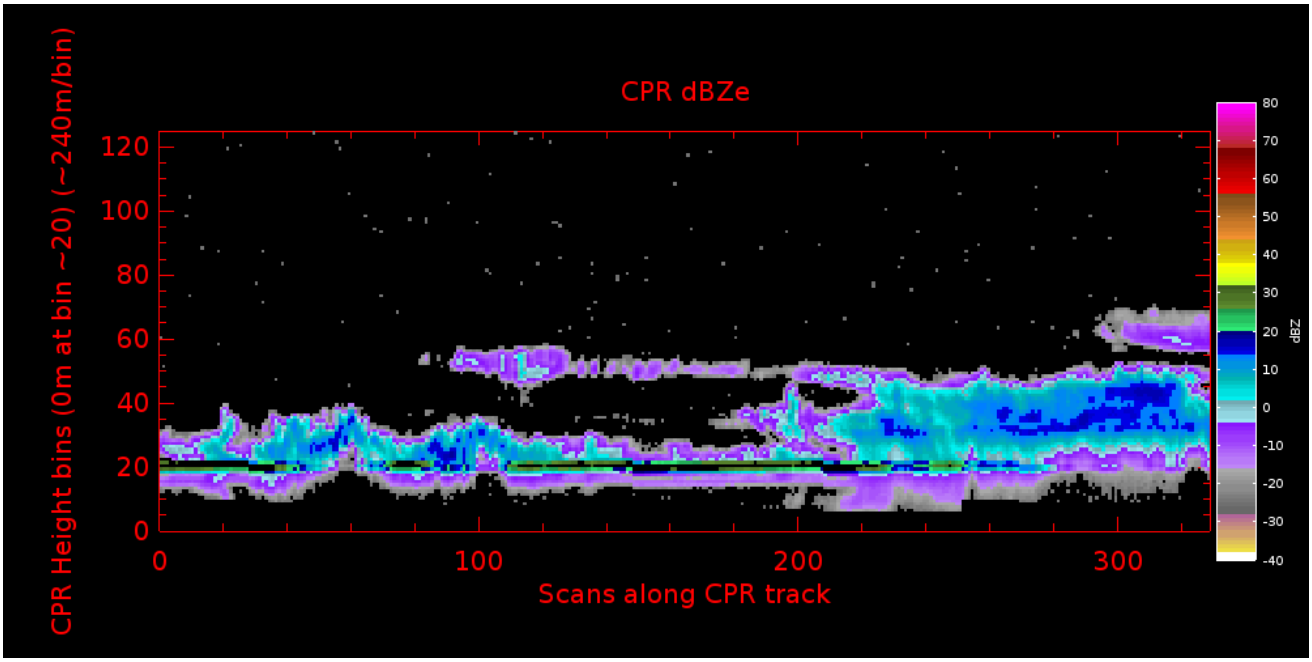

Figure 1: CPR reflectivities (GEOPROF). Image shows the "CPR Reflectivity (GEOPROF)" field from 2006243001113_14T_32S_151W_a766a_01815_CS_50095_TR.hdf

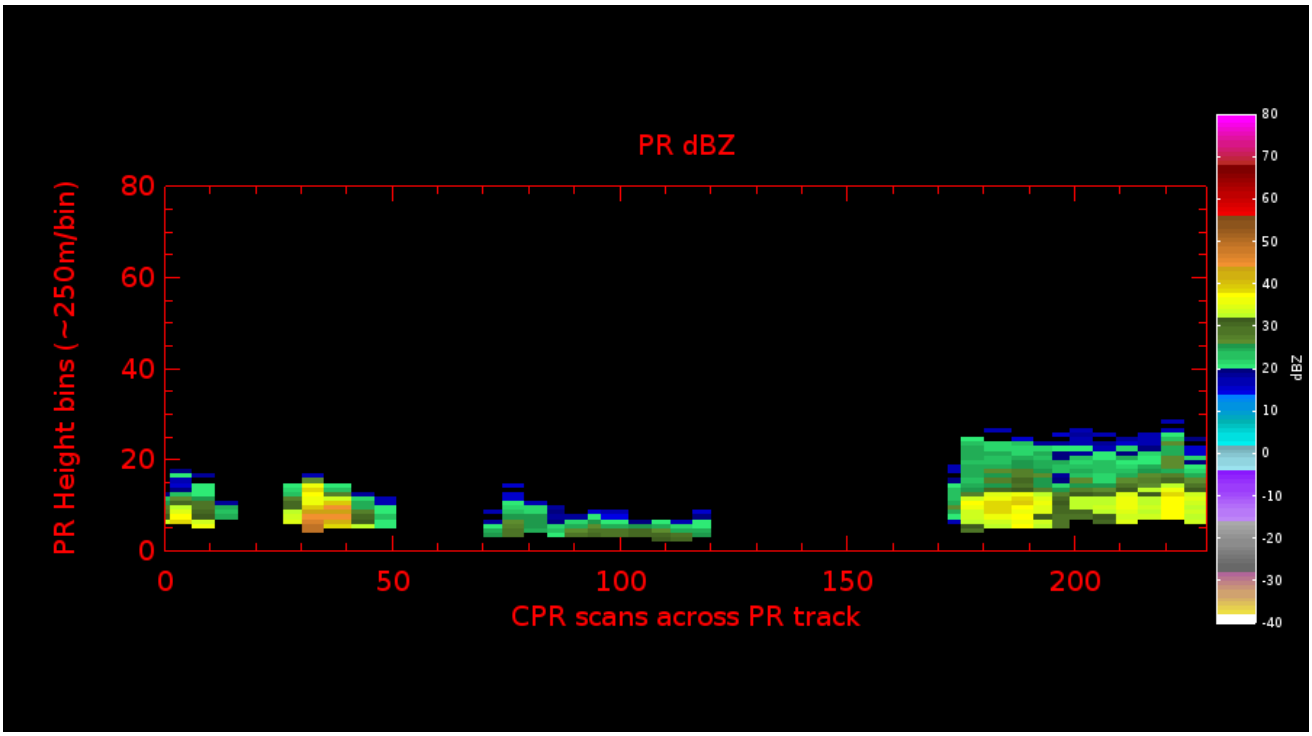

Figure 2: PR attenuation corrected reflectivities (2A25). Image shows the "PR Corrected Z Curtain (2A25)" field from 2006243001113_14T_32S_151W_a766a_01815_CS_50095_TR.hdf

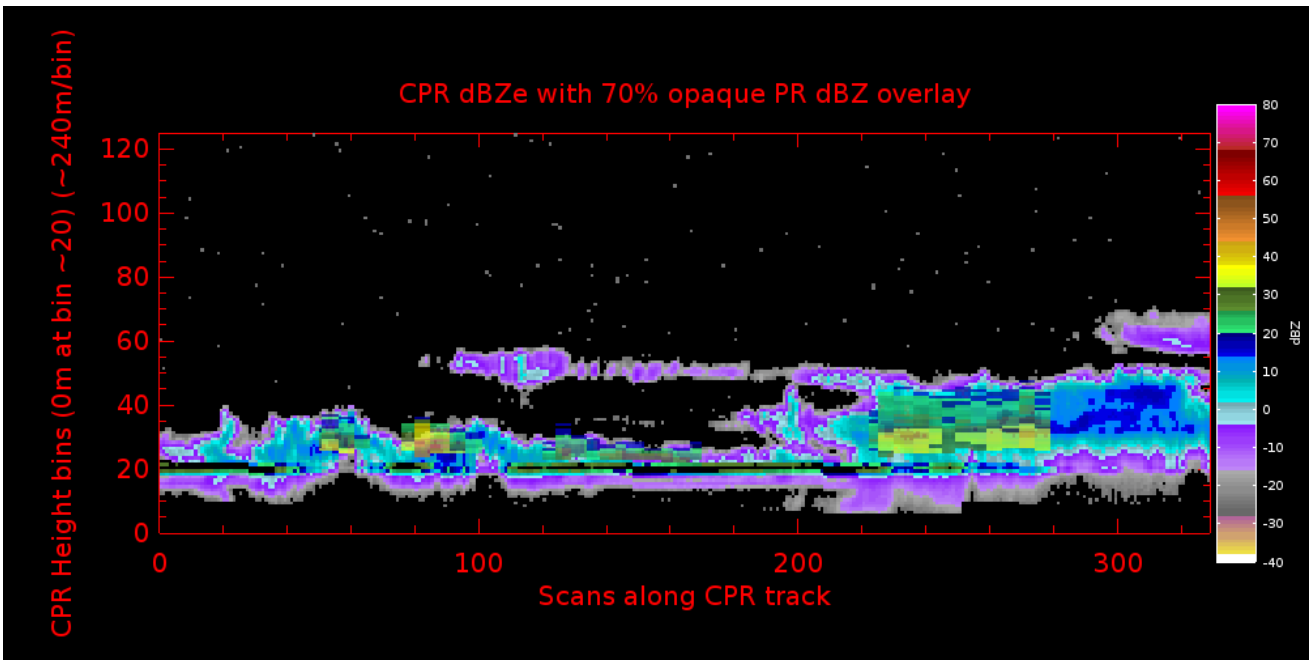

Figure 3: CPR reflectivities with PR attenuation corrected reflectivities as a translucent overlay. This image shows the same data as figures 1 and 2.