CloudSat Data Processing Center—Cloud Profiling Radar (CPR) data processing, products, and user applications

Donald L. Reinke*, P. T. Partain, S. P. Longmore, D. G. Reinke, and S. D. Miller
CIRA/Colorado State Univ., Fort Collins, CO

1.   CloudSat Mission Description

CloudSat is a satellite experiment designed to measure the vertical structure of clouds and, for the first time, will simultaneously observe cloud and precipitation from space. The primary CloudSat instrument is a 94-GHz, near nadir-pointing (0.16^o in the forward direction), Cloud Profiling Radar.   The satellite was put into a nominal 705-km sun-synchronous orbit on April 28th, 2006 and the CPR has been operational since Jun 20th, 2006.   Since operations began, Cloudsat has generated over 600 million vertical profiles of the atmosphere.

A unique aspect of this mission is that CloudSat is flying in formation with other Earth Sciences missions (fig 1). CloudSat was launched in tandem with a second ESSP mission called CALIPSO, which flies a dual frequency lidar instrument called the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP). CloudSat and CALIPSO are part of a constellation of satellites that currently include NASA's EOS Aqua and Aura satellites as well as the CNES satellite carrying a polarimeter (PARASOL). Formation flying enables the fields of view of the CloudSat radar to be overlapped with the lidar footprint and the other measurements of the constellation. The precision of this overlap creates a unique multi-satellite observing system for studying the atmospheric processes of the hydrological cycle.

CloudSat is flying approximately 58 seconds behind NASA's EOS Aqua and 17.5 seconds in front of CALIPSO (lidar), which is flying 1 minute

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*Corresponding author address: Donald L Reinke, CIRA, Colorado State Univ., Fort Collins CO 80525; e-mail: reinke@cira.colostate.edu

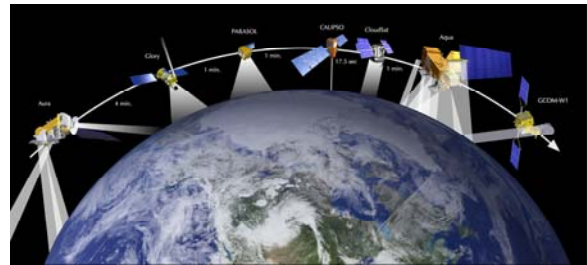in front of the CNES PARASOL (fig 1.).

Figure 1. "A-Train" satellite constellation. (graphic courtesy NASA Earth Science Mission Operations Project).

Additional information about the CloudSat mission may be found at http://cloudsat.atmos.colostate.edu .

2.   CPR Instrument Data

The Cloud Profiling Radar was developed jointly by NASA/JPL and the Canadian Space Agency (CSA).   The overall design of the CPR has a strong heritage from many cloud radars already in operation in ground-based and airborne applications. Most of the design parameters and subsystem configurations are inherited from those for the Airborne Cloud Radar, which has been flown on the NASA DC-8 aircraft since 1998.

The CloudSat radar samples profiles at 625 kHz corresponding to a range sampling distance of 240m. Each profile has 125 vertical "bins". One vertical profile of the atmosphere is recorded every 0.16 seconds by averaging around 600 pulses.

The CloudSat antenna pattern provides an instantaneous footprint of approximately 1.3 km (at Mean Sea Level). The CPR instrument is flown in a sun-synchronous orbit, at an 89°
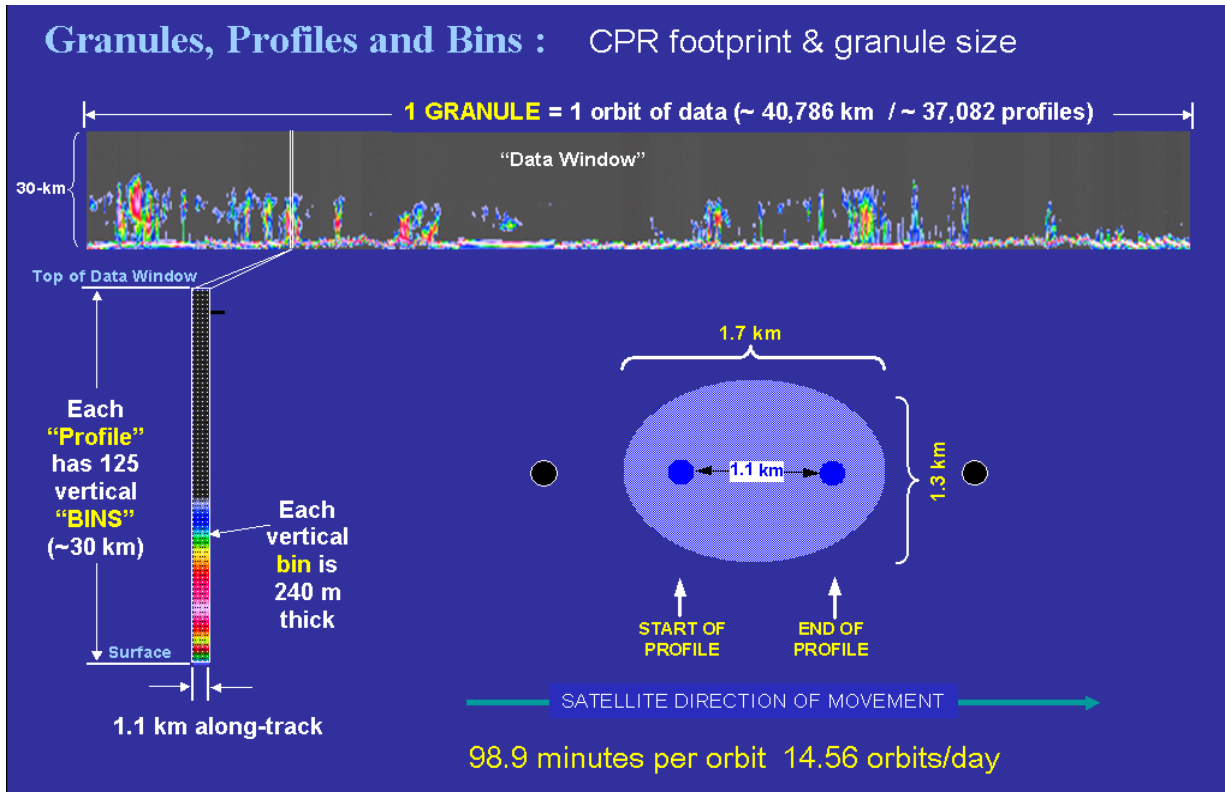
Fig. 2 Radar Footprint, "Profile" and "Bin" defined. Each vertical profile has an approx. footprint of 1.7km (along-track) by 1.3 km (cross-track). The vertical profile consists of 125 240-m thick, "bins". There are apparoximately 37,088 profiles in a single orbit.
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inclination angle, and a nominal altitude of 705 km.

These orbital characteristics produce an along-track velocity of approximately 7 km/sec. Using this velocity, and the sample rate of 0.16 sec/profile, we can approximate that a CPR profile will be generated every 1.1 km along track.

As shown in figure 2, the footprint for a single profile will be approximately 1.3km (across-track) X 1.7 km (along-track).

A CloudSat data "Granule" is defined as one orbit. The start of a granule is determined by the first profile that falls on or past the equator on the descending node.

3. Data Flow and Processing

CloudSat data are "dumped", between 7 and 8 times per day, to one of the global Air Force Satellite Communications Network (AFSCN) sites. From there, the data are routed to the USAF RDT&E Support Center (RSC) in Albuquerque NM, where the data are decommutated, checked for transmission errors, and stored on-line as a set of raw binary files. These raw data files are then accessed by the CIRA CloudSat Data Processing Center (DPC), via internet/ftp, for subsequent level 0 (raw data) through level 2 (derived products) processing. Figure 3 shows the top-level flow of CloudSat Science and Engineering data as well as CPR instrument data. CloudSat Science and Engineering (spacecraft and instrument state-of-health) data are downlinked via the Air Force Satellite Communications network and routed to the CloudSat Data Processing Center at Colorado State University. These data are combined with a variety of "Ancillary" data to produce CloudSat standard data products. These products are archived on DVD and stored on-line for distribution to data users.
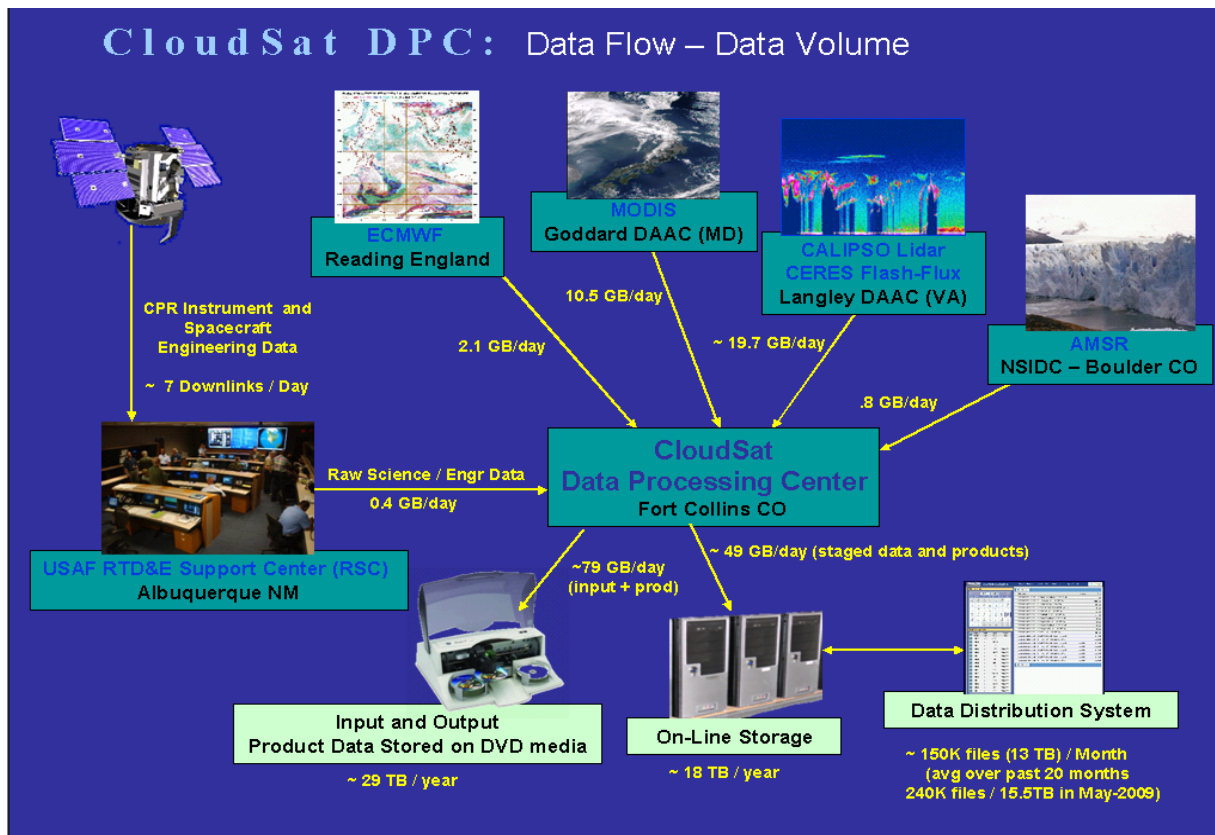
Fig. 3   CloudSat data flow.

4.   Accessing CloudSat Data Products

CloudSat science and engineering data are used to generate the products shown in table 1. These products are accessible through the Data Ordering web page (see figure 4 for the location of the "Data Ordering" link).   Before placing an order, users are required to set up an account with their name, organization, and contact information.   As of Sep 2009, the CloudSat DPC has distributed over 4.5 million data products (>337 TB of data) to scientists in 50 different counties.

5.   User Applications

The "Resources" link contains a list of user applications for accessing and displaying CloudSat data products.   This link can be accessed from www.cloudsat.cira.colostate.edu

Following the resources link produces a list of C, FORTRAN, IDL, and MATLAB examples, as well as sources for HDF viewers and a sample

app to automate the ftp of data from the DPC.

Users who require very large volumes of data can set up an account to access those data directly from our mass storage system.

Standard Data Products	Description
1B-CPR	Radar Backscatter Profiles
2B-GEOPROF	Cloud Geometrical Profile
2B-CLDCLASS	Cloud Classification
2B-CWC-RO	Combined Water Content - Radar Only
2B-TAU	Cloud Optical Depth - Off Nadir
2B-CWC-RVOD	Combined Water Content - Radar + Vis. Optical Depth
2B-FLXHR	Fluxes and Heating Rates
2B-GEOPROF-LIDAR	Cloud Geometrical Profile from CPR and CALIPSO Lidar
2B-CLDCLASS-LIDAR	Cloud Classification from CPR and CALIPSO Lidar
2C-PRECIP-COLUMN	Column Integrated Precipitation
2D-CLOUDSAT-TRMM	CloudSat Cloud Mask plus L2 TRMM at orbit intersections
Auxiliary Products	Description
ECMWF-AUX	ECMWF Auxiliary Data (State Variables)
MODIS-AUX	MODIS Auxiliary Data (data from 22 MODIS channels)

Table 1.   CloudSat Data Products.

Fig. 4 Accessing CloudSat Data products from the DPC website: www.cloudsat.cira.colostate.edu.