National Aeronautics and Space Administration Goddard Earth Science Data Information and Services Center (GES DISC)

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Revision History

August 31, 2015	This document was first created.	Kyle MacRitchie

Table of Contents

1.0 Introduction

This document provides basic information for using Tropical Rainfall Measurement Mission (TRMM) products.

The TRMM datasets consist of products generated for studying precipitation in the tropics. These products include observations of radiances, microwave temperature, radar reflectivity, rainfall rate, vertical rainfall profile, and convective and stratiform heating.

TRMM was launched on November 27, 1997 and decommissioned on April 15, 2015. It re-entered Earth's atmosphere in June 2015.

1.1 Dataset/Mission Instrument Description

Each of the TRMM datasets listed below is created using algorithms that are explained in more detail in section 1.2.

Applicable Data Products

Table 1 below provides an overview of the 18 TRMM products discussed in this document.

		Visible and Infrared Scanner (VIRS) Level 1 Raw and Calibrated Radiance Products	16 orbits / day	2.2 km
		TRMM Microwave Imager (TMI) Level 1 Raw and Calibrated Radiance Product	16 orbits / day	4.4 km, 5.1 km
		TRMM Precipitation Radar (PR) Level 1 Power and Reflectivity Products	16 orbits / day	4.3 km, 5.0 km
		TRMM Precipitation Radar (PR) Level 1 Power and Reflectivity Products	16 orbits / day	4.3 km, 5.0 km
		TRMM Microwave Imager (TMI) Level 2 Hydrometeor Profile Product	16 orbits / day	4.4 km, 5.1 km
		TRMM Precipitation Radar (PR) Level 2 Surface Cross-Section Product	16 orbits / day	4.3 km, 5.0 km
		TRMM Precipitation Radar (PR) Level 2 Rain Characteristics Product	16 orbits / day	4.3 km, 5.0 km
		TRMM Precipitation Radar (PR) Level 2 Rainfall Rate and Profile Product	16 orbits / day	

1.1.1 Dataset/Instruments

The Tropical Rainfall Measurement Mission (TRMM) is a collaborative effort between NASA and the Japanese Aerospace Exploration Agency (JAXA). The TRMM observatory, which housed the first-ever precipitation radar in space, was launched in 1997 into a near circular orbit of approximately 350 kilometers with a period of 92.5 minutes (15.6 orbits per day). During the period of 2001/8/7 to 2001/8/14, the average operating altitude changed from 350 km to 403 km (referred to also as TRMM Boost).The datasets described in this document were created using data from the TRMM observatory and its partner satellites.

Multiple instruments are used throughout the TRMM satellite constellation. They are described briefly below.

: The PR was the first spacebourne instrument designed to provide three-dimensional plots of storm structure. It has a horizontal resolution of about 5 km and a swath width of 247 km. It can provide vertical profiles of rain and snow from the surface to a height of 20 km and is sensitive to light rain rates as low as 0.5 mm/hr.

The TMI is a passive microwave sensor based on the Special Sensor Microwave/Imager (SSM/I). It measures the intensity of radiation at 10.7, 19.4, 21.3, 37, and 85.5 GHz.

The VIRS senses radiation in the visible and infrared wavelengths of 0.63, 1.6, 10.8, and 12 micrometers. The VIRS has a horizontal resolution of 2.4 km and a swath width of about 833 km.

Below is a table summary of the instrument specifications adapted from the NASA Precipitation Measurement Missions website.

	13.8 GHz	10.7, 19.4, 21.3, 37, 85.5 GHz	Wavelengths: 0.63, 1.6, 10.8, 12 µm
	5 km horizontal, 250 m vertical	11 km x 8 km at 37 GHz	2.4 km
	Cross-track	Conical	Cross-track
	247 km	878 km	833 km

. Summary of instrument specifications.

1.2 Algorithm Background

This section describes how each dataset is created.

: The TRMM Visible and Infrared Scanner (VIRS) Level 1B Calibrated Radiance Product contains calibrated radiances and auxiliary geolocation information from the five channels of the VIRS instrument for each pixel of each scan. The EOSDIS "swath" structure is used to accommodate the actual geophysical data arrays. Sixteen files of VIRS 1B01 data are produced each day.

For channels 1 and 2, Level 1B radiances are derived from the Level 1A (1A01) sensor counts by computing calibration parameters (gain and offset) derived from the counts registered during space and solar and/or lunar views. New calibration parameters are produced every one to four weeks. Channels 3, 4, and 5 are calibrated using the internal blackbody and the space view. These calibration parameters, together with a quadratic term determined pre-launch, are used to generate a counts vs. radiance curve for each band, which is then used to convert the earth-view pixel counts to spectral radiances.

Geolocation and channel data are written out for each pixel along the scan, whereas the time stamp, scan status (containing scan quality information), navigation, calibration coefficients, and solar/satellite geometry are specified on a per-scan basis. There are in general 18,026 scans along the orbit pre-boost and 18,223 post-boost, with each scan consisting of 261 pixels. The scan width is about 720 km pre-boost and 833 km post-boost.

This is the TRMM Microwave Imager (TMI) LEVEL 1B calibrated Brightness Temperature (T_b) data product. The TMI calibration algorithm (1B11) converts the radiometer counts to antenna temperatures by applying a linear relationship of the form $T_a = c_1 + c_2$ x count. The coefficients are provided by the instrument contractor. Antenna temperatures are corrected for cross-polarization and spill over to produce brightness temperatures (T_b), but no antenna beam pattern correction or sample to pixel averaging are performed. Temperatures are provided at 104 scan positions for the low frequency channels and 208 scan positions at 85 GHz. There are four samples per pixel (3 dB beam width) at 10 GHz, two samples at 19, 22, and 37 GHz, and one sample per pixel for the 85 GHz.

The PR calibration algorithm (1B21) converts the counts of radar echoes and noise levels into engineering values (power) and outputs the radar echo power and noise power separately. The algorithm also detects and flags the range bin with return power that exceeds a pre-determined threshold value.

The PR reflectivity algorithm (1C21) converts the power and noise estimates from 1B21 to radar reflectivity factors (Z-factors). In order to reduce output data volume, only pixels with power that exceeds the minimum echo detected in 1B21 are converted and stored.

This product contains surface rainfall and vertical hydrometeor profiles on a pixel-by-integrated attenuation (PIA), storm height, Xi, bright band height and the NUBF (Non-Uniform Beam Filling) correction; 2) rain fractions; 3) histograms of the storm height, bright-band height, snow-ice layer, reflectivity, rain rate, path-attenuation and NUBF correction; 4) correlation coefficients. The high resolution grids are in the Planetary Grid 2 structure and contain mean rain rate along with standard deviation and rain fractions.

This dataset contains PR monthly surface rainfall. These data were derived from rain rate statistics and include the estimated values of the probability distribution function of the space-time rain rates at four levels (2 km, 4 km, 6 km, and path-averaged) and the mean, standard deviation, and probability of rain derived from these distributions. Three different rain rate estimates are used as input to the algorithm: (1) the standard Z-R (or 0^{th}-order estimate having no attenuation correction); (2) the Hitschfield-Bordan (H-B); and (3) the rain rates taken from 2A25.

This rainfall product contains data derived from the monthly SSM/I data averaged over 1° x 1° boxes each month. These data are used as input to the 3B43 monthly product described below.

This is a combined rainfall product. 3B31 uses the high quality retrievals done for the narrow swath in 2B31 to calibrate the wide swath retrievals generated in 2A12. For each 0.5° x 0.5° box and each vertical layer, an adjustment ratio is calculated for the swath overlap region for one month. Only TMI pixels with 2A12 pixelStatus equal to zero are included in monthly averages, which effectively removes sea ice.

The data product consists of TRMM Multi-Satellite Precipitation Analysis (TMPA) Rainfall Estimate Product 3B42 Version 7 (V7), which merges satellite rainfall estimates (S) with gauge data (G). First, all non-TRMM microwave precipitation estimates The 3B42 algorithm first combines microwave precipitation estimates from multiple low-earth-orbiting satellites are calibrated to the TRMM Microwave Imager precipitation (TMI; TRMM product 2A12) and then calibrated to the TRMM Combined Instrument precipitation (TCI; TRMM product 2B31). These are merged to produce a 3 hourly microwave-only best estimate. The infrared precipitation estimates (from multiple geosynchronous satellites) are then calibrated to the microwave estimate and used to fill in the regional gaps in the merged microwave field to produce a combined satellite rainfall estimate every 3 hours. These 3-hourly combined satellite estimates are then summed to the monthly scale and recalibrated with a monthly precipitation gauge analysis to provide the final SG-merged precipitation estimate as a Level 3 (L3) 3 hourly 0.25° x 0.25° quasi-global (50°N-S) gridded SG-rainfall database. Estimates of root-mean-square (RMS) precipitation error are also provided.

The data product consists of TRMM Multi-Satellite Precipitation Analysis (TMPA) Rainfall Estimate Product 3B43 Version 7 (V7), which merges satellite rainfall estimates (S) with gauge data (G) into gridded estimates on a calendar month temporal resolution and a 0.25° by 0.25° spatial resolution global band extending from 50°S to 50°N latitude. This algorithm is executed once per calendar month to produce the average best-estimate precipitation rate and RMS precipitation-error estimate field (3B43) described in 3B42 prior to recalibration of the 3 hourly product.

This is the convective and stratiform heating product. Convective and stratiform heating profiles are separated by comparing heating profiles from TRMM sensors to a lookup table of heating profiles mostly generated by the Goddard Cumulus Ensemble Cloud Resolving Model.

1.3 Data Disclaimer

1.3.1 Acknowledgement

If you use these data in publications, please acknowledge the Tropical Rainfall Measuring Mission (TRMM) as well as the Goddard Earth Sciences Data and Information Services Center (GES DISC) for the dissemination of the data. The standard for data citation can be found under the "Data Citation" tab on any of the TRMM product pages:

https://disc.gsfc.nasa.gov/datasets?project=TRMM

1.3.2 Contact Information

If you need assistance or wish to report a problem please use the following contact information:

: gsfc-help-disc@lists.nasa.gov
: 301-614-5268
: 301-614-5268

:
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2.0 Data Organization

All datasets are stored in files that correspond to their temporal resolution. For example, the 3-hourly 3B42 data are stored in eight files per day at 00 UTC, 03 UTC, 06 UTC, etc. and monthly files are stored in separate files for each month.

2.1 File Naming Convention

File names involve some combination of the following attributes:

- <date> The date is always in a format with the last 2 digits of the year following by the month and the day, always with a leading zero. An example for 4 August 2009 would be: .
- <orbit_number> This is the 5 digit orbit number.
- <product_version> This is the product version. The most recent version is 7.

	1B01.<date>.<orbit_number>.<product_version>.HDF	HDF4
	1B11.<date>.<orbit_number>.<product_version>.HDF	HDF4
	1B21.<date>.<orbit_number>.<product_version>.HDF.Z	Compressed HDF4
	1C21.<date>.<orbit_number>.<product_version>.HDF.Z	Compressed HDF4
	2A12.<date>.<orbit_number>.<product_version>.HDF.Z	Compressed HDF4
	2A21.<date>.<orbit_number>.<product_version>.HDF.Z	Compressed HDF4
	2A23.<date>.<orbit_number>.<product_version>.HDF.Z	Compressed HDF4
	2A25.<date>.<orbit_number>.<product_version>.HDF.Z	Compressed HDF4
	2B31.<date>.<orbit_number>.<product_version>.HDF.Z	Compressed HDF4
	3A11.<date>.<product_version>.HDF.Z	Compressed HDF4
	3A12.<date>.<product_version>.HDF.Z	Compressed HDF4
	3A25.<date>.<product_version>.HDF.Z	Compressed HDF4
	3A26.<date>.<product_version>.HDF.Z	Compressed HDF4
	3B31.<date>.<product_version>.HDF.Z	Compressed HDF4
	3A46.<date>.<product_version>.HDF.Z	Compressed HDF4
	3B42.<date>.<hour>.<product_version>.HDF.Z	Compressed HDF4
	3B43.<date>.<product_version>.HDF.Z	Compressed HDF4
	CSH.<date>.<product_version>.HDF	HDF4

. File naming conventions.

2.2 File Format and Structure

TRMM files are in the Hierarchical Data Format Version 4 (HDF-4), developed at the National Center for Supercomputing Applications (https://www.hdfgroup.org). These extensions facilitate the creation of Grid, Point, and Swath data structures, depending on whether the data are orbital or gridded.

Orbital (levels 1 and 2) data are stored in HDF-4 files that use the swath structure.

The variables within the orbital TRMM files (the product IDs that begin with a "1" or a "2") contain Swath data structures with dimensions of (nscan x nray). The gridded variables have dimensions of (longitude x latitude). Three-dimensional variables, found in the gridded files, have a third dimension of height above the surface, measured in kilometers.

Missing data are represented by values that are less than or equal to -99, -9999, -9999, -9999.9, and -9999.9 corresponding to 1-byte integers, 2-byte integers, 4-byte floats, and 8-byte floats.

Array dimensions are ordered so that the first dimension has the most rapidly varying index and the last dimension has the least rapidly varying index, which is sometimes called column-major ordering. Languages such as Fortran, MATLAB, and R use column-major ordering naturally. If you use row-major languages such as C++ and Python, it is recommended that you reverse the order of the dimensions of the arrays for optimal performance.

2.3 Key Science Data Fields

Below are the variables, and the products in which they are found, that we expect to be the most popular.

	surfaceRain	Surface Rainfall Rate	lat x lon	mm hr^{-1}
	convectPreciptiation	Surface Convective Rain Rate	level x lat x lon	mm hr^{-1}
	surfacePrecipitation	Surface Precipitation Rate	lat x lon	mm hr^{-1}
	cldIce	Cloud Ice Water Content	level x lat x lon	g m^{-3}
	cldWater	Cloud Liquid Water Content	level x lat x lon	g m^{-3}
	snow	Snow Liquid Content	level x lat x lon	g m^{-3}
	graupel	Graupel Liquid Water Content	level x lat x lon	g m^{-3}
	latentHeat	Latent Heat Release	level x lat x lon	K hr^{-1}
	precipitation	Surface Precipitation Estimate	lat x lon	mm hr^{-1}
	HQprecipitation	Microwave Precipitation Estimate*	lat x lon	mm hr^{-1}
	IRprecipitation	Infrared Precipitation Estimate*	lat x lon	mm hr^{-1}
	relativeError	Random Error Estimate	lat x lon	mm hr^{-1}
	precipitation	Surface Precipitation Estimate	lat x lon	mm hr^{-1}
	relativeError	Random Error Estimate	lat x lon	mm hr^{-1}

Description of popular variables.

3.0 Data Contents

3.1 Dimensions

The dimensions of the variables within the files vary by processing level, which refers to the “1”, “2”, or “3” at the beginning of the product ID. A summary of the dimensionality of the most common variables is given below. See section 3.3 for more details on each individual dataset.

Most of these variables have dimensions of x . refers to the number of scans in each granule, which varies by file. The second dimension, refers to the number of angle bins in each scan, which is always 49.

These variables have various numbers of dimensions made up of the ones listed below.

: number of clusters at each freezing height, always 100
: number of profiling layers, always 28
: number of pixels in each scan, always 208
: number of freezing height indices, always 13
: number corresponding to the hydrometeor species. Table 5 below lists the species.

1	Cloud liquid water content	g m^{-3}
2	Rain water content	g m^{-3}
3	Cloud ice water content	g m^{-3}
4	Snow water content	g m^{-3}
5	Graupel water content	g m^{-3}
6	Latent heating	K h^{-1}

Description of hydrometeor species.

These variables are on geographic grids and have various combinations of the dimensions listed below.

number of latitudes
: number of longitudes
: number of vertical layers denoting the height above the surface. There are 28 vertical layers beginning at 0.5 km and increasing in 0.5 km intervals to 10 km and then 1 km intervals to 18 km.
All 32-bit variables have attributes to make them COARDS-compliant.

Resolution

TRMM data are available on a variety of grids depending on the products chosen. Table 1 shows the temporal and horizontal resolutions associated with each TRMM product.

Temporal resolutions vary between 16 orbits/day (90 minutes), 3-hourly, and monthly. 3-hourly data exist at the synoptic and intermediate synoptic times of 00, 03, 06, 09, 12, 15, 18, and 21 UTC. Sub-daily data represent observations taken at that instant whereas monthly data represent monthly averages.

The orbital data products (1XXX and 2XXX) have latitude and longitude variables contained within the HDF files to allow proper swath mapping. Gridded files (3XXX) do not have explicit latitude and longitude information. Instead, the gridded files contain the , , , , , metadata and generally span 50°S to 50°N and 180°W to 180°E. Some products only span 38°S to 38°N, see section 3.3 for specific details.

Gridded TRMM products use the center of grid boxes for their latitude and longitude coordinates. For example, the TRMM 3B42 dataset, which spans 50°S to 50°N and 180°W to 180°E has a grid that goes from 49.875°S TO 49.875°N and 179.875°W to 179.875°E. Consult the sample code in Section 4 of this Readme for specific examples.

Detailed information on data resolution can be found in the PPS File Specification document cited at the end of this Readme document.

3.2 Global Attributes

In addition to SDS arrays containing variables and dimension scales, global metadata are also stored in the files. Some metadata are required by standard conventions, some are present to meet data provenance requirements, and others as a convenience to users of TRMM products. A summary of global attributes present in all files is shown in Table 6.

AlgorithmID	The algorithm that generated the product.
AlgorithmVersion	The version of the algorithm specified as the AlgorithmID.
FileName	The file name.
GenerationDateTime	The date and time the granule was generated.
StartGranuleDateTime	The start time of the data in the granule.
StopGranuleDateTime	The stop time of the data in the granule.
GranuleNumber	The granule number.
NumberOfSwaths	The number of swaths in the granule.
NumberOfGrids	The number of grid structures in the granule.
GranuleStart	The granule's orbit starting place.
TimeInterval	The time interval covered by the granule. Possible values are: ORBIT, HALFORBIT, HOUR, 3_HOUR, DAY, MONTH, and CONTACT.
ProcessingSystem	The name of the processing system.
ProductVersion	The data version assigned by ProcessingSystem.
MissingData	The number of missing scans.

Description of global attributes.

FillValue	float32	Floating-point value used to identify missing data. Will normally be set to 1e15. Not included in every TRMM file.
Units	string	The units of the variable. Must be a string that can be recognized by UNIDATA's Udunits package.
Scale_factor	float32	If variable is packed as 16-bit integers, this is the scale_factor for expanding to floating-point.

. Key Metadata Items

A list of key metadata fields can be found in Table 7. Global attributes in a file can be viewed with the software: ncdump –h -c <TRMM file>.

3.3 Products and Variables

	Start Date: 1997-12-08 Stop Date: 2001-08-07	Start Date: 2001-08-24 Stop Date: 2015-04-08
	Latitude: 38°S – 38°N Longitude: 180°W – 180°E	Latitude: 38°S – 38°N Longitude: 180°W – 180°E
	≈ 91.5 min/orbit = ≈ 16 orbits/day	≈ 92.5 min/orbit = ≈ 16 orbits/day
	2.2 km	2.4 km
	Swath Width: 720 km Pixels/Scan: 261 Scans/Second (SS): 2*98.5/60 Seconds/Orbit (SO): 5490 Average Scans/Orbit: nscan = 18026 nscan = SS*SO	Swath Width: 833 km Pixels/Scan: 261 Scans/Second (SS): 2*98.5/60 Seconds/Orbit (SO): 5490 Average Scans/Orbit: 5550 = 18223 nscan = SS*SO
	≈ 137 MB	≈ 138 MB

ECS core metadata	Char Attribute	10,000	-	-	-	-
Product specific metadata	Char Attribute	10,000	-	-	-	-
Specifications for the swath geometry	Char Attribute	5,000	-	-	-	-
Time associated with each scan	Vdata Table	8	nscan	-	-	-
Latitude information	Float SDS	4	261*nscan	-	-	degree
Longitude information	Float SDS	4	261*scan	-	-	degree
Status of each scan	Vdata Table	19	nscan	-	-	-
Spacecraft geocentric information	Vdata Table	88	nscan	-	-	-
Solar unit vector in Geocentric Inertial Coordinates and the Sun-Earth distance	Vdata Table	32	nscan	-	-	-
Raw calibration counts data	Integer SDS	2	5*2*3*nscan	-	-	-
Primary and redundant temperatures for the black body, radiant cooler, and the electronics module	Integer SDS	2	6*nscan	-	0 – 4095	counts
Angles to the satellite and sun from the IFOV pixel position on the earth	Float SDS	4	2*2*27*nscan	-	-	degree
Scene data for the five channels	Float SDS	4	5*261*nscan	depends	depends	mW $cm^{-2}\mu m^{-1}$ sr^{-1}

Solar Position	3 * 8-byte float	Sun Unit Vectors: x-, y-, and z-components
Distance	8-byte float	Sun-Earth Distance (m)

1	Channel number
2	Data word
3	Blackbody, space view, solar diffuser
4	Number of scans

1	zenith, azimuth	The zenith angle is measured between the local pixel geodetic zenith and the direction to the satellite. The azimuth angle is measure clockwise from the local north direction toward the local east direction.
2	object	The object to which the directions point, namely the satellite and the sun.
3	pixel number	Angles are given only for every tenth pixel along a scan: e.g. pixels 1, 11, 21,..., 261.
4	scan number	Scan line number

	Start Date: 1997-12-08 Stop Date: 2001-08-07	Start Date: 2001-08-24 Stop Date: 2015-04-08
	Latitude: 38°S – 38°N Longitude: 180°W – 180°E	Latitude: 38°S – 38°N Longitude: 180°W – 180°E
	≈ 91.5 min/orbit = ≈ 16 orbits/day	≈ 92.5 min/orbit = ≈ 16 orbits/day
	4.4 km at 85.5 GHz	5.1 km at 85.5 GHz
	Swath Width: 760 km Pixels/Scan: 104 (low resolution) 208 (high resolution) Scans/Second (SS): 36.100/60 Seconds/Orbit (SO): 5490 Average Scans/Orbit: nscan = 2991 nscan = SS * SO + 100	Swath Width: 878 km Pixels/Scan: 104 (low resolution) 208 (high resolution) Scans/Second (SS): 36.100/60 Seconds/Orbit (SO): 5550 Average Scans/Orbit: nscan = 3023 nscan = SS * SO + 100
	≈ 16 MB	≈ 16 MB

ECS core metadata	Char Attribute	10,000	-	-	-	-
Product specific metadata	Char Attribute	10,000	-	-	-	-
Specification of the swath geometry	Char Attribute	5,000	-	-	-	-
Time associated with each scan	Vdata Table	9	nscan	-	-	-
Latitude information	Float SDS	4	208*nscan	-	-	degree
Longitude information	Float SDS	4	208*nscan	-	-	degree
Status of each scan	Vdata Table	21	nscan	-	-	-
Spacecraft geocentric information	Vdata Table	88	nscan	-	-	-
Calibration	Vdata Table	95	nscan	-	-	-
Calibration measurement, in counts. Dimensions are: samples, load, channel, and nscan.	Integer SDS	2	16*2*9*nscan	-	-	-
Angle between the local pixel geodetic zenith and the direction to the satellite. This angle is given for every 20th high resolution pixel along a scan: pixel 1, 21, 41,.., 201, 208.	Float SDS	4	12*nscan	-	-	degree
Low resolution channels bright temperature	Integer SDS	2	7*104*nscan	(T-100)*100	-	K
High resolution channels bright temperature	Integer SDS	2	2*208*nscan	(T-100)*100	-	K

	2-byte integer	4-digit year, e.g., 1998
	1-byte integer	The month of the year
	1-byte integer	The day of the month
	1-byte integer	

	Start Date: 1997-12-08 Stop Date: 2001-08-07	Start Date: 2001-08-24 Stop Date: 2015-04-08
	Latitude: 38°S – 38°N Longitude: 180°W – 180°E	Latitude: 38°S – 38°N Longitude: 180°W – 180°E
	≈ 91.5 min/orbit = ≈ 16 orbits/day	≈ 92.5 min/orbit = ≈ 16 orbits/day
	4.3 km	5.0 km
	Swath Width: 215 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5490 Average Scans/Orbit: nscan = 9150 nscan = SS*SO	Swath Width: 247 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5550 Average Scans/Orbit: nscan = 9250 nscan = SS*SO
	≈ 67 MB	≈ 79 MB

ECS core metadata	Char Attribute	10,000	-	-	-	-
Product specific metadata	Char Attribute	10,000	-	-	-	-
Calibration coefficients for the PR. The records consist of: Transmission coefficient (unitless, 1 record), Reception coefficient (unitless, 1 record), and FCIF I/O Characteristics (unitless, 16 records). Descriptions are TBD by NASDA.	Vdata Table	4	18	-	-	-
Information about each ray (angle bin) that is constant for every scan. The record number represents the angle bin number. Each record describes one ray and is defined in Ray Header Table.	Vdata Table	60	49	-	-	-
Specification of the swath geometry	Char Attribute	5,000	-	-	-	-
Time associated with the scan, expressed as 8-byte float UTC second of the day.	Vdata Table	8	nscan	-	-	-
Latitude information	Float SDS	4	nray*nscan	-	-	degree
Longitude information	Float SDS	4	nray*nscan	-	-	degree
Status of each scan	Vdata Table	15	nscan	-	-	-
Spacecraft geocentric information	Vdata Table	88	nscan	-	-	-
Radar transmission power and transmitted pulse width	Vdata Table	6	nscan	-	-	-
System Noise (dBm) is an average of the 4 measured system noise values. Missing data are given the value of -32,734.	Integer SDS	2	nray*nscan	100	-120 ~ -20	dBm
System Noise Warning Flag indicates possible contamination of lower window noise by high towers of rain. 1 means possible contamination; 0 means no possible contamination.	Integer SDS	1	nray*nscan	-	-	-

	Integer SDS	1	nray*nscan	-	-	-
Minimum echo flag indicates the presence of rain in the ray (angle bin).						
	Integer SDS	2	2*nray*nscan	-	-	-
Bin storm height is the range bin number of the storm top.						
	Float SDS	4	nray*nscan	-	-	-
Angle, in degrees, between the local zenith and the beam's center line. The local (geodetic) zenith at the intersection of the ray and the earth ellipsoid is used.						
	Integer SDS	4	nray*nscan	-	-	m
Distance between the spacecraft and the center of the footprint of the beam on the earth ellipsoid.						
	Integer SDS	2	2*29*nscan	-	-	-
Starting range bin number of the oversample (either surface or rain) data, counting from the top down.						
	Integer SDS	2	nray*nscan	-	-	-
Land or ocean information. The values of the flag are: 0 = water, 1 = land, 2 = coast, 3 = water (w/ large attenuation), 4 = land/coast (w/ large attenuation).						
	Integer SDS	2	nray*nscan	-	-	-
Definition TBD by NASDA.						
	Integer SDS	2	nray*nscan	-	-	-
Range bin number of the peak surface echo. This peak is determined by the post observation ground processing, not by the on board surface detection. The range bin number is defined in this volume in the section on Precipitation Radar, Instrument and Scan Geometry.						
	Float SDS	2	nray*nscan	-	-	-
Range bin number of the earth ellipsoid.						
	Integer SDS	2	2*nray*nscan	-	-	-
Range bin number of the lowest clutter free bin. Clutter free bin numbers are given for clutter free certain and possible, respectively. The clutter free certain bin is always less than or equal to the clutter free possible bin number.						
	Integer SDS	2	nray*nscan	-	-	-
Mean range bin number of the DID surface elevation in a 5 km x 5 km box centered on the IFOV.						
	Integer SDS	2	2*nray*nscan	-	-	-
Range bin number of the maximum DID surface elevation in a box centered on the IFOV. The first dimension is the box size, with sizes of 5 km x 5 km and 11 km x 11 km.						
	Integer SDS	2	2*nray*nscan	-	-	-
Range bin number of the minimum DID surface elevation in a box centered on the IFOV. The first dimension is the box size, with sizes of 5 km x 5 km and 11 km x 11 km.						
	Integer SDS	2	140*nray*nscan	100	-120 ~ -20	dBm
Return power (dBm) of the normal sample. Since each ray has a different size, the elements after the end of each ray are filled with a value of -32767. Other bins where data is not written due to a transmission, calibration, or other problem, including an entire scan of missing bins, have the value of -32734. The size of each ray is specified in Ray Header, with an accuracy of 0.9 dBm.						
	Integer SDS	2	5*29*nscan	100	-120 ~ -20	dBm
Return power (dBm) of the surface echo oversample for the central 29 rays (rays #11-39), with an accuracy of 0.9 dBm. Bins where data is not written due to a transmission, calibration, or other problem, including an entire scan of missing bins, have the value of -32734. In the CrossTrack dimension, Offset = -10 and Increment = 1.						
	Integer SDS	2	28*11*nscan	100	-120 ~ -20	dBm
Return power (dBm) of the rain echo oversample for the central 11 rays (rays #20-30), with an accuracy of 0.9 dBm. Bins where data is not written due to a transmission, calibration, or other problem, including an entire scan of missing bins, have the value of -32734. In the CrossTrack dimension, Offset = -19 and Increment = 1.						

Radar Transmission Power	2-byte integer
Total (sum) power of 128 SSPA elements corrected with SSPA temperature in orbit, based on temperature test data of SSPA transmission power. The units are dBm * 100. For this variable, the TSDIS Toolkit does not provide scaling.	
Transmitted Pulse Width	4-byte float
Transmitted pulse width (s) corrected with FCIF temperature in orbit, based on temperature test data of FCIF.	

	No Rain
	Rain Possible
	Rain Possible (echo greater than rain threshold #1 in clutter range)
	Rain Possible (echo greater than rain threshold #2 in clutter range)
	Rain Certain

Bin Storm Height is Range Bin Number of the storm top. The first dimension is threshold, with values of possible rain threshold and certain rain threshold in that order. The Bin Storm Heights are generated in the procedure to determine the Minimum Echo Flag. The Bin Storm Height is the top range bin of the portion of consecutive range bins that flagged the ray as rain possible or rain certain. The range bin number is defined in this volume in the section on Precipitation Radar, Instrument and Scan Geometry.

The first dimension is the Bin Start of Oversample and Surface Tracker Status. The second dimension is the ray. The number of rays is 29 because this information only applies to the rays that have oversample data (rays #11 to #39). The third dimension is the scan. The Surface Tracker Status has the value of 0 (Lock) or 1 (Unlock), where Lock means that (1) the on board surface detection detected the surface and (2) the surface detected later by processing on the ground fell within the oversample bins. Unlock means that Lock was not achieved. The range bin number is defined in this volume in the section on Precipitation Radar, Instrument and Scan Geometry.

	Start Date: 1997-12-08 Stop Date: 2001-08-07	Start Date: 2001-08-24 Stop Date: 2015-04-08
	Latitude: 38°S – 38°N Longitude: 180°W – 180°E	Latitude: 38°S – 38°N Longitude: 180°W – 180°E
	≈ 91.5 min/orbit = ≈ 16 orbits/day	≈ 92.5 min/orbit = ≈ 16 orbits/day
	4.3 km	5.0 km
	Swath Width: 215 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5490 Average Scans/Orbit: nscan = 9150 nscan = SS*SO	Swath Width: 247 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5550 Average Scans/Orbit: nscan = 9250 nscan = SS*SO
	≈ 44 MB	≈ 44 MB

ECS core metadata	Char Attribute	10,000	-	-	-	-
Product specific metadata	Char Attribute	10,000	-	-	-	-
Calibration coefficients for the PR. The records consist of: Transmission coefficient (unitless, 1 record), Reception coefficient (unitless, 1 record), and FCIF I/O Characteristics (unitless, 16 records). Descriptions are TBD by NASDA.	Vdata Table	4	18	-	-	-
Information about each ray (angle bin) that is constant for every scan. The record number represents the angle bin number. Each record describes one ray and is defined in Ray Header Table.	Vdata Table	60	49	-	-	-
Specification of the swath geometry	Char Attribute	5,000	-	-	-	-
Time associated with the scan, expressed as 8-byte float UTC second of the day.	Vdata Table	8	nscan	-	-	-
Latitude information	Float SDS	4	nray*nscan	-	-	degree
Longitude information	Float SDS	4	nray*nscan	-	-	degree
Status of each scan	Vdata Table	15	nscan	-	-	-
Spacecraft geocentric information	Vdata Table	88	nscan	-	-	-
Radar transmission power and transmitted pulse width	Vdata Table	6	nscan	-	-	-
System Noise (dBm) is an average of the 4 measured system noise values. Missing data are given the value of -32,734.	Integer SDS	2	nray*nscan	100	-120 ~ -20	dBm
System Noise Warning Flag indicates possible contamination of lower window noise by high towers of rain. 1 means possible contamination; 0 means no possible contamination.	Integer SDS	1	nray*nscan	-	-	-

	Integer SDS	1	nray*nscan	-	-	-
Minimum echo flag indicates the presence of rain in the ray (angle bin).						
	Integer SDS	2	2*nray*nscan	-	-	-
Bin storm height is the range bin number of the storm top.						
	Float SDS	4	nray*nscan	-	-	-
Angle, in degrees, between the local zenith and the beam's center line. The local (geodetic) zenith at the intersection of the ray and the earth ellipsoid is used.						
	Integer SDS	4	nray*nscan	-	-	m
Distance between the spacecraft and the center of the footprint of the beam on the earth ellipsoid.						
	Integer SDS	2	2*29*nscan	-	-	-
Starting range bin number of the oversample (either surface or rain) data, counting from the top down.						
	Integer SDS	2	nray*nscan	-	-	-
Land or ocean information. The values of the flag are: 0 = water, 1 = land, 2 = coast, 3 = water (w/ large attenuation), 4 = land/coast (w/ large attenuation).						
	Integer SDS	2	nray*nscan	-	-	-
Definition TBD by NASDA.						
	Integer SDS	2	nray*nscan	-	-	-
Range bin number of the peak surface echo. This peak is determined by the post observation ground processing, not by the on board surface detection. The range bin number is defined in this volume in the section on Precipitation Radar, Instrument and Scan Geometry.						
	Float SDS	2	nray*nscan	-	-	-
Range bin number of the earth ellipsoid.						
	Integer SDS	2	2*nray*nscan	-	-	-
Range bin number of the lowest clutter free bin. Clutter free bin numbers are given for clutter free certain and possible, respectively. The clutter free certain bin is always less than or equal to the clutter free possible bin number.						
	Integer SDS	2	nray*nscan	-	-	-
Mean range bin number of the DID surface elevation in a 5 km x 5 km box centered on the IFOV.						
	Integer SDS	2	2*nray*nscan	-	-	-
Range bin number of the maximum DID surface elevation in a box centered on the IFOV. The first dimension is the box size, with sizes of 5 km x 5 km and 11 km x 11 km.						
	Integer SDS	2	2*nray*nscan	-	-	-
Range bin number of the minimum DID surface elevation in a box centered on the IFOV. The first dimension is the box size, with sizes of 5 km x 5 km and 11 km x 11 km.						
	Integer SDS	2	140*nray*nscan	100	-120 ~ -20	dBm
Return power (dBm) of the normal sample. Since each ray has a different size, the elements after the end of each ray are filled with a value of -32767. Other bins where data is not written due to a transmission, calibration, or other problem, including an entire scan of missing bins, have the value of -32734. The size of each ray is specified in Ray Header, with an accuracy of 0.9 dBm.						
	Integer SDS	2	5*29*nscan	100	-120 ~ -20	dBm
Return power (dBm) of the surface echo oversample for the central 29 rays (rays #11-39), with an accuracy of 0.9 dBm. Bins where data is not written due to a transmission, calibration, or other problem, including an entire scan of missing bins, have the value of -32734. In the CrossTrack dimension, Offset = -10 and Increment = 1.						
	Integer SDS	2	28*11*nscan	100	-120 ~ -20	dBm
Return power (dBm) of the rain echo oversample for the central 11 rays (rays #20-30), with an accuracy of 0.9 dBm. Bins where data is not written due to a transmission, calibration, or other problem, including an entire scan of missing bins, have the value of -32734. In the CrossTrack dimension, Offset = -19 and Increment = 1.						

	Start Date: 1997-12-08 Stop Date: 2001-08-07	Start Date: 2001-08-24 Stop Date: 2015-04-08
	Latitude: 38°S – 38°N Longitude: 180°W – 180°E	Latitude: 38°S – 38°N Longitude: 180°W – 180°E
	Surface – 18 km	Surface – 18 km
	≈ 91.5 min/orbit = ≈ 16 orbits/day	≈ 92.5 min/orbit = ≈ 16 orbits/day
	4.4 km at 85.5 GHz	5.1 km at 85.5 GHz
	0.5 km from surface to 4 km 1.0 km from 4 km to 6 km 2.0 km from 6 km to 10 km 4.0 km from 10 km to 18 km	0.5 km from surface to 4 km 1.0 km from 4 km to 6 km 2.0 km from 6 km to 10 km 4.0 km from 10 km to 18 km
	Swath Width: 760 km Pixels/Scan: 208 Scans/Second (SS): 36.100/60 Seconds/Orbit (SO): 5490 Average Scans/Orbit: nscan = 2991 nscan = SS * SO + 100	Swath Width: 878 km Pixels/Scan: 208 Scans/Second (SS): 36.100/60 Seconds/Orbit (SO): 5550 Average Scans/Orbit: nscan = 3023 nscan = SS * SO + 100
	≈ 11 MB	≈ 11 MB

ECS core metadata	Char Attribute	10,000	-	-	-	-
Product specific metadata	Char Attribute	10,000	-	-	-	-
Specification of the swath geometry	Char Attribute	5,000	-	-	-	-
Time associated with each scan	Vdata Table	9	nscan	-	-	-
Latitude information	Float SDS	4	208*nscan	-	-	degree
Longitude information	Float SDS	4	208*nscan	-	-	degree
Status of each scan	Vdata Table	21	nscan	-	-	-
Spacecraft geocentric information	Vdata Table	88	nscan	-	-	-
Indicates the quality of the data	Integer SDS	1	npixel*nscan	-	-	-
Indicates if rain is possible. ≥0 = rain is possible, < 0 = no rain	Integer SDS	1	npixel*nscan	-	-	-

	Start Date: 1997-12-08 Stop Date: 2001-08-07	Start Date: 2001-08-24 Stop Date: 2015-04-08
	Latitude: 38°S – 38°N Longitude: 180°W – 180°E	Latitude: 38°S – 38°N Longitude: 180°W – 180°E
	≈ 91.5 min/orbit = ≈ 16 orbits/day	≈ 92.5 min/orbit = ≈ 16 orbits/day
	4.3 km	5.0 km
	Swath Width: 215 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5490 Average Scans/Orbit: nscan = 9150 nscan = SS*SO	Swath Width: 247 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5550 Average Scans/Orbit: nscan = 9250 nscan = SS*SO
	≈ 11 MB	≈ 11 MB

	Start Date: 1997-12-08 Stop Date: 2001-08-07	Start Date: 2001-08-24 Stop Date: 2015-04-08
	Latitude: 38°S – 38°N Longitude: 180°W – 180°E	Latitude: 38°S – 38°N Longitude: 180°W – 180°E
	≈ 91.5 min/orbit = ≈ 16 orbits/day	≈ 92.5 min/orbit = ≈ 16 orbits/day
	4.3 km	5.0 km
	Swath Width: 215 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5490 Average Scans/Orbit: nscan = 9150 nscan = SS*SO	Swath Width: 247 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5550 Average Scans/Orbit: nscan = 9250 nscan = SS*SO
	≈ 7 MB	≈ 7 MB

ECS core metadata	Char Attribute	10,000	-	-	-	-
Product specific metadata	Char Attribute	10,000	-	-	-	-
Specification of the swath geometry	Char Attribute	5,000	-	-	-	-
Time associated with each scan	Vdata Table	9	nscan	-	-	-
Latitude information	Float SDS	4	208*nscan	-	-	degree

	Integer SDS	1	nray*nscan	-	-	-
The warm rain flag is set as follows: 10 = maybe shallow, isolated; 11 = confidence in shallow, isolated; 20 = maybe shallow but not isolated; 21 = confidence in shallow but not isolated; 0 = not shallow; < 0 = rain not certain or missing						
	Integer SDS	1	nray*nscan	-	-	-
Indicates whether the data are obtained over sea or land, and the confidence in the data						
	Integer SDS	2	nray*nscan	-	-	-
A positive height of bright band is defined in meters above mean sea level. Negative values are defined as: -1111 = no bright band, -8888 = no rain, -9999 = data missing						
	Integer SDS	4	nray*nscan	-	-	-
The maximum value of the bright band.						
	Integer SDS	2	nray*nscan	-	-	-
A positive range bin number that corresponds to the peak of the bright band.						
	Integer SDS	2	2*nray*nscan	-	-	-
Positive bin number of the boundary of the bright band. The first index indicates the bottom.						
	Integer SDS					

100	Stratiform certain	When R_type_V = T_stra; (BB exists) and R_type_H = T_stra;
110	Stratiform certain	When R_type_V = T_stra; (BB exists) and R_type_H = T_others;
120	Probably stratiform	When R_type_V = T_others; and R_type_H = T_stra;
130	Maybe stratiform	When R_type_V = T_stra; (BB detection certain) and R_type_H = T_conv;
140	Maybe stratiform or maybe transition or something else	When R_type_V = T_others; (BB hardly expected) and R_type_H = T_stra;
152	Maybe stratiform	Shallow isolated (type of warm rain) is detected. When R_type_V = T_others; R_type_H = T_stra; and shallowRain = 20 or 21;
160	Maybe stratiform, rain hardly expected near surface	BB may exist but is not detected when R_type_V = T_others; R_type_H = T_stra;
170	Maybe stratiform, rain hardly expected near surface	BB hardly expected. Maybe cloud only. When R_type_V = T_others; R_type_H = T_stra;
200	Convective certain	When R_type_V = T_conv; (no BB) and R_type_H = T_conv;
210	Convective certain	When R_type_V = T_others; and R_type_H = T_conv;
220	Convective certain	When R_type_V = T_conv; and R_type_H = T_others;
230	Probably convective	When R_type_V = T_conv; (BB exists) and R_type_H = T_conv;
240	Maybe convective	When R_type_V = T_conv; and R_type_H = T_stra;
251	Convective	Shallow isolated is detected. When R_type_V = T_conv, R_type_H = T_conv and shallowRain = 10 or 11;
252	Convective	Shallow rain (non-isolated) is detected. When R_type_V = T_conv, R_type_H = T_conv and shallowRain = 20 or 21;
261	Convective	Shallow isolated is detected. When R_type_V = T_conv; R_type_H = T_others; and shallowRain = 10 or 11;
262	Convective	Shallow rain (non-isolated) is detected.When R_type_V[i] = T_conv, R_type_H[i] = T_others; and shallowRain[i] = 20 or 21;
271	Convective	Shallow isolated is detected. When R_type_V = T_others; R_type_H = T_conv; and shallowRain = 10 or 11;
272	Convective	Shallow isolated is detected. When R_type_V = T_others; R_type_H = T_conv; and shallowRain = 20 or 21;
281	Convective	Shallow isolated is detected. When R_type_V = T_conv; R_type_H = T_stra; and shallowRain = 10 or 11;
282	Convective	Shallow rain (non-isolated) is detected.When R_type_V[i] = T_conv, R_type_H[i] = T_stra; and shallowRain[i] = 20 or 21;
291		

0	good	over ocean
10	BB detection may be good	over ocean
20	R-type classification may be good (BB detection is good or BB does not exist)	over ocean
30	Both BB detection and R-type classification may be good	over ocean
50	not good (because of warnings)	over ocean
100	bad (possible data corruption)	over ocean
1	good	over land
11	BB detection may be good	over land
21	R-type classification may be good (BB detection is good or BB does not exist)	over land
31	Both BB detection and R-type classification may be good	over land
51	not good (because of warnings)	over land
101	bad (possible data corruption)	over land
2	good	over coastline
12	BB detection may be good	over coastline
22	R-type classification may be good (BB detection is good or BB does not exist)	over coastline
32	Both BB detection and R-type classification may be good	over coastline
52	not good (because of warnings)	over coastline
102	bad (possible data corruption)	over coastline
4	good	over inland lake
14	BB detection may be good	over inland lake
24	R-type classification may be good (BB detection is good or BB does not exist)	over inland lake
34	Both BB detection and R-type classification may be good	over inland lake
54	not good (because of warnings)	over inland lake
104	bad (possible data corruption)	over inland lake
9	may be good	land/sea unknown
19	BB detection may be good	land/sea unknown
29	R-type classification may be good (BB detection is good or BB does not exist)	land/sea unknown
39	Both BB detection and R-type classification may be good	land/sea unknown
59	not good (because of warnings)	land/sea unknown
109	bad (possible data corruption)	land/sea unknown

When the status flag is "no rain" or "data missing", status flag contains -88 for no rain and -99 for missing data.
Assignment of the above numbers are based on the following rules:

0	good, may be good when status < 100 and not good when status ≥ 100
1	BB detection not so confident
2	R-type classification not so confident (but BB detection is good or doesn't exist)
3	BB detection and R-type classification both not confident
5	Overall quality of the processed data is not good
0	over ocean
1	over land
2	over coastline
4	over inland lake
9	land/sea unknown

In other words, if the Status Flag is ≥ 100, the data are untrustworthy; between 10 and 100 then the data are not confident, equal to 9 then the data may be good; and between 0 and 9 then the data are good.

	Start Date: 1997-12-08 Stop Date: 2001-08-07	Start Date: 2001-08-24 Stop Date: 2015-04-08
	Latitude: 38°S – 38°N Longitude: 180°W – 180°E	Latitude: 38°S – 38°N Longitude: 180°W – 180°E
	≈ 91.5 min/orbit = ≈ 16 orbits/day	≈ 92.5 min/orbit = ≈ 16 orbits/day
	4.3 km	5.0 km
	Swath Width: 215 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5490 Average Scans/Orbit: nscan = 9150 nscan = SS*SO	Swath Width: 247 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5550 Average Scans/Orbit: nscan = 9250 nscan = SS*SO
	≈ 16 MB compressed, 253 MB original	≈ 16 MB compressed, 256 MB original

	Char Attribute	10,000	-	-	-	-
ECS core metadata						
	Char Attribute	10,000	-	-	-	-
Product specific metadata						
	Vdata Table	4	49	-	-	-
Mainlobe Clutter Edge and Sidelobe Clutter Range						
	Char Attribute	5,000	-	-	-	-
Specification of the swath geometry.						
	Vdata Table	8	nscan	-	-	-
Time associated with the scan, expressed as 8-byte float UTC second of the day.						
	Float SDS	4	nray*nscan	-	-	degree
Latitude information						
	Float SDS	4	nray*nscan	-	-	degree
Longitude information						
	Float SDS	4	nray*nscan	-	-	degree
Spacecraft local zenith angle.						
	Vdata Table	15	nscan	-	-	-
Status of each scan.						
	Vdata Table	88	nscan	-	-	-
Spacecraft geocentric information.						
Rain Rate						
Reliability						

	Integer SDS	2	80*nray*nscan	100	0 ~ 80	dBZ
Attenuation corrected reflectivity factor (Z) at the radar range gates from 0 to 20 km along the slant range. Values of reflectivity less than 0.0 dBZ are set to 0.0 dBZ. A value of -88.88 dB (stored as -8888) is a ground clutter flag, -9999 is for missing data in reflectivity profile.						
	Integer SDS	2	5*nray*nscan	-	0 ~ 79	-
Range bin numbers of the nodes at which the values of Attenuation and Z-R Parameters are given (see below). The values of the parameters between the nodes are linearly interpolated.						
	Float SDS	4	5*nray*nscan	-	0.00010 ~ 0.00200	-
It relates the attenuation coefficient, k (dB/km) to the Z-factor: k = α . computed at ncell2dar range g						

	Float SDS	4	2*nray*nscan	-	0 – 50	g km m^{-3}
Vertically integrated value of sum precipitation water content calculated from Ze at each range bin. The first index is the precipitation liquid water content from the freezing height to the actual surface. The second index is the sum of precipitation ice content from the top of the storm to the freezing height.						
	Integer SDS	2	nray*nscan	-	-	-
Method Flag indicates which method is used to derive the rain rate. The default value is 0 (including no rain case). Bit 0 is the least significant bit (i.e., if bit i =1 and other bits =0, the unsigned integer value is 2^i).						
	Float SDS	4	nray*nscan	-	0.0 ~ 100.0	-
Correction factor for the surface reference.						
	Float SDS	4	nray*nscan	-	0.0 ~ 100.0	-
The adjustment parameter computed from the filtered surface reference PIA (2A21 algorithm).						
	Float SDS	4	2*nray*nscan	-	0.0 ~ 100.0	-
Roughly represents the rain rate integrated along the ray using two different methods.						
	Float SDS	4	2*nray*nscan	-	0.0 ~ 100.0	-
Average of zeta in the vicinity of each beam position (average over three scans and three IFOVs). It is calculated using two methods.						
	Float SDS	4	2*nray*nscan	-	0.0 ~ 100.0	-
Standard deviation of zeta in the vicinity of each beam position (using three scans and three IFOVs). It is calculated using two methods.						
	Float SDS	4	2*nray*nscan	-	0.0 ~ 99.0	-
Normalized standard deviation defined as Zeta_sd/Zeta_mn. When Zeta_mn takes on small values (or zero) Xi is set to 99.0. It is calculated using two methods.						
	Float SDS	4	3*nray*nscan	-	1 ~ 10	-

The default value is 0 (normal). Bit 0 is the least significant bit (i.e., if bit i =1 and other bits =0, the unsigned integer value is 2**i). The following meanings are assigned to each bit in the 16-bit integer if the bit = 1.	
0	normal
1	unusual situation in rain average
2	NSD of zeta (xi) calculated from less than 6 points
4	NSD of PIA calculated from less than 6 points
8	NUBF for Z-R below lower bound
16	NUBF for PIA above upper bound
32	epsilon not reliable, epsi_sig less than or equal to 0.0
64	2A21 input data not reliable
128	2A23 input data not reliable
256	range bin error
512	sidelobe clutter removal
1024	probability=0 for all tau
2048	pia_surf_ex less than or equal to 0.0
4096	const Z is invalid
8192	reliabFactor in 2A21 is NaN
16384	data missing

If all bits 0: no rain. Otherwise:	
1	0: over ocean 1: over land
2	over coast, river, etc.
3	OIA from constant-Z-near-surface assumption
4	spatial reference
5	temporal reference
6	global reference
7	hybrid reference
8	good to take statistics of epsilon
9	HB method used, SRT totally ignored
10	very large pia_srt for given zeta
11	very small pia_srt for given zeta
12	no ZR adjustment by epsilon
13	no NUBF correction because NSD unreliable
14	surface attenuation > 60 dB
15	data partly missing between rain top and bottom

	Start Date: 1997-12-08 Stop Date: 2001-08-07	Start Date: 2001-08-24 Stop Date: 2015-04-08
	Latitude: 38°S – 38°N Longitude: 180°W – 180°E	Latitude: 38°S – 38°N Longitude: 180°W – 180°E
	≈ 91.5 min/orbit = ≈ 16 orbits/day	≈ 92.5 min/orbit = ≈ 16 orbits/day
	4.3 km	5.0 km
	Swath Width: 215 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5490 Average Scans/Orbit: nscan = 9150 nscan = SS*SO	Swath Width: 247 km Rays/Scan: nray = 49 Scans/Second (SS): 1/0.6 Seconds/Orbit (SO): 5550 Average Scans/Orbit: nscan = 9250 nscan = SS*SO
	≈ 11 MB compressed	≈ 11 MB compressed

ECS core metadata	Char Attribute	10,000	-	-	-	-
Product specific metadata	Char Attribute	10,000	-	-	-	-
Specification of the swath geometry	Char Attribute	5,000	-	-	-	-
Time associated with each scan	Vdata Table	9	nscan	-	-	-
Latitude information	Float SDS	4	208*nscan	-	-	degree
Longitude information	Float SDS	4	208*nscan	-	-	degree
Status of each scan	Vdata Table	21	nscan	-	-	-
	Vdata Table	88	nscan	-	-	-

	Integer SDS	2	nradarrange * nray*nscan	10	0 – 500	mm hr^{-1}
Instantaneous rain rate at the radar range gates. The accuracy is 0.1 mm hr^{-1}.						
	Integer SDS	2	nradarrange * nray*nscan	10	-125 – 125	mm hr^{-1}
RMS uncertainty in the R-hat estimated at the radar range gates. (The negative sign indicating estimates based on a "rain-possible" detection by the radar rather than the "rain-certain" associated with positive values). The values -125 and 125 are reserved for cases where the RMS uncertainty could not be accurately estimated. The accuracy is 0.5 mm/hr.						
	Float SDS	4	nray*nscan	-	0 – 500	mm hr^{-1}
Surface rain rate.						
	Integer SDS	2	nray*nscan	100	-125 – 125	mm hr^{-1}
RMS uncertainty in RR-Surf. (The negative sign indicating estimates based on a "rain-possible" detection by the radar rather than the "rain-certain" associated with positive values). The values -125 and 125 are reserved for cases where the RMS uncertainty could not be accurately estimated. The accuracy is 0.5 mm/hr.						
	Float SDS	4	nlayer*nray *nscan	-	-	K hr^{-1}
The "hydrometeor heating" calculated from the vertical fluxes of the different hydrometeor species and using average archival temperature/ pressure/humidity soundings which depend on longitude and latitude only. In V7 all the precipitation is assumed to be liquid. Heating is listed for 13 layers.						
	Float SDS	4	4*nray*nscan	-	-	-
Contents and ranges are not public.						

Geolocation is the earth location of the center of the IFOV at the altitude of the earth ellipsoid. The first dimension is latitude and longitude, in that order. The next dimensions are numbers of pixels and scans. Values are represented as floating point decimal degrees. Off-earth is represented as -9999.9. Latitude is positive north, negative south. Longitude is positive east, negative west. A point on the 180° meridian is assigned to the western hemisphere.

D-hat is the correlation-corrected mass-weighted mean drop diameter. The accuracy is 0.01 "normalized" mm (the value 0 indicates no rain or bad data). The average value of dHat is around 1.1 "normalized" mm, a unit which comes from the fact that dHat is related to the true mass-weighted mean drop diameter D* mm by the formula dHat = D*rHat-0.155 (with rHat in mm/hr).

(specified as height above earth ellipsoid)

Layer 1: 16 km – 18 km
Layer 2: 14 km – 16 km
Layer 3: 12 km – 14 km
Layer 4: 10 km – 12 km
Layer 5: 8 km – 10 km
Layer 6: 7 km – 8 km
Layer 7: 6 km – 7 km
Layer 8: 5 km – 6 km
Layer 9: 4 km – 5 km

Layer 10: 3 km – 4 km
Layer 11: 2 km – 3 km
Layer 12: 1 km – 2 km
Layer 13: 0 km – 1 km

	Start Date: 1997-12-01 Stop Date: 2015-03-31
	Latitude: 40°S – 40°N Longitude: 180°W – 180°E
	Monthly
	5° x 5°; nlat = 16, nlon = 72
	≈ 23 KB compressed

ECS core metadata	Char Attribute	10,000	-	-	-	-
Product specific metadata	Char Attribute	10,000	-	-	-	-
GridStructure gives the specification of the geometry of the grids.	Char Attribute	5,000	-	-	-	-
The Monthly Rainfall is the surface rainfall over oceans in 5° x 5° boxes from 40°N x 40°S.	Float SDS	4	nlat*nlon	-	0 – 3000	mm
The number of samples over the oceans in each 5° x 5° box for one month.	Integer SDS	4	nlat*nlon	-	0 – 500,000	-
Indicates how well the histogram of brightness temperatures fits the lognormal distribution function.	Integer SDS	4	nlat*nlon	-	$1 – 10^9$	0
Estimated height of the 0°C isotherm.	Float SDS	4	nlat*nlon	-	0 – 6	km
The mean of non-raining brightness temperatures.	Float SDS	4	nlat*nlon	-	160- 180	K
Logarithmic mean rain rate.	Float SDS	4	nlat*nlon	-	0 – 15	mm h^{-1}
Standard deviation of the logarithmic rain rate.	Float SDS	4	nlat*nlon	-	0 – 1	mm h^{-1}
Probability of rain in each 5° x 5° box.	Float SDS	4	nlat*nlon	-	0 – 1	-
	Integer SDS	2	nlat*nlon	-	-	
	Integer SDS	2	nlat*nlon	-	-	
Note that this product only includes data over oceans. Data over land are assigned the missing value of -9999.						

	Start Date: 1997-12-01 Stop Date: 2015-03-31
	Latitude: 40°S – 40°N Longitude: 180°W – 180°E
	Monthly
	0.5° x 0.5°; nlat = 160, nlon = 720
	≈ 56 MB compressed

	Start Date: 1997-12-01 Stop Date: 2015-03-31
	Latitude: 40°S – 40°N Longitude: 180°W – 180°E
	Monthly
	5° x 5° and 0.5° x 0.5°
	≈ 38 MB compressed

	Integer SDS	2	nlath*nlonh*2	0 to 2,000,000	-
The number of R-Z coefficient pixel counts conditioned on stratiform rain for near-surface and 2km heights over 0.5° x 0.5° boxes for one month.					
	Integer SDS	2	nlath*nlonh*2	0 to 2,000,000	-
The number of R-Z coefficient pixel counts conditioned on convective rain for near-surface and 2km heights over 0.5° x 0.5° boxes for one month.					
	Integer SDS	2	nlath*nlonh*2	0 to 2,000,000	-
The number of R-Z coefficient pixel counts for near-surface and 2km heights over 0.5° x 0.5° boxes for one month.					
	Integer SDS	2	nlath*nlonh	0 to 2,000,000	-
Counts of non-zero near-surface rain conditioned on stratiform rain over 0.5° x 0.5° boxes for one month.					
	Integer SDS	2	nlath*nlonh	0 to 2,000,000	-
Counts of non-zero near-surface rain conditioned on convective rain over 0.5° x 0.5° boxes for one month.					
	Integer SDS	2	nlath*nlonh	0 to 2,000,000	-
Counts of non-zero estimated surface rain conditioned on stratiform rain over 0.5° x 0.5° boxes for one month.					
	Integer SDS	2	nlath*nlonh	0 to 2,000,000	-
Counts of non-zero estimated surface rain conditioned on convective rain over 0.5° x 0.5° boxes for one month.					
	Integer SDS	2	nlath*nlonh	0 to 2,000,000	-
Counts of non-zero estimated surface rain over 0.5° x 0.5° box[redacted]nth.					

Integer SDS

[redacted]

	Integer SDS	4	nlath*nlonh	0 to 2,000,000,000.	-
Near-surface rain counts at a horizontal resolution of 0.5° x 0.5°					
	Integer SDS	4	nlath*nlonh	0 to 2,000,000	-
The number of bright band counts over each 0.5° x 0.5° box for one month					
	Integer SDS	4	nlath*nlonh	0 to 2,000,000	-
The Total Pixel Number 2 is the number of total pixels over 0.5° x 0.5° boxes for one month.					
	Float SDS	4	nlath*nlonh*2	0.0 to 1.0	mm h^{-1}
The B parameter in rainfall-reflectivity relation R = AZ^B from fitting of instantaneous R, Z pairs conditioned on stratiform rain. Computed for near-surface and 2km heights at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh*2	0.0 to 1.0	mm h^{-1}
The A parameter in rainfall-reflectivity relation R = AZ^B from fitting of instantaneous R, Z pairs conditioned on stratiform rain. Computed for near-surface and 2km heights at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh*2	0.0 to 1.0	mm h^{-1}
The B parameter in rainfall-reflectivity relation R = AZ^B from fitting of instantaneous R, Z pairs conditioned on convective rain. Computed for near-surface and 2km heights at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh*2	0.0 to 1.0	mm h^{-1}
The A parameter in rainfall-reflectivity relation R = AZ^B from fitting of instantaneous R, Z pairs conditioned on convective rain. Computed for near-surface and 2km heights at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh*2	0.0 to 1.0	mm h^{-1}
The B parameter in rainfall-reflectivity relation R = AZ^B from fitting of instantaneous R, Z pairs. Computed for near-surface and 2km heights at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh*2	0.0 to 1.0	mm h^{-1}
The A parameter in rainfall-reflectivity relation R = AZ^B from fitting of instantaneous R, Z pairs. Computed for near-surface and 2km heights at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 400.0	mm h^{-1}
Standard deviation of non-zero near-surface rain conditioned on stratiform rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 400.0	mm h^{-1}
Mean of non-zero near-surface rain conditioned on stratiform rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 400.0	mm h^{-1}
Standard deviation of non-zero near-surface rain conditioned on convective rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 400.0	mm h^{-1}
Mean of non-zero near-surface rain conditioned on convective rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 400.0	mm h^{-1}
Standard deviation of non-zero estimated surface rain below clutter (see 2A25 algorithm user guide) conditioned on stratiform rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 400.0	mm h^{-1}
Mean of non-zero estimated surface rain below clutter (see 2A25 algorithm user guide) conditioned on stratiform rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 400.0	mm h^{-1}
Standard deviation of non-zero estimated surface rain below clutter (see 2A25 algorithm user guide) conditioned on convective rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 400.0	mm h^{-1}
Mean of non-zero estimated surface rain below clutter (see 2A25 algorithm user guide) conditioned on convective rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 400.0	mm h^{-1}
Standard deviation of non-zero estimated surface rain below clutter (see 2A25 algorithm user guide) at a horizontal resolution of 0.5° x 0.5°					

	Float SDS	4	nlath*nlonh	0.0 to 400.0	mm h^{-1}
Mean of non-zero estimated surface rain below clutter (see 2A25 algorithm user guide) at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 3,000.0	mm h^{-1}
Standard deviation of shallow rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 3,000.0	mm h^{-1}
Mean of shallow rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 3,000.0	mm h^{-1}
Standard deviation of shallow isolated rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 3,000.0	mm h^{-1}
Mean of shallow isolated rain at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 5.0	-
Standard deviation of epsilon0 conditioned on stratiform rain and use of 2A21 SRT at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 5.0	-
Mean of epsilon0 conditioned on stratiform rain and use of 2A21 SRT at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 5.0	-
Standard deviation of epsilon0 conditioned on convective rain and use of 2A21 SRT at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 5.0	-
Mean of epsilon0 conditioned on convective rain and use of 2A21 SRT at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 5.0	-
Standard deviation of epsilon conditioned on stratiform rain and use of 2A21 SRT at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 5.0	-
Mean of epsilon conditioned on stratiform rain and use of 2A21 SRT at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 5.0	-
Standard deviation of epsilon conditioned on convective rain and use of 2A21 SRT at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 5.0	-
Mean of epsilon conditioned on convective rain and use of 2A21 SRT at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 20,000.0	m
Standard deviation of bright band height at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh*2	0.0 to 20,000.0	m
Standard deviation of storm height at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 20,000.0	m
Standard deviation of snow depth at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 20,000.0	m
Mean of snow depth at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 100	dBZ
Mean of maximum reflectivity in bright band at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 100.0	dBZ
Mean of maximum reflectivity in bright band at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 3000.0	mm h^{-1}
Standard Deviation of non-zero near-surface rain rate at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 3000.0	mm h^{-1}
Mean of non-zero near-surface rain rate at a horizontal resolution of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh	0.0 to 20,000.0	m
BB Height Mean gives the monthly means of bright-band height over grid boxes of 0.5° x 0.5°					
	Float SDS	4	nlath*nlonh*2	0.0 to 20,000.0	m
Storm Height Mean gives the monthly means of the storm height, unconditioned and conditioned for stratiform and convective rain over 0.5° x 0.5° grid boxes.					

	Float SDS	4	nlath*nlonh*nh3	0.1 to 80	dBZ
The monthly means of the corrected reflectivity of stratiform rain over 0.5° x 0.5° grid boxes.					
	Float SDS	4	nlath*nlonh*nh3	0.1 to 80.0	dBZ
Conv. Zm Mean 2 gives the monthly means of the corrected reflectivity of convective rain at the fixed heights of 2 km, 4 km, 6 km, and path average over 0.5° x 0.5° grid boxes.					
	Float SDS	4	nlath*nlonh*nh3	0.1 to 80.0	dBZ
Zt Mean 2 gives the monthly means of the corrected reflectivity at the fixed heights of 2 km, 4 km, 6 km, and path average over 0.5° x 0.5° grid boxes.					
	Float SDS	4	nlath*nlonh*nh3	-20.0 to 80.0	dBZ
Strat. Zm Means gives the monthly means of the measured reflectivity of stratiform rain at the fixed heights of 2 km, 4 km, 6 km, and path average over 0.5° x 0.5° grid boxes.					
	Float SDS	4	nlath*nlonh*nh3	-20.0 to 80.0	dBZ
Conv. Zm Mean 2 gives the monthly means of the measured reflectivity of convective rain at the fixed height levels of 2 km, 4 km, 6 km, and path average over 0.5° x 0.5° grid boxes.					
	Float SDS	4	nlath*nlonh*nh3	-20.0 to 80.0	dBZ
Zm Mean 2 gives the monthly means of the measured reflectivity at the fixed height levels of 2 km, 4 km, 6 km, and path average over 0.5° x 0.5° grid boxes.					
	Float SDS	4	nlath*nlonh*nh3	0.0 to 3000.0	mm h^{-1}
Strat. Rain Rate Dev. 2 gives standard deviations of non-zero rain rates for stratiform rain over 0.5° x 0.5° boxes for one month. The rain rates are determined in 2A-25 and evaluated at the Strat. Rain Rate Mean 2.					
	Float SDS	4	nlath*nlonh*nh3	0.0 to 3000.0	mm h^{-1}
Strat. Rain Rate Mean 2 gives means of non-zero rain rates for stratiform rain over 0.5° x 0.5° boxes for one month. The rain rates are determined in 2A-25 and evaluated at the fixed heights of 2 km, 4 km, 6 km, and path average.					
	Float SDS	4	nlath*nlonh*nh3	0.0 to 3000.0	mm h^{-1}
Conv. Rain Rate Dev. 2 gives standard deviations of non-zero rain rates for convective rain over 0.5° x 0.5° boxes for one month. The rain rates are determined in 2A-25 and evaluated at the fixed heights of 2 km, 4 km, 6 km, and path average.					
	Float SDS	4	nlath*nlonh*nh3	0.0 to 3000.0	mm h^{-1}
Conv. Rain Rate Mean 2 gives means of non-zero rain rates for convective rain over 0.5° x 0.5° boxes for one month. The rain rates are determined in 2A-25 and evaluated at the fixed heights of 2 km, 4 km, 6 km, and path average.					
	Float SDS	4	nlath*nlonh*nh3	0.0 to 3000.0	mm h^{-1}
Rain Rate Dev. 2 gives standard deviations of non-zero rain rates over 0.5 x 0.5 boxes for one month. The rain rates are determined in 2A-25 and evaluated at the fixed heights of 2 km, 4 km, 6 km, and path average.					
	Float SDS	4	nlath*nlonh*nh3	0.0 to 3000.0	mm h^{-1}
Rain Rate Mean 2 gives means of non-zero rain rates over 0.5° x 0.5° boxes for one month. The rain rates are determined in 2A-25 and evaluated at the fixed heights of 2 km, 4 km, 6 km, and path average.					
	Char Attribute	5,000	-	-	-
GridStructure gives the specification of the geometry of the grids.					
	Float SDS	4	nlat*nlon*nang*3	-1.000 to 1.000	-
This is the correlation coefficient of three path-integrated attenuations (SRT, HB, and 0th order PIAs) at angles of 0, 5, 10 and 15 for a 5° x 5° box for one month.					
	Float SDS	4	nlat*nlon*3	-1.000 to 1.000	-
These are correlation coefficients of non-zero rain rates for stratiform rain between 3 heights (i.e., correlation coefficient of rain rates at 2 km vs 4 km, 2 km vs 6 km, and 4 km vs 6 km) for a 5° x 5° box for one month.					
	Float SDS	4	nlat*nlon*3	-1.000 to 1.000	-
These are correlation coefficients of non-zero rain rates for convective rain between 3 heights (i.e., correlation coefficient of rain rates at 2 km vs 4 km, 2 km vs 6 km, and 4 km vs 6 km) for a 5° x 5° box for one month.					

	Float SDS	4	nlat*nlon*3	-1.000 to 1.000	-
These are correlation coefficients of non-zero rain rates between 3 heights (i.e., correlation coefficient of rain rates at 2 km vs 4 km, 2 km vs 6 km, and 4 km vs 6 km) for a 5° x 5° box for one month. They are calculated under convective condition, stratiform condition or both.					
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,000	-
Histogram of near-surface rain rate at a horizontal resolution of 5 x 5					
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,000	-
Histogram of epsilon0 conditioned on stratiform rain and use 2A21 SRT at a horizontal resolution of 5° x 5°					
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,000	-

	Integer SDS	2	nlat*nlon*ncat2	0 to 32,767	-	Histogram in counts of non-zero near-surface rainfall conditioned on convective rain for 30 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,767	-	Histogram in counts of non-zero estimated surface rain conditioned on stratiform rain for 30 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,767	-	Histogram in counts of non-zero estimated surface rain conditioned on convective rain for 30 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,767	-	Histogram in counts of non-zero estimated surface rain for 30 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,767	-	Histogram in counts of maximum Z in bright band from nadir ray for 30 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,767	-	Histogram in counts of bright band width from nadir ray for 30 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,767	-	Histogram in counts of bright band heights from nadir ray for 30 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2*nh1	0 to 32,767	-	These are histograms of non-zero rain rate pixels for stratiform rain at five heights (2, 4, 6, 10 and 15 km) and path-average for 20 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2*nh1	0 to 32,767	-	These are histograms of non-zero rain rate pixels for convective rain at five heights (2, 4, 6, 10 and 15 km) and path-average for 20 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2*nh1	0 to 32,767	-	These are histograms of non-zero rain rate pixels at five heights (2, 4, 6, 10 and 15 km) and path-average for 20 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2*nh1	0 to 32,767	-	The Stratiform Zt Histograms are histograms of corrected reflectivity factors for stratiform rain pixels at five heights (2, 4, 6, 10 and 15 km) and path-average for 20 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2*nh1	0 to 32,767	-	The Convective Zt Histograms are histograms of corrected reflectivity factors for convective rain pixels at five heights (2, 4, 6, 10 and 15 km) and path-average for 20 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2*nh1	0 to 32,767	-	The Zt Histograms are histograms of corrected reflectivity factors i for rain pixels at five heights (2, 4, 6, 10 and 15 km) and path-average for 20 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2*nh1	0 to 32,767	-	The Stratiform Zm Histograms are histograms of measured reflectivities of stratiform rain pixels at five heights (2, 4, 6, 10 and 15 km) and path-average for 20 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2*nh1	0 to 32,767	-	The Convective Zm Histograms are histograms of measured reflectivities of convective rain pixels at five heights (2, 4, 6, 10 and 15 km) and path-average for 20 categories over a 5° x 5° box for one month.
	Integer SDS	2	nlat*nlon*ncat2*nh1	0 to 32,767	-	The Zm Histograms are histograms of measured reflectivities of rain pixels at five heights (2, 4, 6, 10 and 15 km) and path-average for 20 categories over a 5° x 5° box i for one month.

	Integer SDS	2	nlat*nlon*ncat2	0 to 32,767	-
These are histograms of the bright-band heights for 30 categories over a 5 x 5 box for one month, given that the bright band is detected.					
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,767	-
These are histograms of the 'effective' storm heights for stratiform rain for 30 categories over a 5° x 5° box for one month.					
	Integer SDS	2	nlat*nlon*ncat2	0 to 32,767	-
These are histograms of the 'effective' storm heights for					

	Integer SDS	4	nlat*nlon	0 to 2,000,000	-
The number of non-zero estimated surface rain pixel counts at a horizontal resolution of 5° x 5°					
	Integer SDS	2	nlat*nlon	0 to 32,767	-
Counts of Near-surface rain fall conditioned on stratiform rain at a horizontal resolution of 5° x 5°					
	Integer SDS	2	nlat*nlon	0 to 32,767	-
Counts of Near-surface rain fall conditioned on convective rain at a horizontal resolution of 5° x 5°					
	Integer SDS	4	nlat*nlon	0 to 2,000,000	-
Near-surface rain counts at a horizontal resolution of 5° x 5°					
	Integer SDS	2	nlat*nlon*nang	0 to 30,000	-
Rain Angle Pixel Number 1 is the total number of non-zero rain rate pixels over each 5° x 5° latitude-longitude grid box for a month. This parameterTJETQ4 545.62 520.78 24.36 reW*-4(e)4(t)-4(o)-2(ta)-4(l n[(-)] TJETQq6)-5Fa_86 669.7 36.84 12.12 reW*					

	Float SDS	4	nlat*nlon	0.0 to 400.0	mm h^{-1}
Mean of non-zero estimated surface rain below clutter (See 2A25 algorithm user guide) conditioned on stratiform rain at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 400.0	mm h^{-1}
Standard deviation of non-zero estimated surface rain below clutter (See 2A25 algorithm user guide) conditioned on convective rain at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 400.0	mm h^{-1}
Mean of non-zero estimated surface rain below clutter (See 2A25 algorithm user guide) conditioned on convective rain at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 400.0	mm h^{-1}
Standard deviation of non-zero estimated surface rain below clutter (See 2A25 algorithm user guide) at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 400.0	mm h^{-1}
Mean of non-zero estimated surface rain below clutter (See 2A25 algorithm user guide) at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 20,000.0	m
Standard deviation of snow depth at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 20,000.0	m
Mean of snow depth at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 100.0	dBZ
Standard Deviation of maximum reflectivity in bright band at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 100.0	dBZ
Mean of maximum reflectivity in bright band at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 3000.0	mm h^{-1}
Standard deviation of non-zero near-surface rain rate conditioned on stratiform rain at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 3000.0	mm h^{-1}
Mean of non-zero near-surface rain rate conditioned on stratiform rain at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 3000.0	mm h^{-1}
Standard deviation of non-zero near-surface rain rate conditioned on convective rain at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 3000.0	mm h^{-1}
Mean of non-zero near-surface rain rate conditioned on convective rain at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 3000.0	mm h^{-1}
Standard deviation of non-zero near-surface rain rate at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 3000.0	mm h^{-1}
Mean of non-zero near-surface rain rate at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 5.0	-
Standard deviation of epsilon0 conditioned on stratiform rain and use of 2A21 SRT at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 5.0	-
Mean of epsilon0 conditioned on stratiform rain and use of 2A21 SRT at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 5.0	-
Standard deviation of epsilon0 conditioned on convective rain and use of 2A21 SRT at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 5.0	-
Mean of epsilon0 conditioned on convective rain and use of 2A21 SRT at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 5.0	-
Standard deviation of epsilon conditioned on stratiform rain and use of 2A21 SRT at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 5.0	-
Mean of epsilon conditioned on stratiform rain and use of 2A21 SRT at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 5.0	-
Standard deviation of epsilon conditioned on convective rain and use of 2A21 SRT at a horizontal resolution of 5° x 5°					

	Float SDS	4	nlat*nlon	0.0 to 5.0	-
Mean of epsilon conditioned on convective rain and use of 2A21 SRT at a horizontal resolution of 5° x 5°					
	Float SDS	4	nlat*nlon	0.0 to 70.0	dBZ

	Float SDS	4	nlat*nlon*nh1	0.0 to 100.0	dBZ
Monthly standard deviations of measured radar reflectivity for stratiform rain at a horizontal resolution of 5° x 5°. The path-averaged standard deviation and those at the fixed heights of 2, 4, 6, 10 and 15 km are calculated using data from 1C-21.					
	Float SDS	4	nlat*nlon*nh1	0.0 to 100.0	dBZ
Monthly means of measured radar reflectivity for stratiform rain at a horizontal resolution of 5° x 5°. The path-averaged mean and means at the fixed heights of 2, 4, 6, 10 and 15 km are calculated using data from 1C-21.					
	Float SDS	4	nlat*nlon*nh1	0.0 to 100.0	dBZ
Monthly standard deviations of measured radar reflectivity for convective rain at a horizontal resolution of 5° x 5°. The path-averaged standard deviation and those at the fixed heights of 2, 4, 6, 10 and 15 km are calculated using data from 1C-21.					
	Float SDS	4	nlat*nlon*nh1	0.0 to 100.0	dBZ
Monthly means of measured radar reflectivity for convective rain at a horizontal resolution of 5° x 5°. The path-averaged mean and means at the fixed heights of 2, 4, 6, 10 and 15 km are calculated using data from 1C-21.					
	Float SDS	4	nlat*nlon*nh1	0.0 to 100.0	dBZ
Monthly standard deviations of measured radar reflectivity at the fixed heights of 2, 4, 6, 10 and 15 km and for path-average over 5° x 5° boxes using data from 1C-21					
	Float SDS	4	nlat*nlon*nh1	0.0 to 100.0	dBZ
Monthly means of measured radar reflectivity at the fixed heights of 2, 4, 6, 10 and 15 km and for path-average over 5° x 5° boxes using data from 1C-21					
	Float SDS	4	nlat*nlon*nh1	0.0 to 3000.0	mm h^{-1}
Monthly standard deviations of non-zero rain rates for stratiform rain over 5° x 5° boxes					
	Float SDS	4	nlat*nlon*nh1	0.0 to 3000.0	mm h^{-1}
Monthly means of non-zero rain rates for stratiform rain over 5° x 5° boxes					
	Float SDS	4	nlat*nlon*nh1	0.0 to 3000.0	mm h^{-1}
Monthly standard deviations of non-zero rain rates for convective rain over 5° x 5° boxes					
	Float SDS	4	nlat*nlon*nh1	0.0 to 3000.0	mm h^{-1}
Monthly means of non-zero rain rates for convective rain over 5° x 5° boxes					
	Float SDS	4	nlat*nlon*nh1	0.0 to 3000.0	mm h^{-1}
Monthly standard deviations of non-zero rain rates over 5° x 5° boxes					
	Float SDS	4	nlat*nlon*nh1	0.0 to 3000.0	mm h^{-1}
Monthly means of non-zero rain rates over 5° x 5° boxes					
	Char Att.	5,000	-	-	-
GridStructure gives the specification of the geometry of the grids.					
	Char Att.	10,000	-	-	-

	Start Date: 1997-12-01 Stop Date: 2015-03-31
	Latitude: 40°S – 40°N Longitude: 180°W – 180°E
	Monthly
	5° x 5°; nlat = 16, nlon = 72
	≈ 6 MB compressed

ECS core metadata	Char Att.	10,000	-	-	-
Product specific metadata	Char Att.	10,000	-	-	-
GridStructure gives the specification of the geometry of the grids.	Char Att.	5,000	-	-	-
Total number of counts (measurements) per month at each 5° x 5° boxes.	Integer SDS	4	nlat*nlon	0 – 2,147,483,647	-
Total number of rain counts (measurements) per month at each 5° x 5° boxes. This is computed at 2km, 4km, 6km, and for the path-average.	Integer SDS	4	nlat*nlon*nh2	0 – 2,147,483,647	-
Probability distribution function (cumulative) in counts of the zeroth order rain rate estimate at each 5° x 5° boxes. The pDf is computed at 2km, 4km, 6km, and for the path-average.	Integer SDS	4	nlat*nlon*ncat3*nh2*nthrsh	1 – 2,147,483,647	-
Probability distribution function (cumulative) in counts of the Hitschfield-Bordan (HB) rain rate estimate at each 5° x 5° boxes. The pDf is computed at 2km, 4km, 6km, and for the path-average.	Integer SDS	4	nlat*nlon*ncat3*nh2*nthrsh	1 – 2,147,483,647	-
Probability distribution function (cumulative) in counts of the Surface Reference Technique (SRT) rain rate estimate at each 5° x 5° boxes. The pDf is computed at 2km, 4km, 6km, and for the path-average.	Float SDS	4	nlat*nlon*ncat3*nh2*nthrsh	1 – 2,147,483,647	-
The mean, variance, and probability of rain parameters for the log-normal model obtained from the zeroth order pDf. Fitting parameters are given at 2km, 4km, 6km, and for the path-average. In addition, 5 thresholds are used.	Float SDS	4	nlat*nlon*nh2*3*nthrsh	1 – 2,147,483,647	-
The 3 fitting parameters for the log-normal model obtained from the HB pDf. Fitting parameters are given at 2km, 4km, 6km, and for the path-average. In addition, 5 thresholds are used.	Float SDS	4	nlat*nlon*nh2*3*nthrsh	-	-
The 3 fitting parameters for the log-normal model obtained from the SRT pDf. Fitting parameters are given at 2km, 4km, 6km, and for the path-average.	Float SDS	4	nlat*nlon*nh2*3*nthrsh	-	-
Reliability parameter for the 0th order fit.	Float SDS	4	nlat*nlon*nh2*nthrsh	-	-
Reliability parameter for the HB fit.	Float SDS	4	nlat*nlon*nh2*nthrsh	-	-
Reliability parameter for the SRT fit.	Float SDS	4	nlat*nlon*nh2*nthrsh	-	-
The mean monthly unconditioned rain rate (mm/h) as determined from the threshold method (in particular, it is determined from the fitting parameters fro the '-th-order method' using a single 'Q' threshold for each height level).	Float SDS	4	nlat*nlon*nh3	0 – 3000	mm h^{-1}

	Start Date: 1997-12-01 Stop Date: 2015-03-31
	Latitude: 40°S – 40°N Longitude: 180°W – 180°E
	Monthly
	0.5° x 0.5°; nlat = 160, nlon = 720
	≈ 37 MB compressed

	Char Attribute	10,000	-	-	-
ECS core metadata					
	Char Attribute	10,000	-	-	-
Product specific metadata					
	Char Attribute	5,000	-	-	-
GridStructure gives the specification of the geometry of the grids.					
	Float SDS	4	nlat*nlon	0 – 3000	mm
Surface rain from 2A12 accumulated in each 0.5° x 0.5° box					
	Float SDS	4	nlat*nlon	0 – 3000	mm
Convective surface rain from 2A12 accumulated in each 0.5° x 0.5° box					
	Float SDS	4	nlat*nlon*nlayer	0 – 10	g m^{-3}
Monthly mean rain water content from 2A12 at each vertical layer in each 0.5° x 0.5° box					
	Float SDS	4	nlat*nlon*nlayer	0 – 10	g m^{-3}
Monthly mean snow liquid content from 2A12 at each vertical layer in each 0.5° x 0.5° box					
	Float SDS	4	nlat*nlon*nlayer	0 – 10	g m^{-3}
Monthly mean graupel liquid content from 2A12 at each vertical layer in each 0.5° x 0.5° box					
	Integer SDS	4	nlat*nlon	1 – 10000	-
The monthly number of pixels with pixelStatus equal to zero for each grid. The major effect of the pixelStatus requirement is to remove sea ice. npixTotalTMI is used to compute the monthly means described above.					
	Float SDS	4	nlat*nlon	0 – 3000	mm
[redacted]					
	Float SDS	4	nlat*nlon*nlayer	0 – 10	g m^{-3}
Rain water content at each vertical layer from 2B31 accumulated in each 0.5° x 0.5° box					
	Float SDS	4	nlat*nlon*nlayer	0 – 10	g m^{-3}

Notes:

- The "scale by" column was omitted because none of the 3B31 variables are scaled.
- The dimension represents the number of profiling layers per grid box. There are 28 vertical layers (nlayer) that span from 0.5 km to 10 km by 0.5 km and then from 10 km to 18 km by 1 km.

	Start Date: 1997-12-01 Stop Date: 2015-03-31
	Latitude: 90°S – 90°N Longitude: 0° – 360°
	Monthly
	1° x 1°; nlat = 80, nlon = 360
	≈ 300 KB uncompressed

	Char Attribute	10,000	-	-	-
ECS core metadata					
	Char Attribute	10,000	-	-	-
Product specific metadata					
	Char Attribute	5,000	-	-	-
GridStructure gives the specification of the geometry of the grids.					
	Float SDS	4	180*360*2	0 – 100 (1st variable) 0 – 10^9 (2nd variable)	mm hr^{-1}
SSM/I data averaged over 1° x 1° grid boxes and one month. The first variable is Precipitation Rate (mm/hr); the range is 0 to 100. The second variable is Number of Observations; the range is 0 to one billion.					

Note that the grids in SSM/I data are different than the standard TSDIS grids in the following ways:

- the longitude dimension precedes the latitude dimension;
- the longitude index begins at the Greenwich meridian;
- the latitude index begins at the northernmost row;
- the latitude range is -90° to +90°;
- Missing data are given the value of -9999.

	Start Date: 1997-12-01 Stop Date: to present
	Latitude: 50°S – 50°N Longitude: 180°W – 180°E
	Monthly
	0.25° x 0.25°; nlat = 400, nlon = 1440
	≈ 0.71 MB compressed, ≈ 11 MB uncompressed

ECS core metadata	Char Attribute	10,000	-	-	-
Product specific metadata	Char Attribute	10,000	-	-	-
GridStructure gives the specification of the geometry of the grids.	Char Attribute	5,000	-	-	-
TRMM Multi-satellite precipitation analysis (TMPA) precipitation estimate	Float SDS	4	nlat*nlon	0 – 100	mm hr^{-1}
TMPA random error estimate	Float SDS	4	nlat*nlon	0 – 100	mm hr^{-1}
Flag to show source of data in each box	Float SDS	4	nlat*nlon	-	-
Pre-gauge-adjusted microwave precipitation estimate in each grid box.	Float SDS	4	nlat*nlon	0 – 100	mm hr^{-1}
Pre-gauge-adjusted infrared precipitation estimate in each grid box.	Float SDS	4	nlat*nlon	0 – 100	mm hr^{-1}
Satellite observation time minus the time of the granule in each grid box.	Integer SDS	1	nlat*nlon	-90 – 90	minute

Notes:

- Missing data are given the value of -9999.9.

	Start Date: 1997-12-01 Stop Date: to present

	Start Date: 1997-12-01 Stop Date: to present
	Latitude: 50°S – 50°N Longitude: 180°W – 180°E
	Monthly
	0.5° x 0.5°; nlat = 148, nlon = 720
	≈ 8.0 MB uncompressed

Note that the layers are the same as those described for 3B31.

4.0 Options for Reading the Data

Examples that show how to read TRMM data files are shown throughout section 4. For the sake of consistency, each example will use TRMM 3B42 3-hourly data from 24 August 2012 at 12 UTC. The name of this file is and is described on page 55. This document will focus on the variable. This tutorial assumes that the file is uncompressed, so its name ends in .HDF.

To uncompress the file on a UNIX-based system (including Mac OS X), use the following command: .

Note that most of the gridded TRMM files do not include latitude or longitude metadata. The bounds for each product are specified in the preceding pages of this README as well as in the descriptions of each HDF file. TRMM data are stored as the center of grid boxes, so for example, 3B42 data that has latitude and longitude bounds of 50°S – 50°N and 180°W – 180°E, respectively, can be represented by a latitude array from -49.875 to +49.875 and a longitude array of -179.875 to +179.875, both with a grid spacing of 0.25.

4.1 Command Line Utilities and Programs

4.1.1 GrADS

The Grid Analysis and Display System (GrADS) is well-suited for the visualization of TRMM data. However, since the TRMM files do not have embedded latitude and longitude data, they are not considered "self-describing". This means that latitude and longitude information must be specified in a separate file for GrADS to correctly interpret the data.

A data descriptor file must be created that tells GrADS information about the latitude and longitude data within the TRMM 3B42 data file. Below are the contents of a sample data descriptor file.

Note that the example below only includes the variable. Simply list other variables underneath (or instead of) the variable to read in different data.

```
DSET 3B42.20120824.12.7.HDF
UNDEF -9999.9
XDEF nlon 1440 LINEAR -179.875 0.25
YDEF nlat  400 LINEAR  -49.875 0.25
TDEF nlat 1 LINEAR 12z24Aug2012 3hr
VARS 1
precipitation=>precip 0 3B42_Precipitation
ENDVARS
```

The following assumes that the contents above are saved in a file called . To open GrADS, type at the system prompt and then choose landscape or portrait mode.

At the GrADS prompt (ga->):

ga->xdfopen precip
Scanning Descriptor File: precip
SDF file 3B42.20120824.12.7.HDF is open as file 1
LON set to 0 360
LAT set to -49.875 49.875
LEV set to 0 0
Time values set: 2012:8:24:12 2012:8:24:12
E set to 1 1

The GrADS output should be the same as the text above in red.

To view an image of the precipitation data, type:
ga-> d precip

To have GrADS shade the data instead of contouring, type:
ga-> gxout shaded
ga-> d precip

If you've already plotted the data with contours, you can clear before plotting the shaded data:
ga-> clear graphics

There are numerous options for customizing plots in GrADS. For more information on using GrADS, or more information on Grads visit http://cola.gmu.edu/grads/.

4.1.2 MATLAB

MATLAB can be used to load, manipulate, and view TRMM precipitation data. To load the variable from the aforementioned TRMM file into MATLAB type:

```
>> precip = permute(hdfread('3B42.20120824.12.7.HDF','precipitation'),[2 1]);
```

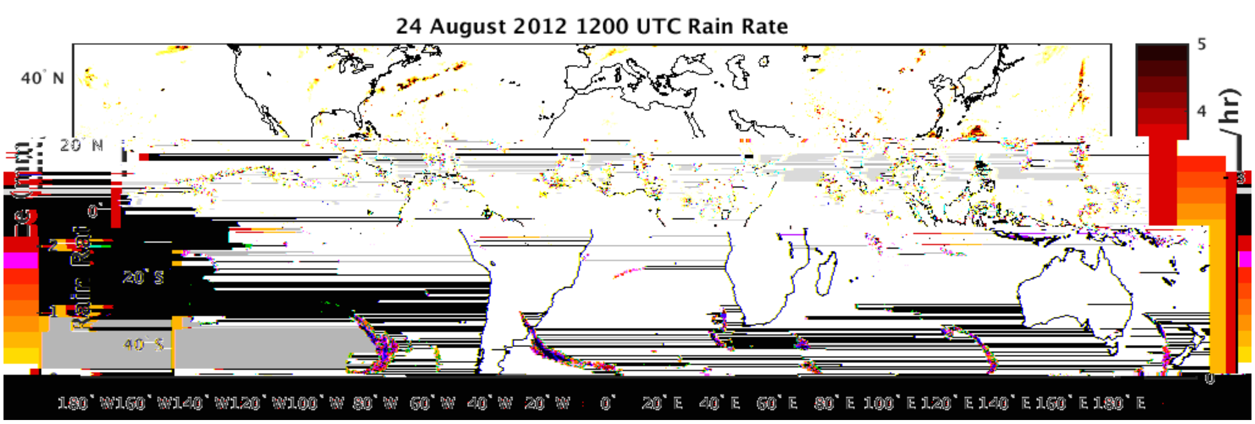
This will load the data into a matrix called . Missing data are represented by , but MATLAB doesn't know that this value refers to missing data. The simplest way to replace the missing numeric values with MATLAB's not-a-number (NaN) values, is to type:

```
>> precip(precip < 0) = NaN;
```

It is okay to set all values less than zero to NaN since precipitation rate is a positive quantity. Users with the Mapping Toolbox can plot the precipitation data on a map using the following code:

```
figure;
axesm('MapProjection','eqdcylin','maplatlimit',[-50 50],'maplonlimit',[-180 180],...
   'ParallelLabel','on','PlabelMeridian','west','MeridianLabel','on','MLabelParallel','south',...
   'FontSize',6,'FontWeight','bold','PLineLocation',20,'MLineLocation',20);
latitudes = -49.875:0.25:49.875; % These must be explicitly defined since they are not in the file.
longitudes = -179.875:0.25:179.875;
[latGrid, lonGrid] = meshgrat(latitudes,longitudes);
geoshow(latGrid,lonGrid,double(precip),'DisplayType','texturemap');

caxis([0 5]);

% There are lots of color maps to choose from, run the command "doc colormap" to see them
colormap(flipud(hot(21)));
chandle = colorbar('Location','EastOutside','FontSize',6,'FontWeight','bold'); % This line places the colorbar
set(get(chandle,'ylabel'),'String','Rain Rate (mm/hr)','FontSize',10,'FontWeight','Bold'); % Set the colorbar's label
set(chandle,'YTick',0:5);

% You should plot the continent boundaries after the shading is done.
states = geoshape(shaperead('landareas', 'UseGeoCoords', true));
geoshow(states,'DefaultFaceColor','none','DefaultEdgeColor','k');
tightmap
title('24 August 2012 1200 UTC Rain Rate','FontSize',8,'FontWeight','bold');
print -dpng sampleTRMMmap.png
```

The code above should save a .png file that looks like Figure 1 below.



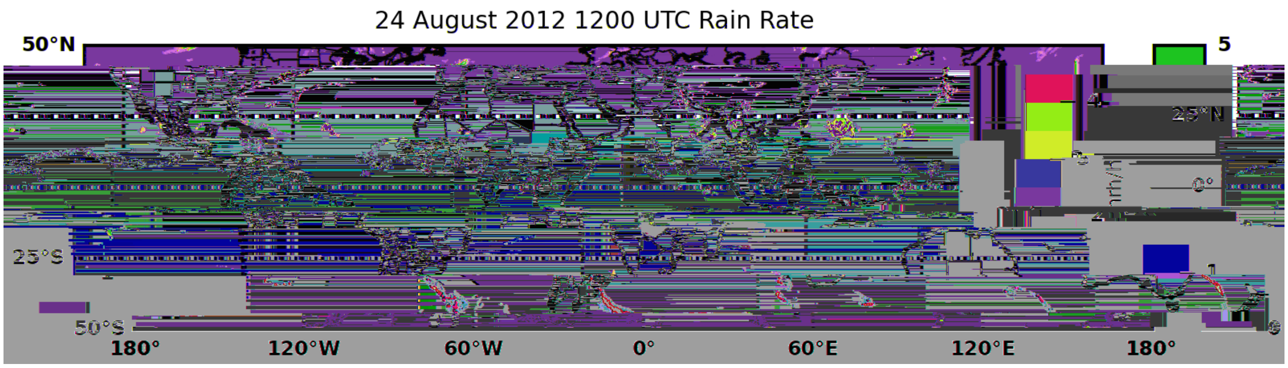
4.1.3 Python

Like GrADS and MATLAB, Python can be used to read, manipulate, and plot data. Below is a script that can be used as-is within Python to read and plot the TRMM data. It was written to be as similar to the aforementioned MATLAB script as possible. Please note that you must have the free numpy, matplotlib, basemap, and pyhdf packages to use this script.

```
# This is a test script that reads and plots the TRMM 3B42 3-hourly data.
from mpl_toolkits.basemap import Basemap, cm
import matplotlib.pyplot as plt
import numpy as np
from pyhdf.SD import SD, SDC

dataset = SD('/path/to/3B42.20120824.12.7.HDF', SDC.READ)

precip = dataset.select('precipitation')
precip = precip[:]
precip = np.transpose(precip)

theLats = np.arange(-49.875,50,0.25)
theLons = np.arange(-179.875,180,0.25)

# Set all the missing values less than 0 to NaNs
np.putmask(precip,precip<0,np.nan)

# Plot the figure, define the geographic bounds
fig = plt.figure(dpi=300)
latcorners = ([-50,50])
loncorners = ([-180,180])

m = Basemap(projection='cyl',\
llcrnrlat=latcorners[0],urcrnrlat=latcorners[1],llcrnrlon=loncorners[0],urcrnrlon=loncorners[1])

# Draw coastlines, state and country boundaries, edge of map.
m.drawcoastlines()
m.drawstates()
m.drawcountries()

# Draw filled contours.
clevs = np.arange(0,5.01,0.5)

# Define the latitude and longitude data
x, y = np.float32(np.meshgrid(theLons, theLats))
cs = m.contourf(x,y,precip,clevs,cmap=cm.GMT_drywet,latlon=True)

parallels = np.arange(-50.,51,25.)
m.drawparallels(parallels,labels=[True,False,True,False])
meridians = np.arange(-180.,180.,60.)
m.drawmeridians(meridians,labels=[False,False,False,True])
```

```
# Set the title and fonts
plt.title('24 August 2012 1200 UTC Rain Rate')
font = {'family' : 'normal', 'weight' : 'bold', 'size' : 6}
plt.rc('font', **font)

# Add colorbar
cbar = m.colorbar(cs,location='right',pad="5%")
cbar.set_label('mm/h')

plt.savefig('testTRMMmap.png',dpi=300)
```

The map shown below as Figure 2 results from the Python code above:



4.1.4 hdp and ncdump

The HDF Toolkit ships with two binary executables, and , that can be used to extract values from any HDF file. These are also available as standalone executable from the utilities folders found within each operating system at: ftp://ftp.hdfgroup.org/HDF/HDF_Current/bin.

can only read HDF files if your local copy of netCDF was originally compiled with HDF support.

To dump the entire file: or

To get just the header information: or

A partial example of output from is given below. (The output is similar.)

```
File attributes:
        Attr0: Name = FileHeader
               Type = 8-bit signed char
               Count= 357
               Value = AlgorithmID=3B42;\012AlgorithmVersion=3B4
              2_7.0;\012FileName=3B42.20120824.12.7.HDF
              ;\012GenerationDateTime=2012-10-26T14:07:
              33.000Z;\012StartGranuleDateTime=2012-08-
              24T10:30:00.000Z;\012StopGranuleDateTime=
              2012-08-24T13:29:59.999Z;\012GranuleNumbe
              r=;\012NumberOfSwaths=0;\012NumberOfGrids
              =1;\012GranuleStart=;\012TimeInterval=3_H
              OUR;\012ProcessingSystem=PPS;\012ProductV
              ersion=7;\012MissingData=;\012
        Attr1: Name = FileInfo
               Type = 8-bit signed char
               Count= 253
               Value = DataFormatVersion=m;\012TKCodeBuildVersio
              n=1;\012MetadataVersion=m;\012FormatPacka
              ge=HDF Version 4.2 Release 4, January 25,
               2009;\012BlueprintFilename=TRMM.V7.3B42.
              blueprint.xml;\012BlueprintVersion=BV_13;
              \012TKIOVersion=1.6;\012MetadataStyle=PVL
              ;\012EndianType=LITTLE_ENDIAN;\012
        Attr2: Name = GridHeader
               Type = 8-bit signed char
               Count= 231
               Value = BinMethod=ARITHMETIC_MEAN;\012Registratio
              n=CENTER;\012LatitudeResolution=0.25;\012
              LongitudeResolution=0.25;\012NorthBoundin
              gCoordinate=50;\012SouthBoundingCoordinat
              e=-50;\012EastBoundingCoordinate=180;\012
              WestBoundingCoordinate=-180;\012Origin=SO
              UTHWEST;\012

Variable Name = precipitation
        Index = 0
        Type= 32-bit floating point
        Ref. = 2
        Compression method = NONE
        Rank = 2
        Number of attributes = 1
        Dim0: Name=nlon
               Size = 1440
               Scale Type = number-type not set
               Number of attributes = 0
        Dim1: Name=nlat
               Size = 400
               Scale Type = number-type not set
               Number of attributes = 0
        Attr0: Name = units
               Type = 8-bit signed char
```

```
Count= 5
Value = mm/hr
```

4.2 Tools/Programming

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This section briefly explains some programs and websites that can be used for TRMM data access, manipulation, and viewing.

ncdump

The ncdump tool can be used as a simple browser for HDF data files, to display the dimension names and sizes; variable names, types, and shapes; attribute names and values; and optionally, the values of data for all variables or selected variables in a netCDF file. The most 29055 TTfETQ EMC (or)6et- common use of ncdump is with the –h option, in which only the header information is displayed.

```
ncdump [-c|-h] [-v ...] [[-b|-f] [c|f]] [-l len] [-n name] [-d n[,n]] filename
```

[-c] Coordinate variable data and header information

n1s a nr

list lists contents of files in <filelist>
dumpsds displays data of SDSs in <filelist>
dumpvd displays data of vdatas in <filelist>.
dumpvg displays data of vgroups in <filelist>.
dumprig displays data of RIs in <filelist>.
dumpgr displays data of RIs in <filelist>.

Giovanni 4

TRMM data can be found on NASA's data visualization website called Giovanni at https://giovanni.gsfc.nasa.gov/giovanni/. Giovanni allows users to create maps, animations, hovmöller diagrams, vertical cross sections, and more using a number of TRMM products including the 3B42, 3B43, and 3A12 products.

HDFView

HDFView is a Java based graphical user interface created by the HDF Group, which can be used to browse TRMM HDF files. HDFView allows users to view all objects in the HDF file hierarchy, which is represented as a tree structure. It also allows users to browse the data within each variable.

HDFView download and documentation can be found at: https://www.hdfgroup.org/products/java/hdfview/.

5.0 Data Services

You can familiarize yourself with TRMM data at: https://disc.gsfc.nasa.gov/datasets?project=TRMM.

Once you know which data you want, you can use the following services:

Mirador

Mirador (located at https://mirador.gsfc.nasa.gov)can be used to locate and download all of the TRMM data products described in this README document. In addition to basic data availability, Mirador allows users to convert some products, such as the 3B42 products, into NetCDF format before downloading.

OPeNDAP

Many TRMM products can be found on the GES DISC OPeNDAP website: https://disc2.gesdisc.eosdis.nasa.gov/opendap/. OPeNDAP allows users to access and manipulate subsets of data without downloading the entire files.

Simple Subset Wizard (SSW)

Many of the TRMM products can be subset, and then downloaded, using the Simple Subset Wizard available here: https://disc.gsfc.nasa.gov/SSW/#keywords=TRMM.

If you need assistance or would like to report a problem:

: gsfc-help-disc@lists.nasa.gov
: 301-614-5224
: 301-614-5268

:
Goddard Earth Sciences Data and Information Services Center
NASA Goddard Space Flight Center
Code 610.2
Greenbelt, MD 20771 USA

6.0 More Information

The TRMM mission website is located at: https://pmm.nasa.gov/trmm.

Information on the TRMM instruments can be found at: https://pmm.nasa.gov/TRMM/trmm-instruments.

The GES DISC TRMM information portal can be found at:

https://disc.gsfc.nasa.gov/information/glossary?title=TRMM

TRMM Version 7 File Specifications:
https://pps.gsfc.nasa.gov/Documents/filespec.TRMM.V7.pdf

TRMM Anomalous Granule Table:
ftp://gpmweb2.pps.eosdis.nasa.gov/tsdis/AB/docs/anomalous.html

Other TRMM documents: http://pps.gsfc.nasa.gov/ppsdocuments.html

J. Simpson, Adler, R.F., and North, G.R., 1988: A proposed tropical rainfall measuring mission (TRMM) satellite. ., , 278–295. (Link)

C. Kummerow, Barnes, W., Kozu, T., Shiue, J., Simpson, J, 1998: The tropical rainfall measuring mission (TRMM) sensor package. , , 809–817. (Link)

Liu, Z. D. Ostrenga, W. Teng and S, Kempler, 2012, Tropical Rainfall Measuring Mission (TRMM) Precipitation Data Services for Research and Applications, Bulletin of the American Meteorological Society, doi: http://dx.doi.org/10.1175/BAMS-D-11-00152.1 (Link)

7.0 Acknowledgements

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