TROPICAL RAINFALL MEASURING MISSION SCIENCE DATA AND INFORMATION SYSTEM

Tropical Rainfall Measuring Mission (TRMM) Realtime System File Specification

Release 2.53

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
Code 610.2
Greenbelt, Maryland 20771

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1. INTRODUCTION

The Tropical Rainfall Measuring Mission (TRMM) is an integral part of the National Aeronautics and Space Administration (NASA) Earth Science Enterprise. The TRMM observatory was launched in 1997 into a near circular orbit of approximately 350 kilometers altitude with an inclination of 35 degrees and a period of 91.5 minutes (15.7 orbits per day). During August 2001, the TRMM altitude was raised to approximately 402.5 kilometers with a period of 92.5 minutes (15.6 orbits per day). The TRMM Science Data and Information System (TSDIS) is the data processing and science information system for TRMM. The Earth Observing System Data and Information System (EOSDIS) serves as the long-term archive for all TRMM data products. The TRMM Realtime system has a target of making each Level-1 and Level-2 realtime product available within three hours after the oldest observation in the product, 90% of the time. The target for the Level-3 Realtime products is five hours after the oldest observation, due to delay in receiving some of the input.

1.1 IDENTIFICATION

This is the File Specification for the TRMM Realtime System. This document describes the file formats for Level 1 and Level 2 TRMM products.

1.2 PURPOSE AND OBJECTIVES

The purpose of this file specification document is to define the file content and format for the TRMM Realtime Level-1, Level-2 and Level-3 data products. Level-1 data products can be divided into Level-1B and Level-1C data products. Level-2 data products can be divided into TRMM Microwave Imager (TMI) and Precipitation Radar (PR) data products.

The specifications in this document incorporate the results from a series of meetings with EOSDIS for agreements on file structure, and TRMM science team members for file contents. Discussions with other missions that have similar data sets have helped to form the initial basis for the file specifications. In addition, characteristics from popular formats were incorporated into the file formats (e.g., the Wentz format is used to help develop the TMI file specification).

1.3 DOCUMENT ORGANIZATION

The document is organized as follows:

Section 1.0 INTRODUCTION - This section presents the information regarding this document in terms of document identification and purpose. It further defines the contents of the document.

Section 2.0 EOSDIS AND HDF - This section describes EOSDIS structures, aspects of Hierarchical Data Format (HDF) which are used in the TSDIS file formats, and the approach to recording metadata.

Section 3.0 FORMATTING CONVENTIONS - This section describes general formatting conventions used in this document.

Section 4.0 LEVEL 1 PRODUCTS - This section describes the file specifications for the Level 1 TMI and Level 1 Visible Infrared Scanner (VIRS) data products. It provides a brief description of the instruments and the scan geometry as an introduction. The structure of the TMI and the VIRS files are provided, along with descriptions of the data objects and the associated metadata.

Section 5.0 LEVEL 2 PRODUCTS - This section describes the file specifications for the Level 2 TMI and Level 2 PR data products. It provides a brief description of the instruments and the scan geometry as an introduction. The structure of the TMI and the PR files are provided, along with descriptions of the data objects and the associated metadata.

Section 6.0 LEVEL 3 PRODUCTS - This section describes the file specifications for the Level 3 TRMM and Other data products. The structure of the data files are provided, along with descriptions of the data objects and the associated metadata.

Section 7.0 ABREVIATIONS AND ACRONYMS - This section lists the abbreviations and acronyms used in this document.

Section 8.0 GLOSSARY - This section defines the unique terminology used in this document.

APPENDIX A ECS CORE METADATA ELEMENTS - This appendix provides a description of each EOSDIS Core System (ECS) Core metadata element .

APPENDIX B PRODUCT SPECIFIC METADATA ELEMENTS - This appendix provides a description of each Product Specific (PS) Core metadata element .

APPENDIX C TRMM AND OTHER DATA METADATA ELEMENTS - This appendix provides a description of each TRMM and Other Data Metadata element.

2. EOSDIS AND HDF

2.1 EOSDIS STRUCTURES

2.1.1 Swath Structure

The swath structure stores satellite data which are organized by scans. TSDIS implements the swath structure in Levels 1B, 1C, 2A, and 2B satellite products. Figure 2.1.1-1 shows a generic swath structure as it is used in TSDIS data products. The swath structure is contained in a Vgroup (Vgroups are defined in Section 2.2), with the name SwathData and the class SwathData. In the SwathData Vgroup are Scan Time, Geolocation, and Instantaneous Field of View (IFOV) data. For all of these objects, the scan dimension has the least rapidly varying index. The Scan Time is a Vdata (8-byte float or several integers whose sizes sum to 8 bytes; Vdata is defined in Section 2.2). The Geolocation is a Scientific Data Set (SDS) (defined in Section 2.2) containing scaled latitude and longitude (2-byte integer). Scan data are data that apply to the whole scan and can take the form of one or more Vdatas or SDSs. The IFOV data occur at every pixel or at regular pixel intervals (e.g., every 10 pixels) and take the form of one or more SDSs.

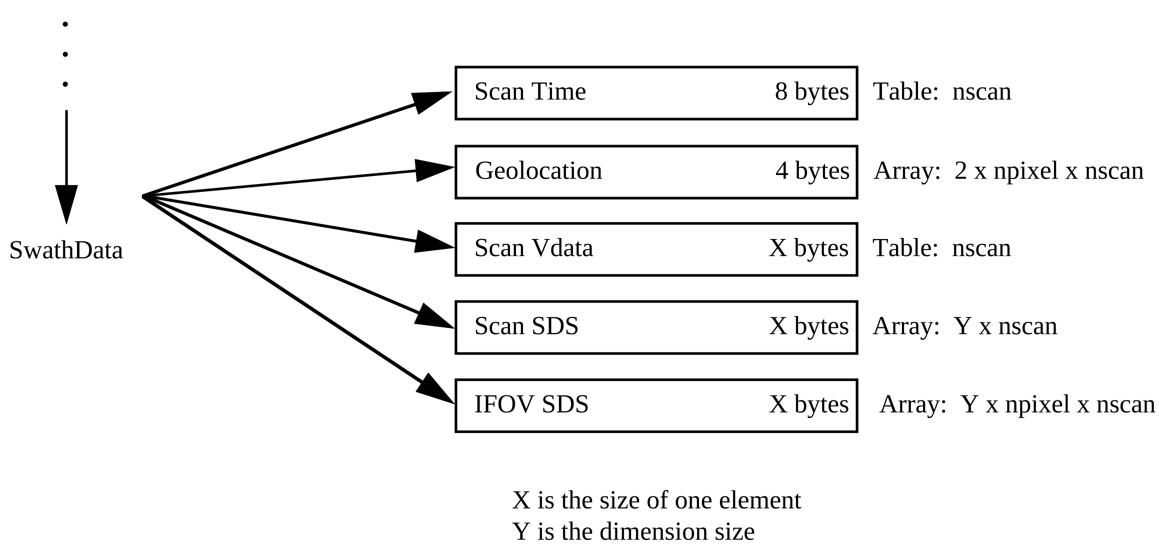


Figure 2.1.1-1
Generic Swath Structure

2.2 HIERARCHICAL DATA FORMAT

Level-1B and Level-2 data products are produced by TSDIS in the HDF format. HDF was developed by the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign and is the selection for the common data format for EOSDIS. HDF manuals and software may be obtained via anonymous ftp at ftp.ncsa.uiuc.edu Communications to NCSA concerning HDF may be made by email to softdev@ncsa.uiuc.edu or by postal mail to:

NCSA Software Tools Group HDF
152 Computing Applications Bldg.
605 E. Springfield Ave.
Champaign, IL 61820
USA

HDF is a multi-object file format for the transfer of graphical and numerical data between heterogeneous machines. The design of this format allows self-definition of data content, and easy extensibility for future enhancements or compatibility with other standard formats. HDF provides these benefits to algorithm developers and data users:

- **versatile file format**: HDF supports six different data models (8-bit raster model, palette model, 24-bit raster model, scientific data (SDS) model, annotation model, and the virtual data (Vdata) model).
- **extensible file format**: Although HDF currently supports six different data models, new data models will need to be incorporated in the future. HDF can easily accommodate new data models either through NCSA or HDF users.
- **self-describing**: HDF permits the inclusion of a data index (metadata) inside the data file which describes the contents of the file. This simplifies data sharing among diverse scientists.
- **portable file format**: HDF files are portable across heterogeneous computer systems. This allows for an HDF file created on one system (e.g., UNIX) to be used on a different system (e.g., Macintosh).
- **data abstraction**: When either reading or writing to an HDF file, the user does not have to be concerned with the physical layout of the file.

2.2.1 Relevant HDF Data Models

The EOSDIS data structures are composed of Vgroups and simple HDF models that are well tested and common to the science community. A Vgroup is like a node in a tree structure. The members of a Vgroup can be data models or more Vgroups. Of the six defined data models, the TSDIS file specifications use the following models:

a) *Scientific Data Set* - An SDS is an HDF structure that stores rectangular gridded arrays of data, together with information about the data. An SDS can contain data that are multi-dimensional, but must be of a singular data type and composed of the following elements:

- The actual data values.
- The number of dimensions (rank) and the size of each dimension
- The type of the data (e.g., integer or floating point)
- (optional) Scales to be used along the different dimensions when interpreting or displaying the data
- (optional) Labels for all dimensions and for the data
- (optional) Units for all dimensions and for the data
- (optional) Format specifications to be used when displaying values for the dimensions and for the data
- (optional) A range, attributing maximum and minimum values for the data set.
- (optional) Calibration information including an offset and scale factor.
- (optional) A fill value for representing missing data in a data set.
- (optional) The coordinate system to be used when interpreting or displaying the data

b) *VData* - The HDF VData model provides a framework for storing related data in a table-like structure in HDF files. Each table is comprised of a collection of similar records called VData records, whose values are stored in fixed-length fields. Each field can support its own data types, however, every VData record in a table must contain the same types of fields.

2.2.2 HDF Structures for Metadata

Metadata are defined as information about data sets which provide a description of the content, format, and utility of the data set. The word metadata is derived from the Greek word Meta, meaning “with”. Metadata may be used to select data for a particular scientific investigation. Each metadata element will have the “label = value” structure. The “label” will be defined by EOSDIS for the core metadata, and by TSDIS for the product specific metadata; the “value” will be supplied by TSDIS. For some core fields though, the values will need to comply with EOSDIS guidelines.

EOSDIS has decided that metadata should be stored in file attributes. Attributes are blocks of text that are attached to either files or SDSs.

2.3 METADATA IMPLEMENTATION

The metadata elements contained in these file specifications were derived from the Proposed ECS Core Metadata Standard Release 2.0, the TSDIS - TSDIS Science User (TSU) Interface Control Specification, and personal communication with algorithm developers.

EOSDIS has divided the metadata elements into two (2) types: core metadata and product specific metadata. Core metadata are common to all or most products in EOSDIS and have been defined by EOSDIS. Product Specific metadata are only related to a particular product, or a group of similar products, and have been defined by TSDIS. Metadata elements are written using Object Development Language (ODL).

Core metadata is stored in one file attribute named CoreMetadata.0. CoreMetadata.0 will contain the following structure:

```
OBJECT = <object_name1>;
        Value = <object_value1>;
        Data_Location = <data_location1>;
        Mandatory = <mand_value1>;
END_OBJECT = <object_name1>;
OBJECT = <object_name2>;
        Value = <object_value2>;
        Data_Location = <data_location2>;
        Mandatory = <mand_value2>;
END_OBJECT = <object_name2>;

.
.
.

OBJECT = <object_nameN>;
        Value = <object_valueN>;
        Data_Location = <data_locationN>;
        Mandatory = <mand_valueN>;
END_OBJECT = <object_nameN>;
END;
```

Product Specific Metadata is stored in another file attribute named ProductMetadata.0. ProductMetadata.0 will contain the following structure:

```
OBJECT = <object_name1>;
        Value = <object_value1>;
        Data_Location = <data_location1>;
        Mandatory = <mand_value1>;
END_OBJECT = <object_name1>;

OBJECT = <object_name2>;
        Value = <object_value2>;
        Data_Location = <data_location2>;
        Mandatory = <mand_value2>;
END_OBJECT = <object_name2>;

OBJECT = <object_nameM>;
```

```
        Value = <object_valueM>;
        Data_Location = <data_locationM>;
        Mandatory = <mand_valueM>;
END_OBJECT = <object_nameM>;
END;
```

where <object_name> is the name of the metadata element, <object_value> is the value of the metadata element, Data_Location is always “PGE”, Mandatory is “TRUE” or “FALSE” depending on whether the data is required by TSDIS to be included. For example, if the metadata element named UTCF_SECONDS had a value of 23 and was not required, it would be stored as follows:

```
OBJECT = UTCF_SECONDS;
        Value = 23;
        Data_Location = “PGE”;
        Mandatory = “FALSE”;
END_OBJECT = UTCF seconds;
```

If the value is a list, for example with three elements, then Value is written as:

(Element1, Element2, Element3)

3. FORMATTING CONVENTIONS

3.1 FILE STRUCTURE FIGURES

The figures that illustrate file structure contain either Vgroups or data objects (metadata objects, SDSs, or Vdatas). Figure 3.1-1 is an example of a product structure with annotations shown in italics. Vgroups are represented as the name of the Vgroup without a box. Data objects are represented as the name of the object inside a box. For metadata objects the estimated maximum total size appears on the right hand side of the box. If the object is a Vdata table, the size of one record appears on the right side of the box and the number of records appears next to the box. If the object is a SDS array, the size of one element appears on the right side of the box and the dimensions of the array appear next to the box.

The sizes for the metadata objects are estimated maxima since the values of many metadata are free text and may vary in length and not all metadata elements are used for all products. None of the sizes take HDF overhead into account. Previous (unpublished) experience gained in the TSDIS prototype study and the HDF internal feasibility study has shown HDF overhead to be less than 10% of the total file size for TSDIS products.

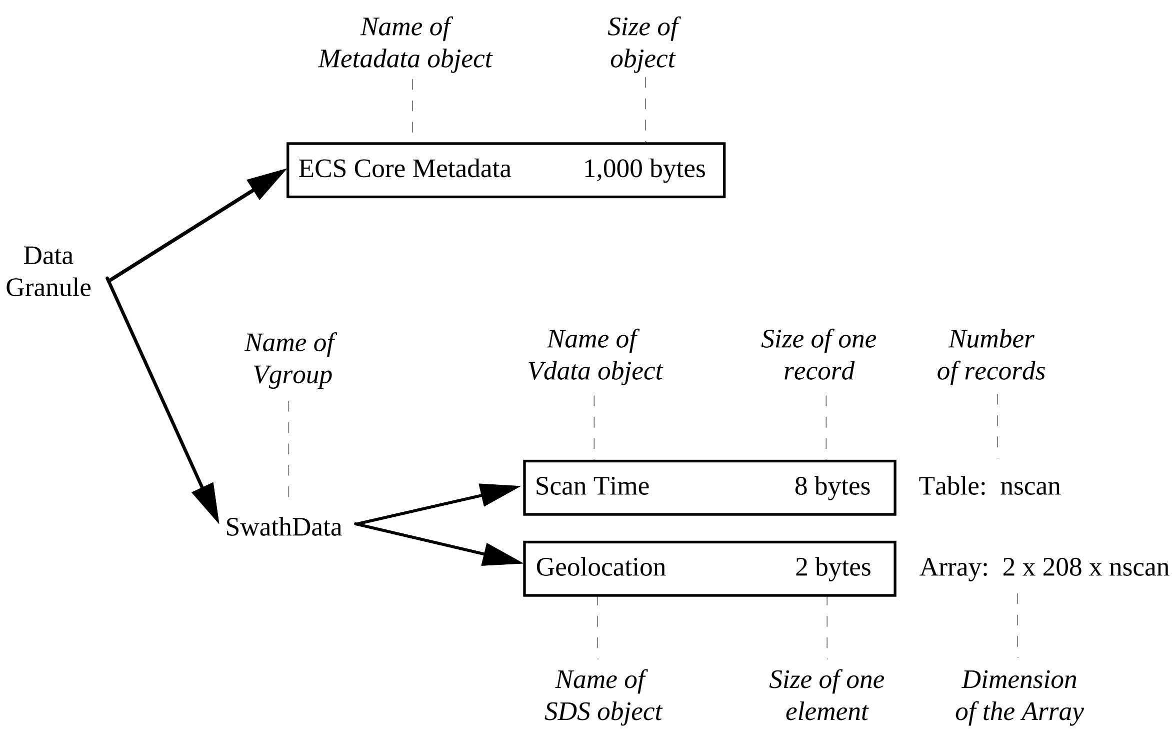


Figure 3.1-1
Example Product Structure

3.2 FILE CONTENTS

In the description of the contents of each object within a file, each object is defined in the following format:

> **Name** (Type of HDF structure, Dimensions, word size and type):
> Description

3.3 MISSING DATA AND EMPTY GRANULES

Missing satellite scans are filled with standard values denoting missing data. Missing satellite scans also have the “missing” byte in Scan Status set to 1. Values less than or equal to -99, -9999, -9999, -9999.9, -9999.9 denote missing or invalid data for 1-byte integer, 2-byte integer, 4-byte integer, 4-byte float, and 8-byte float, respectively. Any exceptions to the use of these standard values are explicitly noted in the description of the object. For the PR instrument, scans whose mode is other than observation mode are filled with missing values.

If an entire granule is missing, an empty granule may be created. If an entire orbit of Level 1B, 1C, 2A, or 2B satellite data is missing, scan data is omitted and the PS metadata named “Orbit Size” has the value zero.

3.4 ARRAY DIMENSION ORDER

In the definition of array dimensions, e.g., npixel x nscan, the first dimension (npixel) has the most rapidly varying index and the last dimension (nscan) has the least rapidly varying index. To implement this format in FORTRAN, declare an array with dimensions as they appear in this document. To implement the format in C, declare an array with dimensions reversed from their appearance in this document.

3.5 ORBIT AND GRANULE DEFINITION

The beginning and ending time of an orbit is defined as the time when the sub-satellite track reaches its southernmost latitude. This time is determined from the definitive ephemeris data. A scan is included in an orbit when its Scan Time is greater than or equal to the Orbit Start Time and less than the Orbit End Time. The average orbit is 91.5 minutes or 5490 seconds. The first partial orbit after launch will be orbit 1, so the first full orbit will be orbit 2.

A granule is defined as one orbit for the VIRS, TMI, and PR instruments.

3.6 SCANS IN A GRANULE

The number of scans in a granule is shown in the structure diagrams and array dimensions as nscan. For VIRS, TMI, and PR, nscan is calculated from a typical number of seconds in an orbit as follows:

NSCAN = SS x SO

Instrument	Scans/Second (SS)	Seconds/Orbit (SO)	NSCAN
TMI	31.600 / 60	5490	2891
VIRS	2 * 98.5 / 60	5490	18026
PR	1 / 0.6	5490	9150

3.7 TIME

Scan Times and Orbit Start Times are stored in the Level-1A headers, the metadata, and in the object named “Scan Time”. The Orbit Start Time is determined from ephemeris data and the definition of the orbit start -- it is independent of any scans. In contrast, a Scan Time is a time associated with a scan of a particular instrument. The Scan Time is the time tag stamped on each science telemetry packet. In particular, the Orbit First Scan Time is the Scan Time of the first scan in an orbit, which occurs at or later than the Orbit Start Time. The Level-1A header stores the Universal Time Correlation Factor (UTCF) derived from the first Attitude Control System (ACS) packet in the orbit. This UTCF is used to translate the Orbit Start Time from Universal Time Coordinated (UTC) to spacecraft clock time. In normal processing, the UTCF, the Scan Times in UTC, and the Scan Times in spacecraft clock time are repeated exactly in Level-1B and higher levels. In the unusual circumstance that the UTCF is found to be incorrect, a corrected UTCF will be stored in Level-1B and higher data products and a flag set to indicate that a corrected UTCF was used. When a corrected UTCF is applied, the UTC Scan Times will be different between (1) Level-1A and (2) Level-1B and higher levels, although the spacecraft clock Scan Times will be the same in Level-1A and Level-1B and higher levels. Another flag in Level-1B and higher levels shows whether a leap second occurred in the granule.

Times are expressed in five formats:

(1) UTC times in Core or PS metadata or a Level-1A header are written in three words: Date, Time, and Milliseconds. For the Begin and End Times in Core metadata, milliseconds is omitted.

Date is a 10 character string with the following characters:

YYYY/MM/DD, where
YYYY = year,
MM = month number,
DD = day of month, and
“/” is a literal.

Time is an 8 character string with the following characters:

HH:MM:SS, where
HH = hour,
MM = minute,
SS = second, and
":" is a literal.

Milliseconds is a 3 character string with the following characters:

MMM, where
MMM = the number of milliseconds later than the last whole second.

(2) In 2A-52, UTC time is stored as in (1) except "/" is replaced by "-".

(3) In 1B-11 and 2A-12, UTC time is stored in separate words for year, month, day of month, hour, minute, and second.

(4) UTC Scan Time in the body of the data is in seconds of the day. The UTC date and time in the metadata can be combined with the Scan Time to get a complete date and time for every scan.

(5) Spacecraft clock time and UTCF have the same format, which is specified in the **TRMM Telemetry and Command Handbook,** Section 3.3.2.

Spacecraft clock time is the accumulated time count since the power-up of the clock card in the TRMM Spacecraft Data System onboard the satellite. Spacecraft time is correlated to UTC time by the UTCF. The sum of the UTCF and Spacecraft time results in a time that represents the total number of seconds since January 1, 1993 at 00:00:00 (UTC) if one assumes that each day has exactly 86400 seconds, even days with leap seconds. This total number of seconds allows easy computation of days since January 1, 1993. However, to accurately compute time differences one must use more complicated methods, which account for leap seconds. For a more thorough discussion of Spacecraft time and UTCF, see the **TRMM Telemetry and Command Handbook,** Section 3.3.2.

Scan Time is a time associated with each satellite science data scan. It is the time tag written in each science telemetry packet. There is one scan per science telemetry packet. The relationship of Scan Time to the time at each IFOV varies by instrument. A description of the relationship between Scan Time and measurement time for each of the three satellite instruments follows. In each description, 'T' is the beginning sample time and 'i' is the IFOV number:

(1) For TMI, the equations shown in Table 3.7-1 were obtained by personal communication with the instrument scientist.

Table 3.7-1

TMI Equations

Channel	Relationship	Indices	Sample Time
1, 2 (10 GHz)	T = Scan Time + 59.185 ms + (i - 1) * 6.600 ms	i = 1 to 104	6.304 ms
3, 4, 5 (19, 21 GHz)	T = Scan Time + 125.544 ms + (i - 1) * 6.600 ms	i = 1 to 104	6.266 ms
6, 7 (37 GHz)	T = Scan Time + 125.544 ms + (i - 1) * 6.600 ms	i = 1 to 104	6.304 ms
8, 9 (85 GHz)	T = Scan Time + 125.544 ms + 1.650 ms + (i - 1) * 3.300 ms	i = 1 to 208	3.004 ms

(2) For VIRS, the following equation was derived from a viewgraph produced at Hughes and presented by Bruce Love on January 20, 1995:

T = Scan Time + 107.6 ms + (OFFSET + (i - 1)) * Sample Time,

where i = 1, 261,
Sample Time = 0.29157 ms,
and OFFSET values are shown in Table 3.7-2.

Table 3.7-2
OFFSET Values

Channel	Offset
1	0
4	2
5	4
3	6
2	8

The value of Sample Time was derived from the viewgraph using the time of the starting and ending channel 1 science data as follows:

Sample Time = (183.7 ms - 107.6 ms) / 261

(3) For PR, the information was obtained by personal communication with a representative of the National Space Development Agency (NASDA).

T = Scan Time + 3.41 ms + (i - 1) * 11.768 ms,

where i = 1 to 49

3.8 SATELLITE COORDINATES AND FLIGHT MODES

The TRMM satellite structural axes are defined so that +Z is the side where PR is mounted and is the direction normally pointed toward the nadir(straight down toward the Earth). +X is the side toward which the TMI and VIRS instruments are mounted, and the side toward which the TMI instruments takes measurements. Solar arrays are mounted on the + and - Y sides, and the +Y axis is such that the +X, +Y and +Z complete a right-hand system.

The two common flight modes for TRMM are +X forward and -X forward. With +X forward, the +X axis of the spacecraft is pointed along the velocity direction (i.e., in the direction the spacecraft is moving toward), +Y is pointed opposite the orbit normal (orbit spin axis), and +Z is toward the nadir. With -X forward the +X axis is opposite the velocity (i.e., in the direction the spacecraft is moving away from), +Y is along orbit normal, and +Z is still toward the nadir. The spacecraft spends about half it's time in each of these two positions. It switches between +X and -X Forward every two to four weeks with a yaw maneuver taking about 20 minutes. This is done in order to keep the sun always in the -Y Hemisphere, as orbit precession and seasonal changes move the sun slowly above and below the orbit plane. (This maintains passive cooling and power design constraints). The flight mode for each scan is written in all Level 1B, 1C, 2A, and 2B satellite products in Scan Status, Current Spacecraft Orientation.

As discussed in the instrument scan geometry sections, the scan directions relative to the flight path change as the mode changes. For TMI, scans are always left to right in the +X spacecraft direction as the microwave antenna rotates about the +Z axis. Thus TMI scans are left to right looking forward along the ground track in the +X forward mode, and are right to left of the ground track in the -X forward mode. For VIRS, scans are right to left of the ground track direction in the +X forward mode, and left to right of the ground track direction in the -X forward mode. PR scans electronically the same direction as VIRS: right to left with +X forward and left to right of the flight path direction with -X forward.

4. LEVEL 1 PRODUCTS

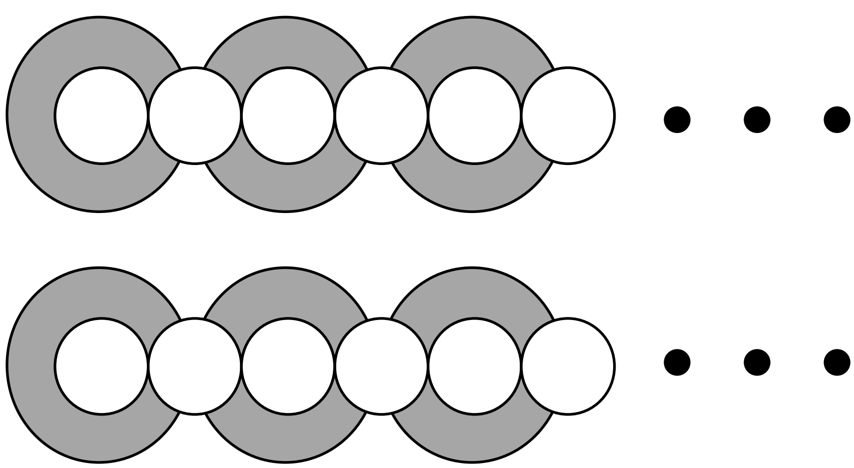
4.1 LEVEL 1 TRMM MICROWAVE IMAGER (TMI)

4.1.1 Instrument and Scan Geometry

The TMI is one of five instruments flown on the TRMM satellite. TMI is similar to the Special Sensor Microwave/Imager (SSM/I) instrument flown on the Defense Meteorological Satellite Program (DMSP) satellites with several key differences:

(1) the addition of vertically and horizontally polarized 10 GHz channels,
(2) the scan geometry is the same for every scan instead of alternating between an A scan and a B scan, and
(3) there are about twice as many pixels per scan.

The TMI is a 9 channel, 5 frequency, linearly polarized, passive microwave radiometric system. The instrument measures atmospheric and surface brightness temperatures at 10.7, 19.4, 21.3, 37.0, and 85.5 GHz. Each frequency has one vertically (V) and one horizontally (H) polarized channel, except for the 21.3 GHz frequency, which has only vertical polarization. The 10.7, 19.4, 21.3, and 37.0 GHz channels are considered low resolution and the 85.5 GHz channels are considered high resolution. TMI has a conical scanning geometry, rotating continuously about a vertical axis, receiving upwelling radiation from 49˚ off nadir. Scene radiation is recorded from left to right looking in the +x direction (see Section 3.8) over an annular sector of 130˚ about the sub-satellite track. The swath width is 758.5 km, covered by 104 low resolution pixels or 208 high resolution pixels. A complete description of the TMI instrument is available in the **TMI Technical Description Document**. Figure 4.1.1-1 shows a simplified version of the scan geometry for two scans. The centers of pixels 1, 3, 5, ... of the high resolution channels (unshaded circles) are collocated with the centers of pixels 1, 2, 3, ... of the low resolution channels (shaded circles).



Low resolution channels appear as shaded circles. High resolution channels appear as open circles in front of the shaded circles. The dots indicate continuation.

Figure 4.1.1-1
TMI Scan Geometry

4.1.2 Design Considerations

The TMI format for the Level-1B product was designed in consultation with Dr. James Shiue (the TMI instrument scientist), Dr. Christian Kummerow (a TMI algorithm scientist), and Mr. Ted Meyer, Mr. Doug Ilg, and Dr. Brand Fortner (of EOSDIS).

The Level-1B format groups like data together. For example, high resolution channel data are in one object rather than, for example, channel, geolocation, and calibration data being interleaved in one object. Satellite Local Zenith angle is given for every twentieth high resolution pixel to save disk space. Considerations were given to two existing formats, the "Wentz" format and the Marshall Space Flight Center (MSFC) format, both currently used for SSM/I data. The TMI Level-1B format is presented in a Swath Structure and formatted in HDF.

4.1.3 TMI Level-1B (1B-11)

The TMI Level 1B Product, 1B-11, "TMI Brightness Temperatures," is formatted in HDF. The following sizing parameter is used in describing these formats:

nscan = the number of scans within one granule. See Section 3.6.

4.1.3.1 Structure

Figure 4.1.3-1 shows the structure of the TMI Level-1B product in terms of the component objects and their sizes. The TMI Level-1B product is stored as a swath structure (see Section 2.1).

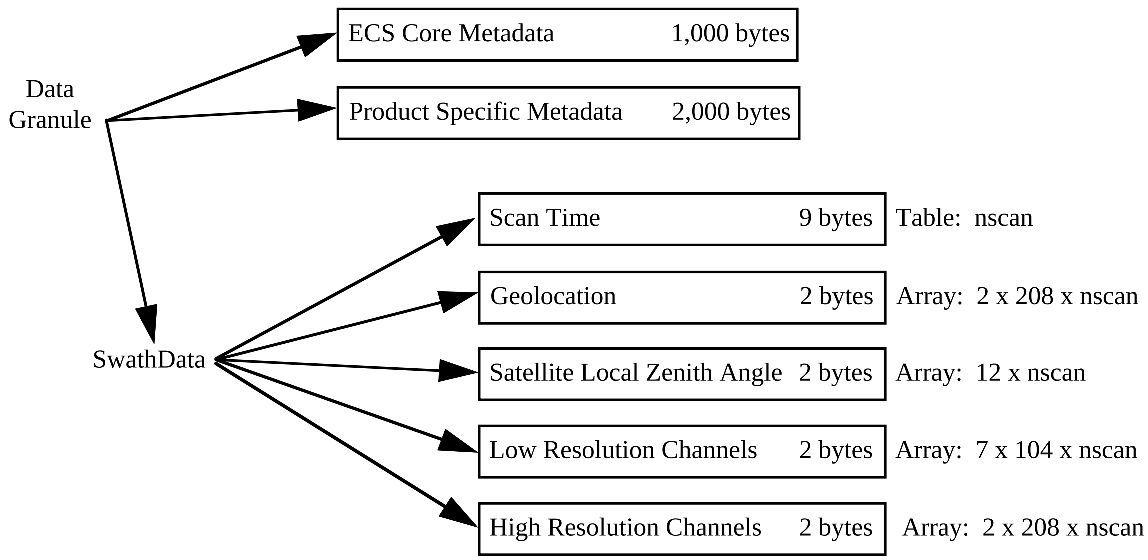


Figure 4.1.3-1
Data Format Structure for 1B11, TMI Level-1B Structure

4.1.3.2 Contents

ECS Core Metadata (Attribute, 1,000-byte character):
ECS Core Metadata are those metadata defined by ECS as Core metadata. See Appendix A.

PS Metadata (Attribute, 2,000-byte character):
Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix B.

Scan Time (Vdata Table, record size 9 bytes, nscan records):
See the following, Table 4.1.3-1.

Table 4.1.3-1
1B-11 Scan Time
(Vdata Table, record size 9 bytes, nscan records)

Name	Format	Description
Year	2-byte integer	4-digit year, e.g., 1998
Month	1-byte integer	The month of the Year
Day of Month	1-byte integer	The day of the Month
Hour	1-byte integer	The hour (UTC) of the Day
Minute	1-byte integer	The minute of the Hour
Second	1-byte integer	The second of the Minute
Day of Year	2-byte integer	The day of the Year

Geolocation (SDS, array size 2 x 208 x nscan, 2-byte integer):

The earth location of the center of the IFOV of the high resolution (85 GHz) channels (channels 8 and 9) at the altitude of the earth ellipsoid. The first dimension is latitude and longitude, in that order. The next dimensions are high resolution pixel and scan. Latitude and longitude in degrees are multiplied by 100 and stored as 2-byte integers. Off-earth is represented as less than or equal to -9999. Latitude is positive north, negative south. Longitude is positive east, negative west. A point on the 180th meridian is assigned to the western hemisphere.

Satellite Local Zenith Angle (SDS, array size 12 x nscan, 2-byte integer):
The angle, in degrees, between the local pixel geodetic zenith and the direction to the satellite. This angle is given for every twentieth high resolution pixel along a scan: pixel 1, 21, 41, ... , 201, 208. The angle is multiplied by 100 and stored as a 2-byte integer.

Low Resolution Channels (SDS, array size 7 x 104 x nscan, 2-byte integer):
Brightness temperature (K) reduced by 100 K, multiplied by 100, and stored as a 2-byte integer (i.e., Stored value = (T - 100 K) * 100)

The dimensions are: channel, pixel, scan. The pixel dimension has Offset = 0 and Increment = -2. The data range for each channel is listed in the two metadata elements: Minimum valid value of channel and Maximum valid value of channel. The channels shown in Table 4.1.3-2 are included.

High Resolution Channels (SDS, array size 2 x 208 x nscan, 2-byte integer):
Brightness temperature (K) reduced by 100 K, multiplied by 100, and stored as a 2-byte integer (i.e., Stored value = (T - 100 K) * 100)

The dimensions are: channel, pixel, scan. The data range for each channel is listed in the two metadata elements: Minimum valid value of channel and Maximum valid value of channel. The channels shown in Table 4.1.3-3 are included.

Table 4.1.3-2
Low Resolution Channels
(SDS, array size 7 x 104 x nscan, 2-byte integer)

Channel	Frequency	Polarization
1	10 GHz	Vertical
2	10 GHz	Horizontal
3	19 GHz	Vertical
4	19 GHz	Horizontal
5	21 GHz	Vertical
6	37 GHz	Vertical
7	37 GHz	Horizontal

Table 4.1.3-3
High Resolution Channels

(SDS, array size 2 x 208 x nscan, 2-byte integer)

Channel	Frequency	Polarization
8	85 GHz	Vertical
9	85 GHz	Horizontal

4.2 LEVEL 1 VISIBLE AND INFRARED SCANNER (VIRS)

4.2.1 Instrument and Scan Geometry

The VIRS sensor is one of the five instruments on the TRMM satellite. The VIRS instrument has a swath width of 720 km and a horizontal resolution of 2 km at nadir. VIRS is similar to the Advanced Very High Resolution Radiometer (AVHRR) now in operation on polar-orbital environmental satellites.

The VIRS measures radiance values in the channels shown in the Table 4.2.1-1. All five Channels will be in operation during daytime, but only Channels 3, 4 and 5 are in operation during nighttime. The VIRS is a cross-track scanning system and records scene radiation from right to left looking in the +x direction (see Section 3.8) over a scan angle of +/- 45^0 from the nadir (subpoint view). The swath width of 720 km is covered by 261 pixels and every scan has the same geometry. The Level-1B product stores radiance for every pixel measured.

Table 4.2.1-1
Channels where VIRS Measures Radiance Values

Channel	Spectral Region	Wavelength (μm)
1	Visible	0.63
2	Near Infrared	1.6
3	Near Infrared	3.75
4	Infrared	10.8
5	Infrared	12.0

4.2.2 Design Considerations

The VIRS format for the Level-1B product was designed in consultation with Dr. William Barnes (VIRS Instrument Scientist), Mr. Ted Meyer, Mr. Doug Ilg, and Dr. Brand Fortner (of EOSDIS).

The Level-1B format groups like data together. For example, channel data are in one object rather than, for example, channel, geolocation, and calibration data being interleaved in one object. The Level-1B format includes navigation and calibration information, which was requested by Dr. Barnes. The Local Direction is supplied for every tenth pixel in a scan line to save space. Data elements are based on the National Oceanic and Atmospheric Administration (NOAA) AVHRR format. The VIRS Level-1B format is presented in a Swath Structure and formatted in HDF.

4.2.3 VIRS Level-1B (1B-01)

The VIRS Level-1B Product, 1B-01, "VIRS Radiance" is written in HDF. The following sizing parameter is used in describing these formats:

- nscan = the number of scans within one granule. See Section 3.6.

4.2.3.1 Structure

Figure 4.2.3-1 shows the structure of the VIRS Level-1B product in terms of the component objects and their sizes. The VIRS Level-1B product is stored as a swath structure (see Section 2.1).

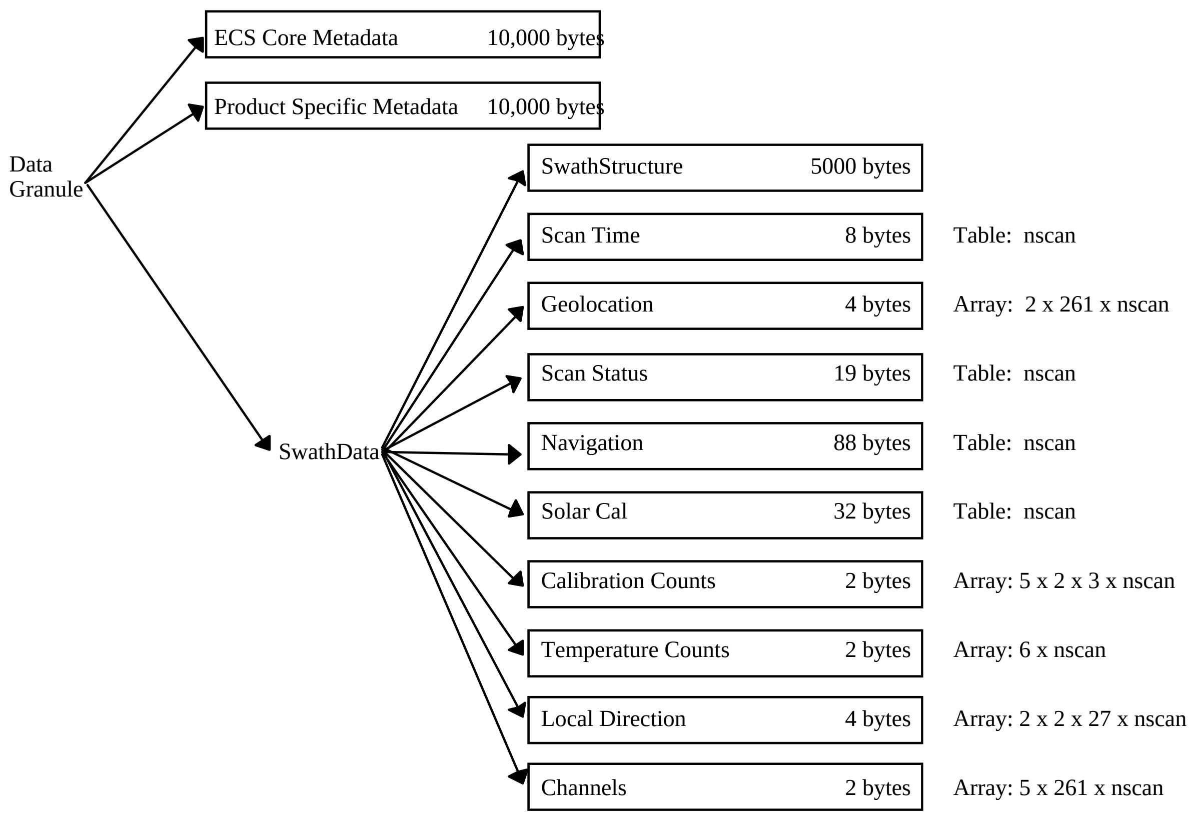


Figure 4.2.3-1
Data Format Structure for 1B-01, VIRS Level-1B

4.2.3.2 Contents

ECS Core Metadata (Attribute, 10,000-byte character):
ECS Core Metadata are those metadata defined by ECS as Core metadata.
See ICS Volume 6.

PS Metadata (Attribute, 10,000-byte character):
Product Specific Metadata are metadata defined by and specific to TSDIS.

See ICS Volume 6.

SwathStructure (Attribute, 5,000-byte character):
SwathStructure gives the specification of the swath geometry. See Section 2.

Scan Time (Vdata Table, record size 8 bytes, nscan records):
See the following, Table 4.2.3-1.

Table 4.2.3-1
1B-01 Scan Time
(Vdata Table, record size 8 bytes, nscan records)

Name	Format	Description
Scan Time	8-byte float	A time associated with the scan. The exact relationship between Scan Time and the time of each IFOV is described in the ICS Volume 3, Section 3. Scan Time is expressed as the UTC seconds of the day.

Geolocation (SDS, array size 2 x 261 x nscan, 4-byte float):
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 pixel and scan. Values are represented as floating point decimal degrees. Off-earth is represented as less than or equal to -9999.9. Latitude is positive north, negative south. Longitude is positive east, negative west. A point on the 180th meridian is assigned to the western hemisphere.

Scan Status (Vdata, record size 19 bytes, nscan records):
The status of each scan is represented in terms of quality, platform and instrument control data, and fractional orbit number as shown in Table 4.2.3-2.

Navigation (Vdata, record size 88 bytes, nscan records):
See the ICS Volume 3, Appendix B.

Solar Cal (Vdata, record size 32 bytes, nscan records):
The three components of the solar unit vector in Geocentric Inertial Coordinates, and the Sun-Earth distance in meters as shown in Table 4.2.3-3.

Table 4.2.3-2
1B-01 Scan Status
(Vdata, record size 19 bytes, nscan records)

Name	Format	Description
Missing	1-byte integer	Missing indicates whether information is contained in the scan data. The values are: 0 Scan data elements contain information 1 Scan was missing in the telemetry data 2 Scan data contains no elements with rain
Validity	1-byte integer	Validity is a summary of status modes. If all status modes are routine, all bits in Validity = 0. Routine means that scan data has been measured in the normal operational situation as far as the status modes are concerned. Validity does not assess data or geolocation quality. Validity is broken into 8 bit flags. Each bit = 0 if the status is routine but the bit = 1 if the status is not routine. Bit 0 is the most significant bit (i.e., if bit i = 1 and other bits = 0, the unsigned integer value is 2**(8-i) - 1). The non-routine situations follow: Bit Meaning if bit = 1 0 Spare (always 0) 1 Non-routine spacecraft orientation (2 or 3) 2 Non-routine ACS mode (other than 4) 3 Non-routine yaw update status (0 or 1) 4 Non-routine instrument status (2) 5 Non-routine QAC (non-zero) 6 VIRS in non-mission mode (non-zero) 7 VIRS condition is abnormal (non-zero)
QAC	1-byte integer	The Quality and Accounting Capsule of the Science packet as it appears in Level-0 data. If no QAC is given in Level-0, which means no decoding errors occurred, QAC in this format has a value of zero.
Geolocation Quality	1-byte integer	Geolocation Quality is broken into 8 one-bit flags. A value of 0 indicates 'good' quality, and 1 indicates 'bad' quality. Bit 0 is the most significant bit (i.e., if bit i = 1 and other bits = 0, the unsigned integer value is 2**(7-i). Each flag is listed below. Note that ranges indicated will be refined in early-orbit check out. Bit Meaning if bit = 1 0 Grossly bad geolocation results: • Spacecraft position vector magnitude outside range 6720 to 6740 km. • Z component of midpoint of scan outside range -4100 to 4100 km. • Distance from S/C to midpoint of scan outside range 340 to 360 km. 1 Unexpectedly large scan to scan jumps in geolocated positions in along and cross track directions for first, middle, and last pixels in each scan. Allowed duration from nominal jump in along track motion = 0.06 km (first pixel), 0.04 km (middle pixel), and 0.06 km (last pixel). Allowed duration from nominal jump in cross track motion = 0.05 km (first pixel), 0.04 km (middle pixel), and 0.05 km (last pixel). Bit set in normal mode only. 2 Scan to scan jumps in yaw, pitch, and roll exceed maximum values. Values are : yaw = 0.0001 radians; pitch = 0.0001 radians; roll = 0.0001 radians. Bit set in normal control mode only.

Table 4.2.3-2 (Continued)
1B-01 Scan Status
(Vdata, record size 19 bytes, nscan records)

Name	Format	Description
Geolocation Quality (Continued)	1-byte integer	3 In normal mode, yaw outside range (-0.003, 0.003) radians; pitch outside range (-0.007, 0.007) radians; roll outside range (-0.007, 0.007). 4 Satellite undergoing maneuvers during which geolocation will be less accurate. 5 Questionable ephemeris quality (including use of predicted Ephemeris for quicklook) or questionable UTCF quality. 6 Geolocation calculations failed (fill values inserted in the per pixel geolocation products, but not in metadata). 7 Missing attitude data. ACS data gap larger than 20 seconds.
Data Quality [5]	5 X 1-byte integer	The Quality of Channel Data for a given channel on a given scan line is the percentage of pixels whose values are within the acceptable range listed in the Metadata. Quality is listed for each channel in order of the channel number.
Fractional Orbit Number	4-byte float	The orbit number and fractional part of the orbit at Scan Time. The orbit number will be counted from the beginning of the mission. The fractional part is calculated as: (Time - Orbit Start Time) / (Orbit End Time - Orbit Start Time)
Current Spacecraft Orientation	1-byte integer	Value Meaning 0 +x forward 1 -x forward 2 -y forward 3 Inertial - CERES Calibration 4 Unknown Orientation
Current ACS Mode	1-byte integer	Value Meaning 0 Standby 1 Sun Acquire 2 Earth Acquire 3 Yaw Acquire 4 Nominal 5 Yaw Maneuver 6 Delta-H (Thruster) 7 Delta-V (Thruster) 8 CERES Calibration
Yaw Update Status	1-byte integer	Value Meaning 0 Inaccurate 1 Indeterminate 2 Accurate
VIRS Instrument Status	1-byte integer	Value Meaning 0 Day (no calibration occurring) 1 Night 2 Monitor Scan Stability 3 Day with Calibration

Table 4.2.3-2 (Continued)
1B-01 Scan Status
(Vdata, record size 19 bytes, nscan records)

Name	Format	Description
VIRS mode	1-byte integer	Value Meaning 0 mission mode 1 safehold mode 2 outgas mode 3 activation mode
VIRS Abnormal Conditions	1-byte integer	Bit 0 is the most significant bit (i.e., if bit i = 1 and other bits = 0, the unsigned integer value is 2**(8-i) - 1). Bit Value Meaning 0 0 normal 1 scan phase error 1 0 normal 1 selftest error 2 0 normal 1 thermal data missing 3 0 normal 1 moon in space view 4 0 normal 1 H/K data drop-out suspected 5 0 normal 1 SV counts for channel 4 or 5 greater than L1B01_MIN_DNSV 6 0 not used 7 0 not used

Table 4.2.3-3
Solar Cal (Vdata, record size 32, nscan records)

Name	Format	Description
Solar Position [3]	3x8-byte float	Sun Unit Vector (X-component) Sun Unit Vector (Y-component) Sun Unit Vector (Z-component) (Geocentric Inertial Coord)
Distance	8-byte float	Sun-Earth Distance (m)

Calibration Counts (SDS, array size 5 x 2 x 3 x nscan, 2-byte integer):
Raw calibration counts are given in four dimensions. The first dimension is the channel number, the second dimension is the data word, the third dimension is blackbody, space view and solar diffuser, in that order, and the fourth dimension is the number of scans.

Temperature Counts (SDS, array size 6 x nscan, 2-byte integer):
Temperatures of the black body, primary and redundant, the radiant cooler temperatures, primary and redundant, the mirror temperature, and the electronics module temperature. All quantities have units of counts, and have minimum values of 0, and maximum values of 4095.

Local Direction (SDS, array size 2 x 2 x 27 x nscan, 4-byte float):
Angles (degrees) to the satellite and sun from the IFOV pixel position on the earth are given in 4 dimensions. The first dimension is zenith and azimuth angles, in that order. The zenith angle is measured between the local pixel geodetic zenith and the direction to the satellite. The azimuth angle is measured clockwise from the local North direction around toward the local East direction. The second dimension is the object to which the directions point, namely the satellite and the sun, in that order. The third dimension is the pixel number. Angles are given only for every tenth pixel along a scan: pixel 1, 11, 21, ..., and 261. For the pixel dimension, Offset = 0 and Increment = -10. The fourth dimension is the scan number.

Channels (SDS, array size 5 x 261 x nscan, 2-byte integer):
Scene data for the five channels, measured in Radiance (mW cm^{-2} μm^{-1} sr^{-1}) multiplied by a scale factor and stored as 2-byte integers. sr means steradian. The scale factors are 500, 1000, 100000, 10000, and 10000 for channels 1, 2, 3, 4, and 5, respectively. The three dimensions are channel, pixel, and scan. The range and accuracy for each channel is shown is Table 4.2.3-4.

Table 4.2.3-4
VIRS Range and Accuracy

Channel	**Minimum (mW cm^{-2} μm^{-1} sr^{-1})**	**Maximum (mW cm^{-2} μm^{-1} sr^{-1})**	**Accuracy**
1	0	65.5	10%
2	0	32.7	10%
3	0	0.111	2%
4	0	1.371	2%
5	0	1.15	2%

5. LEVEL 2 PRODUCTS

5.1 LEVEL 2 TRMM MICROWAVE IMAGER (TMI)

There is only one Level 2A data product for TMI, 2A-12 - TMI Profiling [Principal Investigator (PI): Dr. Christian Kummerow]. The following parameters are used in describing the formats:

- nscan: the number of scans within one granule. See Section 3.6.
- npixel: the number of high resolution pixels within one scan line = 208
- nlayer: the number of profiling layers within one pixel = 14
- ngeo: the number of geolocation data = 2

5.1.1 TMI Profiling (2A-12)

2A-12, "TMI Profiling", generates hydrometeor data using a profiling method. For each pixel, surface rain, vertically totaled cloud liquid water, and vertically totaled precipitation ice are given. The format of this product was designed in consultation with the TMI algorithm scientists.

5.1.1.1 Structure

Figure 5.1.1-1 shows the structure of the 2A-12 product in terms of the component objects and sizes.

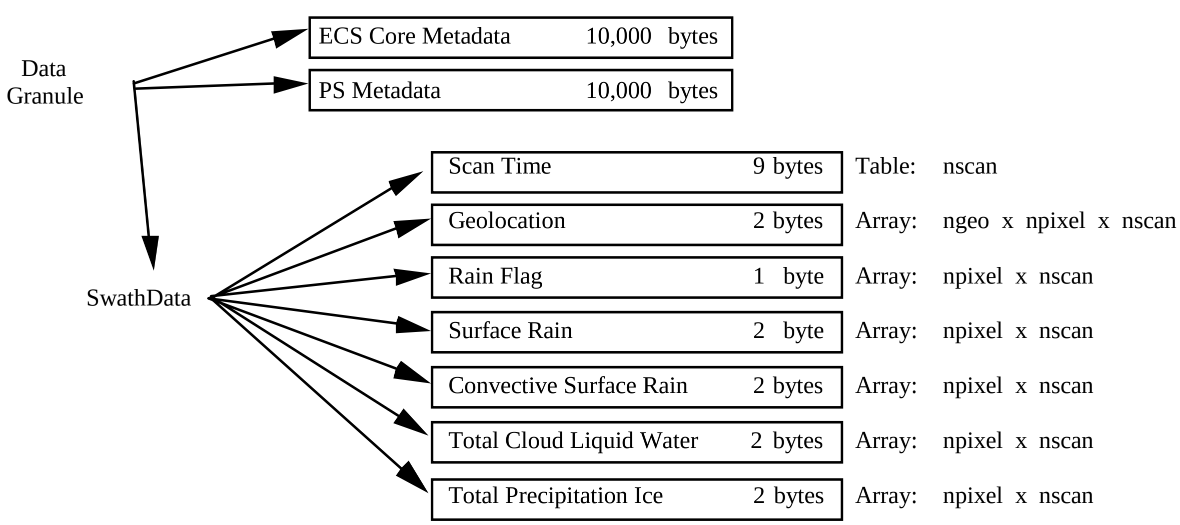


Figure 5.1.1-1
Data Format Structure for 2A-12, TMI Profiling

5.1.1.2 Contents

The contents of objects in the structure are as follows:

ECS Core Metadata (Attribute, 1,000-byte character):
ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix A.

PS Metadata (Attribute, 2,000-byte character):
Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix B.

Scan Time (Vdata Table, record size 9 bytes, nscan records):
The Scan Time is the time associated with each scan. Table 5.1.1-1 gives the description of the content and format. The exact relationship between the Scan Time and the time of each IFOV is described in the ICS Volume 3, Section 3.

Table 5.1.1-1
2A-12 Scan Time

Name	Format	Description
Year	2-byte integer	4-digit year, e.g., 1998
Month	1-byte integer	The month of the Year
Day of Month	1-byte integer	The day of the Month
Hour	1-byte integer	The hour (UTC) of the Day
Minute	1-byte integer	The minute of the Hour
Second	1-byte integer	The second of the Minute
Day of Year	2-byte integer	The day of the Year

Geolocation (SDS, array size ngeo x npixel x nscan, 2-byte integer):
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. Latitude and longitude in degrees are multiplied by 100 and stored as 2-byte integers. Off-earth is represented as -9999. Latitude is positive north, negative south. Longitude is positive east, negative west. A point on the 180^0 meridian is assigned to the western hemisphere.

Rain Flag (SDS, array size npixel x nscan, 1-byte integer):
The Rain Flag indicates if rain is possible. If the value is greater than or equal to zero rain is possible. If the value is less than zero the pixel has been pre-screened as non-raining; the exact value is used to identify the screen itself.

Surface Rain (SDS, array size npixel x nscan, 2-byte integer):
The Surface Rain is the instantaneous rain rate (mm h^{-1}) at the surface for each pixel. It ranges between 0.0 and 3000.0 mm/h and is multiplied by 10 and stored as a 2-byte integer.

Convective Surface Rain (SDS, array size npixel x nscan, 2-byte integer):
The Convective Surface Rain is the instantaneous convective rain rate (mm h^{-1}) at the surface for each pixel. It ranges between 0.0 and 3000.0 mm/h and is multiplied by 10 and stored as a 2-byte integer.

Total Cloud Liquid Water (SDS, array size npixel x nscan, 2-byte integer):
This is the total cloud liquid water content for each pixel. It ranges from 0.00 to 10.00 g m^{-2} and is multiplied by 1000 and stored as a 2-byte integer.

Total Precipitation Ice (SDS, array size npixel x nscan, 2-byte integer):
This is the total precipitation content for each pixel. It ranges from 0.00 to 10.00 g m^{-2} and is multiplied by 1000 and stored as a 2-byte integer.

5.2 LEVEL 2 PRECIPITATION RADAR (PR)

There are three Level 2A products for PR; 2A-23 - PR Qualitative (PI: Dr. Jun Awaka), 2A-25-R1 - PR Surface Rain (PI: Dr. Toshio Iguchi), and 2A-25-R2 - PR Profile (PI: Dr. Toshio Iguchi). The formats of these products are based on the Version 2 algorithm descriptions and consultation with PR algorithm scientists. The following parameters are used in describing the formats:

- nscan: the number of PR scans within one granule. See Section 3.6.
- nray: the number of rays within one PR scan line = 49
- ngeo: the number of geolocation data = 2
- ncell1: the number of radar range cells at which the rain rate is estimated = 20

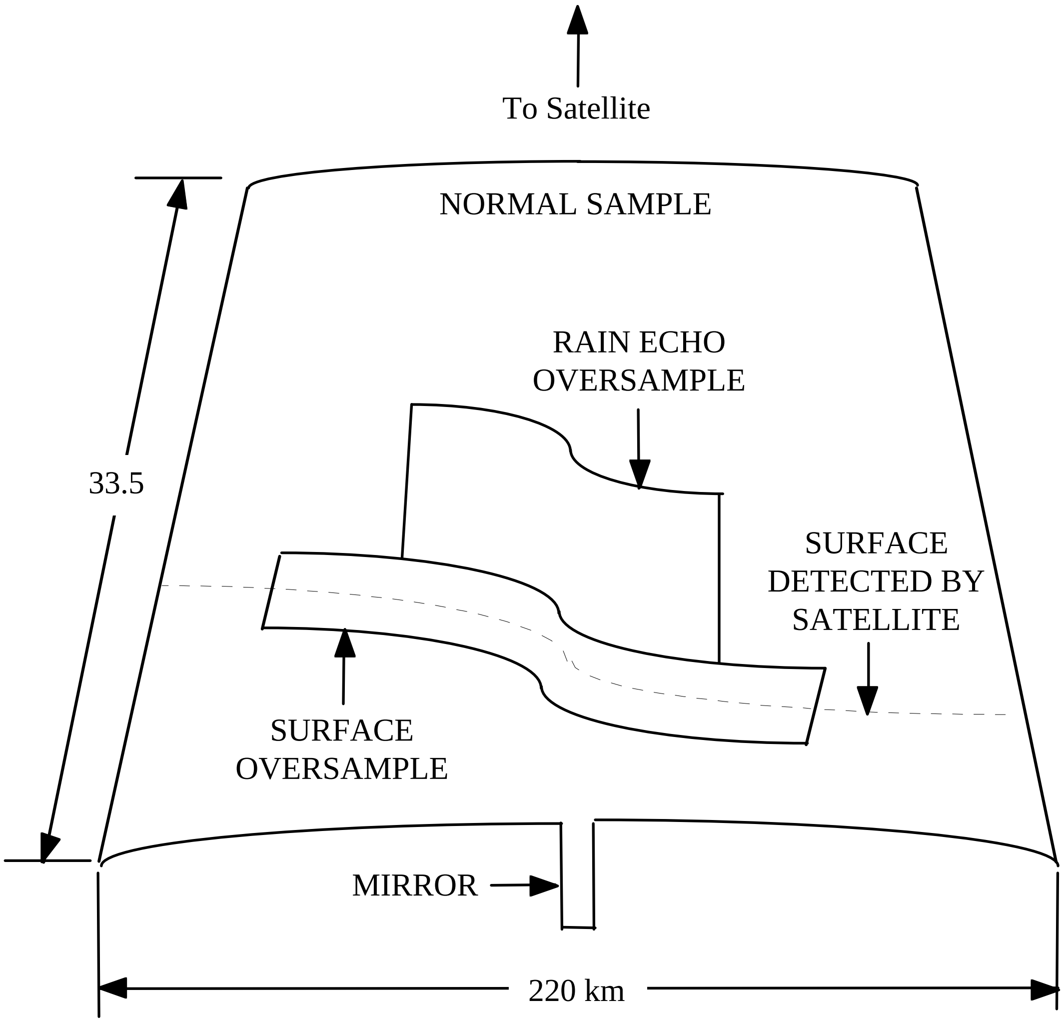
5.2.1 <u>Instrument and Scan Geometry</u>

The Precipitation Radar (PR) is one of five instruments on the TRMM satellite. The PR is an active 13.8 GHz radar, recording energy reflected from atmospheric and surface targets. The PR electronically scans right to left looking in the +x direction (see Section 3.8) of the satellite every 0.6 s with a swath width of 215 km before August 7, 2001 and 247 km after August 24, 2001.

The complex scan geometry is represented in Figure 5.2.1-1. Each scan contains 49 rays sampled over an angular sector of 34˚. For a given ray, the satellite begins recording samples at a fixed distance from the satellite and records a certain number of samples every 125 m along the ray. The starting distance and the number of samples are different for each ray. Assuming the satellite altitude is 350 km , the sampling begins about 23 km above mean sea level and extends for a certain distance along the ray. This distance along the ray is 33.5 km at the two rays farthest from nadir, monotonically declining to 30.25 km at the two rays adjacent to nadir, and jumping to 34.75 km at the single nadir ray. The extra data in the nadir ray is known as “the mirror,” because it records energy reflected not once from a target, but three times (ground to target to ground). Rays other than the nadir ray also sample “below” the surface. The purpose of this extension is “to see” below the surface to clearly detect the location of the surface.

The satellite saves data in three samples. Every other data point in the vertical is saved in the "normal sample," shown in Figure 5.2.1-2. Thus the normal sample has a spacing of 250 m along the ray. The mirror is contained in the normal sample. A subset of the remaining data points is saved in two oversamples: the "surface oversample" and the "rain echo oversample." Both oversamples have a spacing of 250 m along a ray, but a region with both normal sample and oversample has a spacing of 125 m. The PR determines which levels to save in the oversamples based on its on board determination of the surface bin. No data are saved as oversample in rays 1-10 and 40-49. Five levels are saved from rays 11-39 in the surface oversample. If the PR detects the surface in an oversample bin, the surface oversample is centered on the detected surface. If, on the other hand, the PR detects the surface in a normal sample bin, 3 oversample bins are above and 2 oversample bins are below the detected surface. In addition, 28 levels (immediately above the surface oversample) are saved from rays 20-30 in the rain echo oversample.

The PR data received from the satellite contains information referenced to distance from the satellite as described above. However, Level 2 PR products have incorporated this complex information to create data referenced to the level of the earth ellipsoid.



The outer outline encloses the normal sample. The rain echo oversample and the surface oversample occupy subsets of the normal sample region. Both oversamples are vertically located with respect to the surface level detected by the satellite.

Figure 5.2.1-1
PR Scan Geometry

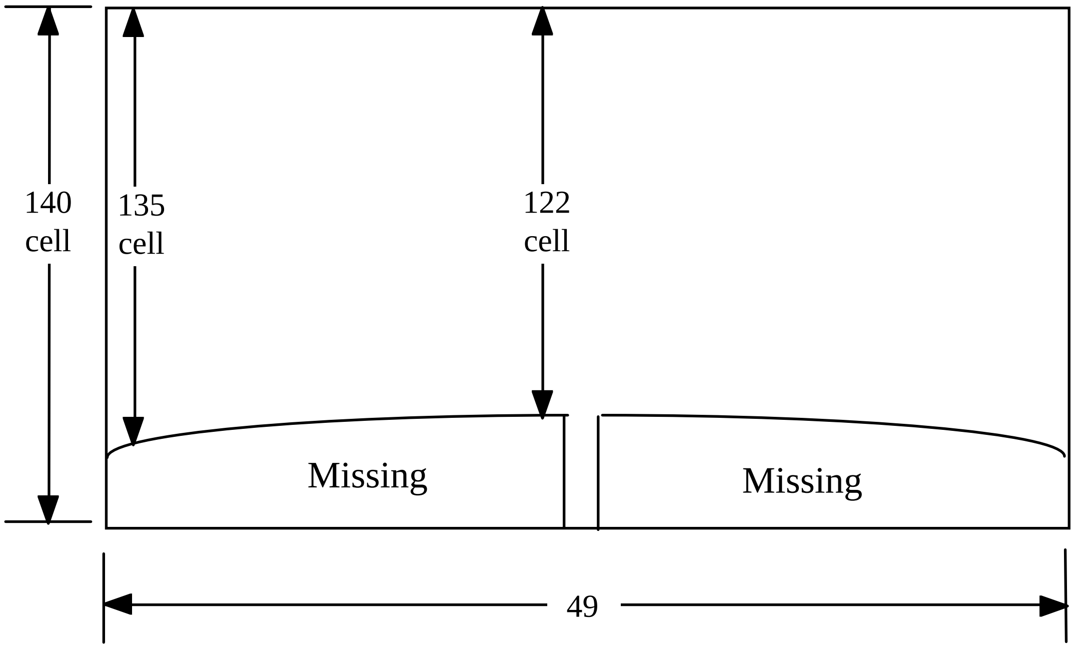


Figure 5.2.1-2
Normal Sample Data Array

5.2.2 Design Considerations

The satellite information includes navigation and calibration information. The Spacecraft Position and Velocity data are represented in 4-byte floating point precision. Spacecraft Geocentric Position is represented to 10m accuracy, which equates to 6 significant digits since the earth's radius is about 6,370,000 m.

5.2.3 PR Qualitative (2A-23)

2A-23, "PR Qualitative", produces a Rain/No-rain flag. If rain is present, this algorithm will detect the Bright Band (BB), determine the heights of the BB and the storm, and classify rain types.

5.2.3.1 Structure

Figure 5.2.3-1 shows the structure of the 2A-23 product in terms of the component objects and their sizes.

5.2.3.2 Contents

The contents of objects in the structure are as follows:

ECS Core Metadata (Attribute, 1,000-byte character):
ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix A.

PS Metadata (Attribute, 2,000-byte character):
Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix B.

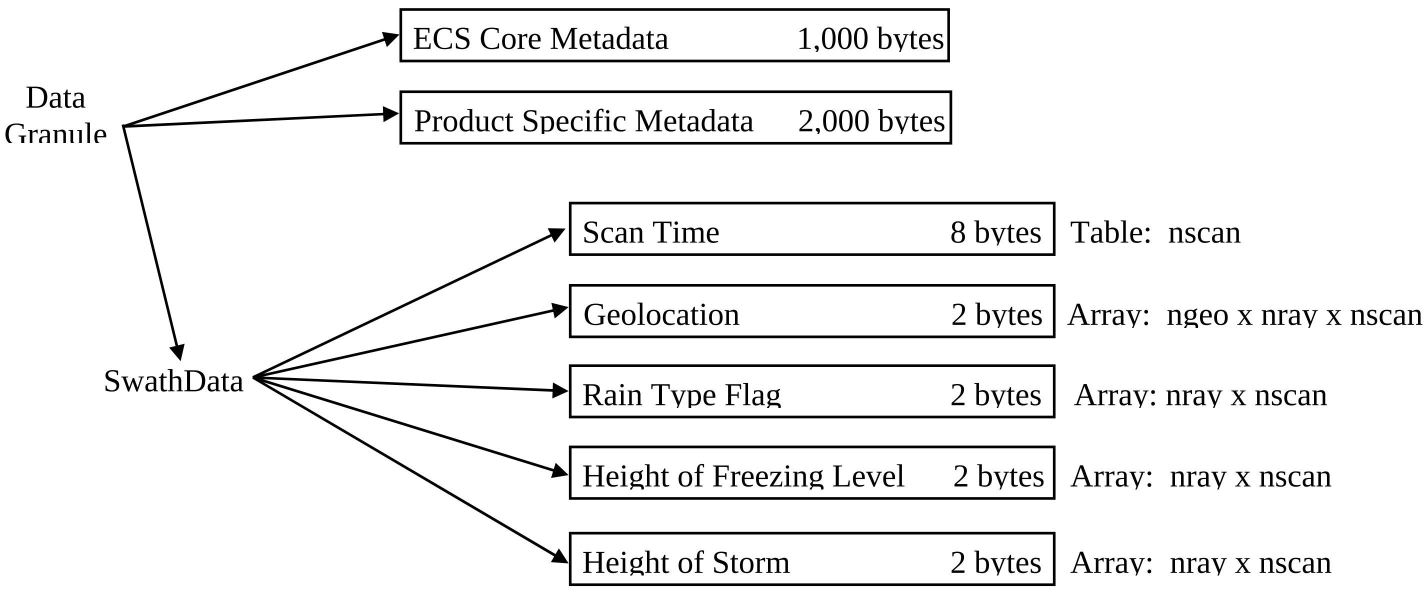


Figure 5.2.3-1
Data Format Structure for 2A-23, PR Qualitative

Scan Time (Vdata Table, record size 8 bytes, nscan records)
See the following, Table 5.2.3-1.

Table 5.2.3-1
2A-23 Scan Time

Name	Format	Description
Scan Time	8-byte float	A time associated with the scan. The exact relationship between the Scan Time and the time of each IFOV is described in ICS Volume 3, Section 3. Scan Time is expressed as the UTC seconds of the day.

Geolocation (SDS, array size ngeo x nray x nscan, 2-byte integer):
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. Latitude and longitude in degrees are multiplied by 100 and stored as 2-byte integers.

Off-earth is represented as -9999. Latitude is positive north, negative south. Longitude is positive east, negative west. A point on the 180^0 meridian is assigned to the western hemisphere.

Rain Type Flag (SDS, array size nray x nscan, 2-byte integer):
The Rain Type is set as follows:

100: Stratiform certain.
When R_type_V[i] = T_stra; (BB exists)
and R_type_H[i] = T_stra;

110: Stratiform certain.
When R_type_V[i] = T_stra; (BB exists)
and R_type_H[i] = T_others;

120: Probably stratiform.
When R_type_V[i] = T_others;(BB may exist but not detected)
and R_type_H[i] = T_stra;
BB not detected by V-profile method, but BB may exist.
Radar echo not strong enough to be convective, and not noise (because H-pattern method classified this as stratiform but not noise (i.e., others)), hence the rain type in this case is most probably stratiform.

130: Maybe stratiform.
When R_type_V[i] = T_stra; (BB detection certain)
and R_type_H[i] = T_conv;
Ambiguous, but rain type may be stratiform because the bright band (BB) certainly detected, and radar echo below BB not so strong (because V-profile method classified this as stratiform).
The H-pattern method classified this as convective not because the existence of very strong radar echo (if so, the V-profile method also would have classified this as convective despite of the existence of BB), but because it satisfied the stand-out condition for convective center against the background area with 11 km radius, which does not necessarily mean that radar echo is very strong.

140: Maybe stratiform or maybe transition or something else.
When R_type_V[i] = T_others; (BB hardly expected)
and R_type_H[i] = T_stra;

152: Maybe stratiform:

Shallow rain (non-isolated) is detected.
When R_type_V[i] = T_others;
R_type_H[i] = T_stra;
and shallowRain[i] = 20 or 21;

160: Maybe stratiform, but rain hardly expected near surface.
BB may exist but is not detected.
When R_type_V[i] = T_others;
and R_type_H[i] = T_stra;

170: Maybe stratiform, but rain hardly expected near surface.
BB hardly expected. Maybe cloud only.
Distinction between 170 and 300 is very small.
When R_type_V[i] = T_others;
and R_type_H[i] = T_stra;

200: Convective certain.
When R_type_V[i] = T_conv; (no BB)
and R_type_H[i] = T_conv;

210: Convective certain.
When R_type_V[i] = T_others;
and R_type_H[i] = T_conv;
Since the criteria for convective by the V-profile method is somewhat stringent, the V-profile method classified this as others, but actually it is convective because H-pattern method classified this as convective (probably by the stand-out condition for convective center against the background area). Though certain, the confidence level would be very slightly lower than that of the case designated by the number 20 (i.e. the case where both methods classified it as convective).

220: Convective certain.
When R_type_V[i] = T_conv;
and R_type_H[i] = T_others;
(or, on a very rare occasion, when only R_type_V[i] is available because of read scan error.)

230: Probably convective. ---> this combination will not appear in ver.6.11 and later.

When R_type_V[i] = T_conv;   (BB exists)
and R_type_H[i] = T_conv;
Somewhat ambiguous because of the existence of the bright band (BB).
But the rain type is probably convective because radar echo below BB is so strong that even the V-profile method classified it as convective, and the H-pattern method also classified it as convective.

240: Maybe convective.
When R_type_V[i] = T_conv;
and R_type_H[i] = T_stra;
Though I tried to set the criteria for convective by the V-profile method as being somewhat more stringent than that of the H-pattern method, it is not always the case.
I expect that this combination would happen in two cases:

(1) When strong convective precipitation exists above Hebb-1km, below which is examined by the H-method, and echo below Hebb-1km is very weak due to strong ATT.

(2) But this combination also occurs when BB detection fails.
(A very large Z at BB height would make the result of V-method as convective when the detection of BB fails. This may occur when BB is associated with strong precipitation: V-method has a chance to miss the BB, hence convective by V-method. A large ATT would make the echo below BB very weak, hence stratiform by H-method.)

In practice, it is very difficult to distinguish the above (1) and (2). In ver. 4.0, the above combination is classified as convective, because it is certain that the echo is strong so that it has a convective nature in both (1) and (2). But, of course, a detailed study is needed in Day-2 improvement of the algorithm.

251: Convective.
Shallow isolated is detected.

When R_type_V[i] = T_conv,
R_type_H[i] = T_conv;
and shallowRain[i] = 10 or 11;

252: Convective.
Shallow rain (non-isolated) is detected.
When R_type_V[i] = T_conv,
R_type_H[i] = T_conv;
and shallowRain[i] = 20 or 21;

261: Convective.
Shallow isolated is detected.
When R_type_V[i] = T_conv,
R_type_H[i] = T_others;
and shallowRain[i] = 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[i] = T_others,
R_type_H[i] = T_conv;
and shallowRain[i] = 10 or 11;

272: Convective.
Shallow rain (non-isolated) is detected.
When R_type_V[i] = T_others,
R_type_H[i] = T_conv;
and shallowRain[i] = 20 or 21;

281: Convective.
Shallow isolated is detected.
When R_type_V[i] = T_conv,
R_type_H[i] = T_stra;
and shallowRain[i] = 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: Convective:
Shallow isolated is detected.
When R_type_V[i] = T_others;
R_type_H[i] = T_stra;
and shallowRain[i] = 10 or 11;

300: Others.
When R_type_V[i] = T_others;
and R_type_H[i] = T_others;
This category includes very weak echo (possibly noise) and/or cloud (very weak echo in the lower altitude but appreciable echo in the upper part, which was not detected as bright band).

312: Others.
Shallow rain (non-isolated) is detected.
When R_type_V[i] = T_others,
R_type_H[i] = T_others;
and shallowRain[i] = 20 or 21;-

313: Others.
If sidelobe clutter were not rejected, shallow isolated would be detected.
When R_type_V[i] = T_others,
R_type_H[i] = T_others;

where

R_type_V: rain type classified by the V-profile method,
R_type_H: rain type classified by the H-pattern method, which is based on SHY95 developed by Prof. Houze and his group.

The above assignment of numbers has the following meaning:

(merged) rainType[i] / 100 = 1: stratiform,
2: convective.
3: others,

(merged) rainType[i] % 100 = Sub-category,

(merged) rainType[i] % 10 = 0: usual,
1: shallow isolated,
2: shallow non-isolated,
3: sidelobe clutter only (once shallow isolated

overwritten as sidelobe clutter only).
rainType[i]%10=3 occurs for type 313 only.

where rainType[i] % 10 means MOD(rainType[i],10) in FORTRAN.

Though rainType is changed to int16, no rain and missing values remain the same, that is

rainType[i] = -88 : no rain
-99 : missing

Height of Freezing Level (SDS, array size nray x nscan, 2-byte integer):
A positive Height of Freezing Level is the height of the 0^0C isotherm above mean sea level in meters, estimated from climatological surface temperature data. Negative values are defined as:
-8888: No rain

Height of Storm (SDS, array size nray x nscan, 2-byte integer):
A positive Height of Storm is the height of the storm top above mean sea level in meters. A positive Height of Storm is given only when rain is present with a high degree of confidence in 1C21, i.e., the Minimum Echo Flag in 1C21 has the value of 2 (rain certain). Negative values are defined as:

-1111: Height of Storm not calculated because rain is not present with a high level of confidence in 1C21

-8888: No rain

5.2.4 PR Surface Rain (2A-25-R1)

2A-25-R1, “PR Surface Rain”, produces an estimate of surface rainfall rate for each radar beam. To compare with ground-based radar data, the attenuation corrected Z is also given.

5.2.4.1 Structure

Figure 5.2.4-1 shows the structure of the 2A-25-R1 product in terms of the component objects and their sizes.

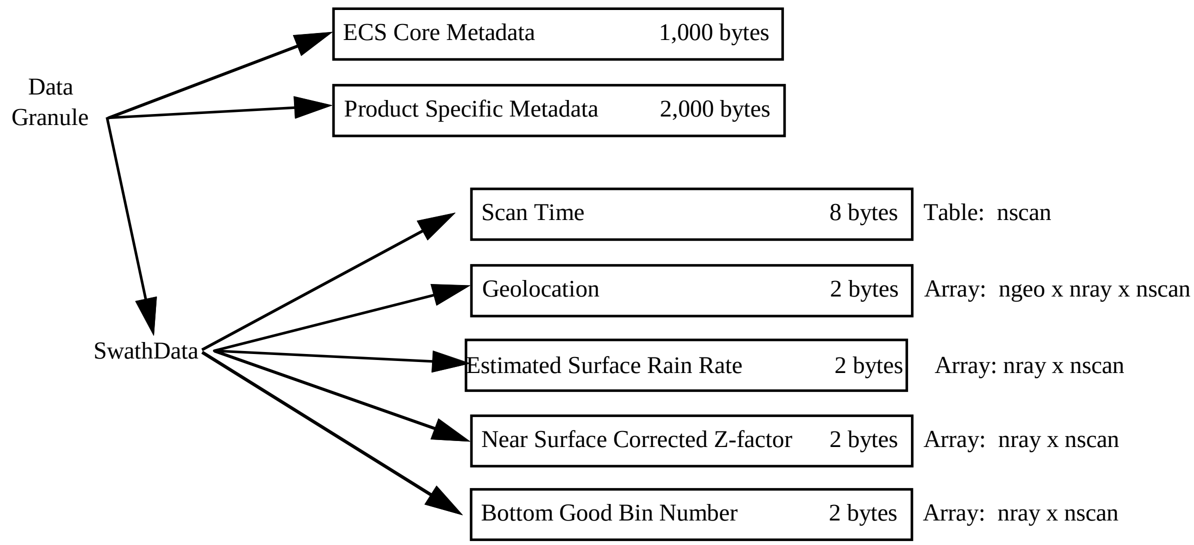


Figure 5.2.4-1
Data Format Structure for 2A-25-R1, PR Profile

5.2.4.2 Contents

The contents of objects in the structure are as follows:

ECS Core Metadata (Attribute, 1,000-byte character):
ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix A.

PS Metadata (Attribute, 2,000-byte character):
Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix B.

Scan Time (Vdata Table, record size 8 bytes, nscan records):
See the following, Table 5.2.4-1.

Table 5.2.4-1
2A-25-R1 Scan Time

Name	Format	Description
Scan Time	8-byte float	A time associated with the scan. The exact relationship between the Scan Time and the time of each IFOV is described in ICS Volume 3, Section 3. Scan Time is expressed as the UTC seconds of the day.

Geolocation (SDS, array size ngeo x nray x nscan, 2-byte integer):
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 pixel and scan. Latitude and longitude in degrees are multiplied by 100 and stored as 2-byte integers. Off-earth is represented as -9999. Latitude is positive north, negative south. Longitude is positive east, negative west. A point on the 180^0 meridian is assigned to the western hemisphere.

Estimated Surface Rain Rate (SDS, array size nray x nscan, 2-byte integer):
This is the estimate of rain rate at the true (detected) surface bin. It ranges from 0.0 to 3000.0 mmh^{-1} and is multiplied by 100 and stored as a 2-byte integer.

Near Surface Corrected Z-factor (SDS, array size nray x nscan, 2-byte integer):
This is the attenuation corrected reflectivity factor (Z) at the radar range gates from 0 to 20 km. It ranges from 0.0 to 80.0 dBZ and is multiplied by 100 and stored as a 2-byte integer. Values of reflectivity less than 0.0 dBZ are set to 0.0 dBZ .

Bottom Good Bin Number (SDS, array size nray x nscan, 2-byte integer):
The Range Bin Number of the bottom of the interval that is processed as meaningful data by the operational 2A25 algorithm. Bin Numbers range from 0 to 79 and have an interval of 250 m. The Earth ellipsoid is Bin Number 79. Bin Number 0 is 19750 m above the earth ellipsoid. The Near Surface Rain and Near Surface Corrected Z-factor are observed one bin less (250 m higher above the Earth ellipsoid) than the Bottom Good Bin Number.

5.2.5 PR Profile (2A-25-R2)

2A-25-R2, “PR Profile”, produces an estimate of vertical rainfall rate profile for each radar beam.

5.2.5.1 Structure

Figure 5.2.5-1 shows the structure of the 2A-25-R2 product in terms of the component objects and their sizes.

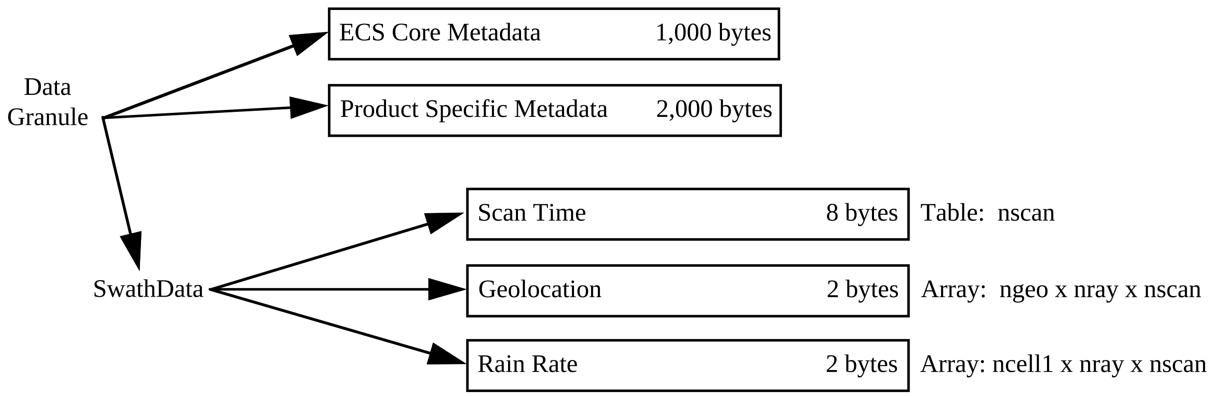


Figure 5.2.5-1
Data Format Structure for 2A-25-R2, PR Profile

5.2.5.2 Contents

The contents of objects in the structure are as follows:

ECS Core Metadata (Attribute, 1,000-byte character):
ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix A.

PS Metadata (Attribute, 2,000-byte character):
Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix B.

Scan Time (Vdata Table, record size 8 bytes, nscan records):
See the following, Table 5.2.5-1.

Table 5.2.5-1
2A-25-R2 Scan Time

Name	Format	Description
Scan Time	8-byte float	A time associated with the scan. The exact relationship between the Scan Time and the time of each IFOV is described in ICS Volume 3, Section 3. Scan Time is expressed as the UTC seconds of the day.

Geolocation (SDS, array size ngeo x nray x nscan, 2-byte integer):
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 pixel and scan. Latitude and longitude in degrees are multiplied by 100 and stored as 2-byte integers. Off-earth is represented as -9999. Latitude is positive north, negative south. Longitude is positive east, negative west. A point on the 180^0 meridian is assigned to the western hemisphere.

Rain Rate (SDS, array size ncell1 x nray x nscan, 2-byte integer):
This is the estimate of rain rate at the radar range gates from 10,000 m to 500 m above the Earth ellipsoid, in increments of 500 m. It ranges from 0.0 to 3000.0 mmh^{-1} and is multiplied by 100 and stored as a 2-byte integer. A value of -88.88 mm/hr (stored as -889) means ground clutter.

6. LEVEL 3 PRODUCTS

6.1 LEVEL 3 TRMM AND OTHER DATA

The system to produce the "TRMM and Other Data" estimates in real time was developed to apply new concepts in merging quasi-global precipitation estimates and to take advantage of the increasing availability of input data sets in near real time. The product is produced quasi-operationally on a best-effort basis at TSDIS, with on-going scientific development by a research team in the NASA/GSFC Laboratory for Atmospheres. As such, users are encouraged to report their experiences with the data, and they should expect episodic upgrades or outages as the system develops. Users who wish to use a long-term, uniformly processed data set like 3B42RT should use the corresponding "TRMM and Other Data" product computed after real time, 3B42. It is available through the GDISC at:
http://disc.gsfc.nasa.gov/data/datapool/TRMM_DP/01_Data_Products/02_Gridded/

There are three Level 3B data products for TRMM and Other Data: 3B40RT High-Quality Merged Microwave Precipitation, 3B41RT Variable-Rainrate Infrared Precipitation, and 3B42RT Merged Infrared Microwave Precipitation. Dr. Robert Adler is the PI for all three products. The formats of these products are based on consultation with Dr. Adler and Dr. Huffman. These formats are binary. The following parameters are used in describing the formats:

- nlat1: the number of 0.25° latitude grid intervals from 90°N to 90°S = 720
- nlat2: the number of 0.25° latitude grid intervals from 60°N to 60°S = 480
- nlon: the number of 0.25° longitude grid intervals from 0°E to 360°E = 1440

6.1.1 High-Quality Merged Microwave Precipitation (3B40RT)

3B40RT, "High-Quality Merged Microwave Precipitation", merges all available TMI and SSM/I microwave precipitation estimates before 5 February 2005, and thereafter all available TMI, SSM/I, AMSR-E, and AMSU-B estimates, into a "high-quality" (HQ) precipitation estimate. The TMI estimates were computed using GPROF-TMI Version 5 up through 4 January 2005, at which time Version 6 was instituted. All AMSR-E estimates have been computed using Version 1 of GPROF-AMSR. The SSM/I estimates were computed using GPROF-SSM/I Version 6 up through 11 February 2004, at which time Version 6.5 was instituted. The AMSU-B precipitation data set is computed operationally at the National Environmental Satellite Data and Information Service (NESDIS) based on the Zhao and Weng (2002) and Weng et al. (2003) algorithm. Before merger, the AMSR-E, SSM/I, and AMSU-B precipitation estimates are calibrated to the TMI precipitation estimates using separate global land and ocean matched histograms.

All the data fields are on a 0.25° latitude x 0.25° longitude grid from 90°N to 90°S and 0° E to 360°E. The origin is the northernmost gridbox whose western edge is on the Prime Meridian; the center of the origin gridbox is at (0.125°E, 89.875°N). The grid increments most rapidly to the east and then to the south. Grid box edges are even multiples of 0.25°.

6.1.1.1 Structure

Table 6.1.1.1-1 shows the structure of the 3B40RT product :

Table 6.1.1.1-1
Structure of the 3B40RT product

Name	Element Size	Dimensions
header	2880 bytes	
precipitation	2 bytes	Array: nlon x nlat1
precipitation_error	2 bytes	Array: nlon x nlat1
total_pixels	1 byte	Array: nlon x nlat1
ambiguous_pixels	1 byte	Array: nlon x nlat1
rain_pixels	1 byte	Array: nlon x nlat1

6.1.1.2 Contents

The contents of the objects in this structure are as follows:

header (2880-byte character):
Metadata describing the file. See Appendix C.

precipitation (array size nlon x nlat1, 2-byte integer):
Precipitation estimate (0.01 mm/hr). If the number of ambiguous pixels is at least 40% of the number of total pixels, the precipitation estimate is given a minus sign. The range is from -31998 (-31.998 mm/hr) to 31998 (31.998 mm/hr). A grid box with insufficient valid data is given the value -31999.

precipitation_error (array size nlon x nlat1, 2-byte integer):
Random error in the precipitation estimate (0.01 mm/hr). Currently all grid boxes are set to the missing value -31999 until further development.

total_pixels (array size nlon x nlat1, 1-byte integer):
Number of pixels (counts), or instrument footprints, in the gridbox.
All values are zero or positive.

ambiguous_pixels (array size nlon x nlat1, 1-byte integer):
Number of pixels (counts) in the gridbox with highly uncertain values.
All values are zero or positive.

rain_pixels (array size nlon x nlat1, 1-byte integer):
Number of pixels (counts) in the gridbox with positive rainfall rate.
All values are zero or positive.

Notes:

Both precipitation and precipitation_error are scaled by 100 before being written to the file as a 2-byte integer. To recover the values in mm/hr after reading the file, divide by 100. Note that requiring precipitation to be non-negative will filter out both values that are highly likely to be artifacts (-31998 ≤ value < 0) and the value for insufficient data (-31999).

Note that we use "gridbox" to denote the values on Level 3 data (i.e., gridded data), while we use "pixel" to denote individual values of Level 2 data (i.e., instrument footprints). Thus, there can be many pixels contributing to a gridbox.

Note that any negative values in the various "number of" fields is a processing error that should be immediately reported to the contact listed in the header.

All the data fields are written in a binary format. They are written with C as blocks of bytes, so there are no extraneous bytes in the files. Because the first two fields are 2-byte integer and the rest are 1-byte integer in each file (to save space), users must exercise care in using FORTRAN direct access to read the data. Alternatively, the files can be opened with different logical record sizes depending on whether one is reading 2-byte integer or 1-byte integer fields. Note well that the units of the logical record size is not part of the FORTRAN 77 standard. On SGI machines it is in 4-byte words, but some other systems expect it in bytes.

6.1.2 Variable-Rainrate Infared Precipitation (3B41RT)

3B41RT, "Variable-Rainrate Infrared Precipitation", estimates precipitation from geostationary infrared (IR) data using spatially and temporally varying calibration by the High Quality Merged Microwave data (HQ). The algorithm is a probability-matched threshold approach that ensures that the histogram of gridbox-average IR precipitation rates matches the histogram of gridbox-average HQ precipitation rates locally. As such, the colder an IR pixel is than the zero-precipitation threshold temperature, the higher the rainrate it receives. We refer to this as a variable-rainrate (VAR) algorithm.

All the data fields are on a 0.25° latitude x 0.25° longitude grid from 60°N to 60°S and 0°E to 360°E.The origin is the northernmost gridbox whose western edge is on the Prime Meridian; the center of the origin gridbox is at (0.125°E, 59.875°N). The grid increments most rapidly to the east and then to the south. Grid box edges are even multiples of 0.25°.

6.1.2.1 Structure

Table 6.1.2.1-1 shows the structure of the 3B41RT product.

Table 6.1.2.1-1
Table Data Format Structure for 3B41RT

name	Element Size	Dimensions
header	2880 bytes	
precipitation	2 bytes	Array: nlon x nlat2
precipitation_error	2 bytes	Array: nlon x nlat2
total_pixels	1 byte	Array: nlon x nlat2

6.1.2.2 Contents

The contents of the objects in this structure follow. Also see the Notes in Section 6.1.1.2.

header (2880-byte character):
Metadata describing the file. See Appendix C.

precipitation (array size nlon x nlat2, 2-byte integer):
Precipitation estimate (0.01 mm/hr). If the number of ambiguous pixels is at least 40% of the number of total pixels, the precipitation estimate is given a minus sign. The range is from

-31998 (-31.998 mm/hr) to 31998 (31.998 mm/hr). A grid box with insufficient valid data is given the value -31999.

precipitation_error (array size nlon x nlat2, 2-byte integer):
Random error in the precipitation estimate (0.01 mm/hr). Currently all grid boxes are set to the missing value -31999 until further development.

total_pixels (array size nlon x nlat2, 1-byte integer):
Number of pixels (counts), or instrument footprints, in the gridbox. All values are zero or positive.

6.1.3 Merged Infared Microwave Precipitation (3B42RT)

3B42RT, "Merged Infrared Microwave Precipitation", is a merger of 3B40RT (HQ) and 3B41RT (VAR). The current scheme is simple replacement - for each gridbox the HQ value is used if available, and otherwise the VAR value is used.

The structure of one data grid is the same as 3B41RT. See Section 6.1.2.

6.1.3.1 Structure

Table 6.1.3.1-1 shows the structure of the 3B42RT product

Table 6.1.3.1-1
Table Data Format Structure for 3B42RT

Name	Element Size	Dimensions
header	2880 bytes	
precipitation	2 bytes	Array: nlon x nlat2
precipitation_error	2 bytes	Array: nlon x nlat2
source	1 byte	Array: nlon x nlat2

6.1.3.2 Contents

The contents of the objects in this structure follow. Also see the Notes in Section 6.1.1.2.

header (2880-byte character):
Metadata describing the file. See Appendix C.

precipitation (array size nlon x nlat2, 2-byte integer):
Precipitation estimate (0.01 mm/hr). If the number of ambiguous pixels is at least 40% of the number of total pixels, the precipitation estimate is given a minus sign. The range is from-31998 (-31.998 mm/hr) to 31998 (31.998 mm/hr). A grid box with insufficient valid data is given the value -31999.

precipitation_error (array size nlon x nlat2, 2-byte integer):
Random error in the precipitation estimate (0.01 mm/hr). Currently all grid boxes are set to the missing value -31999 until further development.

source (array size nlon x nlat2, 1-byte integer):
Source (unitless) of estimate. The only values are -1, 0, or 100 for none, HQ, or VAR, respectively

7. ABBREVIATIONS AND ACRONYMS

A

ACS	Attitude Control System
AVHRR	Advanced Very High Resolution Radiometer

B

BB	Bright Band

D

DMSP	Defense Meteorological Satellite Program

E

ECS	EOSDIS Core System
EOSDIS	EOS Data and Information System

F

FORTRAN	Formula Translation

H

HDF	Hierarchical Data Format

I

ICS	Interface Control Specification
ID	Identifier
IFOV	Instantaneous Field of View

M

MSFC	Marshall Space Flight Center

N

NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency
NCSA	National Center for Supercomputing Applications
NOAA	National Oceanic and Atmospheric Administration

O

ODL	Object Development Language

P

PI	Principal Investigator
PR	Precipitation Radar
PS	Product Specific

S

SDS	Scientific Data Set
SSM/I	Special Sensor Microwave/Imager

T

TMI	TRMM Microwave Imager
TRMM	Tropical Rainfall Measuring Mission
TSDIS	TRMM Science Data and Information System
TSU	TSDIS Science Users

U

UTC	Universal Time Coordinated
UTCF	Universal Time Correlation Factor

V

VIRS	Visible Infrared Scanner

8 GLOSSARY

Attribute	A structure for textual information in HDF attached to an SDS or a file.
Convective rain	Precipitation from a convective cloud with extensive vertical development.
Disdrometer	Equipment designed to measure and record the size distribution of raindrops.
Earth Ellipsoid	An imaginary surface of the earth in the shape of an ellipsoid that coincides with the average Mean Sea Level.
Granule	The amount of information contained in one file (e.g., one orbit for Level-1 and Level-2 satellite data or one hour for Level-1 and Level-2 ground validation data).
Increment	The data element interval to which each geolocation element applies (i.e., if Stride = 2, each successive geolocation applies to every other data element).
Isotherm	A contour of equal or constant temperature.
Metadata	Information which describes a data set (e.g., date recorded, source, or purpose).
Nadir	The point on the earth directly below the satellite.
Offset	The first data element to which the first geolocation element applies.
Scan	A single sweep of a sensor onboard a satellite
Steradian	The unit of solid angle, abbreviated sr. The total solid angle about a point is equal to 4π steradians.
Stratiform rain	Precipitation from a stratiform cloud with extensive horizontal development.
Swath Structure	An EOSDIS defined structure in HDF to store data organized by scans.
Vdata	An HDF object that is a table of records.
Vgroup	An HDF group of objects or other Vgroups.

Appendix A
ECS Core Metadata Elements

ECS Core Metadata Format (Attribute, maximum 1,000-byte character):

ECS Core Metadata are those metadata defined by ECS as Core metadata. A description of each ECS Core metadata element follows. The size column refers to the size of the name plus value. The actual element would take up an additional 100 bytes due to metadata implementation overhead. In other words, the true size is the listed size plus 100 bytes.

Table A.1
ECS Metadata Elements

ECS Metadata Element	Estimated Size (bytes)	Description	Products Using Element
West Bounding Coordinate	50	The degree value for the west longitude of boundary.	All
East Bounding Coordinate	50	The degree value for the east longitude of boundary.	All
North Bounding Coordinate	50	The degree value for the north latitude of boundary.	All
South Bounding Coordinate	50	The degree value for the south latitude of boundary.	All
Beginning Date	50	The date when the granule coverage began. Granule coverage is defined as the orbit for Level-1 and Level-2 satellite data, as the hour of the granule for Level-1 and Level-2 ground validation data, as the day of the granule for rain gauge and disdrometer data, and as the pentad or month of the granule for Level-3 data.	All
Beginning Time	50	The time when the granule coverage began. See beginning date.	All
Ending Date	50	The date when the granule coverage ended. See beginning date.	All
Ending Time	50	The time when the granule coverage ended. See beginning date.	All

Appendix B
PS Metadata Elements

PS Metadata (Attribute, maximum 2,000-byte character):
Product Specific Metadata are metadata defined by TSDIS. The size column refers to the size of the name plus value. The actual element would take up an additional 100 bytes due to metadata implementation overhead. In other words, the true size is the listed size plus 100 bytes. A description of each PS metadata element follows in Table B.1.

Table B.1
PS Metadata Elements

PS Metadata Element	**Estimated Size (bytes)**	**Description**	**Products Using Element**
Granule ID	100	TSDIS granule identifier (ID)	All
Algorithm ID	50	Name of the algorithm (i.e. 1B21)	All
Algorithm Version	50	The version of the science algorithm is written as "M.m", where M is an integer corresponding to major revisions of the code. Major revisions are changes in the science algorithm which do affect the science, are delivered to TSDIS in an official delivery package, and require reprocessing. "m" is an integer corresponding to minor revisions or corrections. Minor revisions or corrections are made so the science algorithm will function properly in TSDIS, do not affect the science, are not delivered to TSDIS in an official delivery package, and do not require reprocessing. "M" is written without leading zeroes, with a range from 1 to 99. "m" is written with leading zeroes, with a range from 00 to 99. At launch, the version of all science algorithms is "1.00".	All
Toolkit Version	50	Version of Toolkit used to create this granule	All
Longitude of Maximum Latitude	50	Longitude of the northernmost extent of the satellite orbit. Decimal degrees with 6 figures precision after the decimal point. Positive east, negative west. A point on the 180th meridian is assigned to the western hemisphere.	L1 and L2 Satellite Products
Orbit Adjust Flag	50	Orbit Adjust Flag. Values are as follows: 0 = no orbit adjust activity during this orbit. 1 = orbit adjustment control modes occurred during this orbit.	L1 and L2 Satellite Products
Attitude Mode Flag	50	Attitude Mode Flag. Values are as follows: 0 = forward mode (+X forward) throughout this orbit 1 = backward mode (-X forward) throughout this orbit 2 = yaw maneuver during this orbit	L1 and L2 Satellite Products
Orbit Size	50	Number of scans in the granule. If the granule is empty, Orbit Size = 0.	L1 and L2 Satellite Products

Appendix C
TRMM and Other Data Metadata Elements

Header (2880-byte character):
The header is the same length as one zonal row of a 2-byte integer data field. The header is ASCII in a "parameter=value" format that makes the file self-documenting. As such, the header can be read with standard text editors, dumped as text with simple application programs, or parsed for input into applications. Successive "parameter=value" sets are separated by spaces, and no spaces or "=" are permitted in "value". A description of each metadata element follows in Table C.1.

Table C.1
TRMM and Other Data Metadata Elements

Element	Description
algorithm_ID	TRMM algorithm identifier, e.g., "3B40RT"
algorithm_version	The version of the science algorithm
granule_ID	TSDIS granule identifier, e.g., "3B40RT.2001121809.bin"
header_byte_length	The number of bytes in the header
file_byte_length	The number of bytes in the file expressed as a formula describing the file structure
nominal_YYYYMMDD	The nominal year, month, and day of month
nominal_HHMMSS	The nominal UTC hour, minute, and second
begin_YYYYMMDD	The start year, month, and day of month
begin_HHMMSS	The start UTC hour, minute, and second
end_YYYYMMDD	The end year, month, and day of month
end_HHMMSS	The end UTC hour, minute, and second
creation_YYYYMMDD	The date the file was created, expressed as year, month, and day of month
west_boundary	The western edge of the data domain
east_boundary	The eastern edge of the data domain
north_boundary	The northern edge of the data domain
south_boundary	The southern edge of the data domain
origin	Location within the grid of the first grid box, e.g.,”northwest”
number_of_latitude_bins	The meridional number of grid boxes
number_of_longitude_bins	The zonal number of grid boxes
grid	The size of one grid box
first_box_center	The geolocation of the the first grid box center

second_box_center	The geolocation of the the second grid box center
last_box_center	The geolocation of the the last grid box center
number_of_variables	The number of data fields
variable_name	A list of the data field names, separated by commas
variable_units	A list of data field units, separated by commas and in the same order as the variable_name list
variable_scale	A list of data field scaling factors, separated by commas and in the same order as the variable_name list. See Notes in Section 6.1.1.2
variable_type	A list of data field word types, separated by commas and in the same order as the variable_name list
byte_order	The order that bytes are written in a data word, either “big_endian” or “little_endian.”
flag_value	A list of special values, separated by commas
flag_name	A list of special value names, separated by commas and in the same order as the flag_value list
contact_name	The name of who to contact with questions
contact_address	The address of the contact
contact_telephone	The telephone number of the contact
contact_facsimile	The facsimile number of the contact
contact_email	The email address of the contact