

TRMM SCIENCE USER - INTERFACE CONTROL SPECIFICATION (ICS)

TROPICAL RAINFALL MEASURING MISSION SCIENCE DATA AND INFORMATION SYSTEM

Interface Control Specification Between the Tropical Rainfall Measuring Mission Science Data and Information System (TSDIS) and the TSDIS Science User (TSU) TSDIS-P907

Volume 5: File Specifications for TRMM Browse Products

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This is the fifth volume of the TSDIS-TSU ICS, which describes the file specification of the browse products. This volume was written based on the TRMM Science Requirements, Version 1 algorithm descriptions, and personal communications with the algorithm developers.

EOSDIS has defined draft standards for a browse package. The first draft version of these standards was released in October, 1995. The browse specifications in this document are based on these standards.

Note that the following products have no browse products and therefore are not discussed in this document: 1B-21, 1B-51, 2A-52, 2A-56, and 2A-57.

1. INTRODUCTION

All the browse images created for TSDIS will be stored in Hierarchical Data Format (HDF). HDF currently supports six data structure types: 8-bit raster images, 24-bit raster images, color palettes, scientific data sets (multi-dimensional arrays), text entries and Vdatas (binary tables). TSDIS will employ 8-bit raster images and color palettes to store browse images. For more information on HDF, refer to the TSDIS-TSU ICS, Volume 3, Section 2.

The HDF 8-bit raster model provides a framework for storing 8-bit raster images along with their image dimensions and color palettes. Any 8-bit raster image accompanied by its dimension record and an optional color palette is recognized as an HDF 8-bit raster image set (RIS8). In HDF, an 8-bit raster image is defined as any bit-mapped image whose rows are painted from left to right using pixels whose values are represented by a stream of 8-bit numbers. Palettes are the means by which color is applied to 8-bit raster image data. Because pixel values are stored as 8-bit numbers, they are limited to values between 0 and 255. Each pixel value appearing in an image is assigned a color through a color look-up table in the palette. In other words, pixel values serve as an index for 256 entries stored in a color look-up table in the palette. The color look-up table is stored in the following order: red, green, and blue intensity for pixel value = 0, then red, green, and blue intensity for pixel value = 1, and so on through pixel value = 255. Since approximately 50 to 60 colors are reserved for screen background use, the number of colors for use in displaying the image is limited to about 200. The image is stored with row zero intended to be displayed at the top. When using IDL to display this image, !ORDER = 1 should be used.

All TSDIS browse images will be stored in RIS8 without a color palette. The color palette is stored outside the RIS8 but within the HDF file. The browse generation software reads the algorithm product, performs the necessary transformations, and writes the RIS8. The final output will be an HDF file containing Metadata, one or more RIS8 with no color palette bound to the image, and the appropriate color palette which is not bound to a single RIS8. Color palettes for a specific algorithm browse are defined with each algorithm browse. Other color palettes apply to more than one algorithm and are defined in Appendix A.

In the implementation of these browse file specifications, the browse software will input a scientific parameter, for example rainfall in mm/hr. Next, the software will convert the scientific parameter to an 8-bit value. Finally the 8-bit value is displayed with the color determined by its color palette. This document specifies the displayed colors in terms of the original scientific parameter, as shown in Figure 1-1. Therefore the mapping from the scientific parameter to the 8-bit value, the meaning of the 8-bit value, and the specific values of the colors are a matter of implementation. Implementation is discussed in the Software Design Specification Volume 8.

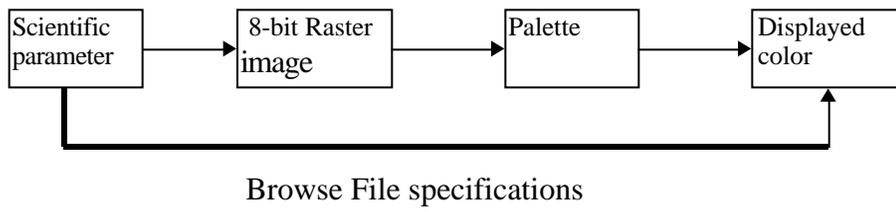


Figure 1-1
The Mapping Specified in the Browse File Specifications

2. SATELLITE BROWSE

A browse product is produced for every satellite algorithm, except 1B-21. At levels 1 and 2, there are all together 8 such daily algorithms (1B-01, 1B-11, 1C-21, 2A-12, 2A-21, 2A-23, 2A-25, and 2B-31). At Level 3, there are 5 monthly algorithms (3A-11, 3A-25, 3A-26, 3B-31, and 3B-43) and one pentad algorithm (3B-42). At Levels 1 and 2, a browse product is produced once per day. At level 3, each monthly product will have one browse product, while each pentad product will have one browse product. Coastlines will be overlaid on the product images during viewing.

2.1 LEVELS 1 AND 2 SATELLITE BROWSE

At levels 1 and 2, a satellite browse product is produced daily for all 16 orbits occurring on that day. A browse product consists of one RIS8 image for the ascending nodes and one RIS8 image for the descending nodes, with all ascending or descending nodes for that day displayed together on their respective images. The product ranges in latitude from 40⁰ S to 40⁰ N and in longitude from 180W to 180E with a horizontal resolution of 30km for TMI and VIRS, and 10km for PR (and 2B-31). The following parameters are used in describing the format.

- nx : The number of grid points in the x direction (East-West); 3960 for PR (and combined) (at 11 equal angle grid points per degree), and 1350 for TMI and VIRS (at 15 equal angle grid points per 4 degrees).
- ny : The number of grid points in the y direction (North-South); 880 for PR (and combined) (at 11 equal angle grid points per degree), and 300 for TMI and VIRS (at 15 equal angle grid points per 4 degrees)

Due to the large grid dimensions, the browse viewer, while displaying the images, has to reduce grid points by sub-sampling from the stored browse images with a default “magnification” factor stored in the PS Metadata (see Appendix C). This magnification factor is -2 for 1B-01, 1B-11 and 2A-12, and -4 for 1C-21, 2A-21, 2A-23, 2A-25 and 2B-31. A magnification factor of -2 means the browse viewer uses every other pixel stored in the browse image, and -4 is every fourth pixel.

2.1.1 Algorithm 1B-01 - VIRS calibration

The browse product for this algorithm displays 11 μ m radiance from channel 4 converted to an 8-bit value appropriate for use with the color palette. Two images, each with a dimension of nx lines x ny pixels, are produced. One image holds the ascending orbit data and another holds the descending orbit data for that day. Figure 2.1.1-1 shows the structure of the 1B-01 image product in terms of its component objects and sizes.

ECS Core Browse Metadata	5000 bytes	
PS Browse Metadata	10000 bytes	
Browse Structure Metadata	5000 bytes	
Ascending Image	1 byte	Array: nx x ny
Descending Image	1 byte	Array: nx x ny
Coastline Overlay	1 byte	Array: nx x ny
Color Palette	1 byte	Array: 768

Figure 2.1.1-1
 Data Format Structure for 1B-01 Browse

The contents of objects in the structure are as follows:

ECS Core Browse Metadata (Attribute, approximately 5000-byte character):
 ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix B.

PS Browse Metadata (Attribute, approximately 10000-byte character):
 Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix C.

Browse Structure Metadata (Attribute, approximately 5000-byte character):
 Browse Structure Metadata provides information defined by EOSDIS for viewing purposes. See Appendix D.

Ascending Image (RIS8, nx x ny, 1 byte integer):
 This image will display 1 μm radiance ($\text{mW} * \text{cm}^{-2} * \mu\text{m}^{-1} * \text{sr}^{-1}$) of the VIRS instrument for all ascending nodes of the orbits for that day.

Descending Image (RIS8, nx x ny, 1 byte integer):
 This image data is the same as the ascending image data except that it will contain the descending nodes of the orbits.

Coastline Overlay (RIS8, nx x ny, 1-byte integer)

This is the overlay image of coastlines. The background has the value 0; the lines have the value 1.

Color Palette (Palette, 768, 1 byte integer):

A common color palette will be used for both ascending and descending images. The 768 bytes can be divided into 256 sets with each set consisting of 24 bits. We can consider the 24 bits as a group of 3 8-bit numbers, where each 8-bit number represents the red, green and blue intensities. The gray shade lookup table, used for the AVHRR in the Pathfinder project, is adapted and specified in Table 2.1.1-1.

Table 2.1.1-1
 Gray Shade Color Table for 1B01 Browse

Input radiance	Image color
Missing value	black
value <= Lbound	dark gray
↑	
value	gray shades
↓	
value >= Ubound	light gray

Notes:

- range = Ubound - Lbound
- Lbound and Ubound are 0.48 and 1.28 mW cm⁻² μm⁻¹ sr⁻¹, respectively.
- The values between lower and upper bounds are linearly mapped to the gray shade color values.

2.1.2 Algorithm 1B-11 - TMI calibration

The structure and contents for this algorithm are identical to those of algorithm 1B-01, with two differences:

- 1) the algorithm output is a modified 3-channel composite RGB. Brightness temperatures (Tb) observed at 85.5 GHz (vertical and horizontal polarization) and at 37 GHz (vertical polarization) will be assigned to the red, green, and blue (RGB) color intensities, respectively, resulting in a 24-bit image. The assignment of brightness temperature, Tb, to intensity count, C, is inversely linear: If Tb < 50 K, C = 255. If 50 K <= Tb <= 305 K, C = 305 - Tb. If 305 K < Tb, C = 0. The 24-bit color image will then be converted to 8-bit raster image data. The method is described in TSDIS SDS, Volume 8, Appendix B - Browse Specifications.

- 2) the conversion also creates a color palette appropriate for brightness temperature. This palette produces colors that approximate the colors displayed using the complete 3-channel composite RGB method.

2.1.3 Algorithm 1C-21 - PR Reflectivities

The browse image for algorithm 1C-21, PR reflectivities, displays reflectivity (dBZ) along 3 cross sections. These cross sections are along-track Range Height Indicator (RHI) at nadir, Constant Altitude Plan Position Indicator (CAPPI) at a 2 km altitude and a CAPPI at a 4 km altitude. Two images are produced for this algorithm. One image holds the ascending nodes and another holds the descending nodes of the orbits for that day.

Figure 2.1.3-1 shows the structure of the 1C-21 image product in terms of its component objects and sizes.

ECS Core Browse Metadata	5000 bytes	
PS Browse Metadata	10000 bytes	
Browse Structure Metadata	5000 bytes	
Ascending Image CAPPI at 2km CAPPI at 4km RHI at Nadir	1 byte	Array: nx x ny
Descending Image CAPPI at 2km CAPPI at 4km RHI at Nadir	1 byte	Array: nx x ny
Coastline Overlay	1 byte	Array: nx x ny
Color Palette	1 byte	Array: 768

Figure 2.1.3-1
 Data Format Structure for 1C-21 Browse

The contents of objects in the structure are as follows:

ECS Core Browse Metadata (Attribute, approximately 5000-byte character):
 ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix B.

PS Browse Metadata (Attribute, approximately 10000-byte character):

Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix C.

Browse Structure Metadata (Attribute, approximately 5000-byte character):

Browse Structure Metadata provides information defined by EOSDIS for viewing purposes. See Appendix D.

Ascending Image (RIS8, nx x ny, 1 byte integer):

This image will display all the 3 output products (RHI at nadir, CAPPI at 2 km and CAPPI at 4 km) in 3 swaths of adjacent bands along the satellite track. The 2 km CAPPI is displayed at the geographically correct position, but the 4 km CAPPI and the RHI at nadir are not displayed at the geographically correct position. The 4 km CAPPI is displayed immediately to the left of the 2 km CAPPI. The nadir RHI is displayed immediately to the right of the 2 km CAPPI, with lower altitude reflectivities to the right. The CAPPIs are displayed with a 10 km resolution, while the RHI at nadir is displayed with a 500 m resolution. This image will contain the ascending node of the orbits.

Descending Image (RIS8, nx x ny, 1 byte integer):

This image data is the same as the ascending image data except that it will contain the descending node of the orbits.

Coastline Overlay (RIS8, nx x ny, 1-byte integer):

This is the overlay image of coastlines. The background has the value 0; the lines have the value 1.

Color Palette (Palette, 768, 1 byte integer):

A common color palette will be used for both ascending and descending images. The color palette is the Standard Reflectivity Lookup Table (Table A-1).

2.1.4 Algorithm 2A-12 - TMI Profiling

The structure and contents for this algorithm are identical to those of algorithm 1B-01, with two exceptions:

- 1) the algorithm output is surface rainfall.
- 2) the color palette is the Standard Rainfall Rate Lookup Table (Table A-2).

2.1.5 Algorithm 2A-21 - Surface cross section

The structure and contents for this algorithm are identical to those of algorithm 1C-21, with two exceptions:

- 1) the algorithm output is surface cross section sigma zero. A single swath is displayed in a geographically correct position, whereas 1C-21 displays 3 swaths.
- 2) the color palette is the one appropriate for sigma zero values. This color palette uses the rainbow color spectrum (purple to red). The maximum (red) value is 15 dB, and the minimum (purple), -20 dB. Anything less than -20 dB is “gray”. Anything greater than 15 dB is “white”. Missing data are “black”.

2.1.6 Algorithm 2A-23 - PR Qualitative

The structure and contents for this algorithm are identical to those of algorithm 1C-21, with two exceptions:

- 1) the algorithm outputs are (1) rain-type including warm rain and (2) height of bright band. An image with two swaths in adjacent bands along the satellite track will be displayed for both the ascending and descending cases. The height of bright band is displayed at the geographically correct position, but the rain-type which includes the warm rain is displayed immediately to the left of the height of bright band.
- 2) the color palette uses the Standard Rainfall Type Lookup Table (Table A-3) and the Lookup Table of the Bright Band Height (Table 2.1.6-1).

2.1.7 Algorithm 2A-25 - PR Profile

The structure and contents for this algorithm are identical to those of algorithm 1C-21 except 2A-25 displays the rainfall rate instead of reflectivity of the 3 cross sections mentioned in 1C-21. The color palette uses the Standard Rainfall Rate Lookup Table (Table A-2).

2.1.8 Algorithm 2B-31 - TRMM Combined

The structure and contents for this algorithm are identical to those of algorithm 1C-21 except the parameter is the surface rain rate. A single swath is displayed in a geographically correct position, whereas 1C-21 displays 3 swaths. The color palette uses the Standard Rainfall Rate Lookup Table (Table A-2).

Table 2.1.6-1
 Lookup Table of the Bright Band

Avg(Hbb)	Color
no bright band	black
0.0km < Hbb_ave < 0.5km	dim grey
0.5km <= Hbb_ave < 1.0 km	slate blue
1.0km <= Hbb_ave < 1.5km	blue
1.5km <= Hbb_ave < 2.0km	turquoise
2.0km <= Hbb_ave < 2.5km	cyan
2.5km <= Hbb_ave < 3.0km	green
3.0km <= Hbb_ave < 3.5km	green yellow
3.5km <= Hbb_ave < 4.0km	yellow
4.0km <= Hbb_ave < 4.5km	gold
4.5km <= Hbb_ave < 5.0km	orange
5.0km <= Hbb_ave < 5.5km	red
5.5km <= Hbb_ave < 6.0km	violet red
6.0km <= Hbb_ave < 6.5km	magenta
6.5km <= Hbb_ave < 7.0km	pink
7.0km <= Hbb_ave	white

2.2 LEVEL 3 SATELLITE BROWSE

The level 3 monthly and pentad satellite browse products are created at the same resolution as the product itself. For 4 of the monthly algorithms (3A-11, 3A-25, 3A-26, and 3B-31), the products are gridded as 5 x 5 degrees resolution maps, whereas the two pentad products (3B-42 and 3B-43) have 1⁰ x 1⁰ resolution. The image viewer, while displaying the images, expands the images by a default magnification factor of 10 for 5⁰ or 2 for 1⁰ grid boxes, which is stored in the metadata file. The following parameters are used in describing the format.

- nlat_5: The number of 5⁰ x 5⁰ grid boxes in latitude from 40⁰ N to 40⁰ S (16).
- nlon_5: The number of 5⁰ x 5⁰ grid boxes in longitude (72).
- nlat_1: The number of 1⁰ x 1⁰ grid boxes in latitude from 40⁰ N to 40⁰ S (80).
- nlon_1: The number of 1⁰ x 1⁰ grid boxes in longitude (360).
- nlat_over: The number of rows in the overlay.
- nlon_over: The number of columns in the overlay.

2.2.1 Algorithm 3A-11 - TMI emission

3A-11 output consists of monthly oceanic surface rainfall of 5⁰ x 5⁰ resolution maps. The gridded data are used to generate the browse image for this algorithm. Figure 2.2.1-1 shows the structure of the image product in terms of its component objects and sizes.

ECS Core Browse Metadata	5000 bytes	
PS Browse Metadata	10000 bytes	
Browse Structure Metadata	5000 bytes	
Image	1 byte	Array: nlat_5 x nlon_5
Coastline Overlay	1 byte	Array: nlat_over x nlon_over
Color Palette	1 byte	Array: 768

Figure 2.2.1-1
 Data Format Structure for 3A-11 Browse

The contents of objects in the structure are as follows:

ECS Core Browse Metadata (Attribute, approximately 5000-byte character):
 ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix B.

PS Browse Metadata (Attribute, approximately 10000-byte character):
 Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix C.

Browse Structure Metadata (Attribute, approximately 5000-byte character):
 Browse Structure Metadata provides information defined by EOSDIS for viewing purposes. See Appendix D.

Image (RIS8, nlat_5 x nlon_5, 1 byte integer):
 This image will display 5⁰ x 5⁰ gridded data of the oceanic monthly accumulated surface rainfall.

Coastline Overlay (RIS8, nlat_over x nlon_over, 1-byte integer)
 This is the overlay image of coastlines. The background has the value 0; the lines have the value 1.

Color Palette (Palette, 768, 1 byte integer):
 The color palette uses the Standard Monthly Rainfall Accumulation Lookup as specified in Table A-5.

2.2.2 Algorithm 3A-25 - PR profile

The structure and contents for this algorithm are identical to those of algorithm 3A-11.

2.2.3 Algorithm 3A-26 - Surface rainfall

The structure and contents for this algorithm are identical to those of algorithm 3A-11.

2.2.4 Algorithm 3B-31 - TRMM Combined

The structure and contents for this algorithm are identical to those of algorithm 3A-11.

2.2.5 Algorithm 3B-42 - TRMM and Others GPI calibration

The $1^0 \times 1^0$ gridded surface accumulated rainfall (1 day) are used to generate the browse image for this algorithm. Figure 2.2.5-1 shows the structure of the image product in terms of its component objects and sizes.

ECS Core Browse Metadata	5000 bytes	
PS Browse Metadata	10000 bytes	
Browse Structure Metadata	5000 bytes	
Image	1 byte	Array: nlat_1 x nlon_1
Coastline Overlay	1 byte	Array: nlat_over x nlon_over
Color Palette	1 byte	Array: 768

Figure 2.2.5-1
 Data Format Structure for 3B-42 Browse

The contents of objects in the structure are as follows:

ECS Core Browse Metadata (Attribute, approximately 5000-byte character):
 ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix B.

PS Browse Metadata (Attribute, approximately 10000-byte character):
 Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix C.

Browse Structure Metadata (Attribute, approximately 5000-byte character):
 Browse Structure Metadata provides information defined by EOSDIS for viewing purposes. See Appendix D.

Image (RIS8, nlat_1 x nlon_1, 1 byte integer):
 This image will display $1^0 \times 1^0$ gridded data of the 1 day accumulated surface rainfall

Coastline Overlay (RIS8, nlat_over x nlon_over, 1-byte integer)
 This is the overlay image of coastlines. The background has the value 0; the lines have the value 1.

Color Palette (Palette, 768, 1 byte integer):

The color palette uses the Standard Daily Rainfall Accumulation Lookup Table (Table A-6). The cut off values are 1/30 of those in 3A-11 for the monthly accumulated rainfall (e.g., 0 -50 mm/hr in 3A-11 becomes 0 - 1.6 mm/hr in 3B-42 for light blue color).

2.2.6 Algorithm 3B-43 - TRMM and Other Data Sources

The structure and contents for this algorithm are identical to those of algorithm 3B-42 except that the image displays monthly accumulation of surface rainfall and the Standard Monthly Accumulation Lookup Table (Table A-5) is used.

3. GV BROWSE

At levels 1 and 2, all GV browse products (1C-51, 2A-53, 2A-54, and 2A-55) are daily, consisting of 24 hourly browse images which are produced using the first volume scan in each 1 hour granule unless there is a coincident satellite overpass. If there is a coincident satellite overpass, the coincident volume scan is used. Level 3 browse products consist of one pentad (3A-53) and 2 monthly (3A-54, 3A-55) browse products.

The GV browse image maps will be stored in the browse file using the same dimensions as those of the GV product files. The browse viewer can expand the images by a default magnification factor contained in metadata, i.e., the dimension of the display image equals the dimension of the stored browse image times the corresponding magnification factor. Magnification factors of 2A-53, 2A-54 and 3A-53 are 3 for single radar sites and 2 for multiple radar sites. The magnification factors of 1C-51, 2A-55 and 3A-55 are 1.

Overlays are required by all algorithms except the CFAD images. Overlay information includes coastlines (default white solid line) and concentric circles centered on the radar (default white, radii 50km, 100km, 150km and 200km). The magnification factor of both overlays is 1 which indicates that the overlay images are stored in the browse file at the dimension of the display image.

3.1 ALGORITHM 1C-51 -QC REFLECTIVITIES

The algorithm 1C-51 browse product contains 24 hourly radar reflectivity maps derived from a volume scan in each one hour granule. The base scan is used as input to remap to a 1km grid. The range applied here is the bin resolution times the number of bins from center. The browse images have dimensions defined as follows:

- nx1: The number of grid points of the browse image object in the x direction of a 3-D Cartesian coordinate system, which is 400.
- ny1: The number of grid points of the browse image object in the y direction of a 3-D Cartesian coordinate system, which is 400.
- nx2: The size of the overlay image in the x direction of a 3-D Cartesian coordinate which is 400.
- ny2: The size of the overlay image in the y direction of a 3-D Cartesian coordinate which is 400.

Figure 3.1-1 shows the structure of 1C-51 product in terms of the component objects and their sizes.

ECS Core Browse Metadata	5000 bytes	
PS Browse Metadata	10000 bytes	
Browse Structure Metadata	5000 bytes	
Image	1 byte	Array: nx1 x ny1 x 24
Coastline Overlay	1 byte	Array: nx2 x ny2
Range Ring Overlay	1 byte	Array: nx2 x ny2
Satellite Swath Overlay	1 byte	Array: nx2 x ny2 x 24
Color Palette	1 byte	Array: 768

Figure 3.1-1
 Data Format Structure for 1C-51 Browse

The contents of objects in the structure are as follows:

ECS Core Browse Metadata (Attribute, approximately 5000-byte character):
 ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix B.

PS Browse Metadata (Attribute, approximately 10000-byte character):
 Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix C.

Browse Structure Metadata (Attribute, approximately 5000-byte character):
 Browse Structure Metadata provides information defined by EOSDIS for viewing purposes. See Appendix D.

Image (RIS8, nx1 x ny1 x 24, 1-byte integer):
 This image displays the radar reflectivity of the lowest level sweep of a volume scan in each 1 hour granule.

Coastline Overlay (RIS8, nx2 x ny2, 1-byte integer):
 This is the overlay image of coastlines. The background has the value 0; the lines have the value 1.

Range Ring Overlay (RIS8, nx2 x ny2, 1-byte image):
 This is the overlay image of radar range rings with radii of 50km, 100km, 150km, and 200km. The background has the value 0; the lines have the value 1.

Satellite Swath Overlay (RIS8, nx2 x ny2, 1-byte integer):

An overlay showing the edges of satellite coverage. The edges of PR coverage are shown with solid lines with tickmarks pointing inward toward the satellite track. The edges of TMI coverage are shown with dashed lines with tickmarks pointing inward toward the satellite track. The background has the value 0; the lines have the value 1.

Color Palette (Palette, 768, 1 byte integer):

The color palette is the Standard Reflectivity Lookup Table as specified in Table A-1.

3.2 ALGORITHM 2A-53 - RADAR SITE RAIN MAP

2A-53 contains instantaneous rainfall rate from a volume scan in each hour granule and uses the color palette for standard rainfall rate as specified in Table A-2. The browse image has dimensions of nx1 x ny1. The dimension of the overlay images is nx2 x ny2. These parameters are defined as follows:

- nx1: The number of grid points of browse images in the x direction of a 3-D Cartesian coordinate which is 151 for single radar sites and 363 for Texas multiple radar site, 257 for Florida multiple radar site.
- ny1: The number of grid points of browse images in the y direction of a 3-D Cartesian coordinate which is 151 for single radar sites and 285 for Texas multiple radar sites, 353 for Florida multiple radar site.
- nx2: The size of the overlay images in the x direction of a 3-D Cartesian coordinate which equals the x dimension of the display image, i.e., nx1 times magnification-factor.
- ny2: The size of the overlay images in the y direction of a 3-D Cartesian coordinate which equals the y dimension of the display image, i.e., ny1 time magnification-factor.

Figure 3.2-1 shows the structure of the 2A-53 product in terms of the component objects and their sizes.

ECS Core Browse Metadata	5000 bytes	
PS Browse Metadata	10000 bytes	
Browse Structure Metadata	5000 bytes	
Image	1 byte	Array: nx1 x ny1 x 24
Coastline Overlay	1 byte	Array: nx2 x ny2
Range Ring Overlay	1 byte	Array: nx2 x ny2
Satellite Swath Overlay	1 byte	Array: nx2 x ny2 x 24
Color Palette	1 byte	Array: 768

Figure 3.2-1
 Data Format Structure for 2A-53 Browse

The contents of objects in the structure are as follows:

ECS Core Browse Metadata (Attribute, approximately 5000-byte character):

ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix B.

PS Browse Metadata (Attribute, approximately 10000-byte character):

Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix C.

Browse Structure Metadata (Attribute, approximately 5000-byte character):

Browse Structure Metadata provides information defined by EOSDIS for viewing purposes. See Appendix D.

Image (RIS8, nx1 x ny1 x 24, 1-byte integer):

This image displays the instantaneous rainfall rate from the volume scan in each 1 hour granule.

Coastline Overlay (RIS8, nx2 x ny2, 1-byte integer)

This is the overlay image of coastlines. The background has the value 0; the lines have the value 1.

Range Ring Overlay (RIS8, nx2 x ny2, 1-byte image)

This is the overlay image of radar range rings with radii of 50km, 100km, 150km, and 200km. The background has the value 0; the lines have the value 1.

Satellite Swath Overlay (RIS8, nx2 x ny2, 1-byte integer)

An overlay showing the edges of satellite coverage. The edges of PR coverage are shown with solid lines with tickmarks pointing inward toward the satellite track. The edges of TMI coverage are shown with dashed lines with tickmarks pointing inward toward the satellite track. The background has the value 0; the lines have the value 1.

Color Palette (Palette, 768, 1 byte integer)

The color palette is the Standard Reflectivity Lookup Table as specified in Table A-2.

3.3 ALGORITHM 2A-54 - RADAR SITE CONVECTIVE/STRATIFORM MAP

The data format structure and contents for this algorithm are identical to those of algorithm 2A-53 except that the image displays instantaneous rainfall type (convective, stratiform etc.) of a volume scan in each hour granule and uses the color palette for standard rainfall type as specified in Table A-3.

3.4 ALGORITHM 2A-55 - RADAR SITE 3D REFLECTIVITIES

The Algorithm 2A-55 browse product contains 24 hourly images from the lowest level of the 3D reflectivity product and contour plots of CFADs for 4 selected rain categories (total rainfall, total

convective rainfall, total stratiform rainfall and total anvil). These images are generated for each hour granule, and put into one single image object with a dimension of $n_x \times n_y$. The dimensions are defined as follows:

- nx: The x-dimension of the whole image, which is 453 for single radar sites, 726 for Texas multiple radar site, and 771 for Florida multiple radar site.
- ny: The y-dimension of the whole image, which is 853 for single radar sites, 890 for Texas multiple radar site, and 710 for Florida multiple radar site.

Figure 3.4-1 shows the allocations of each individual CFAD and reflectivity map within one browse image object. Four CFADs are put in a 2x2 matrix on top of the reflectivity map for the single radar sites and Texas multiple radar site, while they are displayed in one column along the left side of the reflectivity map for Florida multiple radar site. Overlay images are only required by the lowest level reflectivity map and assigned to a dimension of $n_x_map \times n_y_map$. n_x_map and n_y_map are defined as follows:

- n_x_map : The x-dimension of the map image, which is 453 for single radar sites, 726 for Texas multiple radar site and 514 for Florida multiple radar site.
- n_y_map : The y-dimension of the map image, which is 453 for single radar sites, 570 for Texas multiple radar site and 710 for Florida multiple radar site.

Figure 3.4.2 shows the structure of the 2A-55 product in terms of the component objects and their sizes.

The contents of objects in the structure are as follows:

ECS Core Metadata (Attribute, approximately 5000-byte character):

ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix B.

PS Metadata (Attribute, approximately 10000-byte character):

Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix C.

Browse Structure Metadata (Attribute, approximately 5000-byte character):

Browse Structure Metadata provides information defined by EOSDIS for viewing purposes. See Appendix D.

Image (RIS8, $n_x \times n_y \times 24$, 1 byte integer):

This object includes an hourly image of the CFADs for four selected rain categories (total rainfall, total convective, total stratiform and total anvil) and the Lowest Level Reflectivity map.

Coastline Overlay (RIS8, $n_x_map \times n_y_map$, 1-byte integer):

This is the overlay image of coastlines. The background has the value 0; the lines have the value 1.

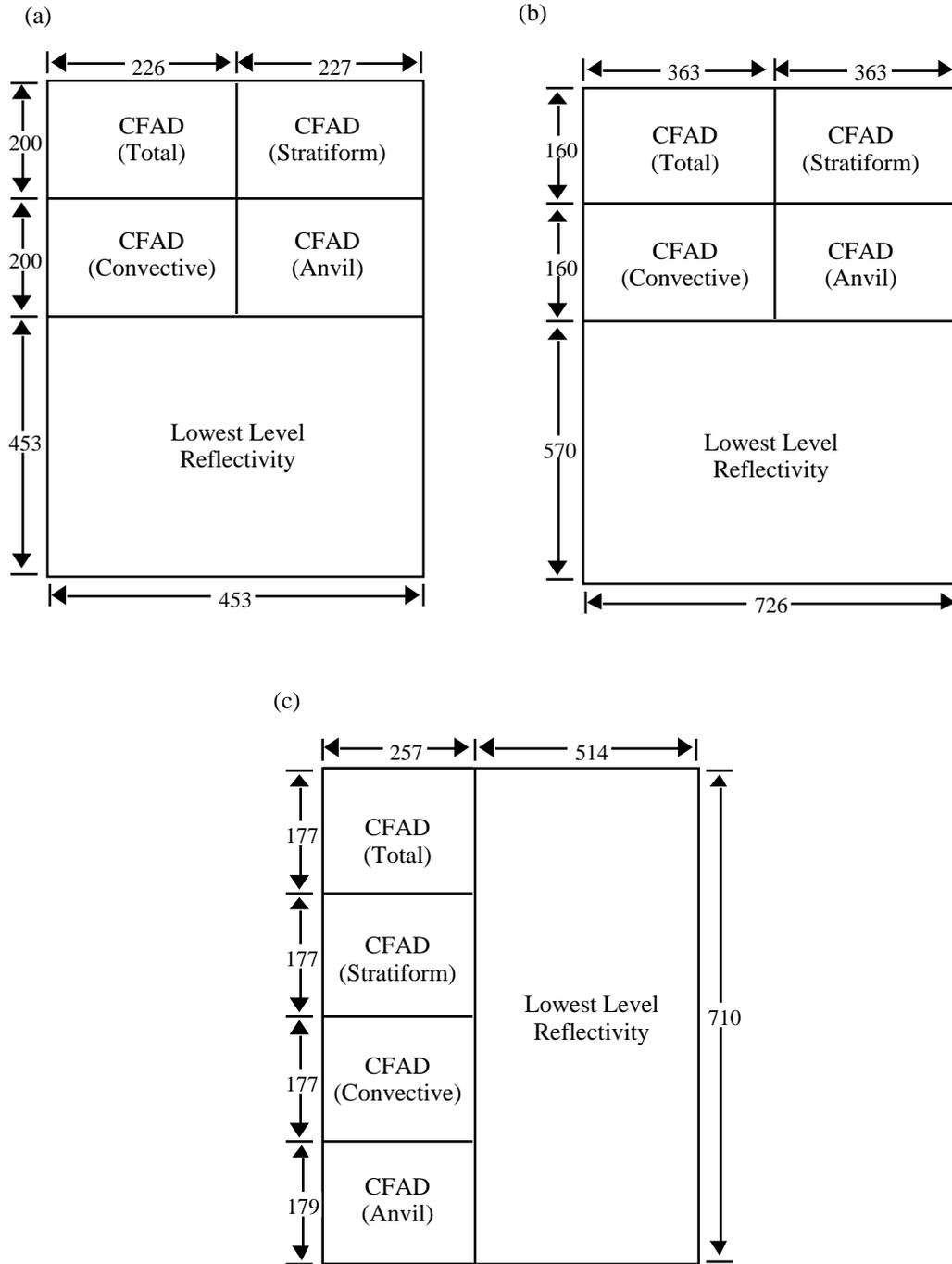


Figure 3.4-1
 Browse Image for 2A-55. (a) Single radar site;
 (b) Texas multiple radar site; (c) Florida multiple radar site

ECS Core Metadata	5000 bytes	
PS Metadata	10000 bytes	
Browse Structure Metadata	5000 bytes	
Images Total Rainfall CFAD Total Convective CFAD Total Stratiform CFAD Total Anvil CFAD	1 byte	Array: nx x ny x 24
Coastline Overlay	1 byte	Array: nx_map x ny_map
Range Ring Overlay	1 byte	Array: nx_map x ny_map
Satellite Swath Overlay	1 byte	Array: nx_map x ny_map x 24
Color Palette	1 byte	Array: 768

Figure 3.4-2
 Data Format Structure for 2A-55 Browse

Range Ring Overlay (RIS8, nx_map x ny_map, 1-byte image):

This is the overlay image of radar range rings with radii of 50km, 100km, 150km, and 200km. The background has the value 0; the lines have the value 1.

Satellite Swath Overlay (RIS8, nx_map x ny_map, 1-byte integer):

An overlay showing the edges of satellite coverage. The edges of PR coverage are shown with solid lines with tickmarks pointing inward toward the satellite track. The edges of TMI coverage are shown with dashed lines with tickmarks pointing inward toward the satellite track. The background has the value 0; the lines have the value 1.

Color Palette (Palette, 768, 1 byte integer):

This color palette is applied to the display of lowest level radar reflectivity. It uses the standard color table of radar reflectivity as specified in Table A-1.

3.5 ALGORITHM 3A-53 - 5-DAY SITE RAIN MAP

Algorithm 3A-53 browse product displays 5-day surface rainfall accumulation using data from all radars at a site, and uses the color palette for standard rainfall accumulation as specified in Table A-4. The browse image has a dimensions which are defined as follows:

- nx1: The number of grid points of the browse image in the x direction of a 3-D Cartesian coordinate which is 151 for single radar sites and 363 for Texas multiple radar site, 257 for Florida multiple radar site.
- ny1: The number of grid points of the browse image in the y direction of a 3-D Cartesian coordinate which is 151 for single radar sites and 285 for Texas multiple radar site, 353 for Florida multiple radar site.
- nx2: The size of the overlay image in the x direction of a 3-D Cartesian coordinate which is equal to the x dimension of the display image, i.e., nx1 times magnification-factor.
- ny2: The size of the overlay image in the y direction of a 3-D Cartesian coordinate which is equal to the y dimension of the display image, i.e., ny1 times magnification-factor.

Figure 3.5-1 shows the structure of 3A-53 browse product in terms of the component objects and their sizes.

ECS Core Browse Metadata	5000 bytes	
PS Browse Metadata	10000 bytes	
Browse Structure Metadata	5000 bytes	
Image	1 byte	Array: nx1 x ny1
Coastline Overlay	1 byte	Array: nx2 x ny2
Range Ring Overlay	1 byte	Array: nx2x ny2
Color Palette	1 byte	Array: 768

Figure 3.5-1
 Data Format Structure for 3A-53 Browse

The contents of objects in the structure are as follows:

ECS Core Browse Metadata (Attribute, approximately 5000-byte character):

ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix B.

PS Browse Metadata (Attribute, approximately 10000-byte character):

Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix C.

Browse Structure Metadata (Attribute, approximately 5000-byte character):

Browse Structure Metadata provides information defined by EOSDIS for viewing purposes. See Appendix D.

Image (RIS8, nx1 x ny1, 1-byte integer):

This image displays 5-day surface rainfall accumulation.

Coastline Overlay (RIS8, nx2 x ny2, 1-byte integer)

This is the overlay image of coastlines. The background has the value 0; the lines have the value 1.

Range Ring Overlay (RIS8, nx2 x ny2, 1-byte image)

This is the overlay image of radar range rings with radii of 50km, 100km, 150km, and 200km. The background has the value 0; the lines have the value 1.

Color Palette (Palette, 768, 1 byte integer)

The color uses the Standard Pentad Rainfall Rate Lookup Table (Table A-4).

3.6 ALGORITHM 3A-54 - 30-DAY SITE RAIN MAP

The data format structure and contents of this algorithm are identical to those of algorithm 3A-53 except that algorithm 3A-54 browse product displays monthly surface rainfall accumulation using data from all radars at a site and uses the color palette for standard monthly rainfall accumulation as specified in Table A-5.

3.7 ALGORITHM 3A-55 - MONTHLY 3D STRUCTURE

Algorithm 3A-55 browse product contains the CFADs for 4 selected rain categories (total rainfall, total convective rainfall, total stratiform rainfall, and total anvil rainfall). These browse images are generated from the monthly 3A-55 product file. Figure 3.7-1 shows the structure of the 3A-55 product in terms of the component objects and their sizes. The definitions of the dimension parameters are identical to those in 2A-55.

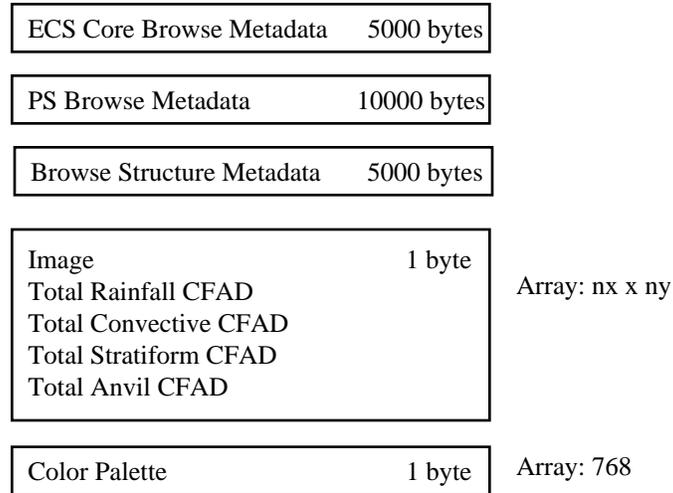


Figure 3.7-1
 Data Format Structure for 3A-55 Browse

The contents of objects in the structure are as follows:

ECS Core Browse Metadata (Attribute, approximately 5000-byte character):
 ECS Core Metadata are metadata useful to most products stored at EOSDIS. See Appendix B.

PS Browse Metadata (Attribute, approximately 10000-byte character):
 Product Specific Metadata are metadata defined by and specific to TSDIS. See Appendix C.

Browse Structure Metadata (Attribute, approximately 5000-byte character):
 Browse Structure Metadata provides information defined by EOSDIS for viewing purposes. See Appendix D.

Image (RIS8, nx x ny, 1 byte integer)
 This object includes the monthly CFADs for four selected rain categories (total rainfall, total convective, total stratiform and total anvil).

Color Palette (Palette, 768, 1 byte integer)
 This color palette is applied to the display of lowest level radar reflectivity. It uses the standard color table of radar reflectivity as specified in Table A-1.

4. ISSUES

- 1) Should Color bar be burnt onto the image, or should they be placed in a separate HDF object? Issue closed - browser will use metadata to display color bar.
- 2) In ECS core metadata, additional information is required for the general keywords (Geophysical parameter, spatial and temporal) parameters. Do we need these parameters? Closed - we know the values of the core metadata.
- 3) How to define start time of a 24 hour GV day? Can it coincide with satellite day? Closed - Day begins at 0000 UTC.
- 4) Will the satellite track be displayed (overlay or burnt-in) on GV images? Closed. Track will be burnt in to GV L1, L2 images.
- 5) Do we need coastlines for L3 satellite products?
- 6) Geophysical parameter keyword to be determined by whom? Closed. We know the values of core metadata.
- 7) Spatial keyword to be determined by whom? Closed. We know the values of core metadata.
- 8) Temporal Keyword to be determined by whom? Closed. We know the values of core metadata.

5. ABBREVIATIONS AND ACRONYMS

C

CAPPI Constant Altitude Plan Position Indicator
CFAD Contoured Frequency by Altitude Diagram

D

DIF Directory Interchange Format

E

ECS EOSDIS Core System
EOSDIS EOS Data and Information System

G

GPI GOES Precipitation Index
GV Ground Validation

H

HDF Hierarchical Data Format

I

ICS Interface Control Specification

P

PR Precipitation Radar
PS Product Specific

R

RHI Range Height Indicator
RIS Raster Image Set

S

SDS Scientific Data Set

T

TBD To Be Determined
TMI TRMM Microwave Imager
TRMM Tropical Rainfall Measuring Mission
TSDIS TRMM Science Data and Information System
TSU TSDIS Science User

V

VIRS Visible Infrared Scanner

Appendix A Standard Color Tables

This section provides the standard color lookup tables for the browse products. The color tables are developed by TSDIS and are refined with subsequent input from the TSDIS algorithm developers.

Table A-1
 Standard Reflectivity Lookup Table

Reflectivity (dBZ)	Color
Missing	black
No rain or ≤ -15	light gray
-14.9999 - 0	dark purple
0 - 10	light purple
10 - 15	dark blue
15 - 20	light blue
20 - 25	very light blue
25 - 30	green
30 - 35	yellow
35 - 40	orange
40 - 45	very very dark red
45 - 50	very dark red
50 - 55	dark red
55 - 60	light red
60 - 65	very light red
65 - 70	very very light red

Table A-2
 Standard Rainfall Rate Lookup Table

Rain (mm/hr)	Image color
Missing	black
0.0	white
0.0 - 0.5	light blue
0.5 - 1.0	dark blue
1.0 - 5.0	cyan
5.0 - 10.	green
10. - 20.	yellow
20. - 40.	orange
>40.	red

Table A-3
 Standard Rainfall Type Lookup Table

Rain type	Color
no rain	black
stratiform	green
convective	red
warm rain	yellow
other	gray

Table A-4
 Standard Pentad(5-day) Rainfall Accumulation Lookup Table

Rain (mm)	Image color
Missing	black
0.0	white
0 - 8.3	light blue
8.3 - 16.6	dark blue
16.6 - 33.3	cyan
33.3 - 50.	green
50.- 66.6	yellow
66.6 - 83.3	orange
> 83.3	red

Table A-5
 Standard Monthly Rainfall Accumulation Lookup Table

Rain (mm)	Image color
Missing	black
0.0	white
0 - 50	light blue
50 - 100	dark blue
100 - 200	cyan
200 - 300	green
300 - 400	yellow
400 - 500	orange
>500.	red

Table A-6
Standard Daily Rainfall Accumulation Lookup Table

Rain (mm)	Image color
Missing	black
0.0	white
0 - 1.6	light blue
1.6 - 3.3	dark blue
3.3 - 6.6	cyan
6.6 - 10.0	green
10.0 - 13.3	yellow
13.3 - 16.6	orange
> 16.6	red

Appendix B ECS Core Metadata Element Description

ECS Core Metadata (Attribute, approximately 5000-byte character):

ECS Core metadata are attributes that are shared by most data products being supported by EOSDIS. For browse purposes, only a subset of core metadata is required. This subset includes attributes in the following categories: granule(s) identification; parameter and science content information; geographic and temporal extent. A description of each metadata element follows.

ECS Core Metadata Element	Size (bytes)	Description
Name of Image	50	The name of the variable displayed in the image. (e.g., PR reflectivity)
Parameter of Image Product	100	Identifying output parameter. In case of multiple outputs, outputs are separated by ':'
Point of Contact	100	Developer name/organization name related to the image.
Spatial Coverage type	32	This attribute denotes whether the locality/ coverage requires horizontal, vertical or both spatial domain and coordinate system definitions.
Spatial Coverage	150	Horizontal and/or vertical detection capability being represented within the data of this image. Bounding coordinate (name, values) will be used in describing the spatial coverage of a image.
Temporal Range Type	39	This tells the system how temporal coverage is specified for the image.
Start Date Tag	60	Value is YYYY/MM/DD where YYYY is the year, MM is the month, DD is the day of the image data.
End Date Tag	60	Value is YYYY/MM/DD where YYYY is the year, MM is the month, DD is the day of the image data
Start Time Tag	60	The start time of the browse image. Accuracy is to the closest hour. Value is HH, where HH ranges from 0 to 23
End Time Tag	60	The end time of the browse image. Accuracy is to the closest hour. Value is HH, where HH ranges from 0 to 23

Appendix C PS Metadata Element Description

PS Metadata (Attribute, approximately 10000-byte character):
 Product Specific Metadata are metadata defined by and specific to TSDIS. A description of each PS metadata element follows.

PS Metadata Element	Size (bytes)	Description
ID of Data Granule	50	Unique identifier of the data granule (TSDIS Granule ID)
Frequency	20	Frequency of the browse product. Values are : "daily"; "pentad"; "monthly"
List of Input Files	1000	List of all files used to generate this browse product (e.g., file1, file2, ...)
Source of Input files	50	Name of the data centers generating input files (e.g., TSDIS, NMC)
Instrument/Radar Site	50	One of the three instruments: PR, VIRS, TMI, Combined, or name of the radar site
Product Resolution	50	Resolution of browse product (e.g., 10 km, 2km)
Annotation-Parameter	200	A brief description of the parameter displayed, e.g., "Reflectivity"
Annotation-Parameter Position	300	The x and y position of the annotation parameter in the image. For 2A-55 and 3A-55 this is 5 positions(x1,y1,x2,y2,...x5,y5)
Annotation-Time	500	The time of the browse product (e.g., "14:30:21Z") (only used for GV L1 and L2)
Annotation-Time Position	300	The x and y position of annotation-time in the image.
Annotation-Sat Time Asc	500	List of satellite observation times in HHMM, where HH=hour and MM=minute, for the Ascending Node
Annotation-Sat Time Des	500	List of satellite observation time in HHMM, where HH=hour and MM=minute, for the Descending Node.
Annotation-Sat Time Y Asc	500	List of satellite observation time image y positions for the Ascending Node
Annotation-Sat Time Y Des	500	List of satellite observation time image y positions for the Descending Node.
Annotation-Sat Time X Asc	500	List of satellite observation time image x positions for the Ascending Node
Annotation-Sat Time X Des	500	List of satellite observation time image x positions for the Descending Node.
Annotation-Sat Orbit	200	List of orbit numbers.
Annotation-Sat Orbit Lon Asc	200	List of orbit overlay longitude for the Ascending Node.
Annotation-Sat Orbit Lon Des	200	List of orbit overlay longitude for the Descending Node.
Annotation-Percent Rain	300	A list of 24 character strings. Each string is of the form "%Rain = xxx". xxx will range from 0 to 100.
Annotation-Percent Rain Location	200	A list of 24 pairs of x y pixel coordinates of the %rain annotation. The coordinates are measured from the lower left edge of the image.
Color Bar Minimum	50	Minimum value from raster image to be used for the color bar.
Color Bar Maximum	50	Maximum value from raster image to be used for the color bar.
Color Bar Labels	100	List of the labels of the color bar tickmarks. For reflectivity the list would be ("-15", "-10", "0", "10", "20", "30", "40", "50", "60", "70").
Color Bar Positions	100	List of normalized positions along the color bar where the tickmarks are to be drawn. For reflectivity the list would be (0., .059,1.0).
Color Bar Units	50	The units of the color bar (e.g., "dBZ")
Color Bar Second Labels	100	The second color bar labels (1B-01 only)
Color Bar Second Positions	100	Same as Color Bar Positions, but for the second color bar labels. (1B-01 only)
Color Bar Second Units	50	Same as Color Bar Units, but for the second color bar labels.

PS Metadata Element	Size (bytes)	Description
Magnification Image	50	Initial magnification factor to display images. This is always an integer. A negative value means reduction.
Magnification Coastal Overlay	50	Initial magnification factor to display the Coastal Overlay This is always an integer. A negative value means reduction.
Magnification Range Ring Overlay	50	Initial magnification factor to display the Range Ring Overlay. This is always an integer. A negative value means reduction.
Magnification Satellite Swath Overlay	50	Initial magnification factor to display the Satellite Swath Overlay. This is always an integer. A negative value means reduction.
Default Coastal Overlay Color	50	“WHITE”
Default Range Ring Overlay Color	50	“WHITE”
Default Lat Lon Overlay Color	50	“WHITE”
Default GV Circles Overlay Color	50	“RED”
Default Satellite Swath Overlay Color	50	A color that contrasts with the image, either “WHITE” or “BLACK”.
Latitude Increment	30	The default latitude increment of a latitude-longitude overlay map (required only by satellite browse product)
Longitude Increment	30	The default longitude increment of a latitude-longitude overlay map (required only by satellite browse product)
Radar Range Increment	30	The range increment of a radar range ring overlay map (required only by GV browse product).
Radar Center	50	Radar center position in x,y raster coordinates (required only by GV browse product).
GV Radar Positions	200	A list of GV Radar positions (raster image coordinates) for overlay of GV circles. The order is (x1, y1,..., xN, yN).
GV Radar Radii	50	A list of GV Radar radii (raster image pixel units) for overlay of GV circles. Radii are listed in the same order as the positions.
Image Has Data	80	List of 24 integer values indicating if there was data in the granule that produced this image. 0 - no data, 1 - image has data
Coincidence Occurred	80	List of 24 integer values indicating if coincidence occurred for this VOS. 0 - no coincidence, 1 - coincidence
Generation Date	50	Date the image was generated
Size	20	The size of image volume in Mbytes with an accuracy to the tenth of Mbytes.

Appendix D Browse Structure Metadata

Browse Structure Metadata (Attribute, approximately 5000-byte character):

The browse structure metadata consists of many sets of text description attributes. Each browse object has one set. For example, algorithm 1B-01 has an ascending image, a descending image, and a color palette and so would have two sets of attributes within the browse structure metadata, one set for the ascending image and one set for the descending image. Each type of object has specific required and optional attributes. Text attributes include the type, object_id, object_title, etc. A description of one set of text attributes (metadata elements) follows.

Browse Structure Metadata Element	Size (bytes)	Description	Object Using Element
Type	15	This defines the subclass of object. For example, the type for an image object may be: raw, grid, or swath	image, text, table
Object_id (object descriptor)	15	Name of HDF object which is associated with the object attributes.	image, text, table
Object_title	100	The title of the browse image, which consists of the algorithm, the date, and the radar site (for GV browse products). For example, TMI emission's title for May 1998 would be "3A-11 1998/05", and Level-1 GV's, title would be "1C-51 1998/05/15 Darwin".	image, text, table
Default Resolution	50	This defines the resolution of the initial presentation of the image. If not provided the actual resolution of the RIS browse object will be used for initial presentation.	Image
Projection	50	All attributes that will be required to completely define the projection being presented in the image.	Image (gridded)
Description	5000	A simple text description of what the image represents	image, text, table
Palette	15	Name of the palette included in the HDF file which should be used with the 8-bit image. If not included the default palette will be used.	optional