TRMM Data Reprocessing and New Data Products

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1. Introduction

The Tropical Rainfall Measuring Mission (TRMM), a joint mission between NASA and the National Space Development Agency (NASDA) of Japan, is designed to monitor and study tropical rainfall and the associated release of energy. TRMM has acquired more than five years of data since its launch in November 1997. All TRMM standard products are processed by the TRMM Science Data and Information System (TSDIS) and archived and distributed to general users by the Goddard Earth Sciences Distributed Active Archive Center (GES DAAC). In addition to the standard products, the GES DAAC generates and/or maintains a set of derived TRMM products (e.g., satellite coincidence subsets, parameter subsets, resampled gridded subsets, GIS-compatible files) to facilitate use of TRMM data by the general public.

The TRMM satellite algorithms are continually being evaluated and improved by the TRMM Science Team. TRMM data are periodically reprocessed to incorporate the improved science algorithms, currently at version 5. A brief history of TRMM reprocessing of product version 1 to 5 is provided, including the distinction between versions 5 and 5A related to TRMM's satellite operating altitude change in 2001. The upcoming TRMM version 6 reprocessing is discussed, including major changes in the algorithms, improvements to the products, release of new data products, and enhancements to GES DAAC data access and visualization tools that reflect these changes.

2. TRMM Standard Products and Reprocessing

The real-time processing and reprocessing of the TRMM science data are performed by TSDIS. Raw instrument data are received in near-real-time by TSDIS and then processed by the first tier of TRMM science algorithms to produce calibrated, swath-level, instrument data. With the latter, the second tier of algorithms are used to compute geophysical parameters, such as precipitation rate, also at the swath-level resolution. Finally, the third tier algorithms are used to produce gridded geophysical parameters from the first- and second-tier instrument data. TRMM instrument algorithms are shown in Figure 1 (TRMM Data Processing Overview). Detailed information about the TRMM algorithms and product status can be found at http://trmm.gsfc.nasa.gov/data_dir/ProductStatus.html.

TRMM data are provided at five levels (level 0 to level 4), representing the processing done at different stages after GSFC receives the raw data. Level 0 is the time-ordered and quality-checked raw data received from the satellite. Level 1 products are the Visible/Infrared Scanner (VIRS) calibrated radiances, the TRMM Microwave Imager (TMI) brightness temperatures, and the Precipitation Radar (PR) return power and reflectivities, at instrument pixel resolution. Level 2 products are derived geophysical parameters (e.g., rain rate, cloud liquid water, latent heat) at the same resolution and location as those of the Level 1 data. Level 3 gridded products are space-time averaged parameters. Level 4 products are analyzed products or those produced from merging measurements from TRMM and other sources. All TRMM satellite standard data products and their short names can be found in Figure 1. These standard TRMM products are available to the general public at http://lake.nascom.nasa.gov/data/dataset/TRMM/.

To date, there have been five versions of TRMM data. The processing of version 1 TRMM products was started shortly after TRMM launch in 1997. The version 2 TRMM reprocessing started on March 1, 1998. These first two versions of TRMM data were provided only to the algorithm developers within the TRMM Science Team for algorithm evaluations. The third TRMM reprocessing started on June 1, 1998, and the version 3 orbital products were first released to public at that time. The fourth reprocessing started on September 1, 1998. The current TRMM product (version 5) started on November 1, 1999. A major product change for version 5 was that of the temporal resolution of product 3B42 from pentad to daily. Table 1 summarizes the temporal coverage and reprocessing start date for most TRMM satellite data products.

Table 1. TRMM Data Product Versions.

Product Version	Temporal Coverage	Reprocessing Start-date
1	Launch – 02/28/1998	Early 12/1998
2	Launch – 05/31/1998	03/01/1998
3	Launch – 08/31/1998	06/01/1998
4	Launch – 10/31/1999	09/01/1998
5	Launch – 08/06/2001	11/01/1999
5A	08/24/2001 – Present	See sec. 3

As currently planned, reprocessing of TRMM data product version 6 will start in May 2003. The daily 1°x1^{o} gridded rainfall product 3B42 will be changed to a 3-hourly 0.25^{o}x 0.25^{o} gridded rainfall product. More information about TRMM version 6 reprocessing will be available from the GES DAAC Hydrology Homepage at http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/hydrology/hd_main.shtml before the reprocessing begins.

3. TRMM Operational Altitude Change

The average operating altitude for TRMM was changed from 350 km to 403 km (referred to as TRMM boost). This significantly extends the mission lifetime of TRMM. The boost maneuver began on August 7, 2001. The maneuver was completed on August 22, 2001, bringing TRMM up to around the targeted final operating altitude of 402.5 km. After the fine adjustment maneuver on August 24, 2001, the average operating altitude for TRMM became 403 km.

About one month after the TRMM boost, the post-boost VIRS and TMI data products were released. All post-boost TRMM PR data products were released in early December 2001. Algorithms of post-boost TRMM PR products have been changed. The caveats for post-boost PR products from TRMM PR algorithm scientists can be accessed at ftp://lake.nascom.nasa.gov/data/TRMM/Documentation/TRMM_Boost_PR_Caveats.html. A summary of the pre- and post-boost swath widths and resolutions is provided in Table 2.

Table 2. Characteristics of TRMM Instruments.

	Swath Width (km)		Ground Resolution (km)	
	Pre-boost	Post-boost	Pre-boost	Post-boost
VIRS	720	833	2.2	2.4
TMI	760	878	5.0*	5.1*
PR	220	247	4.0	5.0

*Ground resolutions of TMI are those at 85.5 GHz (highest resolution).

There are some data gaps from August 13-17, 2001, when the instruments onboard TRMM were turned off, because of a problem related to the satellite attitude control. To distinguish the pre- and post-boost data, post-boost files are designated version "5A."

4. New TRMM Products and TRMM Ancillary Data Set

4.1 TRMM Real-time Precipitation Data Set

A new Experimental TRMM Real-time Multi-satellite Precipitation Data Set, created by G.J. Huffman et al. of the GSFC Laboratory for Atmospheres and the TSDIS, is now available to the general public. The data set currently contains three 0.25^{o}-degree gridded products, providing merged microwave (3B42RT), microwave-calibrated infrared (IR) (3B41RT), and combined microwave-IR (3B40RT) estimates of precipitation on quasi-global grids computed in near-real-time starting in late January 2002. The characteristics of the data set are summarized in Table 3.

Table 3. Characteristics of the TRMM Real-time Data Set.

Data Product	Resolution		Coverage	
	Temporal	Spatial	Temporal*	Spatial
3B40RT	3-hour	0.25^{o}x0.25^{o}	01/30/02	70°S-70°N
3B41RT	1-hour	0.25^{o}x0.25^{o}	01/29/02	50°S-50°N
3B42RT	3-hour	0.25^{o}x0.25^{o}	01/29/02	50°S-50°N

* Listed is start date, end date is present.

The data set and related README, documentation, and read software can be accessed from ftp://aeolus.nascom.nasa.gov/pub/merged/. The 3B42RT GrADS formatted files are also available from the GES DAAC (ftp://lake.nascom.nasa.gov/data/TRMM/Gridded/3B42RT/).

For quick exploration, analyses, and visualization of TRMM gridded products, a TRMM Online Analysis System was developed by the GES DAAC, (http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/hydrology/TRMM_analysis.html). Figure 2, generated by this system shows rain rate of the Tropical Storm Isidore derived from the TRMM real-time product 3B42RT. The image shows that Isidore was moving ashore on September 26, 2002, packing winds just below hurricane strength at north-northeast of New Orleans and west of Poplarville, Mississippi. The storm brought steady downpours with 10-12 inch accumulations in two days.

The TRMM real-time data set is also available through a web-based mapping tool created at the GES DAAC (http://daac.gsfc.nasa.gov/WEBGIS/). The tool, which implements interoperable standards set by the Open GIS Consortium (OGC), allows users to combine the real-time rainfall layers with additional layers generated either from other GES DAAC data or from externally created maps. Future development of this tool will allow users to save these maps into GIS-compatible formats. More information is available in "An Interoperable Web Mapping Application at the GES DAAC" (Paper 6.13 of 19th Conference on IIPS).

4.2 GPROF 6.0 Quarter-Degree Gridded Orbit-by-Orbit Precipitation Data Set

A new ancillary data, Goddard Profiling Algorithm Version 6 (GPROF 6.0) Quarter-Degree Gridded Orbit-by-Orbit Precipitation Data Set, created by E. J. Nelkin and G. J. Huffman, is available to the general public. The data set currently contains a suite of five products providing instantaneous, gridded values of precipitation totals and supporting information for each file (half-orbit or fraction thereof) for most of the SSM/I F13, F14, and F15 data from November 1, 2001 to the present. The products include precipitation estimates, pixel counts, a quality measure, and an average time tag for each grid box, all based on the GPROF 6.0 physical retrieval algorithm, applied to SSM/I data. The amount of data contained in a data file is usually a half-orbit (approximately 50 minutes worth of data), but it can be as small as one minute of data. Therefore, the temporal resolution varies with the availability of quality-checked SSM/I data. The spatial coverage of the products is global in the sense that they are provided on a global grid. However, all of the products have meaningful values only on a subset of the grid points. The data set is currently being updated in near-real-time at the TSDIS and acquired by the GES DAAC twice daily. The data and documentation can be accessed via ftp from ftp://lake.nascom.nasa.gov/data/TRMM/Ancillary/3A_GPROF6/. Soon, it will be visible through the Ancillary Data Product Group of the TRMM Search and Order System at http://lake.nascom.nasa.gov/data/dataset/TRMM/01_Data_Products/06_Ancillary/index.html.

A parallel archive of the GPROF6.0 Half-Degree Gridded Orbit-by-Orbit Precipitation Data Set will continue to be available for the entire SSM/I record, from July 1987 through the present. It is available via ftp from ftp://lake.nascom.nasa.gov/data/TRMM/Ancillary/ssmi/.

5. Conclusions

TRMM data are periodically reprocessed to incorporate improved science algorithms, currently at version 5. As currently planned, the reprocessing of TRMM product version 6 will start in May 2003. A new 3-hourly $0.25^{o} \times 0.25^{o}$ gridded rainfall product, 3B42 version 6, will be released to replace the version 5 daily $1^{o} \times 1^{o}$ gridded product. All TRMM data products can be accessed from http://lake.nascom.nasa.gov/data/dataset/TRMM/.

A new Experimental TRMM Real-time Multi-satellite Precipitation Data Set is available via ftp from ftp://aeolus.nascom.nasa.gov/pub/merged/.

A new ancillary data, GPROF 6.0 Quarter-Degree Gridded Orbit-by-Orbit Precipitation Data Set, is available via ftp from ftp://lake.nascom.nasa.gov/data/TRMM/Ancillary/3A_GPROF6/.

For more information about TRMM data and other precipitation data sets, please visit the GES DAAC Hydrology Data Page at http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/hydrology/hd_data.shtml or send email to hydrology@daac.gsfc.nasa.gov.
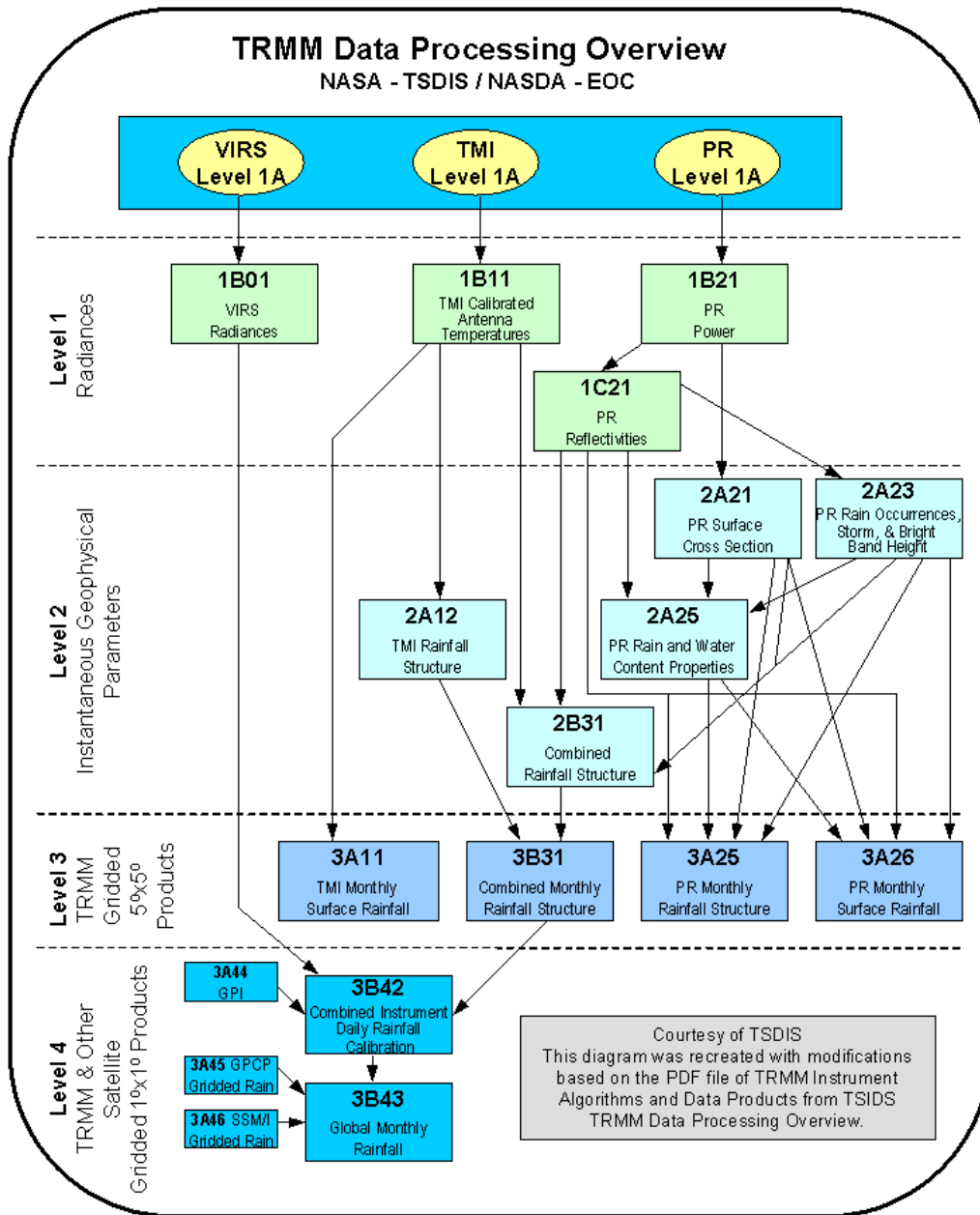
Figure 1. TRMM Data Processing Overview.

Figure 2. Image of Tropical Storm Isidore precipitation, generated by
the GES DAAC TRMM Online Analysis System.