Tropical Rainfall Measurement Mission (TRMM) Operation Summary

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The Tropical Rainfall Measurement Mission (TRMM) is a joint U.S. and Japan mission to observe tropical rainfall, which was launched by H-II No. 6 from Tanegashima in Japan at 6:27 JST on November 28, 1997. After the two-month commissioning of TRMM satellite and instruments, the original nominal mission lifetime was three years. In fact, the operations has continued for approximately 17.5 years. This paper provides a summary of the long term operations of TRMM.

Key Words: TRMM, Precipitation Radar, Long Term Operation, Data Products

1. Introduction

TRMM satellite is the first space mission dedicated to measuring tropical rainfall. TRMM mainly observes rain structure, rate and distribution in tropical and subtropical regions, the data plays an important roll for understanding mechanisms of global climate change and monitoring environmental variation. TRMM satellite and operation overview is described in section 2, and long-term operation history of satellite/instruments was shown in section 3. The products of TRMM is described in section 4.

2. TRMM Overview

Overview perspective on TRMM is that “TRMM is a research satellite designed to improve our understanding of the distribution and variability of precipitation within the tropics as part of the water cycle in the current climate system. By covering the tropical and sub-tropical regions of the Earth, TRMM provides much needed information on rainfall and its associated heat release that helps to power the global atmospheric circulation that shapes both weather and climate. In coordination with other satellites in NASA's Earth Observing System, TRMM provides important precipitation information using several space-borne instruments to increase our understanding of the interactions between water vapor, clouds, and precipitation, that are central to regulating Earth's climate.”[1)]

TRMM carried three precipitation instruments into a 35 degree inclined orbit: the Visible Infrared Scanner (VIRS); the TRMM Microwave Imager (TMI); the Japanese provided Precipitation Radar (PR). In addition it carried two Earth Observing System (EOS) instruments: the Lightening Imaging Sensor (LIS) and the Clouds and Earth’s Radiant Energy Sensor (CERES). LIS proved a particularly synergistic instrument to the three TRMM precipitation instruments.

The 35 degree inclined orbit provided good revisit times for the tropics and sub-tropics. It also facilitated diurnal cycle research.

2.1. Responsibilities of US and Japan

TRMM is a US-Japan joint project. In the project, Japan (CRL, Communications Research Laboratory (Currently named NICT, National Institute of Information and Communications Technology), and JAXA) provided the PR and the launch of the TRMM satellite by H-II rocket. The US provided the spacecraft bus and the four sensors except for the PR and operates the TRMM satellite. NASA/Goddard Space Flight Center (GSFC) via Tracking and Data Relay Satellite System (TDRSS) performs the on-orbit spacecraft operation. Table 1 show the responsibilities of US and Japan on the development and operation of the TRMM systems.

Table 1. Responsibilities of US and Japan

Primary Elements	US	Japan
H-II Rocket		X
Spacecraft Bus	X	
Precipitation Radar (PR)		X
TRMM Microwave Imager (TMI)	X	
Visible Infrared Scanner (VIRS)	X	
Clouds and the Earth’s Radiant Energy System (CERES)	X	
Lightning Imaging Sensor (LIS)	X	
S/C Tracking and Operation	X	
Data System	X	X

2.2. TRMM Characteristics

The spacecraft main characteristics is shown in Table 2.

The original altitude was approximately 350 km, and the design lifetime was 3 years and 2 months. However, the satellite altitude was changed to about 402.5 km, which lead more than 17 years operation. This altitude change history is described in section 3.

TRMM satellite has five (5) instruments on board, which are: PR, TMI, VIRS, CERES, and LIS.

Table 2. Main Characteristics of the TRMM Satellite

Launch weight	Approx. 3.62 t
Launcher	H-II Rocket
Lunch date	November 28, 1997 (JST)
Altitude	Approx. 350 km (402.5 km after Aug. 25, 2001)
Inclination	Approx. 35 degrees
Orbit	Non-Sunsyncronous
Shape	5.1 m (length), 14.6 m (in paddle direction)
Weight	Total: 3620 kg Fuel: 890 kg Dry weight: 2730 kg
Power	Approx. 1100 W [Measured Ave. 850 W]
Data transmission	Via TDRSS 32 Kbps (Real Time), 2 Mbps (Play Back)
Design life	3 years and 2 months

2.3. Overview of Operations and Data Flow

TRMM telemetry data is formatted in CCSDS packet basis, and then transmitted to the White Sands station via TDRSS. From White Sands New Mexico, the raw data was transmitted to the Sensor Data Processing Facility (SDPF) at the GSFC. SDPF processed the packet data into level 0 raw binary data. After launch and until 2000, the SDPF provided 3 quick-look raw data files per day with an additional one being orderable by the TRMM Science Data Information System (TSDIS) or the Japanese PR processing system. After 2000, TSDIS started to generate near-real time data and SDPF sent quicklook data from each of the TDRSS contacts to TSDIS for processing.

For research production products SDPF produced daily level 0 raw files (in the case of PR it created 4 6-hour raw files. This daily data was then transmitted to the TSDIS for science processing. During version 7 TSDIS had evolved into the Precipitation Processing System (PPS) but the handling of TRMM data remained as it was under TSDIS.

PPS processed all the near-realtime (NRT) data and made it available to the general user community. NRT data included TMI brightness temperature products and rain retrievals; VIRS radiances; and PR reflectivity, rain type, and 3-D precipitation products.

PPS also processed the daily level 0 files from TMI, VIRS and PR to level 1 swath products, level 2 retrieval products and level 3 gridded products. PPS distributed these data to the TRMM science team and other interested science users. It also transmitted all products from level 0 through level 3 for all the TRMM precipitation instruments to the GSFC EOS Data and Information System (EOSDIS) Distributed Active Archive Center (DAAC) for long-term archive and support.

The EOSDIS GSFC DAAC made the TRMM distributed the TRMM data to the boarder user community. It also ensured the incorporation of the TRMM data into the overall EOSDIS archive and distribution concepts and tools.

Level 0 processed CERES and LIS data is transmitted to the Langley Research Center EOSDIS DAAC and the Marshall Space Flight Center EOSDIS Global Hydrology Research Center (GHRC) DAAC, respectively. All processing of data from these instruments were a direct EOSDIS responsibility and carried out by these EOSDIS DAACs.

PPS transmitted PR Level 0 data to Japan along with the ephemeris files required for geolocating the data. In Japan, PR higher level processing is performed at the JAXA Earth Observation Center (EOC). The higher-level products (Level 1-3 products) produced by EOC or GSFC/PPS are distributed to users, which include many scientists in the fields of climatology, meteorology, hydrology etc., in Japan, US and various other countries. Data products by PPS and EOC are described in Section 4.

3. Operations History

TRMM subsystems and instruments have performed very well except for CERES. CERES has suspended operation after May 29 2001 because it experienced problems with its power source.

3.1. Mission Operation Phase and Altitude

The launch and in-orbit checkout phase starts with the launch and requires approximately 60 days. The major activities of this phase are launching of TRMM, orbit injection/stabilization, satellite checkout, orbital descent to mission altitude, turning the instruments on, and calibration. The H-II rocket injected TRMM into an orbit of 380 km with the orbital inclination at 35 degrees. TRMM rotates around the earth approximately every 90 minutes, and 16 orbits a day. All subsystems and equipments except for CERES completed their operation checkouts 26 days after launch. At this point (Dec. 29), the satellite entered a normal operation stage, and science observation started. During the initial operation, a number of descent trajectory controls have been carried out, and then the orbit of TRMM was transferred to the mission altitude, 350 km +/- 1.25 km, and orbit period of 91.5 minutes. The Fig. 1. shows the original altitude plan and corresponding mission phases.

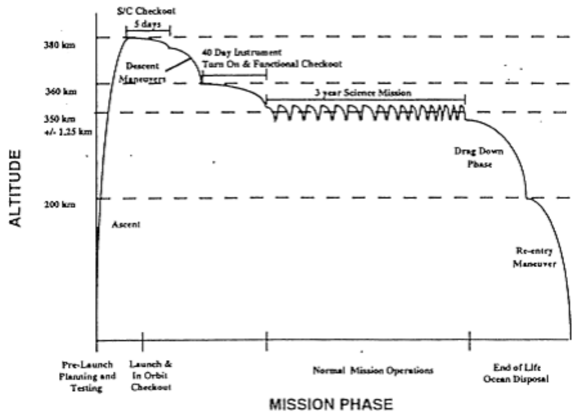

Fig. 1. Mission Operations Phase and Altitude (as of pre-launch)

TRMM completed its nominal three-years mission in January 2001, and is continuing to operate. Based on the latest mission analysis about necessary fuel for a controlled reentry, TRMM lifetime would be 1.5 years shorter than the previous estimate as of 2001. Consequently, the satellite altitude was raised to 402.5 km +/- 1.0 km in August 2001, in order to extend observation period. From August 7 to August 24, 6 Delta-V Maneuvers were performed. After sequential three maneuvers, the satellite moved to the Sun Acquisition mode for four days because TDRSS operation was priorized for the International Space Station mission. Fig. 2 shows the altitude change history during the boost.

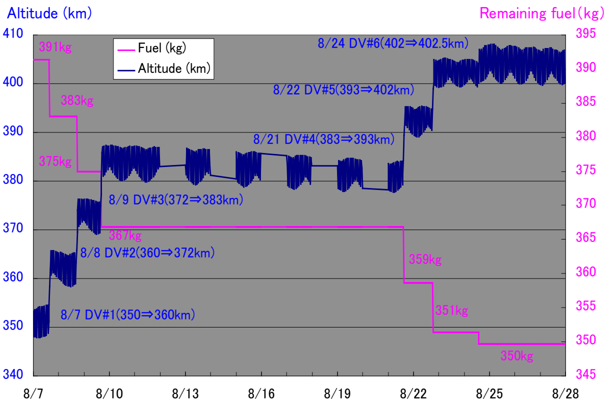

Fig. 2. Altitude and Estimated Remaining Fuel during Boost

After the boost, although the remaining fuel was at its limit for controlled re-entry in September 2005, JAXA and NASA decided to continue the mission until September 30, 2009 for the long-term scientific achievements of TRMM instead of the re-entry.

On July 8, 2014, the TRMM Flight Operations Team noted a significant pressure drop of the propellant tank of ~3 psi (recently only ½ psi drop is expected) during execution of drag make-up maneuver (DMUM) #610A (14:46:40-14:47:19.5GMT). A more significant pressure drop of ~10 psi was recorded following execution of DMUM #610B (15:27:11-15:27:31.25GMT). Through the analysis by Flight Dynamics Facility, the remaining propellant is estimated as about 1 kg. This remaining fuel was reserved for a debri avoidance maneuver in case. Then, the end of mission was started. The actual altitude history during end of mission phase is shown in Fig. 3.

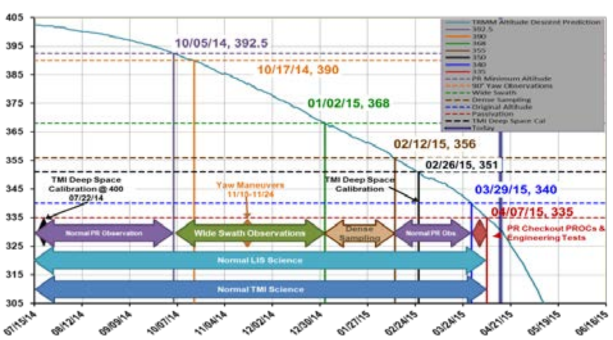

Fig. 3. Altitude History during the Descent

3.2. Satellite Operation History and Events

TRMM utilizes the TDRSS to perform telemetry and command contacts with the spacecraft. With 15-16 TDRSS passes per day the Mission Operations Center performs science and housekeeping data recovery activities as week and routine maintenance of the spacecraft bus. These routine activities include: stored command uplink, TDRSS ephemeris uplink, spacecraft ephemeris uplink, solid state recorder (SSR) management, software patch uplink, etc. To maintain the operational orbit, the Flight Operations Team (FOT) plans and executes routine Drag Make-Up Maneuvers to raise the orbit. TRMM operated in an environment where the Beta angle (the angle of the orbit normal to the sun vector) varied between +60° and -60°. Effectively this changed the illumination angle of the sun on the spacecraft and effected the thermal balance as well as the power generation. To mitigate the thermal concerns, the FOT performed Yaw Maneuvers to maintain the sun angle on the desired side of the spacecraft. To generate the requisite power, the FOT altered the charging rate by commanding different charge levels (V/T Levels) at different Beta angles.

During the 17 years of operations, the TRMM spacecraft performed exceptionally. TRMM performed 610 DMUMs and 271 Yaw Maneuvers successfully to maintain the orbital requirements and numerous V/T Level changes to maintain the battery charge. A sample year of operations is shown in Fig. 4.

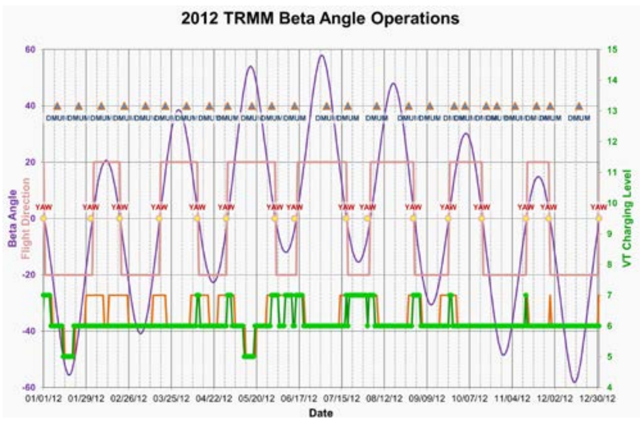

Fig. 4. Beta Angle Operations & DMUMs

Due to the low orbit of TRMM, there was attempts to minimize the drag profile of the spacecraft. For this reason, the solar arrays, in addition to tracking the sun during spacecraft day, were “feathered”, or positioned normal to the flight direction during spacecraft night which greatly reduced the effects of drag on the mission and extended operations. However, on December 29, 2003 one of the solar array drive assemblies (SADA) showed higher than expected temperatures and nearly stuck. By design this SADA was pointed more to the sun than the other. As a proactive measure this array was parked to be perpendicular to the sun vector at the middle of spacecraft day to maximize power generation on that array.

TRMM maintained over 99% data capture rate during the long mission. However, there were five (5) transitions to a contingency mode that interrupted the science due to anomalous performance of the spacecraft bus. Two (2) transitioned to Low Power Mode and three (3) transitions to Sun-Acquisition Mode. In each case, science operations halted temporarily while the problem was investigated and resolved.

On March 3, 1998, TRMM transitioned into Low Power Mode. This was due to a failed Power Interface electronics component which manifested itself as a low battery state of charge. TRMM was configured to the redundant component for the remainder of its mission.

On April 25, 1998, TRMM transitioned into Sun-Acquisition Mode. The transition was caused by interference of the sun and moon in the earth sensor which confused the control software. The software was corrected and science operations continued.

On January 3, 1999, TRMM transitioned into Sun-Acquisition Mode due to incorrect pointing of the Solar Array. This was a sign that the SADA rotation would need to be stopped to mitigate a failure which would leave the array at an undesirable position. Science operations continued.

On March 23, 2000, TRMM transitioned into Low Power Mode. This was due to faulty telemetry from the redundant Power Interface electronics component. The problem was corrected and science operations continued.

On August 13, 2001, TRMM transitioned into Sun Acquisition Mode during the reboost from 350 km to 402.5 km. Since the Earth Sensor Assembly (ESA) was designed to view the earth at an altitude of 350 km, during the descent, they effectively lost the view of the earth’s limb, or edge. This “loss of nadir” caused the transition. The FOT turned off the ESA and used other sensors to continue the mission.

The Leonid Meteor Storm was estimated active so that the PR was moved to the Stand-by mode in November 1998, 1999, 2000, 2001 and 2002. Following this peak, the PR instrument was kept in normal observation due to the low estimated risk.

During the final years of operations, the TRMM batteries, which had been designed for a three-year mission, began to show signs of degradation and wear. Beginning in 2011, cells in TRMM battery #2 started to short temporarily and the entire battery began to warm. With help from the NASA GSFC experts, the FOT applied various strategies to lengthen the battery life to assure the maximum science mission.

On March 21, 2014, the FOT powered off the VIRS to save battery capacity for the remaining instruments.

On August 10, 2014, the FOT turned off the LIS and placed PR into Internal Calibration Mode due to excessive shorting in Battery 2.

On August 17, 2014, operations was changed to share the power during difficult beta angles for the batteries. PR was prioritized above LIS to have the maximum available of science operations.

On October 24, 2014, operations was reversed to allow LIS to maximize their science gathering operations as TRMM’s altitude fell below 390 km.

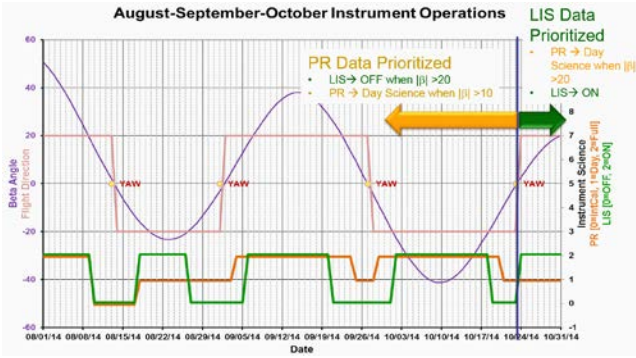

Fig. 5. Beta Angle Instrument Operations

On February 12, 2015, operation was returned to allow PR to maximize science data as TRMM fell below 360 km, the original orbit altitude. Actually, PR provided the important precipitation observation results for one and a half month. Fig. the 3-dimensional hurricane. Fig.6 is one of TRMM's last hurricane hot towers on February 19, 2015, seen when PR had descended back to near its original 350 km orbit.

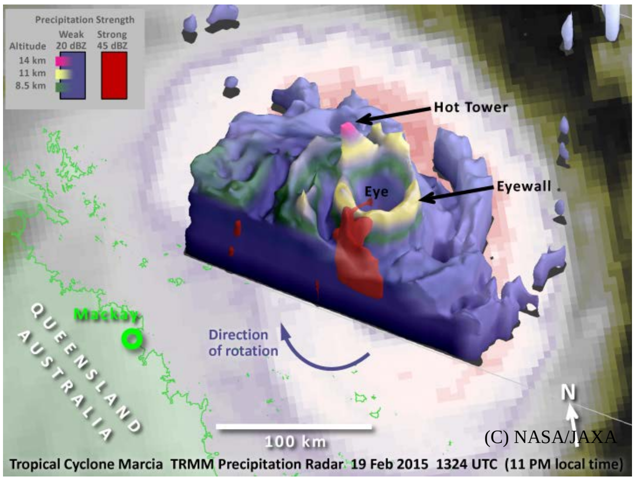

Fig. 6. Hurricane hot towers observed by PR

TRMM continued the observation around orginal altitude, 350km. Then, PR was turn off on Apirl 1, 2015 after TRMM fell below 340 km. TMI and LIS were also ceased thier observation and turn off on April 8, and the spacecraft bus was finally passivated on April 15, 2015. The spacecraft slowly descends from its orbit now.

3.3. Collision Avoidance Operation

TRMM conducted routine screening of the space environment since 2005 to ensure satellite safety. In conjunction with the Joint Space Operations Center (JSpOC). Over the course of the mission, TRMM conducted one (1) Debris Avoidance Maneuver (DAM). This was conducted on November 18, 2013 to mitigate a close approach with a piece of debris and was coordinated as a routine DMUM to save fuel.

In June of 2011, following the retirement of the space shuttle, and prior to the onset of increased solar drag environment, the ISS increased its altitude from roughly 350 km to 400 km. As a result the International Space Station (ISS) and TRMM flew in roughly the same orbital regime from then until end of mission. As a precaution, the TRMM team and ISS constructed an Operational Agreement to document the sharing of information back and forth to ensure that no close approaches between the two vehicles were un mitigated. TRMM and ISS flew successfully until the end of the TRMM mission.

3.4. PR Operations and Events

PR have continued normal observation mode except for some events such as stand-by or safety mode due to the satellite stand-by mode (see section 3.2) and the calibration mode and analysis mode for PR performance evaluation. JAXA has been checking the HK out-of-limit and monitor its trend every weekday, and warrants the quality of PR data by the following routine calibration of PR for 17 years.

- Internal Cal. : everyday over Australia (1 to 3 paths per one day)
- External Cal. : twice per year (several paths per one opportunity)
- LNA analysis : ten times per year

PR TX and RX external calibration results has been stable and within +/- 1 dB range during the 17 years of operation (See Fig. 7). And Sea surface σ0 data observed by PR has also been stable (See Fig. 8). PR system noise level has also been stable except for the gap at Frequency Converter IF unit (FCIF) / System Control Data Processing (SCDP) switch from A side to B side (See Fig. 9).

The PR's observation performance has been stable and has satisfied all requirements.

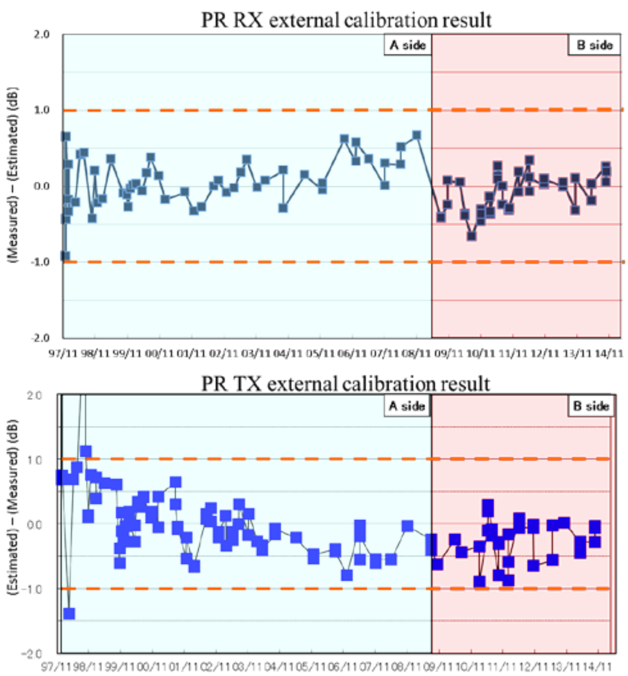

Fig. 7. Results from PR External Calibration

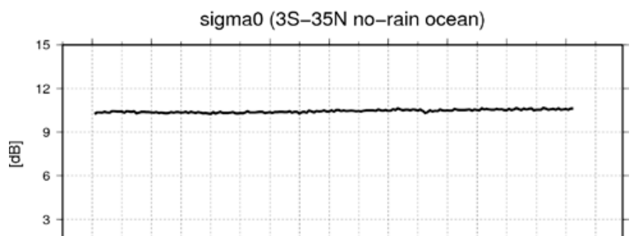

Fig. 8. Sea surface σ0 data observed by PR

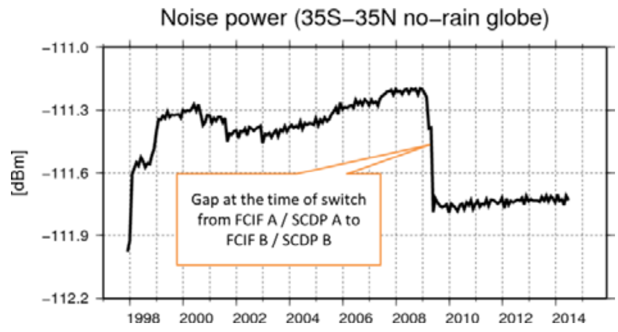

Fig. 9. PR system noise level

In addition to the routine command, JAXA had the special command as follows;

(a) PR Range offset change for 402.5 km normal observation (August 7, 2001) [no normal observation data from Aug. 7 to Aug. 22]
(b) PR TX off to measure noise signal (June 7,14 and 21, 2004)
(c) Ka sampling experiment (March 15 and 16, 2007)
(d) SCDP-B/FCIF-B switch by the SCDP-A/FCIF-A failure (June 17, 2009) [no normal observation data from May 29 to Jun.18]
(e) End of mission experiments (October 2014 ~ February 2015) [no normal observation data from Oct. 8, 2014 to Feb. 12, 2015]
(f) PR Range offset change for 350 km normal observation (February 12, 2015)
(g) Check-out activities and turn-off (April 1, 2015)

Commands of above (b), (c) and (e) were performed for the future mission study.

PR range offset was changed corresponding to the satellite altitude by command (a) and (f). PR characteristics were different between 350 km altitude and 402.5 km altitude (see Table 3).

In June 2009, failure occurred somewhere in FCIF A or SCDP A. These components were switched to B side in above (d). Using the redundant component, PR could perform well for all mission term.

Table 3. PR characteristics before and after orbit boost

	350 km (1998.1~2001.8, 2015.2~3)	402.5 km (2001.8~2015.2)
Horizontal Data Spacing	4.3 km	5 km (cross track) 4.3 km (along track)
Footprint Size	4.34 +/- 0.12 km	5 km
Minimum Detectable Rain Rate	0.5 mm/h	0.7 mm/h
Swath Width	215 ~ 220 km	245 ~ 250 km
Observation Echo Height	>15 km	>13.5 km

3.5. Other Instruments Operations

The four (4) other instruments on TRMM are the LIS, CERES, TMI and VIRS.

LIS and VIRS were internally calibrated and no operational activities during the operational mission. Occasionally (3-4 per annum), LIS would need to be reset via ground command, but had no impact on the platform or other instruments Similarly, VIRS would require an occasional command (6-10 per annum) to reset the housekeeping data connection to the platform, but would not impact the other instruments or spacecraft bus.

During the initial checkout of the spacecraft and instruments, the CERES instrument required an external calibration source. This was completed by holding the spacecraft inertially pointing for an orbit so that the CERES instrument could view deep space. Obviously, this would interrupt the science data from PR as well as the other instruments. This maneuver was called a “Deep Space Calibration Maneuver”. CERES was turned off in May 29, 2001 due to an instrument anomaly. These activities were successfully conducted on the following dates:

- January 7, 1998 (3 orbits)
- January 8, 1998 (3 orbits)
- September 2, 1998 (1 orbit)

During the descent from the operational orbit of 402.5 km to the passivation altitude of 335 km, TRMM executed three (3) other instrument driven maneuver sets. Specifically, TMI requested a set of Deep Space Calibration maneuvers similar to the ones called for by CERES.

1) The first set was completed at 400 km on July 22, 2014. This consisted of three (3) orbits each separated by an orbit of nominal earth pointing orbits.
2) The second set was completed at 350 km on February 26 and 27, 2015. This also consisted of three (3) orbits, each separated by an orbit of nominal earth pointing orbits.
3) The third set was completed at 342 km and 341 km on March 25 and 26, 2015. Each consisted of two orbits of deep space orientation with a 90° yaw each separated by an orbit of nominal earth pointing.

4. TRMM Products

JAXA/EOC and NASA/PPS produce and distribute TRMM products from PR, TMI and VIRS. CERES products are released by NASA Langley Research Center (LaRC), and NASA LIS is from Marshall Space Flight Center (MSFC).

TRMM standard products were established by the Joint TRMM Science Team (JTST) during the implementation of the TRMM mission. The JTST evolved into the Joint Precipitation Measurement Missions (PMM) Science Team (JPST) and this group still determines the data products that are determined to be TRMM standard products and their reprocessing as necessary.

TRMM data products were processed into 3 major groups as defined by EOSDIS. Level 1 which contained 1A which were raw data that was placed into TRMM orbit products as well as 1B which were geolocated products at instrument field of view (IFOV) in TRMM orbits. PR also had a 1C product that provided geolocated radiances at IFOV in TRMM orbits.

The second level were geolocated products that contained geophysical parameters at the IFOV in TRMM orbits.

The third level were time and space gridded files. In TRMM these were monthly gridded products in .5 degree x .5 degree grids.

Fig. 10 provides the dependencies among the TRMM precipitation products.

Table 4. TRMM Level 1 Products

TRMM ID	INSTRUMENT	CONTENT
1A01*	VIRS	Packets by orbit
1A11*	TMI	Packets by orbit
1A21*	PR	Packets by orbit
1B01	VIRS	Geolocated Radiances at IFOV in orbits
1B11	TMI	Geolocated brightness temperatures at IFOV orbits
1B21	PR	Geolocated radar powers at IFOV orbits
1C21	PR	Geolocated reflecitivities at IFOV orbits

* These products are internal data.

Table 5. TRMM Level 2 Products

TRMM ID	INSTRUMENT	CONTENT
2A12	TMI	Rain at IFOV orbits
2A21	PR	SRT at IFOV orbits
2A23	PR	Rain Type at IFOV orbits
2A25	PR	3-D Rain at IFOV orbits
2B31	Combined TMI/PR	Rain at IFOV orbits
2H25	PR	Latent Heating at IFOV orbits
2H31	Combined	Latent Heating IFOV orbits

Table 6. TRMM Level 3 Gridded Products

TRMM ID	INSTRUMENT	CONTENT
3A11	TMI	5 deg x 5 deg rain from level 1B
3A12	TMI	.5 deg x .5 deg rain from 2A12
3A25	PR	.5 deg x .5 deg rain from 2A21,2A23, 2A25
3B42	Merged radiometers	.25 x .25 deg 3 hour rain from many radiometers
3B43	Merged radiometers	.25 x .25 deg monthly rain from many radiometers
3B31	Combined TMI/PR	.5 deg x .5 deg rain from 2B31
3G25	PR	Daily gridded orbits of LH 2H25
3G31	Combined	Daily gridded orbits of LH 2H31
3H25	PR	Monthly .5 deg x .5 deg LH
3H31	Combined	Monthly .5 deg x .5 deg LH

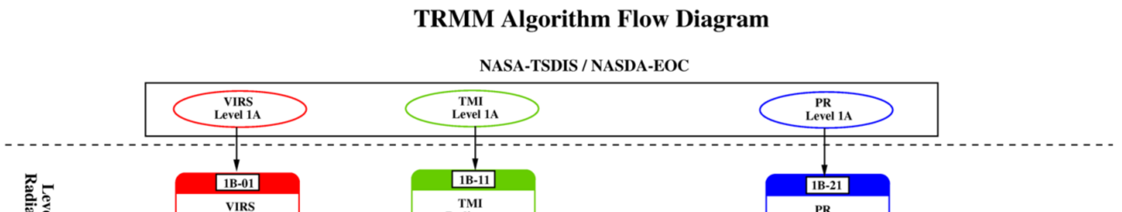

Fig. 10. TRMM Processing Flow Chart

In addition to the US-Japan Standard products, NASA and JAXA has research products using TRMM data respectively. One of JAXA research products, JAXA developed the Global Satellite Mapping of Precipitation (GSMaP) products by multiple satellite data, which activities were sponsored by Core Research for Evolution Science and Technology (CREST). [2)]

4.1. Data release history

PR started its observation on December 8, 1997. Then the first image was released on December 17. After the initial checkout was finished, Version 4 products were started to process in January 1998 for its evaluation, and PR data were released to the public on August 29, 1998.

TRMM has JPST, they approve the product quality and schedule. PR, TMI, VIRS, and PR/TMI Combined products are always released together at product version up like as Table 7.

4.2. Next algorithm improvement plan

The JPST has established that the next version of TRMM reprocessing which would be version 8 will actually be the first reprocessing under the Global Precipitation Measurement (GPM) mission. This means that version 8 of TRMM reprocessing will put the TRMM data within the GPM context as another constellation partner. So as one step TRMM data will be changed to the HDF5 format and will obtain the GPM naming conventions.

Table 7. TRMM Products Release

date	events
Dec. 9, 1997	PR first observation, First image release on Dec. 17
Aug. 29. 1998	Level 1 (ver. 4) products release Level 2-3 (ver. 4) products release
Nov. 4, 1999	Version 5 products release
Apr. 14, 2004	Version 6 product release
July 20, 2011	Version 7 product release
Feb. 27, 2012	Latent Heat (SLH) product release
Mar. 3, 2012	Latent Heat (CSH) product release
Winter of 2016 (TBD)	Version 8 (planned)

The most important change will be that intercalibration of the brightness temperatures will be done using GPM core satellite data rather than TRMM data. This means that TRMM will be intercalibrated by GPM. And the PR calibration coefficient table will be tuned for 17 years. Additionally the GPM algorithms will be used to process the TRMM data. This will ensure a consistent mission data set as well as take advantage of all the new approaches found in the GPM algorithms over the original TRMM algorithms.

It is the intent that every time GPM data is reprocessed TRMM data will also be reprocessed back to beginning of the mission with the new GPM algorithms.

GPM product was released as version 3 in September, 2014. The version 4 products will be released in Autumn 2015 using one year data from the launch. After that, TRMM version 8 algorithm will be prepared and planed to start in winter in 2016.

4.3. Data services from JAXA and NASA

JAXA distribute JAXA Earth observation satellite products including TRMM and GPM via “G-Portal”. G-Portal can disseminate products on internet and without charge, except for high resolution products and/or commercial based products as Advanced Land Observing Satellite (ALOS), and ALOS-2 which will be coming soon. User can get products in two ways. (A)Users can search products by physical quantities and by satellites/sensors and to get selected products with thumbnails and browses. (B)Users also can obtain products by SFTP. The URLs are as follows;

(A) https://www.gportal.jaxa.jp

(B) sftp://sftp.gportal.jaxa.jp

And the catalogue data is also disseminated via CATS-I (Catalogue Transfer Service - Interface). http://catsi.jaxa.jp

NASA TSDIS provides the Remote Science Terminal (RST) for searching, querying and ordering TRMM data. With the migration of TRMM processing to the PPS, the more powerful Science Terminal Ordering Resource Module (STORM) was introduced. https://storm-pps.gsfc.nasa.gov/storm/ STORM provides all the searching, querying and ordering capabilities of the original RST but also provides subsetting capabilities.

STORM users can order data and establish standing orders by establishing geographical areas of interest. The system will then only provide that part of the data that is within the users specified area of interest. This geographical subsetting can be done on level 1b, level 2 and even level 3 data.

In addition to geographical subsetting and combined with geographical subsetting, STORM also provides users with the ability to subset parameters from the larger TRMM data file and receive their products containing only the parameter(s) that were selected. As with geographical subsetting, such parameter subsetting can be setup to be a standing order. So whenever data was produced the desired subset would be created as a special product for the user.

STORM also provides online capabilities to graphical view the contents of the data products. This gives users the ability to see whether a product contains the data that they expect.

General users may access the GSFC DAAC which has its own interface that is integrated with the general EOSDIS architecture. This allows users to find out about any data within the EOSDIS system. In addition the GSFC DAAC also provides some tools for subsetting and analyzing TRMM merged radiometer data. All TRMM data can be ordered through the EOSDIS GSFC DAAC.

5. Conclusion

TRMM operation was successfully concluded and exceeded its design goal by collecting 17 years of rainfall data, which includes a half year overlap observation with GPM. TRMM and GPM will make continuous precipitation observation from the space over 20 years or more data, which is highly expected as a benchmark rainfall climatology.

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References

1) NASA TRMM Home Page, http://pmm.nasa.gov/trmm/
2) JAXA/EORC TRMM Home Page, http://www.eorc.jaxa.jp/