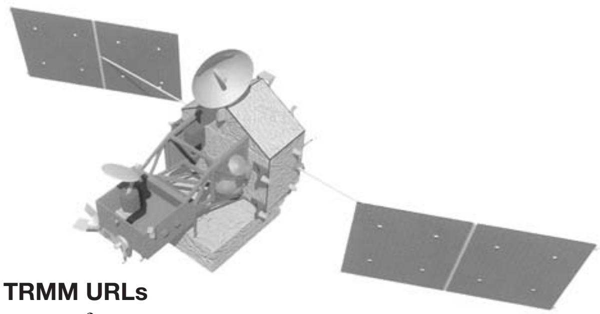
TRMM

Tropical Rainfall Measuring Mission



TRMM URLs

trmm.gsfc.nasa.gov
www.jaxa.jp/missions/projects/sat/eos/trmm/

Key TRMM Facts

Joint with Japan

Orbit:

Type: Non-sun-synchronous

Altitude: 350 km, boosted to 402 km on August 22, 2001

Inclination: 35°

Period: 91 minutes

Repeat Cycle: Changes 24 hours of local time in 46-day precession cycle

Dimensions: 5.2 m high

Mass: 3512 kg

Power: 1100 W

Design Life: 3 years (now operating for 7 years)

Summary

TRMM is a joint mission between NASA and the Japan Aerospace Exploration Agency (JAXA). It was designed to monitor and study tropical rainfall and the associated release of energy that helps to power the global atmospheric circulation, shaping both weather and climate around the globe.

TRMM was originally designed to carry out a three-year mission, but has operated successfully for over eight years. TRMM completed all of its research and technology objectives by 2001, and continues to provide data used worldwide in the monitoring and forecasting of hazardous weather on a demonstration basis. The TRMM spacecraft is expected to continue until at least 2010, when the core spacecraft for the Global Precipitation Measurement (GPM) mission—a TRMM follow-on—is planned for launch.

Instruments

- Clouds and the Earth's Radiant Energy System (CERES)
- Lightning Imaging Sensor (LIS)
- Precipitation Radar (PR)
- TRMM Microwave Imager (TMI)
- Visible and Infrared Scanner (VIRS)

Points of Contact

- *U.S. TRMM Project Scientist:* Robert Adler, NASA Goddard Space Flight Center
- *U.S. TRMM Deputy Project Scientist:* Arthur Hou, NASA Goddard Space Flight Center
- *Japan TRMM Project Scientist:* Tetsuo Nakazawa, Japan Meteorological Research Institute

Other Key Personnel

- *TRMM Program Scientist:* Ramesh Kakar, NASA Headquarters
- *TRMM Program Executive:* Steve Neeck, NASA Headquarters

Mission Type

Earth Observing System (EOS) Exploratory Mission

Launch

- *Date and Location:* November 27, 1997, from the Tanegashima Space Center, Japan
- *Vehicle:* Japanese H-II F6

Relevant Science Focus Areas

(see NASA's Earth Science Program section)

- Climate Variability and Change
- Water and Energy Cycles
- Weather

Related Applications

(see Applied Sciences Program section)

- Air Quality
- Aviation
- Disaster Management
- Energy Management
- Invasive Species
- Public Health
- Water Management

TRMM Science Goals

- Obtain and study multiyear science data sets of tropical and subtropical rainfall measurements.
- Understand how interactions between the sea, air, and land masses produce changes in global rainfall and climate.
- Improve modeling of tropical rainfall processes and their influence on global circulation in order to predict rainfall and its variability at various periods of time.
- Test, evaluate, and improve satellite rainfall measurement techniques.

TRMM Mission Background

TRMM is a joint mission with Japan launched on November 27, 1997, aboard a Japanese H-II rocket. The TRMM orbit is non-sun-synchronous and initially was at an altitude of 350 km, until the satellite was boosted to 402 km on August 22, 2001. The objectives of TRMM center on rainfall and energy, including latent heat of condensation. The primary rainfall instruments on TRMM are the TRMM Microwave Imager (TMI), the Precipitation Radar (PR), and the Visible and Infrared Scanner (VIRS). Additionally, the TRMM satellite carries two related EOS instruments: The Clouds and the Earth's Radiant Energy System (CERES) and the Lightning Imaging Sensor (LIS).

The combination of satellite-borne passive and active sensors provides critical information regarding the three-dimensional distributions of precipitation and heating in the tropics. Coincident measurements from TMI and PR are complementary: Passive microwave radiometers measure the integrated effects of liquid and ice along the instrument viewing direction while active microwave sensors (radars) provide specific height information on liquid and ice within the cloud.

VIRS adds cloud-top temperatures and structures to complement the descriptions from the radar and radiometer. While direct precipitation information from VIRS is less reliable than that obtained by the microwave sensors, VIRS serves an important role as a bridge between the high-quality but infrequent observations from TMI and PR and the more-frequent observations and longer time series of data available from the geostationary Visible/Infrared (VIS/IR) satellite platforms.

CERES and LIS were designated as EOS instruments and play an important role in rounding out the TRMM science objectives. LIS maps the global frequency of lightning events and plays an important role in coupling the occurrence of lightning to precipitation, thus enhancing our overall understanding both of lightning and of precipitation processes. CERES allows for determination of the total radiant energy balance. Taken together with the latent heating derived from precipitation measurements, a significantly improved picture of the atmospheric energy system can emerge. Unfortunately, an electronics failure limited CERES data collection to the periods of January–August 1998 and March 2000. Fortunately, this captured the peak and decay of the large 1998 El Niño event, and provided a calibration overlap with the Terra Mission.

TRMM Instruments

CERES
Clouds and the Earth's Radiant Energy System

A three-channel, broadband radiometer (0.3 to > 100 μm, 0.3–5 μm, 8–12 μm) designed to measure major elements of the Earth's radiation balance.

LIS
Lightning Imaging Sensor

Staring telescope/filter imaging system (0.777 μm) with 5-km spatial resolution and 2-ms temporal resolution over an imaging area of 600 km × 600 km.

PR
Precipitation Radar

An electronically scanning radar operating at 13.8 GHz; 4.3-km instantaneous field-of-view at nadir; 220-km swath. Provided by JAXA.

TMI
TRMM Microwave Imager

A nine-channel conical scanning passive microwave imager making measurements from 10 to 85 GHz, 37- to 4.6-km resolution respectively, covering 760-km swath.

VIRS
Visible and Infrared Scanner

A five-channel cross-track imaging radiometer (0.62, 1.63, 3.78, 10.83, and 12.03 μm) with nominal 2-km resolution at nadir and 720-km swath.

TRMM data are sent to the NASA TRMM Science Data and Information System (TSDIS) at NASA GSFC via the Tracking and Data Relay Satellite System (TDRSS) and the White Sands Receiving Station. GSFC is responsible for all science data processing and data distribution to the TRMM algorithm development team. Upon data product generation, the data are sent to the GSFC Earth Sciences Distributed Active Archive Center (GES DAAC) for archiving and distribution to the general user community.

CERES

Clouds and the Earth's Radiant Energy System

The CERES instrument is described in the Aqua section.

LIS

Lightning Imaging Sensor

Investigates the distribution and variability of lightning over Earth with storm-scale spatial resolution.

LIS Background

LIS is designed to investigate the global incidence of lightning, its correlation with convective rainfall, and its relationship with the global electric circuit. Conceptually, LIS is a simple device, consisting of a staring imager optimized to locate both intracloud and cloud-to-ground lightning with storm-scale resolution over a large region of Earth's surface, to mark the time of occurrence, and to measure the radiant energy. It will monitor individual storms within the field of view (FOV) for 80 seconds, long enough to estimate the lightning flash rate. Location of lightning flashes is determined to within 5 km over a 600-km × 600-km FOV.

The LIS design uses an expanded optics wide-FOV lens, combined with a narrow-band interference filter that focuses the image on a small, high-speed, charge-coupled-device focal plane. The signal is read out from the focal plane into a real-time data processor for event detection and data compression. The particular characteristics of the sensor design result from the requirement to detect weak lightning signals during the day when the background illumination, produced by sunlight reflecting from the tops of clouds, is much brighter than the illumination produced by the lightning.

A combination of four methods is used to take advantage of the significant differences in the temporal, spatial, and spectral characteristics between the lightning signal and the background noise. First, spatial filtering is used to match the instantaneous FOV of each detector element in the LIS focal-plane array to the typical cloud-top area illuminated by a lightning event (about 5 km). Second, spectral filtering is applied, using a narrow-band interference filter centered about the strong hypoiodite ion (OI) emission multiplet in the lightning spectrum at 777.4 nm. Third, temporal filtering is applied. The lightning pulse duration is of the order of

Key LIS Facts

Provided by NASA Marshall Space Flight Center (MSFC)

Heritage: Optical Transient Detector

Instrument Type: Staring telescope/filter imaging system that detects the rate, location, and radiant energy of lightning flashes

Swath: 600 km × 600 km

Spatial Resolution: 5 km

Temporal Resolution: 2 ms

Wavelength: Operating at 0.7774 μm

Dimensions:

Sensor head assembly (cylindrical): 20 cm × 30 cm

Electronics Assembly: 30 cm × 20 cm × 30 cm

Mass: 20 kg

Duty Cycle: 100%

Power: 33 W

Data Rate: 6 Kbps

Thermal Control: Heater, radiator

Thermal Operating Range: 0–40° C

Field of View (FOV): 80° × 80°

Instrument IFOV: 0.7°

Direct Broadcast: No

400 μs, whereas the background illumination tends to be constant on a time scale of seconds. The lightning signal-to-noise ratio improves as the integration time approaches the pulse duration. Accordingly, an integration time of 2 ms is chosen to minimize pulse splitting between successive frames and to maximize lightning detectability. Finally, a modified frame-to-frame background subtraction is used to remove the slowly varying background signal from the raw data coming off the LIS focal plane. If, after background removal, the signal for a given pixel exceeds a specified threshold, that pixel is considered to contain a lightning event.

LIS investigations are striving to understand processes related to, and underlying, lightning phenomena in the Earth atmosphere system. These processes include the amount, distribution, and structure of deep convection on a global scale, and the coupling between atmospheric dynamics and energetics as related to the global distribution of lightning activity. The investigations will contribute to a number of important EOS mission objectives, including cloud characterization and hydrologic-cycle studies. Lightning activity is closely coupled to storm convection, dynamics, and microphysics, and can be correlated to the global rates, amounts, and distribution of convective precipitation, to the release and transport of latent heat, and to the chemical cycles of carbon, sulfur, and nitrogen. LIS standard products include intensities, times of occurrence, and locations of lightning events.

The performance of LIS has exceeded specifications and has been returning unprecedented data on lightning activity. LIS is enabling investigators to quantify relationships between lightning, convection, and ice production.

LIS Principal Investigator

Hugh Christian, NASA Marshall Space Flight Center

LIS URL

thunder.msfc.nasa.gov/lis.html

PR

Precipitation Radar

Measures the three-dimensional (3-D) rainfall distribution over both land and ocean, and defines the layer depth of the precipitation.

PR is the first spaceborne instrument designed to provide 3-D maps of storm structure. The measurements yield invaluable information on the intensity and distribution of the rain, the rain type, the storm depth and the height at which the snow melts into rain. The estimates of the heat released into the atmosphere at different heights based on these measurements can be used to improve models of the global atmospheric circulation.

PR has a horizontal resolution at the ground of about 4 km and a swath width of 220 km. One of its most important features is its ability to provide vertical profiles of the rain and snow from the surface to a height of about 20 km. PR is able to detect fairly

Key PR Facts

Provided by Japan (JAXA)

Heritage: 1st space-borne precipitation radar

Instrument Type: 128-element active phased array system

Scan Type: Cross-track

Swath: 220 km

Observable Range: Surface to 15-km altitude

Range Resolution: 250 km

Horizontal Resolution: 4.3 km (nadir)

Vertical Resolution: 0.25 km (nadir)

Frequency: 13.8 GHz horizontal polarization

Dimensions: 2.3 m × 2.3 m × 0.7 m (platform and antenna)

Power: 224 W

Data Rate: 93.2 Kbps

Number of Independent Samples: 64

Direct Broadcast: No

light rain rates down to about 0.7 mm/hr. For intense rain rates, where the attenuation effects can be strong, new methods of data processing have been developed that help correct for this effect. PR is able to separate out rain echoes for vertical sample sizes of about 250 m when looking straight down.

PR Project Scientist (Japan)

Kenichi Okamoto, Communications Research Laboratory

TMI

TRMM Microwave Imager

Provides information on the integrated column precipitation content, cloud liquid water, cloud ice, rain intensity, and rainfall types.

TMI is a passive microwave radiometer designed to provide quantitative rainfall information over a wide swath. By carefully measuring the minute amounts of microwave energy emitted by Earth and its atmosphere, TMI is able to quantify the water vapor, the cloud water, and the rainfall intensity in the atmosphere. It is a relatively small instrument that consumes little power. This, combined with the wide swath and the good, quantitative information regarding rainfall, makes TMI the "workhorse" of the rain-measuring package on TRMM.

Improving on History

TMI is not a new instrument. It is based on the design of the highly successful Special Sensor Microwave Imager (SSM/I) which has been flying continuously on satellites of the Defense Meteorological Satellite Program (DMSP) since 1987. TMI measures the intensity of radiation at five separate frequencies: 10.7, 19.4, 21.3, 37, and 85.5 GHz. These frequencies are similar to those of the SSM/I, except that TMI has the additional 10.7-GHz channel designed to provide a more-linear response for the high rainfall rates common in tropical regions. The other main improvement is due to improved ground resolution. This improvement, however, is not the result of any instrument improvements, but rather a function of the lower altitude of TRMM (350 km compared to 860 km of SSM/I). TMI has a 760-km-wide swath on the surface. The higher resolution of TMI, as well as the additional 10.7 GHz frequency, make TMI a better instrument than its predecessors. The additional information supplied by PR further helps to improve algorithms. The improved rainfall products over a wide swath complement and enhance the continuing measurements being made by the SSM/I and future radiometers as well as being an integral part of the TRMM efforts.

Measuring Rainfall with Microwaves

Calculating rainfall rates using a passive microwave instrument like TMI is not a trivial task. It requires some fairly complicated calculations, the physical basis of which is the Planck radiation law.

Key TMI Facts

Provided by NASA Goddard Space Flight Center (GSFC)

Heritage: Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I)

Instrument Type: Multichannel passive microwave radiometer

Scanning Mode: Conical

Incidence Viewing: Incident Angle equals 52.8° (at 350 km)

FOV: Channel dependent (IFOV given below applies to the 350-km orbit)

Instrument IFOV:
Ch 1–2: 60 km × 36 km;
Ch 3–4: 31 km × 18 km;
Ch 5: 27 km × 17 km;
Ch 6–7: 16 km × 10 km;
Ch 8–9: 7 km × 4 km

Swath: 760 km (on beam centers)

Spatial Resolution: Approximately equals IFOVs

Frequency: 10.65, 19.35, 37.0, and 85.5 GHz at dual polarization and 22.235 GHz at vertical polarization

Dimensions: Instrument electronics housed in a drum-shaped housing about 40-cm diameter by 40 cm height, with the antenna reflector (65 cm × 61 cm) attached to the top of the drum (focal length 51 cm, F/D = 0.348) and the whole instrument spinning at 32 rpm

Mass: 54.1 kg

Power: 66.5 W

Duty Cycle: Continuous

Data Rate: 8.5 kbps

Direct Broadcast: No

Planck's law tells us how much energy a hypothetical body that absorbs all the radiation incident upon it would emit. Of course, real world objects don't absorb all the energy incident upon them. So Planck's law has to be combined with laws that govern electromagnetic wave interactions with particles and surfaces, e.g., absorption and scattering, to determine exactly how much energy a given object will emit. The amount of radiation emitted is a function of the temperature of the surface and also of the wavelength of the radiation. This function is a very useful relationship to use in remote sensing. It means that if we measure how much energy a surface emits, we can invert Planck's law and solve for the temperature of the surface. For microwave radiation, the amount of energy emitted also depends on the state of surface. This means that a surface composed of air will behave very differently than a surface composed of water, or a surface composed of rock and soil.

Surfaces such as lakes and oceans only emit about one-half the microwave energy that Planck's law would predict they should. Therefore when a water surface is viewed by a passive microwave radiometer, the surface appears to be very 'cold' relative to its actual temperature. The temperature that the radiometer observes is referred to as the 'brightness temperature' of the surface, and in the case of water, is about one-half the value of the actual temperature of the surface. In contrast, raindrops in the atmosphere absorb the emission from the water surface below them and reemit the radiation at a much warmer temperature. This means that raindrops will appear warmer than the colder water surface when viewed by a passive microwave sensor. Therefore when viewing a body of water, we can conclude that the higher the brightness temperature of the scene, the more raindrops are present, i.e., the more intense the precipitation is in that region. Research over the past three decades has made it possible to obtain fairly accurate rainfall estimates over water surfaces based on the brightness temperature of the scene.

Land surfaces have very different physical properties than water surfaces. The brightness temperature of a land surface is usually about 90% of the actual surface temperature. This means that the contrast between the surface and raindrops for land surfaces is nowhere near as large as it is for water surfaces. However, certain properties of rainfall can still be inferred over land surfaces using passive microwave techniques. High frequency microwaves (as measured by the 85.5 GHz channel on TMI) are strongly scattered by the ice present in many rain clouds. This reduces the microwave signal at the sensor and offers a contrast against the warm land background.

TMI Project Scientist

James Shiue, NASA Goddard Space Flight Center

Key VIRS Facts

Provided by NASA GSFC

Heritage: Advanced Very High Resolution Radiometer (AVHRR)

Instrument Type: Scanning radiometer

Scan Type: Cross-track

FOV: +45°

Instrument IFOV: 6.02 mrad

Swath Width: 720 km; post-boost: 833 km

Spatial Resolution: 2.2 km; post-boost: 2.4 km

Wavelength: 0.63, 1.6, 3.75, 10.8, 12.0 μm

Dimensions: 103 cm × 96 cm × 52 cm

Mass: 48.6 kg

Power: 51.2 W

Duty Cycle: 100%

Data Rate: 49.8 Kbps (day), 28.8 Kbps (night)

Direct Broadcast: No

VIRS

Visible and Infrared Scanner

Provides high-resolution observations of cloud coverage, cloud type, and cloud-top temperature/height.

VIRS Background

VIRS is one of the three instruments in the rain-measuring package on TRMM and provides a very indirect indicator of rainfall. It also ties TRMM measurements to other measurements that are made routinely using the meteorological Polar-orbiting Operational Environmental Satellite System (POESS) and those that are made using the Geostationary Operational Environmental Satellites (GOES) operated by the United States.

VIRS senses radiation coming from Earth in five spectral regions, ranging from visible to infrared, at wavelengths of 0.63–12 µm. VIRS is included in the primary instrument package on TRMM because of its ability to delineate rainfall, but even more importantly, because it serves as a transfer standard to other measurements that are made routinely using the POESS and GOES satellites. The intensity of the radiation in the various spectral regions (or bands) can be used to determine the reflectance (visible and near infrared) or brightness temperature (infrared) of the scene.

If the sky is clear, the temperature will correspond to that of the surface of Earth, and, if there are clouds, the temperature will tend to be that of the cloud tops. Colder temperatures will produce greater intensities in the shorter wavelength bands, and warmer temperatures will produce greater intensities in the longer wavelength bands. Since colder clouds occur at higher altitudes the measured temperatures are useful as indicators of cloud heights, and the highest clouds can be associated with the presence of rain.

A variety of techniques use the infrared (IR) images from VIRS to estimate precipitation. Higher cloud tops are positively correlated with precipitation for convective clouds (generally thunderstorms), which dominate tropical (and therefore global) precipitation accumulations. One notable exception to this correlation is with the high cirrus clouds that generally flow out of thunderstorms. These cirrus clouds are high and therefore 'cold' in the infrared observations, but they do not rain. To differentiate these cirrus clouds from water clouds (cumulonimbus), a technique, which involves comparing the two infrared channels at 10.8 and 12.0 µm, is employed. However, IR techniques usually have significant errors for instantaneous rainfall estimates. The strength of infrared observations lies in the ability to monitor the clouds continuously from geostationary altitude. By comparing the visible and infrared observations from TRMM with the rainfall estimates of TMI and PR, scientists hope to learn much more about the relationship of the cloud tops as seen from geostationary orbit.

VIRS uses a rotating mirror to scan across the track of the TRMM observatory, thus sweeping out a region 720 km wide as the observatory proceeds along its orbit. Looking straight down (nadir), VIRS can pick out individual cloud features as small as 2 km.

VIRS Project Scientist

William Barnes, NASA Goddard Space Flight Center

VIRS Instrument Scientist

Cheng-Hsuan Lyu, NASA Goddard Space Flight Center

TRMM References

CERES References

See the Aqua section for a list of CERES references.

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TRMM Data Products

For more information about the data products please see *The EOS Data Products Handbook, Volume 1* (revised January 2004) available at: eos.nasa.gov/eos_homepage/for_scientists/data_products/

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
CERES *Data Set Start Date: December 28, 1997; Data Set End Date: March 2000 (only intermittent data starting September 1, 1998)*			
Bi-Directional Scans Product	0, 1	Global for latitudes 40°N – 40°S	20 km at nadir/0.01 second
ERBE-like Instantaneous TOA Estimates	2	Global, 40°N – 40°S	20 km at nadir/0.01 second
ERBE-like Monthly Regional Averages (ES-9) and ERBE-like Monthly Geographical Averages (ES-4)	3	Global, 40°N – 40°S	2.5°, 5.0°, 10.0°, region and zone, global/monthly (by day and hour)
Single Scanner TOA/Surface Fluxes and Clouds	2	Global, 40°N – 40°S	20 km at nadir/0.1 second
Clouds and Radiative Swath	2	Global, 40°N – 40°S	20 km at nadir/0.1 second
Monthly Gridded Radiative Fluxes and Clouds	3	Global, 40°N – 40°S	1° region/hourly
Synoptic Radiative Fluxes and Clouds	3	Global, 40°N – 40°S	1° region/3-hour, monthly
Average (AVG) (used for the CERES Monthly Regional Radiative Fluxes and Clouds data product) and Zonal Average (ZAVG) (used for the CERES Monthly Zonal and Global Radiative Fluxes and Clouds data product)	3	Global, 40°N – 40°S	1° region, 1° zone, global/monthly
Monthly Gridded TOA/Surface Fluxes and Clouds	3	Global, 40°N – 40°S	1° region/hourly
Monthly TOA/Surface Averages	3	Global, 40°N – 40°S	1° region/monthly
LIS *Data Set Start Date: December 1, 1997*			
500 km × 500 km Equal Area Monthly Grid	2	Global, 35°N – 35°S	4 km × 4 km pixel at nadir, orbit granules/ 2 ms resolution; 2.5 × 2.5 monthly, 47-day moving average
Orbit Attributes	3	Global, 35°N – 35°S moving average	4 km × 4 km pixel at nadir, orbit granules/ 2 ms resolution; 2.5 × 2.5 monthly, 47-day
Threshold Attributes	3	Global, 35°N – 35°S moving average	4 km × 4 km pixel at nadir, orbit granules/ 2 ms resolution; 2.5 × 2.5 monthly, 47-day
Browse Area	3	Global, 35°N – 35°S moving average	4 km × 4 km pixel at nadir, orbit granules/ 2 ms resolution; 2.5 × 2.5 monthly, 47-day

TRMM Data Products

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
LIS *(cont.)*			
Vector Statistics	3	Global, 35°N – 35°S	4 km × 4 km pixel at nadir, orbit granules/ 2 ms resolution; 2.5 × 2.5 monthly, 47-day moving average
Metadata Description	3	Global, 35°N – 35°S	4 km × 4 km pixel at nadir, orbit granules/ 2 ms resolution; 2.5 × 2.5 monthly, 47-day moving average
Summary Data	3	Global, 35°N – 35°S	4 km × 4 km pixel at nadir, orbit granules/ 2 ms resolution; 2.5 × 2.5 monthly, 47-day moving average
Flash Rate Data	3	Global, 35°N – 35°S	4 km × 4 km pixel at nadir, orbit granules/ 2 ms resolution; 2.5 × 2.5 monthly, 47-day moving average
Ephemeris Data	3	Global, 35°N – 35°S	4 km × 4 km pixel at nadir, orbit granules/ 2 ms resolution; 2.5 × 2.5 monthly, 47-day moving average
Event Rate Sets	3	Global, 35°N – 35°S	4 km × 4 km pixel at nadir, orbit granules/ 2 ms resolution; 2.5 × 2.5 monthly, 47-day moving average
PR *Data Set Start Date: December 7, 1997*			
Radar Total Power, Noise, and Reflectivity	1B	36°S – 36°N; 15–16 orbits per day with a swath width of 220 km before August 2001 and 253 km after August 2001	5 km (after August 2001)
Rain Occurrence and Rain Type and Bright Band Height	2	36°S – 36°N; 15–16 orbits per day with a swath width of 220 km before August 2001 and 253 km after August 2001	5 km (after August 2001)
Surface Cross-Section as Function of Scan Angle	2	36°S – 36°N; 15–16 orbits per day with a swath width of 220 km before August 2001 and 253 km after August 2001	5 km (after August 2001)
Range Profiles of Rain and Water Content	2	36°S – 36°N; 15–16 orbits per day with a swath width of 220 km before August 2001 and 253 km after August 2001	5 km (after August 2001)

TRMM Data Products

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
TMI *Data Set Start Date: December 7, 1997*			
Monthly Accumulated Rainfall and Vertical Structure, Monthly Combined Accumulated Surface Rainfall	3	40°N – 40°S	5° × 5° and 0.5° × 0.5°/monthly
Calibrated Brightness Temperatures	1B	38°S – 38°N; 15–16 orbits per day with a swath width of 760 km before August 2001 and 875 km after August 2001	5 km
Surface Rainfall and Vertical Structure	2	38°S – 38°N; 15–16 orbits per day with a swath width of 760 km before August 2001 and 874 km after August 2001	5 km
Monthly Surface Rainfall	3	40°N – 40°S over oceans only	5° × 5° and 0.5° × 0.5°/monthly
TRMM			
Instantaneous Radar Site Rain Map	2A	150-km radius of ground validation radar, continuous	2 km (minimum)
Instantaneous Radar Site Convective/Stratiform Map	2A	150-km radius of ground validation radar, continuous	2 km (minimum)
Instantaneous Radar Site 3-D Reflectivities	2A	150-km radius of ground validation radar, continuous	2 km (minimum)
Combined Surface Rainfall Rate and Vertical Structure	2	36°S – 36°N; 15–16 orbits per day with a swath width of 220 km before August 2001 and 253 km after August 2001	5 km (after August 2001)
Monthly Combined Accumulated Rainfall and Vertical Structure	3	Day and Night, 40°N – 40°S	5° × 5°, 14 levels/monthly
1° Daily Combined Rainfall and Monthly Combined Instrument Rainfall	4	Day and Night, 40°N – 40°S	1° × 1°/daily, monthly
5-Day Site Rain Map	3	150-km radius of ground validation radar, continuous	2 km × 2 km/5-day accumulation

TRMM Data Products

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
TRMM *(cont.)*			
30-Day Site Rain Map	3	150-km radius of ground validation radar, continuous	2 km × 2 km/30-day accumulation
Monthly 3-D Structure	3	150-km radius of ground validation radar, continuous	2 km × 2 km/30-day accumulation
VIRS *Data Set Start Date: December 7, 1997*			
Calibrated Radiances	1B	38°S – 38°N; 15–16 orbits per day with a swath width of 720 km before August 2001 and 830 km after August 2001	2 km

TRMM Data Products