Tropical Rainfall Measuring Mission

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TRMM images are available from: http://trmm.gsfc.nasa.gov/

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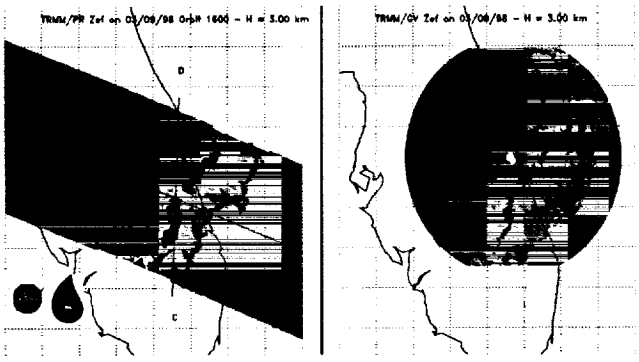
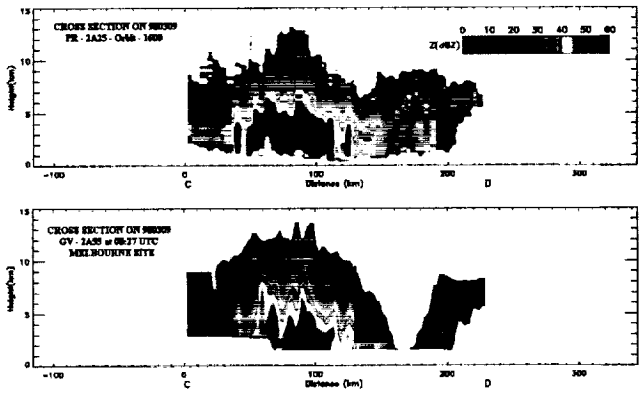
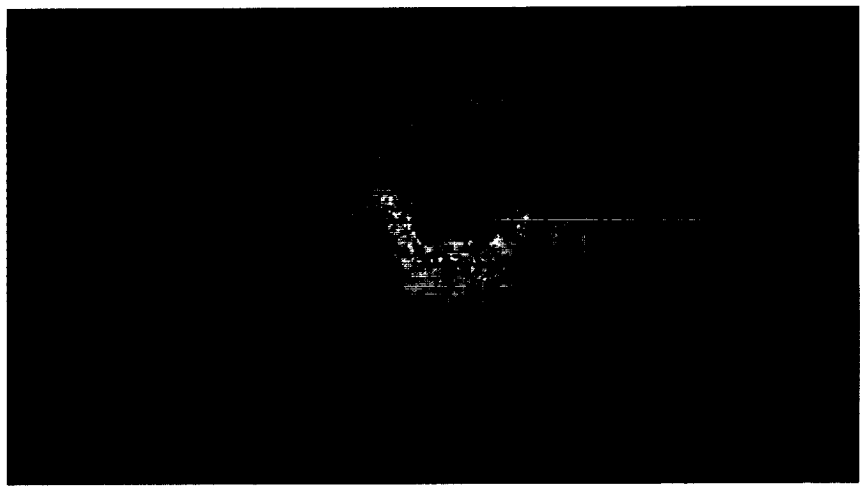
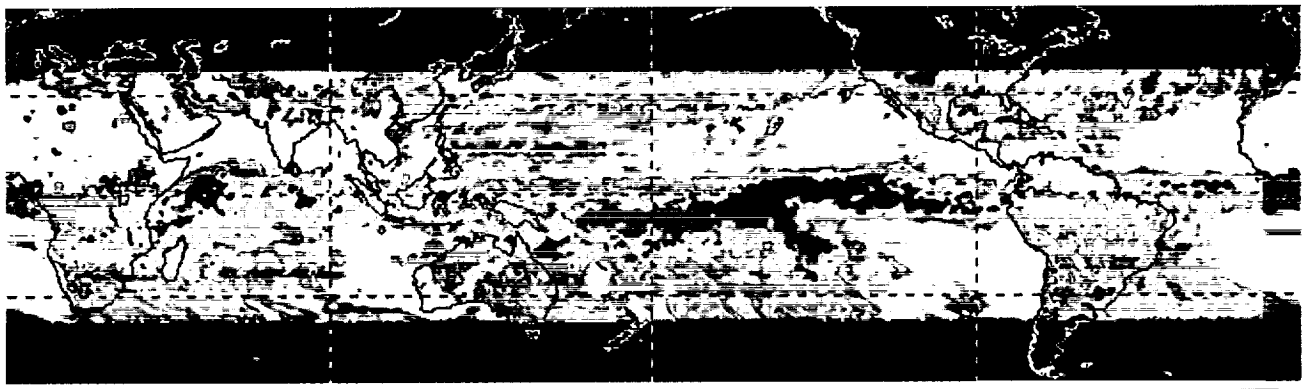




Comparison of horizontal rain rate distribution at 3km and vertical rain rate profile derived from the TRMM precipitation radar (PR 2A25) with the ground radar (GV 2A55) when the TRMM satellite passed over Melbourne, Florida on March 9, 1998. (Figures courtesy of Dr. Kummerow et al.)

Hurricane Bonnie over the North Carolina coast, August 26, 1998. This image combines precipitation radar (PR) and visible and infrared sensor (VIRS) data. The narrow light-colored band is the PR swath, with progressively higher rain intensity in green, yellow, and orange.





TRMM Microwave Imager (mm/day)

0 4 8 12 16 20+

NASDA
NATIONAL SPACE DEVELOPMENT AGENCY OF JAPAN

Tropical rainfall affects the lives and economies of a majority of the Earth's population. Tropical rain systems, such as hurricanes, typhoons, and monsoons, are crucial to sustaining the livelihoods of those living in the tropics. Excess rainfall can cause floods and great property and crop damage, whereas too little rainfall can cause drought and crop failure.

The latent heat release during the process of precipitation is a major source of energy that drives the atmospheric circulation. This latent heat can intensify weather systems, affecting weather thousands of kilometers away, thus making tropical rainfall an important indicator of atmospheric circulation and short-term climate change.

Tropical forests and the underlying soils are major sources of many of the atmosphere's trace constituents. Together, the forests and the atmosphere act as a water-energy regulating system. Most of the rainfall is returned to the atmosphere through evaporation and transpiration, and the atmospheric trace constituents take part in the recycling process. Hence, the hydrological cycle provides a direct link between tropical rainfall and the global cycles of carbon, nitrogen, and sulfur, all important trace materials for the Earth's system.

Because rainfall is such an important component in the interactions between the ocean, atmosphere, land, and the biosphere, accurate measurements of rainfall are crucial to understanding the workings of the Earth-atmosphere system. The large spatial and temporal variability of rainfall systems, however, poses a major challenge to estimating global rainfall. So far, there has been a lack of rain gauge networks, especially over the oceans, which points to satellite measurement as the only means by which global observation of rainfall can be made.

The Tropical Rainfall Measuring Mission (TRMM), jointly sponsored by the National Aeronautics and Space Administration (NASA) of the United States and the National Space Development Agency (NASDA) of Japan, provides visible, infrared, and microwave observations of tropical and subtropical rain systems. The satellite observations are complemented by ground radar and rain gauge measurements to validate satellite rain estimation techniques. Goddard Space Flight Center's involvement includes the observatory, four instruments, integration and testing of the observatory, data processing and distribution, and satellite operations. TRMM has a design lifetime of three years.

Data generated from TRMM and archived at the GDAAC are useful not only for hydrologists, atmospheric scientists, and climatologists, but also for the health community studying infectious diseases, the ocean research community, and the agricultural community.

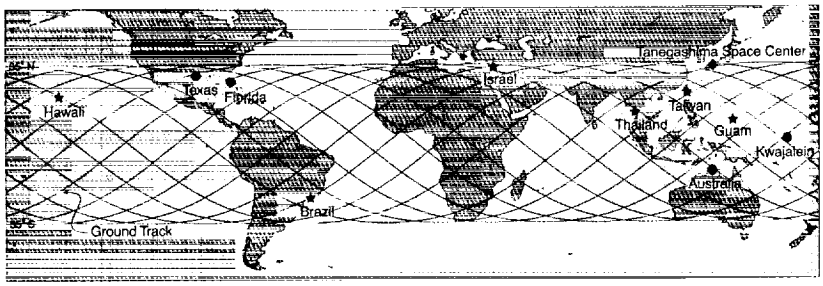
TRMM Orbit and Instruments

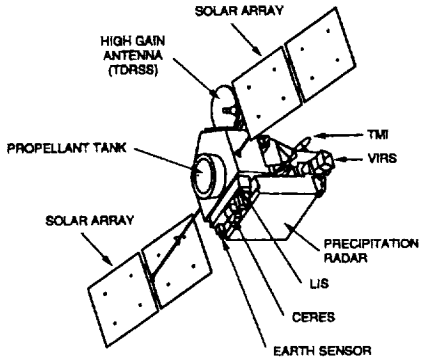
The TRMM satellite's low inclination (35 degrees), non-sun-synchronous, and highly precessing orbit allows it to fly over each position on the Earth's surface at a different local time each day. This kind of sampling allows the examination of the diurnal cycle of precipitation. The orbit is maintained at approximately 350 km. The characteristics of the three rain instruments and associated science applications are shown in the following table.

	Precipitation Radar (PR)	**TRMM Microwave Imager (TMI)**	**Visible/Infrared Scanner (VIRS)**
Frequency/Wavelength	Vertical polarization: 13.8 GHz	Dual polarization: 10.65, 19.35, 37, & 85.5 GHz Vertical polarization: 21 GHz	.63, 1.6, 3.75, 10.8, & 12 μm
Scanning Mode	Cross track	Conical	Cross track
Ground Resolution	4 km at nadir	Ranges from 5 km at 85.5 GHz to 45 km at 10 GHz	2.2 km
Swath Width	220 km	760 km	720 km
Science Applications	3-D rainfall distribution over both land and oceans, and latent heat release into the atmosphere	Surface rainfall rate, rain type, distribution, and structure	Cloud coverage, cloud type, cloud top temperature, and precipitation index

In addition, a Lightning Imaging Sensor (LIS) and a Clouds and Earth's Radiant Energy System (CERES) are carried on the TRMM satellite. The LIS is a calibrated optical sensor operating at 0.7774 micron and observes distribution and variability of lightning. The horizontal resolution of LIS at nadir is 5 km and the swath width is 590 km. The CERES is a visible/infrared sensor which measures emitted and reflected radiative energy from the surface of the Earth and the atmosphere and its constituents. The TRMM CERES operates at 0.3 to 5.0 microns in the shortwave range and 8.0 to 12.0 microns in the longwave range. LIS data are available from the Global Hydrology Resource Center (http://ghrc.msfc.nasa.gov), and CERES data are available from the NASA Langley DAAC (http://eosweb.larc.nasa.gov/).

TRMM Ground Track for 35° Orbit With Ground Truth Verification Sites





Ground Validation (GV) radar sites include Darwin, Australia; Thailand; Israel; Taiwan; Sao Paolo, Brazil; Guam; Kwajalein; Hawaii; Melbourne, Miami, Key West, and Tampa Bay in Florida; Lake Charles in Louisiana; and New Braunfels, Corpus Christi, and the Texas A&M research radar in Texas.

TRMM Science Data Products at the GDAAC

The GDAAC archives and distributes TRMM standard products, processed from the TRMM science data by the TRMM Science Data and Information System (TSDIS). Level 1 products are the VIRS calibrated radiances, the TMI brightness temperatures, and the PR return power and reflectivity measurements. Level 2 products are derived geophysical parameters (e.g., rain rate and latent heat) at the same resolution and location as those of the Level 1 data. Level 3 products are space-time averaged parameters. Level 4 products are analyzed products or those produced from merging measurements from TRMM and other sources. TRMM standard products are listed in the table on page 4.

Also included as TRMM standard products are surface-based observations of rainfall from rain gauges and ground radars, which are used to calibrate and validate the satellite measurements.

TRMM Data Access and Services at GDAAC

TRMM standard products are available to the general public at **http://lake.nascom.nasa.gov/data/dataset/TRMM/index.html.** In addition, subsets of the TRMM data are available to facilitate analyses and processing by users, including satellite-ground coincidence subsets, gridded orbital data at various resolutions, parameter subsets, regional subsets, and others as needed. Data related to various TRMM validation experiments are available from **http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/TRMM_FE/trmm_fe.html.** Data sets are distributed via ftp or sent via tapes.

Potential TRMM data users, especially those with specific needs, are urged to contact the GDAAC Hydrology Data Support Team:

Email:	**hydrology@daac.gsfc.nasa.gov**
Fax:	**(301) 614-5268**

To stay informed about the latest developments in TRMM data products and services at the GDAAC, please visit our Hydrology Web site: **http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/hydrology/hd_main.html**

TRMM Standard Products

TSDIS ID	parameter	horizontal res.	vertical res.	temporal res.	units	spatial coverage
1B-01	VIRS rad. 0.63,1.6,3.75, 10 & 12 μm	2.2 km	n/a	swath	mW cm-2 um-1 sr-1	720 km
1B-11	TMI TB* 10, 19, 21, 37, 85.5 GHz	5 - 45 km	n/a	swath	K	760 km
1B-21	PR (14 GHz) returned power	4 km	250m	swath	dBm	220 km
1C-21	PR reflectivity	4 km	250m	swath	dBZ	220 km
1B-51	GV (4 radar sites): #			all VOSs		400 km radius
	GV reflectivity	2 km		5-10 min	dBZ	
	GV differential reflectivity ZDR	2 km		5-10 min	dB	
	GV mean vel.	2 km		5-10 min	m/s	
1C-51	GV (15 radar sites) cal. reflectivity			##		###
	same as 1B-51					
2A-12	TMI profile:					760 km
	cloud/precipitation water & ice	5 km	14 layers	swath	g/m**3	
	latent heat				deg C/day	
	surface rain				mm/hr	
2A-21	PR surface cross section	4 km	n/a	swath	dB	220 km
	PR path attenuation	4 km	n/a	swath	dB	220 km
2A-23	rain qualitative:	4 km	n/a	swath		220 km
	rain type, strati./conv./warm rain					
	storm, freezing and bright band height				m	
2A-25	PR profile:	4 km	250 m	swath		220 km
	rain rate				mm/hr	
	reflectivity				mm**6 m**-3(dB)	
	attenuation				dB	
	rain top/bottom height				m	
2B-31	TRMM combined	4 km	250 m	swath		220 km
	rain rate				mm/hr	
	drop size distribution parameters				mm	
	path integrated attenuation				dB	
2A-52	GV site rain existence (% rain)	300 km**		##		###
2A-53	GV site rain map	2 km		##	mm/hr	###
2A-54	GV site conv./strat. map	2 km				###
2A-55	GV site 3-D reflectivity	2 km	1.5 km		dBZ	###
	contoured freq. by altitude diag. (CFAD)					###
2A-56	rain gage			1 min	mm/hr	
2A-57	disdrometer			1 min		
3A-11	TMI emission rain	5x5 deg	n/a	monthly		40N-40S
	rain rate				mm	
	conditional rain rate				mm/hr	
	rain frequency					
	freezing height				km	
3A-25	PR rainfall (monthly avg of 2A-25)	5x5 and 0.5x0.5 deg	n/a	monthly		40N-40S
	rain rate at 2, 4, 6, 10, 15 km		5 levels		mm/hr	
	fractional rain					
	histogram of storm height, bright band					
	snow ice layer					
	surface rain rate					
	path attenuation					
3A-26	surface rain total	5x5 deg		monthly	mm	40N-40S
3B-31	rainfall combined	5x5 deg	14 layers	monthly		40N-40S
	surface rain rate				mm	
	cloud water & ice, rain, grauples				g/m**3	
3B-42	TRMM and other GPI calibration	1x1 deg		daily	mm	40N-40S
3B-43	TRMM & other data source	1x1 deg		monthly	mm	40N-40S
3A-53	5 day GV site rain map	2 km		5 day	mm	###
3A-54	GV site rainfall	2 km		monthly	mm	###
3A-55	monthly 3D map			monthly		###
	vert. profile of reflectivity					
	contoured frequency by altitude diagram					
3A-46	SSM/I rain	1x1 deg		monthly	mm/hr	

GV sites: Direct Data (DD) sites include Darwin, Kwajalein. Melbourne & Houston. Only DD sites have L1B data.
Direct Product (DP) sites are Principal Investigator sites.
DP sites include Taiwan, Israel, Thailand, Brazil, Tampa Bay, Key West, Miami, Guam, Lake Charles, New Braunfels, Corpus Christi.
Multiple radar sites are Florida and Texas. They have combined radar products by merging all radars within the site.
nominally 2 VOSs/hr except when there is TRMM satellite coincidence.
coverage is 300 x 300 km for single sites, 724 x 568 km for Texas site and 512 x 704 km for Florida site
*All TMI channels have both vertical and horizontal polarization except 21 GHz which has only vertical polarization

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