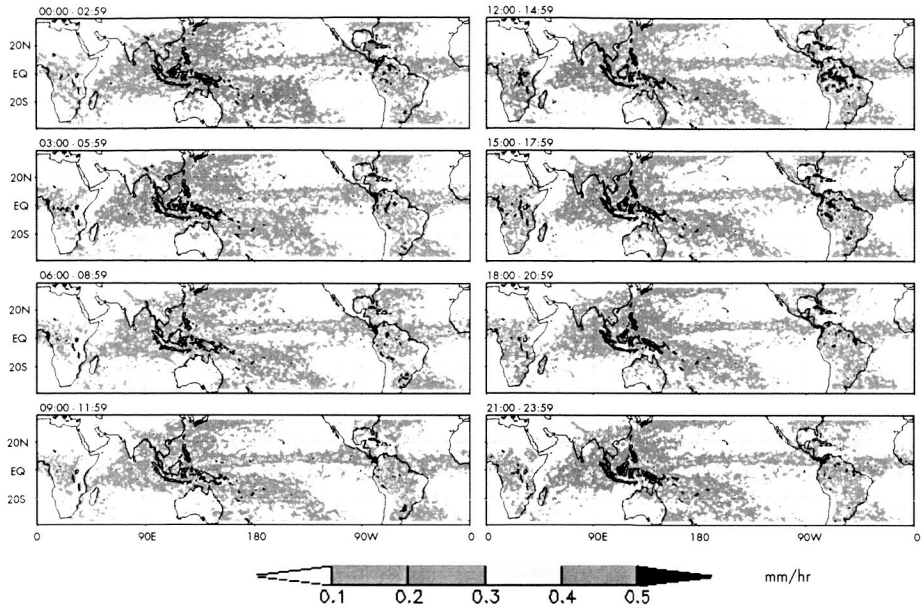
TRMM Data from the Goddard Earth Sciences (GES) DISC DAAC

Tropical Rainfall Measuring Mission (TRMM)

Data and Information Services Center (DISC) • Distributed Active Archive Center (DAAC)

December 2002



Diurnal Cycle of Precipitation from the TRMM Combined Instrument Algorithm

(January 1998 - December 2000)

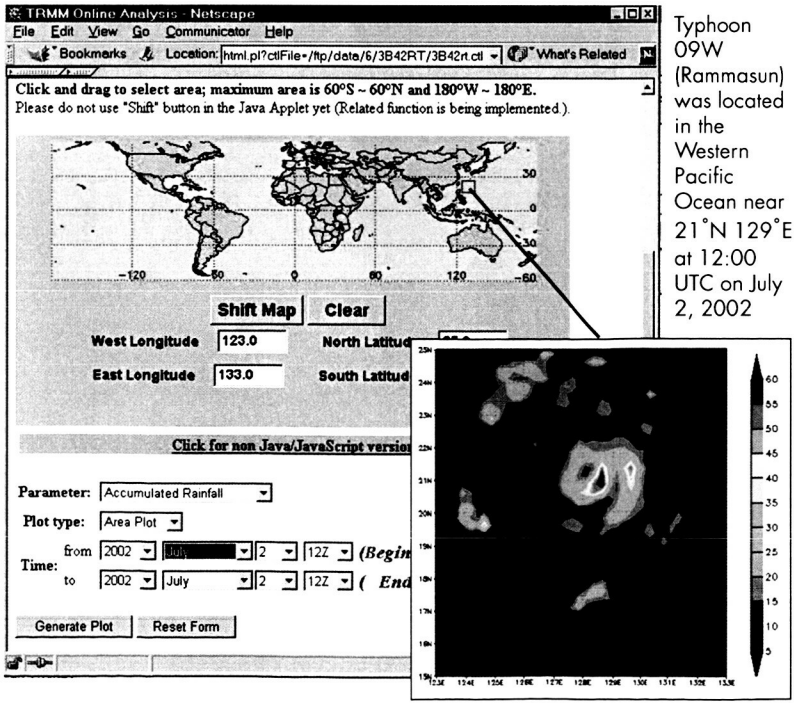
The off-diurnal sampling of the TRMM orbit allows the estimation of the diurnal cycle of precipitation over the global tropics and subtropics. The eight panels show the 3 hourly average TRMM Combined Instrument Algorithm (TCA, product ID 2B31) rainfall binned into 3 hourly geographical local time and 1x1 degree boxes, with the upper left panel showing the average rainfall for 0-2:59 local time. A nocturnal to early morning maximum occurs over the oceanic rain belts. Rainfall over the continents generally shows a maximum in early afternoon. There is also a dramatic shift of the maximum rainfall over the maritime continent from early morning in the coast to late afternoon over land. This diurnal data set will be useful for testing Global General Circulation and regional prediction Models.

(Courtesy: L. Chiu and A. Chang)

TRMM Online Analysis System

TRMM Online Analysis System, developed by the GES DAAC Hydrology team, provides users with a friendly web-based interface for quick exploration, analysis, and visualization of the TRMM Level-3 rainfall products, the TRMM near-real-time 3-hourly experimental rainfall product, and the Willmott and Matsuura global climate data. Users can plot area averages (area plot) and time series (time plot) for selected areas and time periods. The TRMM Online Analysis System can be accessed at:

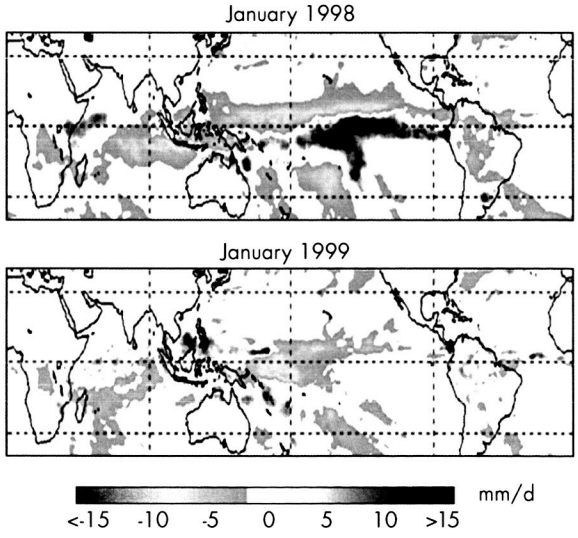
http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/hydrology/TRMM_analysis.html



Typhoon 09W (Rammasun) was located in the Western Pacific Ocean near 21°N 129°E at 12:00 UTC on July 2, 2002

TRMM Views El Niño/La Niña Evolution (1998 and 1999)

Monthly Rainfall Anomaly Fields
(from TRMM merged analysis)



January 1998:
Height of El Niño,with positive anomalies in the equatorial Pacific; negative values to the north and west.

January 1999:
Height of La Niña, with negative anomalies in the western Pacific; positive values over the Maritime Continent.

(Courtesy: R. Adler *et al.*)

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. It is currently in its fifth year of operation.

Data generated from TRMM and archived at the GES DAAC 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 was maintained at approximately 350 km before August 7, 2001. During the period of August 7, 2001 to August 24, 2001, the average operating altitude for TRMM was changed from 350 km to 403 km (referred to as TRMM Boost). This has significantly extended the mission lifetime of TRMM. Since the TRMM Boost, its orbit has been maintained at approximately 403 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: Pre-Boost	4.3 km	4.4 km at 85.5 GHz	2.2 km
Post-Boost	5.0 km	5.1 km at 85.5 GHz	2.4 km
Swath Width: Pre-Boost	215 km	760 km	720 km
Post-Boost	247 km	878 km	833 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

Tropical Rainfall Measuring Mission (TRMM) Subsets and Ancillary Data Sets at the GES DAAC

December 2002

	Product	Description		Horizontal Resolution	Temporal Resolution	Spatial Coverage	Data Access
TRMM Subset Data	CSI	Coincidence Subsetted Intermediate products. 9 TRMM orbital CSI products (1B01, 1B11, 1B21, 1C21, 2A12, 2A21, 2A23, 2A25, 2B31); and 4 TRMM Ground Validation CSI products (1C51, 2A53, 2A54, 2A55).		*	*	*	2, 3
	PS	Parameter Subsets. Surface rainfall derived from 2A12, 2A25, and 2B31.	PS2A12	*	*	*	2, 5
			PS2A25	*	*	*	
			PS2B31	*	*	*	
	G	Gridded Orbital Subsets.	G1B01	0.25° x 0.25°	*	*	2, 6
			G2A12	0.5° x 0.5°	*	*	
			G2B31	0.1 x 0.1°	*	*	
	RG	Geographical Region Subsets of Gridded Orbital Subsets for field experiment sites, US states, and other regions of interest under TRMM coverage.	RG1B01	0.25° x 0.25°	*	*	7
			RG2A12	0.5° x 0.5°	*	*	
			RG2B31	0.1 x 0.1°	*	*	
TRMM Real-time Data	3B4XRT	TRMM Real-time Multi-Satellite Precipitation Data Set.	3B40RT	0.25° x 0.25°	3-hourly	Global	9
			3B41RT	0.25° x 0.25°	hourly	60N - 60S	
			3B42RT	0.25° x 0.25°	3-hourly	60N - 60S	
TRMM Ancillary Data	GPI	NOAA's GPI IR Rain Data (TRMM 3A44).		1.0° x 1.0°	daily	Global	4
	GPCC	GPCC Rain Gauge Analysis for GPCP (TRMM 3A45B).		1.0° x 1.0°	monthly	Global	4
	GPCP	GPCP Version 2 Combined Precipitation Data Set.		2.5° x 2.5°	monthly	Global	8
	GOES 8 & GOES 10	GOES radiance data. Contains four IR and one visible channels.		4 km	30 min	Western hemisphere	4
	GMS 5	Images of Visible and Infrared Spin Scan Radiometer (VISSR). Contains three IR and one visible channels.		4 km	hourly	Eastern hemisphere	4
	METEOSAT 7	Images of the earth and its atmosphere from METEOSAT 7, a geostationary satellite operated by Europe's Meteorological Satellite Organization.		2.5 - 5.0 km	3 per day	Europe, the Middle East, Africa, and the Atlantic Ocean	4
	Merged Global IR	IR brightness temperature data, merged from all available geostationary satellites (GOES-8/10, METEOSAT-7/5 & GMS).		4 km	hourly	60N - 60S	1, 4
	GPROF 6.0 (SSMI)	Gridded Orbit-by-Orbit Precipitation Data Sets.	Half-degree	0.5° x 0.5°	hourly	Global	4
			Quarter-degree (near-real-time)	0.25° x 0.25°	hourly	Global	1, 4
	GSSTF	Goddard Satellite-Based Surface Turbulent Fluxes.	Version 1	2.0° x 2.5°	monthly	Global	4
			Version 2	1.0° x 1.0°	monthly	Global	
	GSSRB	Goddard Satellite-Retrieved Surface Radiation Budget.		0.5° x 0.5°	monthly	40N - 40S 90E - 170W	4
	TOVS	Contains temperature/humidity profiles, cloud cover information, and surface parameters, derived from NOAA-11 and NOAA-14.		1.0° x 1.0°	daily	Global	4
	AVHRR	NDVI product, and atmospherically corrected channel radiance.		8 km	Daily & 10-day	Global	4
	NCEP	NCEP 4-time daily analyses.		1.0° x 1.0°	6-hourly	Global	10
	CAMS	Climate Analysis and Monitoring System.		0.5° x 0.5°	monthly	Global	10
	ETOPO5	The Earth Topography Five Minute Grid Data.		5 min	n/a	Global	4

Data Access

1: http://lake.nascom.nasa.gov/data/dataset/TRMM/01_Data_Products/06_Ancillary/
2: http://lake.nascom.nasa.gov/data/dataset/TRMM/01_Data_Products/04_Subset/
3: ftp://lake.nascom.nasa.gov/data/TRMM/Ground_Instruments/csi/
4: ftp://lake.nascom.nasa.gov/data/TRMM/Ancillary/
5: ftp://lake.nascom.nasa.gov/data/TRMM/Orbital/
6: ftp://lake.nascom.nasa.gov/data/TRMM/Gridded/
7: ftp://lake.nascom.nasa.gov/data/TRMM/Geo_Regions/
8: ftp://daac.gsfc.nasa.gov/data/hydrology/precip/gpcp/gpcp_v2_combined/
9: ftp://aeolus.nascom.nasa.gov/pub/merged/
10: ftp://larry.gsfc.nasa.gov/pub/ncep_data/

Temporal Coverage

TRMM Subset Data: Dec. 1997 - Present
TRMM Real-time Data: Jan. 2002 - Present
Most of TRMM Ancillary Data overlap with the temporal coverage of TRMM data.

* Refer to TRMM Standard Products (on the reverse side).

TRMM Standard Products (http://lake.nascom.nasa.gov/data/dataset/TRMM/)

Product ID	Parameter	Horizontal ** Resolution (Pre-boost)	Vertical Resolution	Temporal Resolution	Units	Spatial ** Coverage (Pre-boost)
1B01	VIRS rad. 0.63, 1.6, 3.75, 10.8 &12 µm	2.2 km	n/a	swath	mW cm-2 um-1 sr-1	720 km
1B11	TMI TB* 10.65, 19.35, 21, 37, 85.5 GHz	4.4 km @ 85.5 GHz	n/a	swath	K	760 km
1B21	PR (14 GHz) returned power	4.3 km	250m	swath	dBm	215 km
1C21	PR reflectivity	4.3 km	250m	swath	dBz	215 km
1B51	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	
1C51	GV calibration reflectivity same as 1B51			##		###
2A12	TMI profile:					
	cloud/precipitation water and ice	4.4 km	14 layers	swath	g/m^3	
	latent heat				deg C/day	
	surface rain				mm/hr	
2A21	PR surface cross section	4.3 km	n/a	swath	dB	220 km
	PR path attenuation	4.3 km	n/a	swath	dB	220 km
2A23	rain qualitative:	4.3 km	n/a	swath		220 km
	rain type, strati./conv./warm rain					
	storm, freezing and bright band height				m	
2A25	PR profile:	4.3 km	250 m	swath		220 km
	rain rate				mm/hr	
	reflectivity				dBz	
	attenuation				dB	
	rain top/bottom height				m	
2B31	TRMM combined	4.3 km	250 m	swath		220 km
	rain rate				mm/hr	
	drop size distribution parameters				mm	
	path integrated attenuation				dB	
2A52	GV site rain existence (% rain)	300 km		##		###
2A53	GV site rain map	2 km		##	mm/hr	###
2A54	GV site conv./strat. map	2 km				###
2A55	GV site 3-D reflectivity contoured freq. by altitude dia. (CFAD)	2 km	1.5 km		dBz	### ###
2A56	rain gauge			1 min	mm/hr	
3A11	TMI emission	5x5 deg	n/a	monthly		40N-40S
	rain accumulation				mm	
	conditional rain rate				mm/hr	
	rain frequency					
	freezing height				km	
3A25	PR rainfall (monthly avg of 2A25)	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					
3A26	surface rain rate	5x5 deg		monthly	mm/hr	40N-40S
3B31	rainfall combined	5x5 deg	14 layers	monthly		40N-40S
	surface rain accumulation				mm	
	cloud water and ice, rain, grauples				g/m^3	
3B42	TRMM and other GPI calibration	1x1 deg		daily	mm/hr	40N-40S
3B43	TRMM and other data source	1x1 deg		monthly	mm/hr	40N-40S
3A53	5 day GV site rain map	2 km		5 day	mm	###
3A54	GV site rainfall	2 km		monthly	mm	###
3A55	monthly 3-D map			monthly		###
	vert. profile of reflectivity					
	contoured frequency by altitude diagram					
3A46	SSM/I rain	1x1 deg		monthly	mm/hr	

GV sites: Darwin, Kwajalein, Melbourne, Houston, and Guam.

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.

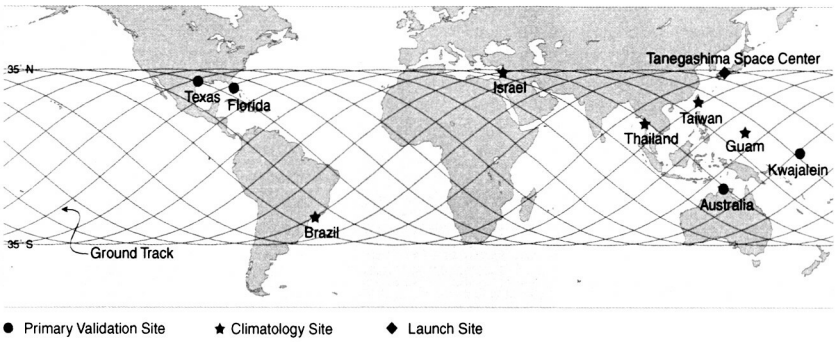
Coverage is 300 x 300 km for single sites, 724 x 568 km for Texas site and 512 x 704 km for Florida site.

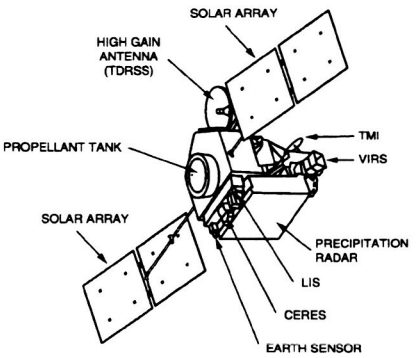
*All TMI channels have both vertical and horizontal polarization except 21 GHz which has only vertical polarization.

**Corresponding post-boost information are given in the "TRMM Orbit and Instruments" section of the TRMM Brochure.

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 μm and observes distribution and variability of lightning. The horizontal resolution of LIS at nadir is 5 km and the swath width is 590 km (pre-boost). 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 μm in the shortwave range and 8.0 to 12.0 μm 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; 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 GES DAAC

The GES DAAC 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 in the insert of this brochure.

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 GES DAAC

TRMM standard products are available to the general public at **http://lake.nascom.nasa.gov/data/dataset/TRMM/**. 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/fieldexp/TRMM_FE/**. Data sets are distributed via ftp or sent via tapes.

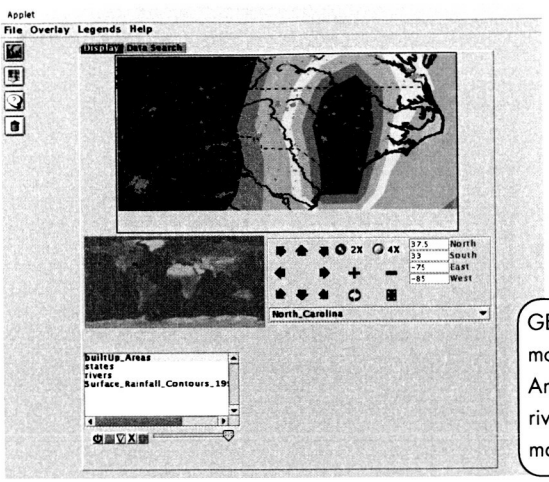
Potential TRMM data users, especially those with specific needs, are urged to contact the GES DAAC Hydrology Data Support Team:

***Email:* hydrology@daac.gsfc.nasa.gov**
***Toll Free:* 1-877-422-1222**
***Fax:* 301-614-5268**

To stay informed about the latest developments in TRMM data products and services at the GES DAAC, please visit our Hydrology Web site at

http://daac.gsfc.nasa.gov/hydrology/

GIS Application of TRMM Data



The GES DAAC has developed several tools to make TRMM data more easily available to the GIS community, including an automated data converter to GIS formats, as well as a web-based mapping tool (http://daac.gsfc.nasa.gov/WEBGIS/). The latter implements the interoperable standards set by the Open GIS Consortium (OGC). This mapping tool allows users to combine TRMM rainfall layers with multiple layers generated either from other GES DAAC data or from externally created maps.

GES DAAC Web GIS tool, showing contour map of TRMM accumulated monthly rainfall. Contour map was generated by GES DAAC's Online Analysis System. Other map layers shown are political boundaries, major rivers, and population centers, all generated by independent, externally maintained map servers.

Selected Applications of TRMM Data

Country	Applications
Australia	Environmental causes of diabetes: comparing annual diabetes incidence with annual rainfall (crop moisture and toxins).
Australia	Historical rainfall data for Southeast Asia for climate regionalization and stream flow.
Australia	Historical rainfall data for Thailand.
France	Mean monthly precipitation data (1998 to 2001) of northern Uganda.
France	Daily historical rainfall in Dominican Republic - used by a bank for crop insurance.
Germany	Regionalization of marginality of agricultural land in West Africa.
Iran	ENSO impacts on climate in southeast Iran.
United Kingdom	Simulating precipitation events in Florida.
United Nations	World Food Program: using TRMM monthly rainfall for monitoring maize yield potential in Southeast Asia and southern Africa.
USA	Comparing 3B42 daily 1x1 deg. rainfall with Acoustic Rain Gauge estimates at deep ocean TAO mooring sites.
USA	Blending 3B43 monthly rainfall with weather station data.
USA	Correlating TOMS Aerosol Index data with TRMM rainfall rates.
USA	Tropical rainfall and dust transport.
USA	Rainfall data and drought conditions in Afghanistan.
USA	Correlating U.S. monthly rainfall with Pacific and other SSTs.
USA	Monsoons over Southeast Asia.
USA	Monsoons over Ethiopia.
USA	Early warning systems for mosquito-borne diseases (temperature and rain).
USA	Precipitation over Upper Oconee Basin, GA.
USA	TRMM monthly rainfall for Amazon Basin, used together with tree plot data to derive climatic correlates of species diversity, biomass, and community structure in rain forests. TRMM data helpful in filling in the gaps between measuring stations.

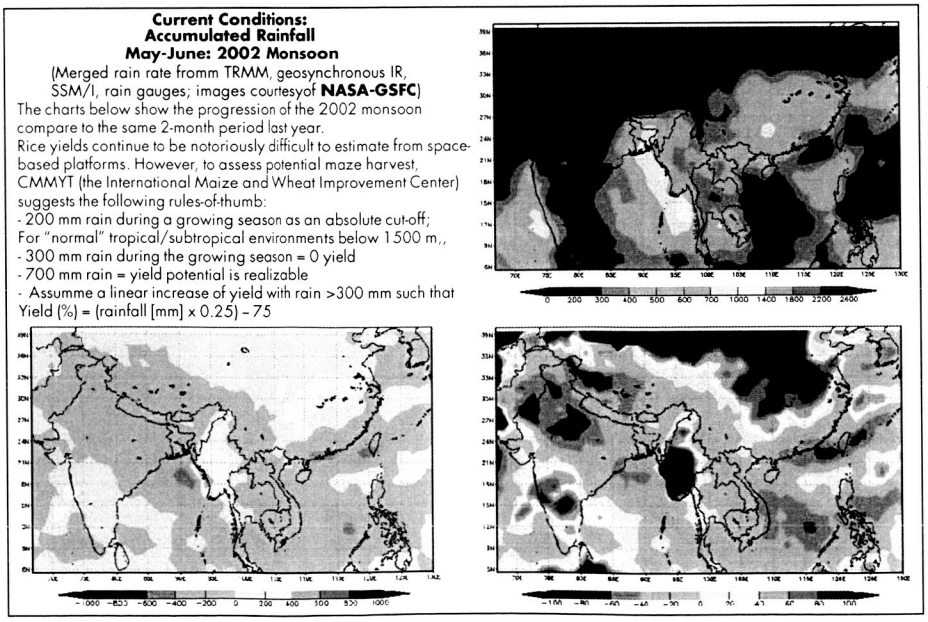
Current Conditions:
Accumulated Rainfall
May-June: 2002 Monsoon

(Merged rain rate fromm TRMM, geosynchronous IR, SSM/I, rain gauges; images courtesyof **NASA-GSFC**)

The charts below show the progression of the 2002 monsoon compare to the same 2-month period last year.

Rice yields continue to be notoriously difficult to estimate from space-based platforms. However, to assess potential maze harvest, CMMYT (the International Maize and Wheat Improvement Center) suggests the following rules-of-thumb:

- 200 mm rain during a growing season as an absolute cut-off;
For "normal" tropical/subtropical environments below 1500 m,,
- 300 mm rain during the growing season = 0 yield
- 700 mm rain = yield potential is realizable
- Assumme a linear increase of yield with rain >300 mm such that Yield (%) = (rainfall [mm] x 0.25) - 75



TRMM Data Application at United Nations (U.N.)

The Vulnerability Analysis and Mapping (VAM) unit of the U.N. World Food Program (WFP) uses TRMM precipitation data and rainfall plots for drought/flood assessments and crop yield estimates.

Left panel is a page from the Current Conditions Report by the WFP VAM unit. It shows the progression of the 2002 monsoon compared to the same 2-month period of the previous year.

(Courtesy: L. Milich)

GES DISC DAAC
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http://trmm.gsfc.nasa.gov/

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