TROPICAL RAINFALL MEASURING MISSION

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Introduction

This abstract describes the Tropical Rainfall Measuring Mission (TRMM) with particular emphasis on rainfall estimation products applicable to drought monitoring activities. The TRMM is a joint project of NASA and the Japanese Aerospace Exploration Agency. The NASA TRMM team develops tools and methods for combining and analyzing precipitation data from both terrestrial and space-based sources and publishes high quality data products resulting from this work. TRMM also operates the world's flagship precipitation observation platform, the TRMM satellite. Since its inception in 1998, TRMM has attracted a large and active community of scientists interested in rainfall prediction and measurement. This abstract provides an overview of the TRMM rainfall products that are suitable for monitoring hydrologic extremes.

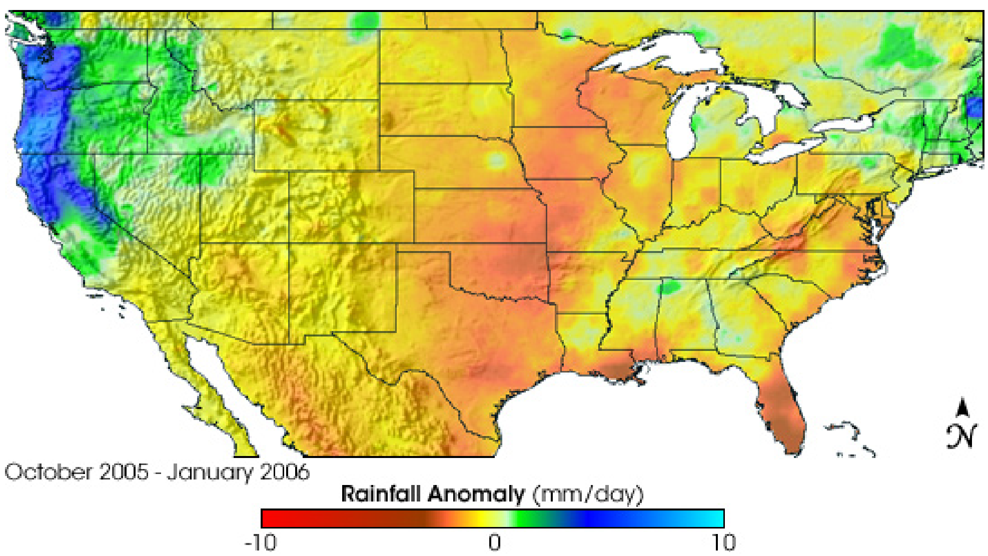

Figure 1: This image, generated using TRMM data products, depicts La Nina-like conditions across the United States. Drought across the south contributed to several devastating wildfires. NASA image.

As its name implies, TRMM was originally conceived mainly for the study of tropical rainfall. Over the years, however, TRMM has proven to be an invaluable resource in other application areas, such as flood and drought monitoring in the United States (Fig. 1). Despite its name, TRMM covers an area of the earth's surface that extends well beyond the tropics, covering a swath between 38°N to 38°S. Using additional satellite inputs, TRMM data products provide coverage extending from 50°N to 50°S. TRMM makes these data available in both near-real time and delayed research-quality formats.

Input Data

Chief among TRMM's space-based data sources is the instrument suite aboard the TRMM satellite. Aloft since 1998, the TRMM satellite incorporates three state-of-the-art sensors that work both separately and in conjunction to detect and measure precipitation. These instruments include the Precipitation Radar (PR), the TRMM Microwave Imager (TMI) and the Visible Infrared Scanner (VIRS). Data gathered by these instruments have undergone extensive ground validation using terrestrial weather radar at sites throughout the world. The combination of PR, TMI and VIRS provides an exceptional multi-faceted view of precipitation events (Fig. 2).

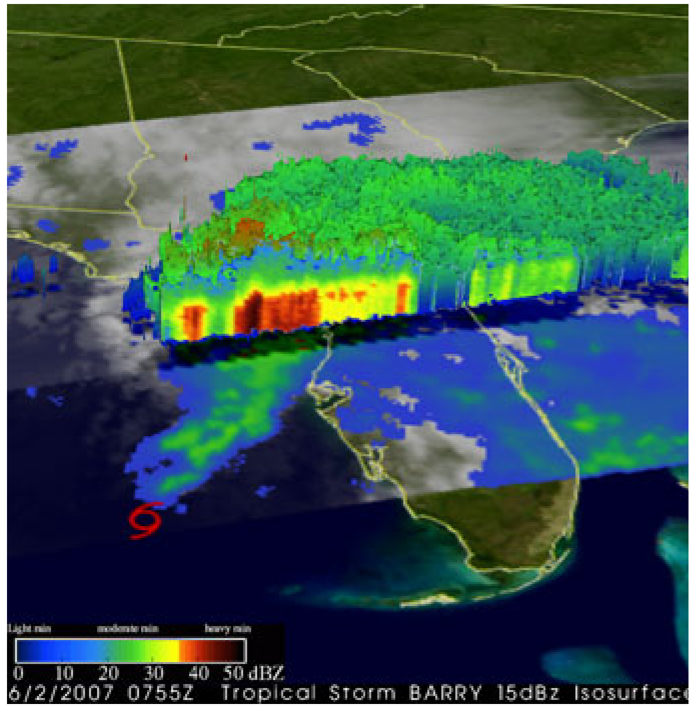

Figure 2: The background image shows the horizontal pattern of rain intensities estimated from TRMM satellite data. Rain rates in the center swath are based on the TRMM Precipitation Radar (PR), and those in the outer swath on the TRMM Microwave Imager (TMI). The rain rates are overlaid on infrared (IR) data from the TRMM Visible Infrared Scanner (VIRS). NASA image.

Designed to provide three dimensional maps of storm structure, the Precipitation Radar is the first of its kind to fly on an earth orbiting satellite. Measurements made by the PR indicate rain intensity, distribution, and type, as well as storm depth and the height at which snow melts to form rain. Though ground-based weather radar has been a mainstay of rainfall estimation since World War II, technical obstacles have previously precluded deployment of such instruments in space. The PR overcomes these obstacles for the first time.

The TRMM Microwave Imager is a passive microwave sensor that measures minute quantities of microwave energy emitted by the earth and its atmosphere. TMI measurements quantify water vapor, cloud water and rainfall intensity over a wide swath. Though other satellites carry microwave sensors, TMI has an extra 10.7 GHz channel, absent in other packages, specifically tuned to measure the high rates of rainfall common in the tropics. In addition, the TRMM satellite's comparatively low altitude allows the TMI to capture data at a higher ground resolution than similar instruments aboard other, higher flying satellites.

The TRMM satellite's Visible and Infrared Scanner is used to estimate the altitudes of cloud tops. Higher cloud tops, which appear colder to VIRS, indicate a likelihood of precipitation. On their own, infrared techniques have significant errors for instantaneous rainfall estimates; however, when used in conjunction with the other sensors aboard the TRMM satellite, as well as data from other orbiting platforms, VIRS data can improve TRMM rainfall estimates.

In addition to TRMM satellite measurements, the TRMM products also incorporate measurements made by a variety of other low earth orbit platforms. These include passive microwave data from Defense Meteorological Satellite Program satellites, the *Aqua* satellite and the National Oceanic and Atmospheric Administration satellite series; as well as infrared data collected by the international constellation of geosynchronous earth orbiting satellites. The combination process is illustrated schematically in Fig. 3. Long-latency research quality TRMM products also incorporate monthly terrestrial rain gauge data for improved accuracy.

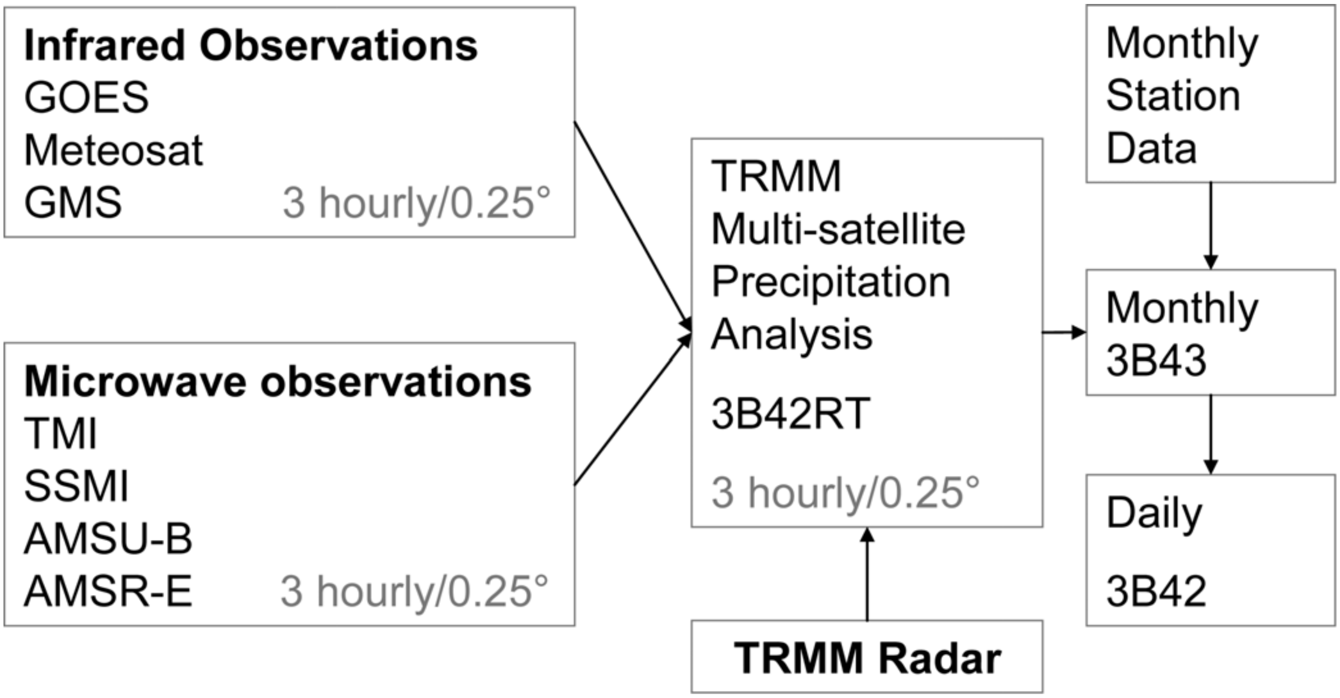

Figure 3: Schematic diagram of TRMM processing and outputs.

TRMM Data Products

TRMM makes available a large assortment of data products designed for various purposes; we focus here on those most applicable to drought monitoring applications. These products come in near-real time and long latency research quality configurations (Table 1).

3B42-RT

For projects and analyses that require near-real time data, such as storm and flood monitoring, the most useful information source is the near-real time 3-hourly 0.25° 3B42-RT. The 3B42-RT product combines microwave, infrared and radar data. 3B42-RT has a temporal resolution of three hours and is published daily with a 6 hour and 40 minute delay. Daily totals compiled by the FEWS NET team at the U.S Geological Survey Center for EROS, are also available. The images at EROS may be easier to analyze, since they do not require accessing the data in HDF format, and come in GIS compatible formats.

Note that while the 3B42-RT extends from 50-60°N, the data in this range is considered unreliable. Our analysis of the real time products suggests that changes in the processing methodology may produce systematic changes in mean precipitation before and after 2005. Users should read the documentation carefully[1], and evaluate the data they use for systematic variations. Note that small systematic bias values in daily precipitation can accumulate rapidly when summed over the course of a season.

[1] ftp://trmmopen.gsfc.nasa.gov/pub/merged/3B4XRT_README.pdf

3B42 and 3B43

Since 1998, the TRMM data have been reprocessed several times to incorporate improvements in processes and algorithms. Each reprocessing is denoted by a version number. The current version of the TRMM products is version 6. The 3B42 product also known as 3B42v6 is the 3B42RT scaled to match the monthly rain gauge analyses used in 3B43. The output is rainfall for 0.25x0.25° grid boxes every 3 hours available with a month of delay.

The research quality monthly (3B43) and thee-hourly (3B42) incorporate monthly station data, and thus are more accurate. Their long latency can be an obstacle, however, to operational applications. These gridded datasets share a spatial resolution of 0.25° degrees, and covers an area of the earth extending from 50°N to 50°S.

Data Access

The main TRMM web site is available at the following URL: http://trmm.gsfc.nasa.gov/

This site contains links to publications, documentation, TRMM news, and, above all, TRMM data.

The 3 hour data sets 3B42, 3B43, could be obtained from the following link
http://daac.gsfc.nasa.gov/data/datapool/TRMM_DP/01_Data_Products/02_Gridded/index.html

The US Geological Survey Center for EROS makes available BIL and ARCGIS grids formats, for the 3B42-RT, daily totals at ftp://edcftp.cr.usgs.gov/pub/edcuser/fewsips/global/

Table 1. TRMM data characteristics

TRMM 3B42-RT Characteristics	
Temporal Coverage	Start Date: 1998-01-01; Stop Date: -
Geographic Coverage	Latitude: 60°S - 60°N; Longitude:180°W - 180°E
Temporal Resolution	3-Hourly
Frequency of Availability	3 Hourly
Publication delay	6 hours 40 minutes
Horizontal Resolution	0.25° x 0.25°; nlat = 480, nlon = 1440
Average File Size	Compressed: ~285 KB; Original: ~4.5 MB
File Type	HDF

TRMM 3B42 Characteristics	
Temporal Coverage	Start Date: 1998-01-01; Stop Date: -
Geographic Coverage	Latitude: 50°S - 50°N; Longitude:180°W - 180°E
Temporal Resolution	3-Hourly
Frequency of Availability	Monthly
Publication delay	~1 month
Horizontal Resolution	0.25° x 0.25°; nlat = 400, nlon = 1440
Average File Size	Compressed: ~285 KB; Original: ~4.5 MB
File Type	HDF

TRMM 3B43 Characteristics	
Temporal Coverage	Start Date: 1998-01-01; Stop Date: -
Geographic Coverage	Latitude: 50°S - 50°N; Longitude:180°W - 180°E
Temporal Resolution	Monthly
Frequency of Availability	Monthly
Delay between time of observation and product availability	~1 month
Horizontal Resolution	0.25° x 0.25°; nlat = 400, nlon = 1440
Average File Size	Compressed: ~4.5 MB; Original: ~4.5 MB
File Type	HDF

References

Qu, J.J., Gao W., Kafatos, M., Murphy, R.E., Salomonson, V.V., 2006,Tropical Rainfall Measuring Mission Data and Access Tools, Chapter 12, Earth Science Satellite Remote Sensing, Vol. 2: Data, Computational Processing, and Tools, Springer Berlin Heidelberg, 10.1007/978-3-540-37294-3. 202-219.

Huffman G.J., Adler R. F., Bolvin D.T., Gu G., Nelkin E.J., Bowman K.P., Hong Y., Stocker E.F., Wolff D.B. (2006) The TRMM multi-satellite precipitation analysis: quasi-global, multi-year, combined-sensor precipitation estimates at fine scale. J Hydrometeor., 8, 38-55.

——, R.F. Adler, M. Morrissey, D.T. Bolvin, S. Curtis, R. Joyce, B. McGavock, and J. Susskind, 2001: Global precipitation at one-degree daily resolution from multisatellite observations. J. Hydrometeor., 2, 36–50.

——, R.F. Adler, B. Rudolph, U. Schneider, and P. Keehn, 1995: Global Precipitation Estimates Based on a Technique for Combining Satellite-Based Estimates, Rain Gauge Analysis, and NWP Model Precipitation Information, J. Clim., 8, 1284-1295.

——, 1997: Estimates of Root-Mean-Square Random Error for Finite Samples of Estimated Precipitation, J. Appl. Meteor., 1191-1201.

——, R.F. Adler, P. Arkin, A. Chang, R. Ferraro, A. Gruber, J. Janowiak, A. McNab, B. Rudolph, and U. Schneider, 1997: The Global Precipitation Climatology Project (GPCP) Combined Precipitation Dataset, Bul. Amer. Meteor. Soc., 78, 5-20.

——, R.F. Adler, M. Morrissey, D.T. Bolvin, S. Curtis, R. Joyce, B McGavock, J. Susskind, 2001: Global Precipitation at One-Degree Daily Resolution from Multi-Satellite Observations. J. Hydrometeor., 2(1), 36-50.

Internet links

http://daac.gsfc.nasa.gov/precipitation/TRMM_README/TRMM_3B42_readme.shtml
http://daac.gsfc.nasa.gov/precipitation/TRMM_README/TRMM_3B43_readme.shtml
ftp://trmmopen.gsfc.nasa.gov/pub/merged/3B4XRT_README.pdf