

THE NASA GES-DISC-DAAC PRECIPITATION DATA AND INFORMATION SERVICES CENTER (PDISC)

Gilberto Vicente*, Hualan Rui, Bill Teng, Zhong Liu, Li Lu, Patricia Hrubiak
John Bonk, Jim McManus, Long Chiu and Gregory Leptoukh

Goddard Earth Science (GES), Data and Information Services Center (DISC)
Distributed Active Archive Center (DAAC)
NASA Goddard Space Flight Center, Code 902, Greenbelt, MD, USA

1. INTRODUCTION

This article describes the latest contribution from the Goddard Earth Science (GES), Data and Information Services Center (DISC), Distributed Active Archive Center (DAAC), to the scientific and public user communities who are interested in the precipitation and related data sets and products. The Precipitation Data and Information Services Center (PDISC) provides an integrated view connecting rainfall estimation basic research to its estimation from space and contributions to the understanding of the Earth's energy and water balance and long-term climate prediction.

We address various rainfall estimation products derived from visible/infrared (VIS/IR), passive and active microwave (MW) measurements acquired by polar and geosynchronous satellites. Special attention is given to the 6-years data and products derived from the Tropical Rainfall Measuring Mission (TRMM) satellite Precipitation Radar (PR) and Microwave Imager (TMI). All TRMM data and related products are archived, distributed, and accessible to users through various GES-DISC-DAAC-PDISC user-friendly ordering systems, with analysis tools, documentation, and data read software. The intention is to make TRMM and other precipitation related data and products more widely used for climate, health, environment, agriculture, and interdisciplinary research and applications.

<http://daac.gsfc.nasa.gov/hydrology/pdisc/>

2. PDISC DATA ACCESS

The PDISC provides a collection of global rainfall data at satellite instrument pixel resolution and on regular grids from satellite, ground based instrument, and assimilation and analysis results. The data is divided in the following way:

2.1 Most Popular Data Sets

- Monthly 1x1 Degree TRMM and Other Sources Rainfall Data (3B43)
- TRMM Daily 1x1 Degree TRMM and Other-GPI Calibration Rainfall Data (3B42)

- TRMM 3B42RT
- GPCP Monthly 1x1 Degree Rainfall Data
- GPCP version 2 Combined Precipitation Data Set
- GPI Pentad 1x1 Degree Rainfall Data (3A44)
- Global-merged IR Brightness Temperature Data
- Quarter-degree Gridded GPROF 6.0 Data

2.2 Other Data Sets in the PDISC

Tropical Rainfall Measuring Mission (TRMM) Data

- All TRMM Standard Data Products
- TRMM Orbital Products
- TRMM Gridded Products
- TRMM Ground-Based Instrument Data
- TRMM Subset Data Groups
- TRMM Data Mining

Ancillary Data

- Half-degree GPROF 6.0 Data (SSM/I)
- Quarter-degree GPROF 6.0 Data (SSM/I)
- Globally-merged Full Resolution IR Brightness Temperature Data
- Satellite Retrieved Sea Surface Radiation Budget (GSSRB)
- Satellite-Based Surface Turbulent Fluxes (GSSTF)
- GPI IRPROD (3A44)
- GPCP 1x1 degree (3A45B)
- GOES 8
- GOES 10
- GMS-5
- METEOSAT-7
- Earth Topography Five Minute Grid Elevation Data (ETOPO5)

Global Precipitation Data

- Arkin & Janowiak GPI: IR-Based Monthly Rainfall for the GPCP

* Corresponding author address: Gilberto A. Vicente, NASA Goddard Space Flight Center, Code 902 Greenbelt, MD, 20771; vicente@daac.gsfc.nasa.gov

- Chang SSM/I Derived Monthly Rain Indices for the GPCP
- GPCP Rain Gauge Analysis for the GPCP
- GPCP Version 2 Combined Precipitation Data Set
- Jaeger Global Monthly Mean Precipitation
- Legates Surface and Ship Observations of Precipitation
- NOAA/NASA SSM/I Pathfinder Precipitation

Interdisciplinary Hydrology Data Collections

- GPCC Global Rain Gauge Analysis
- SMMR Monsoon Rain
- SMMR Sea Ice Concentration
- Global Soils Data

Hydrology Field Experiments

- TRMM Global Validation Field Experiments
- Southern Great Plains Soil Hydrology Experiments

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

3 PRECIPITATION RELATED DATA SETS BY SATELLITE INSTRUMENTS

The GES DISC DAAC distributes precipitation-related products from the AIRS and MODIS instruments, from the TOVS instrument and from instruments aboard the TRMM and UARS satellites. Following are details on the satellites and instruments providing precipitation data to the DAAC.

3.1 MODIS (Terra and Aqua)

The Moderate Resolution Imaging Spectroradiometer (MODIS) is the key instrument aboard the **Terra** and **Aqua** satellites. It is an optical scanner that views the Earth in 36 channels with spatial resolution ranging from 250 meters to 1 kilometer. MODIS yields unique amounts and quality of precipitation-related data that include aerosols, cloud products, humidity, precipitable water and water vapor.

Aerosols

Suspension of particles of condensed matter (liquid, solid or mixed) in a carrier gas (usually air). Aerosols are important in the precipitation formation as nuclei for the condensation of water droplets and ice crystals. The MODIS level 2 data collection contains four products describing ambient aerosol optical thickness and size distribution over the ocean and the moist parts of the continents. All products have 10-km spatial resolution at nadir. The products are: daytime aerosol optical thickness over the ocean; daytime aerosol ratio of large/small modes over the ocean; daytime aerosol

mean particle size over the ocean; and daytime aerosol optical thickness over land.

Precipitable Water

Total depth of liquid water that would result if all water vapor contained in a vertical column of air could be “wrung out” leaving the air completely dry. It indicates the total humidity of the air above a location, and is a good indicator of the amount of moisture potentially available to supply rainfall.

The MODIS Precipitable Water product consists of column water-vapor amounts. During the daytime, a near-infrared algorithm is applied over clear land areas of the globe and above clouds over both land and ocean. Over clear ocean areas, water-vapor estimates are provided over the extended glint area. An infrared algorithm for deriving atmospheric profiles is also applied both day and night for Level 2. There are two MODIS Water Vapor data product files: MOD05_L2, containing data collected from the Terra platform; and MYD05_L2, containing data collected from the Aqua platform.

Cloud Products

This data collection contains nine level 2 products. They are daytime cloud particle phase at 1 to 5-km resolution; daytime effective cloud particle radius at 1 to 5-km resolution; daytime cloud optical thickness at 1 to 5-km resolution; 24-hour cloud top temperature at 5-km resolution; 24-hour cloud height at 5-km spatial resolution; 24-hour cloud effective emissivity at 5-km spatial resolution; 24-hour cloud phase at 5-km resolution; 24-hour cloud fraction at 5-km spatial resolution; and daytime cirrus cloud product at 1-km spatial resolution.

http://daac.gsfc.nasa.gov/hydrology/pdisc/modis_access.shtml

3.2 AIRS/AMSU-A

The Atmospheric Infrared Sounder (AIRS) and the Advanced Microwave Sounding Unit (AMSU-A) are aboard the **Aqua** satellite. AIRS is a high spectral resolution spectrometer with 2378 bands in the thermal infrared (3.7 - 15.4 μm) and 4 bands in the visible (0.4 - 1.0 μm) and AMSU-A is a multi-channel microwave temperature/humidity sounder that measures global atmospheric temperature profiles and provides information on atmospheric water in all of its forms (with the exception of small ice particles, which are transparent at microwave frequencies).

AIRS/Aqua Level-2 Support Products

The main AIRS/Aqua derived precipitation related variables available through PDISC are skin surface temperature, air temperature and humidity vertical profiles, precipitable water, water vapor, cloud amount and frequency, cloud emissivity, cloud liquid water/ice, cloud precipitable water, cloud heights, sea surface

temperature, surface pressure and precipitation rates with the following coverage: LON -180.0-180.0 at .25 degrees resolution; LAT -90.0-90.0 at .25 degrees resolution; Time 2002-08-30 to current date.

http://daac.gsfc.nasa.gov/hydrology/pdisc/airs_access.shtml

3.3 TRMM

The TRMM data and products are classified in three distinct levels of complexities: Level 1 products are the Visible/Infrared Scanner (VIRS) calibrated radiances, the TRMM Microwave Imager (TMI) brightness temperatures, and the 13.8 GHz Precipitation Radar (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 (orbital data products). Level-3 products are space-time averaged parameters, analyzed products or those produced from merging measurements from TRMM and other sources (gridded products). These include GOES Precipitation Index (GPI) and Special Sensor Microwave Imager (SSM/I) derived products.

TMI Hydrometeor Profile

TMI Hydrometeor (cloud liquid water, precipitable water, cloud ice, precipitable ice) profiles in 14 layers at 5 km horizontal resolution, along with latent heat and surface rain, over a 760 km swath

TRMM PR Rain Rate, Profile and Characteristics

Main PDISC products: Rain type; storm, freezing, and bright band heights; at 4 km horizontal resolution over a 220 km swath. Rain rate, reflectivity, and attenuation profiles, at 4 km horizontal, and 250 m vertical, resolutions, over a 220 km swath

Combined TRMM Rainfall Profile (PR, TMI)

Combined PR/TMI rain rate and path-integrated attenuation at 4 km horizontal, and 250 m vertical, resolutions, over a 220 km swath

http://daac.gsfc.nasa.gov/hydrology/pdisc/inst_data.shtml

4 TOOLS AND SERVICES

The DAAC provides several tools for use in reading, analyzing and visualizing satellite precipitation data and products as well as others:

4.1 MODIS Online Visualization and Analysis System (MOVAS)

Developed by the GES DISC DAAC and AeroCenter (of GSFC's Laboratory for Atmospheres), this Java and non-Java tool provides users with an easy-to-use, web-based interface for visualization and analysis of MODIS atmosphere monthly global product (MOD08_M3). Users can generate image or ASCII output for area average (area plot), time series (time plot), and

Hovmoller diagram (longitude-time plot or latitude-time plot) for selected area and time period. Image animation is available for area plot.

<http://lake.nascom.nasa.gov/movas/>

4.2 TRMM Online Visualization and Analysis System (TOVAS)

Developed by the GES DISC DAAC, TOVAS provides users with a friendly web-based interface for visualization and analysis of TRMM level 3 rainfall products and other rainfall gridded products and other precipitation data. It is applicable to a variety of research and applications, such as climate study and monitoring, weather events study and monitoring, agricultural crop monitoring, rainfall algorithm study, and data products comparison.

Currently, there are eight precipitation products available through the TOVAS, of which six are TRMM products and two are monthly precipitation products produced, respectively, by Cort J. Willmott and Kenji Matsuura from the Center for Climatic Research, Department of Geography, University of Delaware, and by the Global Precipitation Climatology Center.

Product Name	Description, Spatial & Temporal Resolutions and Coverages
3B42RT	Experimental TRMM Real-Time Multi-Satellite Precipitation Analysis (MPA-RT) 0.25°x0.25°, 3-hourly, global 50°S-50°N, 2002/02 – present
3B42 V6	TRMM and Others GPI Rainfall Estimate 0.25°x0.25°, 3-hourly, global 50°S-50°N, 1998/01 – present
3B43 V6	TRMM and Others Data Sources Rainfall Estimate 0.25°x0.25°, monthly, global 50°S-50°N, 1998/01 – present
3A12 V6	TRMM Microwave Imager (TMI) rain, latent heat, cloud liquid water profiles 0.5°x0.5°, 14 vertical layers, monthly, global 40°S-40°N, 1998/01 – present
3B42 V5	TRMM and Others GPI Rainfall Estimate 1.0°x1.0°, daily, global 40°S-40°N, 1998/01-2004/03
3B43 V5	TRMM and Others Data Sources Rainfall Estimate 1.0°x1.0°, monthly, global 40°S-40°N, 1998/01-2004/03
Willmott	Willmott and Matsuura Global Precipitation 0.5°x0.5°, monthly, global land, 1959/01-1999/12
GPCC	Global Precipitation 1.0°x1.0°, monthly, global land, 1998/01-2004/03

<http://lake.nascom.nasa.gov/tovas/>

4.3 TRMM Orbit Viewer

The Orbit Viewer is an IDL-based language tool for displaying the TRMM HDF data.. The viewer makes it easier to perform an initial examination of TRMM data files and allow the display of TRMM data at the full

instrument resolution on a map of the tropics. Vertical cross sections and 3D images of rain structure can also be created. Instructions for using the viewer's many features are provided in the tutorial that is included in the installation as a PDF file. The tutorial can also be downloaded separately from the FTP site. With a resolution of approximately 90 dots-per-inch (dpi), the images generated by the Orbit Viewer are suitable for on-screen display or for informal presentations. The Orbit Viewer, however, is not designed to create the high-resolution images (300-600 dpi) for publication.

http://daac.gsfc.nasa.gov/hydrology/pdisc/TRMM_ov.shtml

4.4 TRMM ReadHDF Tool

Read_HDF reads in a TRMM HDF data file and writes out user-selected SDS arrays and Vdata tables as separate flat binary files. New functionalities include options to choose ascii output format, and to run in batch mode. This software currently runs on UNIX systems.

http://daac.gsfc.nasa.gov/hydrology/pdisc/read_HDF.shtml

4.5 TRMM Data Mining

The TRMM data mining system accepts user's data mining algorithms, integrates them into the DAAC system, runs the algorithms during scheduled periods, and delivers the resultant files to users in their requested formats. This data mining service can efficiently minimize the problem of data storage for users, work around the limitation of network distribution capacity, and reduce the cost of tape handling.

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

4.6 The Parameter Information Locator Tool (PILoT)

PILoT permits a search of DAAC data products by parameter. A broad search can be performed by specifying just the parameter name, or a more specific search can be performed by specifying details such as Earth science topics, variables etc.

<http://daac.gsfc.nasa.gov/www/PILoT/>

4.7 The ISCCP Convection Co-locator

The international Satellite Cloud Climatology Project (ISCCP) has produced a global dataset (currently covering the period 1983-2001) describing the properties of clouds (Schiffer and Rossow 1983, Rossow and Schiffer 1999). This dataset can be used more effectively for the study of specific cloud processes or other related meteorological phenomena if the information about particular types of clouds can be separated from these general, global statistics. To support studies related to 'deep' convection, the primary process by which the tropical atmosphere is heated by precipitation and radiation, the ISCCP

dataset has been analyzed to identify and describe the properties of mesoscale deep convective cloud systems. This led to the creation of the ISCCP Convection Co-locator to allow one to find the nearest mesoscale convective system and to obtain the complete life history of its cloud properties (from ISCCP data) by entering the coordinates (lat, lon, time, date). The program returns the characteristics of this system as seen by ISCCP. This tool is resident at the Goddard Institute for Space Studies (GISS).

<http://isccp.giss.nasa.gov/cgi-bin/CT.pl>

5 PRECIPITATION SCIENCE RESEARCH AND APPLICATIONS

The Hydrology Data Support Team at the Goddard DAAC provides examples of TRMM data usage in scientific research along with the means for quick and easy grasping of the scientific concepts embodied in the TRMM data. Following are a few of the many applications of remote sensing precipitation data and products.

5.1 Seasonal Rainfall from TRMM

Rainfall analyses and climatology: Series of TRMM 3B43 seasonal rainfall anomaly and climatology created based on six years of monthly TRMM 3B43 data (Jan. 1998 to Dec 2003). The seasonal rainfall anomalies were derived from 3B43 seasonal averaged data with their seasonal climatology removed. The climatology is created from the TRMM 3B43 product which in turn is derived from four other precipitation data sets.

http://daac.gsfc.nasa.gov/hydrology/pdisc/trmm_season_img.shtml

http://daac.gsfc.nasa.gov/hydrology/pdisc/precip_climatology.shtml

The Willmott 1950-1999 land only climatology: Created using data from the Global Historical Climatology Network (GHCN version 2) and Legates and Willmott's (1990a and b) station records of monthly and annual mean air temperature (T) and total precipitation (P).

http://daac.gsfc.nasa.gov/hydrology/pdisc/precip_climatology.shtml

5.2 TRMM most popular rainfall products

Near real time 3-hourly TRMM and other satellite rainfall: Experimental product created by G. J. Huffman, R. F. Adler, and D. T. Bolvin, working in the Laboratory for Atmospheres, NASA Goddard Space Flight Center, Code 912, Greenbelt, MD, 20771 USA, and produced quasi-operationally by E. F. Stocker, working in the TRMM Science Data and Information System (TSDIS), NASA Goddard Space Flight Center, Code 902, Greenbelt, MD, 20771 USA.

Spatial coverage: 50°S – 50°N
 Spatial resolution: 0.25° x 0.25°
 Temporal resolution: 3 hours

<http://lake.nascom.nasa.gov/tovas/3B42RT/#description>

TRMM Level-1 orbital data products: Orbital data products from VIRS, TMI, and PR, at the sensor's resolution 1997-12-07 23:57:17 2004-10-26 23:00:30.

Data Product	Data Description
1B01: Visible and Infrared Radiance (VIRS)	Calibrated VIRS (0.63, 1.6, 3.75, 10.8, and 12 um) radiances at 2.2 km resolution over a 720 km swath
1B11: Microwave Brightness Temperature (TMI)	Calibrated TMI (10.65, 19.35, 21, 37, and 85.5 GHz) brightness temperatures at 5 to 45 km resolution over a 760 km swath
1B21: Radar Power (PR)	Calibrated PR (13.8 GHz) power at 4 km horizontal, and 250 m vertical, resolutions over a 220 km swath
1C21: Radar Reflectivity (PR)	Calibrated PR (13.8 GHz) reflectivity at 4 km horizontal, and 250 m vertical, resolutions over a 220 km swath
2A12: Hydrometeor Profile (TMI)	TMI Hydrometeor (cloud liquid water, prec. water, cloud ice, prec. ice) profiles in 14 layers at 5 km horizontal resolution, along with latent heat and surface rain, over a 760 km swath
2A21: Radar Surface Cross-Section (PR)	PR (13.8 GHz) normalized surface cross-section at 4 km horizontal resolution and path attenuation (in case of rain), over a 220 km swath
2A23: Radar Rain Characteristics (PR)	Rain type; storm, freezing, and bright band heights; from PR (13.8 GHz) at 4 km horizontal resolution over a 220 km swath
2A25: Radar Rainfall Rate and Profile (PR)	PR (13.8 GHz) rain rate, reflectivity, and attenuation profiles, at 4 km horizontal, and 250 m vertical, resolutions, over a 220 km swath
2B31: Combined Rainfall Profile (PR, TMI)	Combined PR/TMI rain rate and path-integrated attenuation at 4 km horizontal, and 250 m vertical, resolutions, over a 220 km swath
1A01: VIRS Raw Data (VIRS)	Reconstructed, unprocessed VIRS (0.6, 3, 1.6, 3.75, 10.8, and 12 um) data
1A11: TMI Raw Data (TMI)	Reconstructed, unprocessed TMI (10.65, 19.35, 21, 37, and 85.5 GHz) data

http://lake.nascom.nasa.gov/data/dataset/TRMM/01_Data_Products/01_Orbital/index.html

TRMM Gridded Data Products: Gridded data products from VIRS, TMI, and PR, at a range of spatial and temporal resolutions 1997-12-01 00:00:00 2004-10-01 00:00:00.

Data Product	Data Description
3A11: Monthly 5° x 5° Oceanic Rainfall	Rain rate, conditional rain rate, rain frequency, and freezing height for a latitude band from 40 degree N to 40 degree S, from TMI
3A12: Monthly 0.5° x 0.5° mean 2A12, profile, and surface rainfall	0.5 x 0.5 degree gridded monthly product comprised of mean 2A12 data and calculated vertical hydrometeor profiles as well as mean surface rainfall
3A25: Monthly 5°x5° and .5°x.5° Spaceborne Radar Rainfall	Total and conditional rain rate, radar reflectivity, path-integrated attenuation at 2, 4, 6, 10, 15 km for convective and stratiform rain; storm, freezing, and bright band heights, and snow-ice layer depth for a latitude band from 40°N to 40°S, from PR
3A26: Monthly 5° x 5° Surface Rain Total	Rain rate probability distribution at surface, 2 km, and 4 km for a latitude band from 40°N to 40°S, from PR
3B31: Monthly 5° x 5° Combined Rainfall	Rain rate, cloud liquid water, rain water, cloud ice, grauples at 14 levels for a latitude band from 40 degree N to 40 degree S, from PR and TMI
3A46: Monthly 1° x 1° SSM/I Rain	Global rain rate from SSM/I
3B42: 3-Hour 0.25° x 0.25° TRMM and Other-GPI Calibration Rainfall	Calibrated geosynchronous IR rain rate using TRMM estimates
3B43: Monthly 0.25° x 0.25° TRMM and Other Sources Rainfall	Merged rain rate from TRMM, geosynchronous IR, SSM/I, rain gauges
CSH: Monthly 0.5° x 0.5° Convective & Stratiform Heating	TRMM Monthly 0.5° x 0.5° Convective/Stratiform Heating

http://lake.nascom.nasa.gov/data/dataset/TRMM/01_Data_Products/02_Gridded/index.html

5.3 Other TRMM applications

Diurnal cycle of precipitation: TRMM has made it possible to monitor global tropical rainfall diurnal patterns and their intensities, an issue of critical importance to many nations which depend on knowledge of rainfall variability to prepare for possible secondary effects of large swings in rainfall rates. The diurnal cycle of precipitation was derived from the combined (PR, TMI) Rainfall Profile algorithm (2B31).

http://daac.gsfc.nasa.gov/hydrology/trmm_app/trmm_diurnal.shtml

Tropical Rainfall Potential (TRaP): The Satellite Analysis Branch (SAB) of NOAA's National Environmental Satellite, Data, and Information Service produces an experimental graphical representation of

the forecast Tropical Rainfall Potential (TRaP), for any tropical system in the Western Hemisphere and many in the Eastern Hemisphere. In the TRaP system, the latest rainfall estimates for tropical storms derived from SSM/I, AMSU, or TRMM are used to initialize a simple algorithm for estimating cumulative rainfall for those storms predicted to hit land within 24 hours and performing an extrapolation of the rain rate values. The TRMM rainfall estimates are useful because they are the highest resolution of all the POES and the dynamic range of the rainfall estimates is greater than AMSU or SSM/I.

<http://www.ssd.noaa.gov/PS/TROP/trap-img.html>

Famine Early Warning System Network (FEWS NET): High resolution data from the TRMM Microwave Imager (TMI) are used by FEWS NET, a partnership of U.S. agencies with environmental monitoring expertise and several African regional early warning groups, in support of its mission to predict and ameliorate famine in seventeen drought-prone African countries.

<http://www.fews.net/resources/gcontent/pdf/1000023.pdf>

Land Data Assimilation Systems (LDAS): North American (NLDAS) and Global (GLDAS) LDAS systems are being developed that will lead to more accurate reanalysis and forecast simulations by numerical weather prediction (NWP) models. Specifically, these systems will reduce the errors in the stores of soil moisture and energy which are often present in NWP models and which degrade the accuracy of forecasts. NLDAS is currently running retrospectively and in near real-time on a 1/8th-degree grid while GLDAS is running at 1/4 degree resolution. The systems are currently forced by terrestrial (NLDAS) and space based (GLDAS) precipitation data, space-based radiation data and numerical model output. In order to create an optimal scheme, the projects involve several LSMs, many sources of data, and several institutions. Data from the project can be accessed on the NLDAS and GLDAS forcing pages, the NLDAS and GLDAS model output pages, as well as on the NLDAS and GLDAS Realtime Image Generator pages.

<http://ldas.gsfc.nasa.gov/>

6.0 CONCLUSION

This article describes the GES-DISC-DAAC Precipitation Data and Information Services Center (PDISC). By addressing various rainfall estimation products derived from visible/infrared (VIS/IR), passive and active microwave (MW) measurements acquired by both polar and geosynchronous satellites, the PDISC provides an integrated view connecting rainfall estimation basic research to its estimation from space. This contributes to the understanding of the Earth's energy and water balance and long-term climate prediction. Special attention is given to the 6-years data and products derived from the Tropical Rainfall

Measuring Mission (TRMM) satellite Precipitation Radar (PR) and Microwave Imager (TMI).

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