



GPM, TRMM, and Other Global Precipitation Products and Services at NASA GES DISC

Z. Liu^{1,2}, B. Vollmer¹, A. Savtchenko^{1,3}, D. Ostrenga^{1,3}, B. DeShong^{1,3}, F. Fang^{1,3}, M. Greene^{1,4}, R. Albayrak^{1,3}, J. Su^{1,3}, C.-L. Shie^{1,5}, E. Sherman^{1,3}, J. Acker^{1,3}, A. Li¹, W. Teng^{1,3}, J. Wei¹, G.-D. Lei^{1,3} and D. Meyer¹

¹GES DISC

²CSISS, George Mason University

³ADNET Systems, Inc.

⁴Telophase Corp

⁵Univ. of Maryland at Baltimore County

The 9th Workshop of the International Precipitation Working Group



Outline

- Introduction
- GPM, TRMM, and other (global, regional) precipitation products at GES DISC
- Data services
- Giovanni
- Summary



Introduction

- Precipitation is a key environmental variable. For example, in agriculture, precipitation, temperature, water (soil moisture), solar radiation, NDVI, etc., are key variables.
- Rainfed agriculture – major farming practices that rely on rainfall for water.
- Rainfed agriculture: >95% of farmed land (sub-Saharan Africa); 90% (Latin America); 75% (Near East and North Africa); 65% (East Asia); 60% (South Asia).
- Droughts and floods can cause severe crop loss.
- The Goddard Earth Sciences (GES) Data and Information Services Center (DISC), one of 12 NASA data centers, is located in Greenbelt, Maryland, USA.
- The NASA GES DISC is a major data archive center for global precipitation, water & energy cycles, atmospheric composition, and climate variability.



In Kenya 2016 <http://venturesafrica.com/kenya-battles-drought/>



In the U.S. <https://www.scientificamerican.com/article/heat-drought-continues-threaten-us-corn-crops/>



Precipitation Product Overview

- GPM (Global Precipitation Measurement)
- TRMM (Tropical Rainfall Measuring Mission)
- GPCP (Global Precipitation Climatology Project) of MEaSUREs
- MERRA-2 (Modern-Era Retrospective analysis for Research and Applications, Version 2)
- NLDAS (North America Land Data Assimilation System)
- FLDAS (Famine Early Warning System Network Land Data Assimilation System)
- GLDAS (Global Land Data Assimilation System).



Global Precipitation Products (more details)

- Single sensor (microwave, radar, and combined instrument) products from TRMM (1997 – 2015; 40° N-S) and GPM (2014 – present; 65° N-S): orbital and gridded
- TRMM Multi-satellite Precipitation Analysis (TMPA, 0.25-deg. 3-hr, monthly, 1998 – present; 50° (60° NRT) N-S)
- **Integrated Multi-satellitE Retrievals for GPM (IMERG, NRT and research, 0.1-deg., 0.5-hr, monthly, 2014 – present), Version 05.** Retrospective processing (back to the TRMM era, available soon).
- GPCP (Global Precipitation Climatology Project). Version 3 is coming soon.
- GLDAS (Global Land Data Assimilation System, 0.25-deg., 3-hourly and 1-deg., monthly, 1948-2010 (v 2.0), 2000-present (v 2.1))
- NLDAS (North America Land Data Assimilation System, 0.125-deg., hourly and monthly, 1979 - present)
- FLDAS (Famine Early Warning System Network Land Data Assimilation System, 0.1 deg., daily, monthly, 1982 – present)
- MERRA-2 (Modern-Era Retrospective analysis for Research and Applications, Version-2, 0.5 x 0.625 deg. hourly, 3-hourly, monthly, 1980-present)



Not Entirely Independent

- TMPA (PMW, IR, GPCC, etc.)
- IMERG (PMW, IR, GPCC, etc.)
- GPCC (gauges only, sampling)
- GPCP (PMW, IR, GPCC, etc.)
- GLDAS (TMPA, PERSIANN, CMAP, CMORPH, NRL, GTS)
- MERRA-2 (CMAP, GPCP)



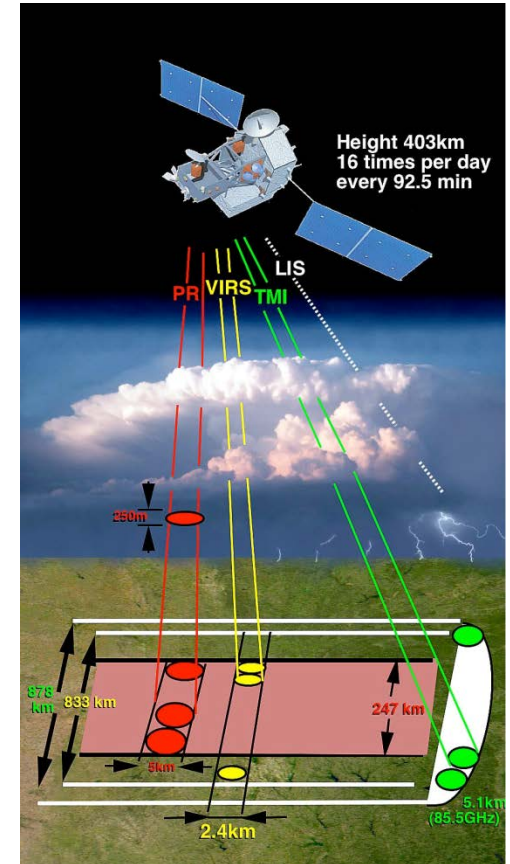
Issues in Satellite-based Precipitation Estimates

- Over oceans, passive microwave (PMW) retrievals are found to rival radar retrievals. Over land, it is more difficult (variations of the surface emissivity, in particular over snow and ice)
- IR techniques relate cloud top temperatures to surface rainfall (underestimation of warm rain, false alarms for anvils and thick cirrus clouds with cloud brightness temperatures)
- Precipitation radar: Attenuation correction, complex terrain and minimum detectable signals (snow, light rain, etc.)
- Algorithm changes; multi-satellite, multi-sensor, multi-algorithms, etc.
- Complex terrains, orographic effect, snow and ice surface, lacking gauges and radars, light rain, blowing snow, etc.
- Lack of ground observations for bias correction
- A challenge to capture and document data quality information.
- Effective communication with users.



TRMM (Tropical Rainfall Measuring Mission)

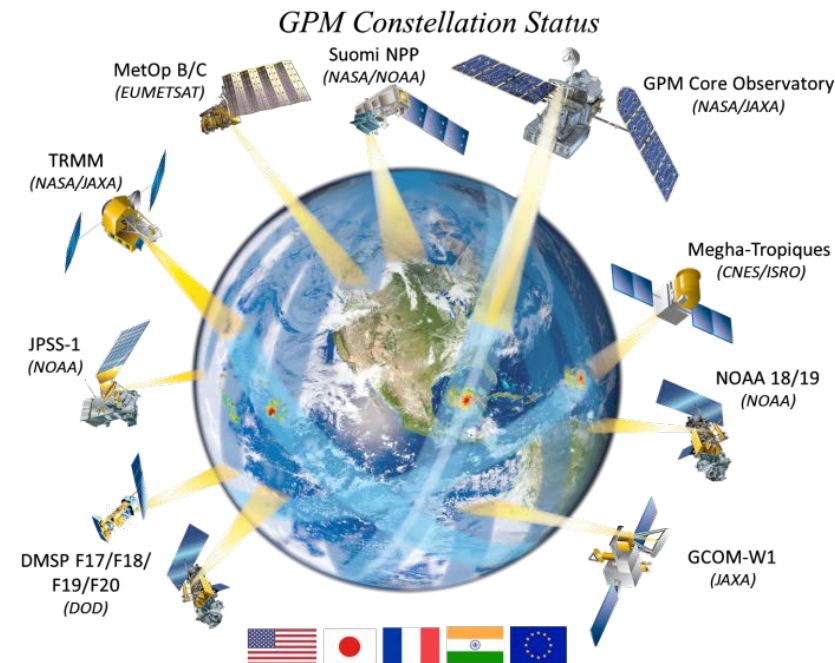
- NASA/JAXA mission (Nov. 1997 – Apr. 2015) to monitor and study tropical rainfall
- Precipitation related instruments (TMI, PR, LIS, VIRS)
- Orbital and gridded datasets
- Single sensor, multi-sensor, multi-satellite datasets.





GPM (Global Precipitation Measurement)

- NASA/JAXA mission (Feb. 2014 – present) to monitor and study global precipitation (rain and snow)
- Quantify rainfall rates from 0.22 mm h^{-1} to 110 mm h^{-1} (60 mm h^{-1} for microwave imager) and detect falling snow at instrument footprint scales (from Walter Petersen)
- Precipitation related instruments (GMI, PR)
- GPM constellation of international satellites
- Orbital and gridded datasets. Single sensor, multi-sensor, multi-satellite datasets.





Data Services (How to find data?)

EARTHDATA Find a DAAC

GES DISC

Atmospheric Composition, Water & Energy Cycles and Climate Variability

Feedback Help Login

Explore...

Data Collections - Enter search (e.g., rainfall, GPM, TRM) [Icons] [Search]

Browse Data by Category -

Archive Size: 2,200,351 TB
Archived Data Files: 115,037,125
Files Distributed*: 2,340,854,143
Data Volume: 2,340,854,143

Projects & Missions

Cloud Absorption Radiometer (CAR)
The Cloud Absorption Radiometer (CAR) is an airborne multi-wavelength scanning radiometer that can perform several functions including, d...

MEASUREs
MEASUREs: Making Earth System Data Records for Use in Research Environments, is a NASA project, solicited through Research Opportunities in ...

SSBUV
The Shuttle Solar Backscatter Ultraviolet (SSBUV), nearly identical to Nimbus-7 SBUV and NOAA SBUV/2 instruments flown on eight space shutt...

[View All Projects & Missions](#)

Featured Gallery Images

is colored in red show is on a Level 2 swath.

Lake Oroville Precipitation, February 1

[View All Gallery Images](#)

News

Release of GPS Radio Occultation Boundary Layer Depth Products
Oct 25, 2018

OCO-2 Releases Lite product V9r
Oct 17, 2018

New Version 01 TIS-1 Level 3 Products Released to Public
Oct 5, 2018

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NASA Official Long Pham
Web Curator: M. Hegde

Science Focus Areas
Atmospheric Composition
Water & Energy Cycles
Climate Variability

Tools
Giovanni
MERRA Subsetter
Data Rods for Hydrology
DQViz
AIRS NRT Viewer
OGC Web Map Service
OPeNDAP and GDS

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Data Services (cont.)

- TRMM, GPM, NLDAS, GLDAS, MERRA
- precipitation, soil moisture, temperature, etc.




The screenshot displays the NASA Earth Science Data Information Services Center (DISC) website. The header includes the text "GES DISC" and "Atmospheric Composition, Water & Energy Cycles and Climate Variability". Navigation links for "Feedback", "Help", and "Hi, Zhong" are visible. A search bar is active with "TRMM" entered. A dropdown menu is open, listing various options: "Data Collections", "Data Documentation", "Alerts", "FAQs", "Glossary", "How-To's", "Image Gallery", "News", and "Tools". The background features a satellite image of Earth.

Archive Size: 2,200.827 TB
Archived Data Files: 115,038,250
Files Distributed*: 2,340,860,935
Data Volume Distributed*: 22,197.155 TB



Data Services (cont.)

Explore...

Data Collections ▾ TRMM   

Browse Data by Category ▾

Subject	Aerosols	Infrared Wavelengths	Sea Ice
Measurement	Air Quality	Ionosphere/Magnetosphere Dynamics	Sea Surface Topography
Source	Altitude	Land Surface/Agriculture Indicators	Sensor Characteristics
Processing Level	Atmospheric Chemistry	Land Use/Land Cover	Snow/Ice
Project	Atmospheric Phenomena	Microwave	Soils
Temporal Resolution	Atmospheric Pressure	Natural Hazards	Solar Activity
Spatial Resolution	Atmospheric Radiation	Ocean Chemistry	Solar Energetic Particle Flux
	Atmospheric Temperature	Ocean Heat Budget	Solar Energetic Particle Properties
	Atmospheric Water Vapor	Ocean Optics	Solid Precipitation
	Atmospheric Winds	Ocean Pressure	Sun-Earth Interactions
	Atmospheric/Ocean Indicators	Ocean Temperature	Surface Radiative Properties
	Clouds	Ocean Winds	Surface Thermal Properties
	Cryospheric Indicators	Paleoclimate Indicators	Surface Water
	Ecological Dynamics	Platform Characteristics	Topography
	Ecosystems	Precipitation	Ultraviolet Wavelengths
	Frozen Ground	Protists	Vegetation
	Glaciers/Ice Sheets	Radar	Visible Wavelengths
	Ground Water		

Radio O

is an airborne multi-wave

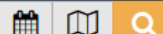


Data Services (cont.)

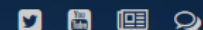
GES DISC

Atmospheric Composition, Water & Energy Cycles and Climate Variability

Data Collections trmm



Feedback Help Hi, Zhong



Data Collections Showing 1 - 25 of 71 datasets associated with trmm

Refine By

Subject Sort

- Aerosols (1)
- Air Quality (1)
- Atmospheric Radiation (11)
- Atmospheric Temperature (9)
- Atmospheric Water Vapor (8)

More...

Measurement Sort

- 24 Hour Precipitation Amount (1)
- Atmospheric Heating (10)
- Attitude Characteristics (8)
- Brightness Temperature (2)
- Cloud Liquid Water/Ice (8)

More...

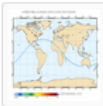


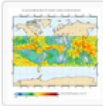


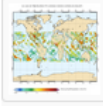


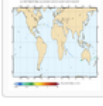
Source Sort

- Aqua AMSR-E (4)
- DMSP 5D-2/F13 SSM/I (1)
- DMSP 5D-2/F14 SSM/I (1)
- DMSP 5D-2/F15 SSM/I (1)
- DMSP 5D-3/F16 SSMIS (1)

More...

Processing Level Sort

- 1 (7)
- 1A (4)
- 1R (6)

Image	Dataset	Source	Temporal Resolution	Spatial Resolution	Process Level	Begin Date	End Date
 Hover	GPM PR on TRMM Spectral Latent Heating Profiles L2 1.5 hours 5 km V06 (GPM_2HSLH_TRMM.06) - Atmospheric Temperature, Atmospheric Winds, Precipitation	TRMM PR	90 minutes	5 km x 5 km	3	1997-12-07	2015-04-01
		 Get Data	 Ingest Status				
 Hover	GPM TMI on TRMM (GPROF) Climate-based Radiometer Precipitation Profiling L3 1 month 0.25 degree x 0.25 degree V05 (GPM_3GPROFTRMMTMI_CLIM.05) - Atmospheric Water Vapor, Precipitation	TRMM TMI	1 month	0.25 ° x 0.25 °	3	1997-12-01	2015-04-08
		 Get Data	 Ingest Status				
 Hover	GPM TMI on TRMM (GPROF) Climate-based Radiometer Precipitation Profiling L3 1 day 0.25 degree x 0.25 degree V05 (GPM_3GPROFTRMMTMI_DAY_CLIM.05) - Atmospheric Water Vapor, Precipitation	TRMM TMI	1 day	0.25 ° x 0.25 °	3	1997-12-08	2015-04-08
		 Get Data	 Ingest Status				
 Hover	GPM PR on TRMM Gridded Orbital Spectral Latent Heating Profiles L3 1.5 hours 0.5x0.5 degree V06 (GPM_3GSLH_TRMM.06) - Atmospheric Temperature, Atmospheric Winds, Precipitation	TRMM PR	1.5 hours	0.5 ° x 0.5 °	3	1997-12-07	2015-04-01

Recommended data collections +



Data Services (cont.)

GES DISC

Atmospheric Composition, Water & Energy Cycles and Climate Variability

Data Collections 3b43

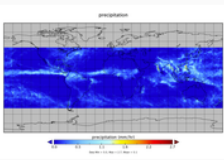


Feedback Help Hi, Zhong



Go to Search Results

TRMM_3B43: TRMM (TMPA/3B43) Rainfall Estimate L3 1 month 0.25 degree x 0.25 degree V7



View Full-size Image

The 3B43 dataset is the monthly version of the 3B42 dataset.

This product is created using TRMM-adjusted merged microwave-infrared precipitation rate (in mm/hr) and root-mean-square (RMS) precipitation-error estimates.

It provides a best precipitation estimate in a latitude band covering 50o N to 50o S, an expansion of the TRMM region, from all global data sources, namely high-quality microwave data, infrared data, and analyses of rain gauges. The granule size is one month.

Data Access

- Online Archive
- Earthdata Search
- Giovanni
- Web Services
- Subset / Get Data

Product Summary

Data Citation

Documentation

Shortname: TRMM_3B43
Longname: TRMM (TMPA/3B43) Rainfall Estimate L3 1 month 0.25 degree x 0.25 degree V7
DOI: 10.5067/TRMM/TMPA/MONTH/7
Version: 7
Format: HDF
Spatial Coverage: -180.0,-50.0,180.0,50.0
Temporal Coverage: 1998-01-01 to 2018-07-31
File Size: 4.9 MB per file
Data Resolution
Spatial: 0.25 ° x 0.25 °
Temporal: 1 month



Data Services (cont.)

- Dataset and information search
- Subsetting (spatial and parameter)
- Format conversion (NetCDF, ASCII)
- Time series (Data Rods)
- Machine to machine (OPeNDAP, https, THREDDS, GDS)
- GIS support (in-house GIS specialists)
- Online visualization and analysis (explore and evaluate datasets without downloading software and data)



Data Services (cont.)

Projects & Missions

Cloud Absorption Radiometer (CAR)

The Cloud Absorption Radiometer (CAR) is an airborne multi-wavelength scanning radiometer that can perform several functions including: d...

MEaSURES

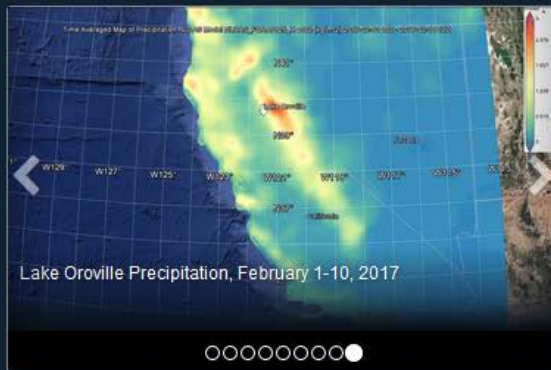
MEaSURES: Making Earth System Data Records for Use in Research Environments, is a NASA project, solicited through Research Opportunities in ...

SSBUV

The Shuttle Solar Backscatter Ultraviolet (SSBUV), nearly identical to Nimbus-7 SBUV and NOAA SBUV/2 instruments flown on eight space shuttl...

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Featured Gallery Images

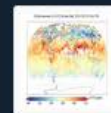


[View All Gallery Images ...](#)

News



Release of GPS Radio Occultation Boundary Layer Depth Products
Oct 25, 2018



OCO-2 Releases Lite product V9r
Oct 17, 2018



New Version 01 TSIS-1 Level 3 Products Released to Public
Oct 5, 2018

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NASA Official: Long Pham
Web Curator: M. Hegde

Science Focus Areas

Atmospheric Composition
Water & Energy Cycles
Climate Variability

Tools

Giovanni
MERRA Subsetter
Data Rods for Hydrology
DQViz
AIRS NRT Viewer
OGC Web Map Service
OPeNDAP and GDS

Resources

HowTo
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Citing Our Data
Contact Us
User Working Group

Monitor

Console





User Services

- FAQs, How-To (recipes), Glossary, etc.
- Social media (Twitter, YouTube, User Forum)
- Help desk (phone, email, online feedback)
- Training materials (ARSET => Applied Remote Sensing Training)



Giovanni (<https://giovanni.gsfc.nasa.gov>) - Data visualization and analysis without downloading data and software)

GIOVANNI

The Bridge Between Data and Science v 4.28

[Feedback](#) [Help](#) [Log out \(zliu\)](#)

AIRS Project recommends not to use total column CO and CH4 ... [1 of 1 messages] [Read More](#)

Select Plot

Maps: Time Averaged Map
 Comparisons: Select...
 Vertical: Select...
 Time Series: Select...
 Miscellaneous: Select...

Select Date Range (UTC)

YYYY-MM-DD HH:mm
 - - [calendar icon] 00:00 to - - [calendar icon] 23:59

Valid Range: 1948-01-01 to 2018-10-26

Please specify a start date.

Select Region (Bounding Box or Shape)

Format: West, South, East, North

[input field] [book icon] [share icon] [close icon]

Select Variables

▼ Disciplines

- Atmospheric Dynamics (17)
- Cryosphere (1)
- Hydrology (105)
- Water and Energy Cycle (90)

▼ Measurements

- Atmospheric Moisture (1)
- Cloud Properties (1)
- Precipitation Anomaly (3)
- Precipitation (107)
- Snow/Ice Anomaly (1)
- Snow/Ice (10)

► Platform / Instrument

► Spatial Resolutions

► Temporal Resolutions

► Wavelengths

► Special Features

► Portal

Number of matching Variables: 119 of 1932 Total Variable(s) included in Plot: 0

Please select at least 1 variable

Keyword: precipitation [Search] [Clear]

	Variable	Units	Source	Temp.Res.	Spat.Res.	Begin Date	End Date	Vert. Slice
<input type="checkbox"/>	Cloud Ice (TRMM_3A12 v7)	g/m ³	TRMM	Monthly	0.5 °	1997-12-01	2015-03-31	0.5 km
<input type="checkbox"/>	Rain Rate (TRMM_3A12 v7)	mm/hr	TRMM	Monthly	0.5 °	1997-12-01	2015-03-31	-
<input type="checkbox"/>	Precipitation Rate (TRMM_3A12 v7)	mm/hr	TRMM	Monthly	0.5 °	1997-12-01	2015-03-31	-
<input type="checkbox"/>	Precipitation (Snow) (TRMM_3A12 v7)	g/m ³	TRMM	Monthly	0.5 °	1997-12-01	2015-03-31	0.5 km
<input type="checkbox"/>	Precipitation (Rain) (TRMM_3A12 v7)	g/m ³	TRMM	Monthly	0.5 °	1997-12-01	2015-03-31	0.5 km
<input type="checkbox"/>	Graupel (TRMM_3A12 v7)	g/m ³	TRMM	Monthly	0.5 °	1997-12-01	2015-03-31	0.5 km
<input type="checkbox"/>	Precipitation (TRMM_3B42 v7)	mm/hr	TRMM	3-hourly	0.25 °	1997-12-31	2018-07-31	-
<input type="checkbox"/>	Near-Real-Time Precipitation Rate (TRMM_3B42RT_Daily v7)	mm/day	TRMM	Daily	0.25 °	2000-03-01	2018-10-26	-
<input type="checkbox"/>	Precipitation Rate (TRMM_3B42_Daily v7)	mm/day	TRMM	Daily	0.25 °	1998-01-01	2018-07-31	-
<input type="checkbox"/>	Precipitation Rate (TRMM_3B43 v7)	mm/hr	TRMM	Monthly	0.25 °	1998-01-01	2018-07-31	-
<input type="checkbox"/>	Surface Convective Precipitation Rate (TRMM_3A12 v7)	mm/hr	TRMM	Monthly	0.5 °	1997-12-01	2015-03-31	-
<input type="checkbox"/>	Near-Real-Time Precipitation Rate (TRMM_3B42RT v7)	mm/hr	TRMM	3-hourly	0.25 °	2003-03-01	2018-10-26	-
<input type="checkbox"/>	Snow water-equivalent (accumulated) (NLDAS_NOAH0125_H	ka/m ²	NLDAS	Hourly	0.125 °	1979-01-02	2018-10-21	-



Responsible NASA Official: [Angela Li](#)
Web Curator: [M. Hegde](#)

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Reset

Plot Data



Giovanni (cont.)

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Select Date Range (UTC)

YYYY-MM-DD

HH:mm

- : to - :

Select Region (Bounding Box or Shape)

Format: West, South, East, North

Valid Range: 2014-03-12 to 2018-10-25

Please specify a start date.

Select Variables

Disciplines

Hydrology (11)

Measurements

Precipitation (11)

Platform / Instrument

Spatial Resolutions

Temporal Resolutions

Portal

Number of matching Variables: 11 of 1932

Total Variable(s) included in Plot: 1

Keyword:

	Variable	Units	Source	Temp.Res [▲]	Spat.Res.	Begin Date	End Date
<input type="checkbox"/>	Multi-satellite precipitation estimate with gauge calibration - Final Run (recommended for general use) (GPM_3IMERGHH v05)	mm/hr	GPM	Half-Hourly	0.1 °	2014-03-12	2018-06-30
<input type="checkbox"/>	Random error for gauge-calibrated multi-satellite precipitation - Final Run (GPM_3IMERGHH v05)	mm/hr	GPM	Half-Hourly	0.1 °	2014-03-12	2018-06-30
<input type="checkbox"/>	Multi-satellite precipitation estimate with climatological gauge calibration - Early Run (GPM_3IMERGHHE v05)	mm/hr	GPM	Half-Hourly	0.1 °	2014-03-12	2018-10-26
<input type="checkbox"/>	Multi-satellite precipitation estimate with climatological gauge calibration - Late Run (GPM_3IMERGHHL v05)	mm/hr	GPM	Half-Hourly	0.1 °	2014-03-12	2018-10-26
<input type="checkbox"/>	Random Error for multi-satellite precipitation with climatological gauge calibration - Late Run (GPM_3IMERGHHL v05)	mm/hr	GPM	Half-Hourly	0.1 °	2014-03-12	2018-10-26
<input type="checkbox"/>	Random Error for multi-satellite precipitation with climatological gauge calibration - Early Run (GPM_3IMERGHHE v05)	mm/hr	GPM	Half-Hourly	0.1 °	2014-03-12	2018-10-26
<input type="checkbox"/>	Daily accumulated precipitation (combined microwave-IR) estimate - Final Run (GPM_3IMERGDF v05)	mm	GPM	Daily	0.1 °	2014-03-12	2018-06-30
<input type="checkbox"/>	Daily accumulated precipitation (combined microwave-IR) estimate - Early Run (GPM_3IMERGDE v05)	mm	GPM	Daily	0.1 °	2014-03-12	2018-10-25
<input checked="" type="checkbox"/>	Daily accumulated precipitation (combined microwave-IR) estimate - Late Run (GPM_3IMERGDL v05)	mm	GPM	Daily	0.1 °	2014-03-12	2018-10-25
<input type="checkbox"/>	Random error for merged satellite-gauge precipitation - Final Run (GPM_3IMERGM v05)	mm/hr	GPM	Monthly	0.1 °	2014-04-01	2018-06-30
<input type="checkbox"/>	Merged satellite-gauge precipitation estimate - Final Run (recommended for general use) (GPM_3IMERGM v05)	mm/hr	GPM	Monthly	0.1 °	2014-04-01	2018-06-30



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Web Curator: [M. Hegde](#)

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Example (Hurricane Maria)



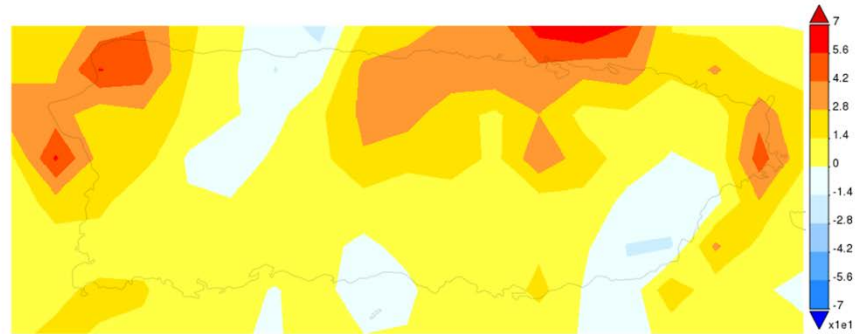
Source: NASA Worldview

Total IMERG-Final rainfall map (in mm) in Puerto Rico (top right) and difference maps (in mm) between IMERG-Early and IMERG-Final (middle) and between IMERG-Early and IMERG-Late (bottom) on September 20, 2017.

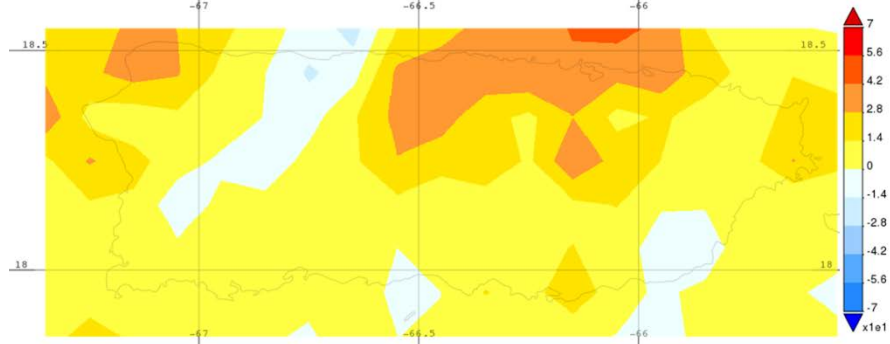
Time Averaged Map of Daily accumulated precipitation (combined microwave-IR) estimate - Final Run daily 0.1 deg. [GPM GPM_3IMERGDF v05] mm over 2017-09-20, Region 67.4341W, 17.8235N, 65.5444W, 18.6365N



Map, Difference of Time Averaged over 2017-09-20, Region 67.4341W, 17.8235N, 65.5444W, 18.6365N
Daily accumulated precipitation (combined microwave-IR) estimate - Early Run daily 0.1 deg. [GPM GPM_3IMERGDE v05] mm minus
Daily accumulated precipitation (combined microwave-IR) estimate - Final Run daily 0.1 deg. [GPM GPM_3IMERGDF v05] mm

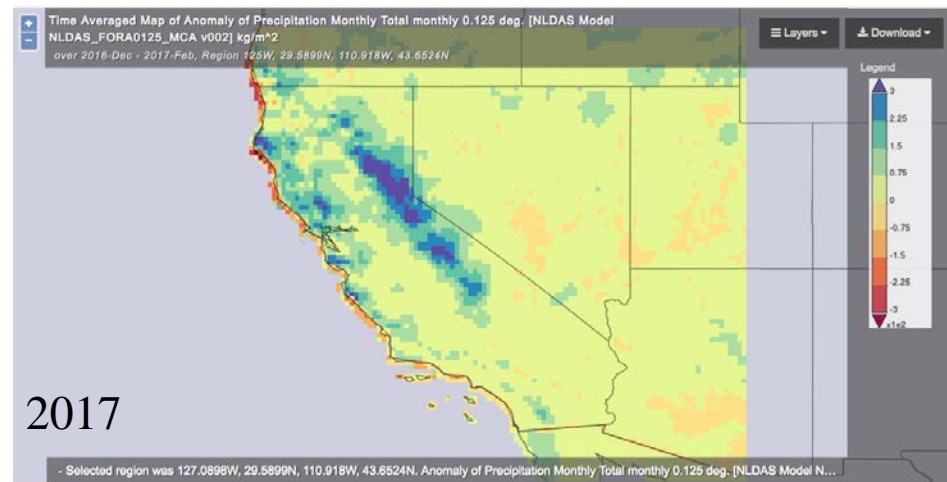
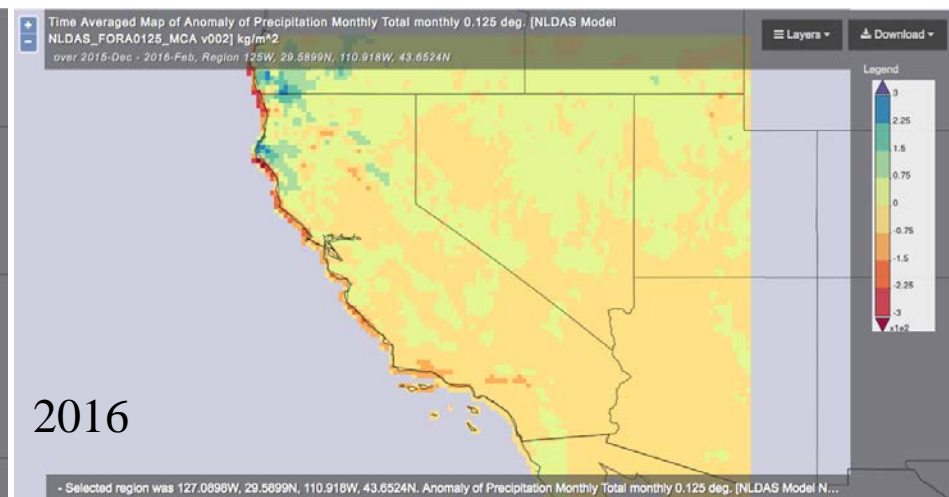
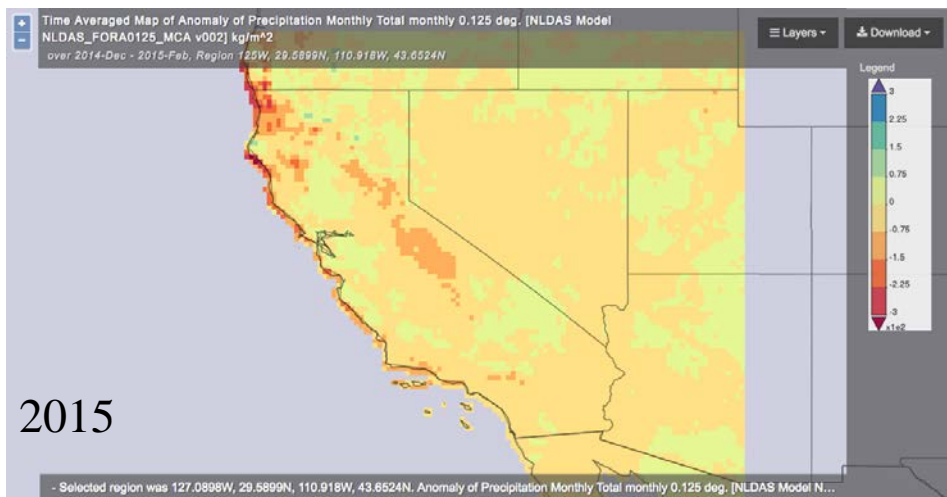


Map, Difference of Time Averaged over 2017-09-20, Region 67.4341W, 17.8235N, 65.5444W, 18.6365N
Daily accumulated precipitation (combined microwave-IR) estimate - Early Run daily 0.1 deg. [GPM GPM_3IMERGDE v05] mm minus
Daily accumulated precipitation (combined microwave-IR) estimate - Late Run daily 0.1 deg. [GPM GPM_3IMERGDL v05] mm





Example (California Droughts)



NLDAS Total Precipitation
Anomaly in Giovanni



Summary

- Global and regional precipitation datasets (satellite-based and data assimilation)
- Other datasets are available (temperature, wind, soil moisture, etc.)
- Data services (search, subsetting, format conversion, GIS, etc.)
- Giovanni (online tool for visualization, analysis, evaluation, etc.)
- User services



Information

- Data information and services:
<https://disc.gsfc.nasa.gov/> Search for: TRMM (GPM, TRMM, IMERG, NLDAS, GLDAS, MERRA)
- Giovanni: <https://giovanni.gsfc.nasa.gov> or Google search “NASA giovanni” Search for “GPM”, “TRMM”, “MERRA”, “GLDAS”
- Comments and suggestions: gsfc-help-disc@lists.nasa.gov