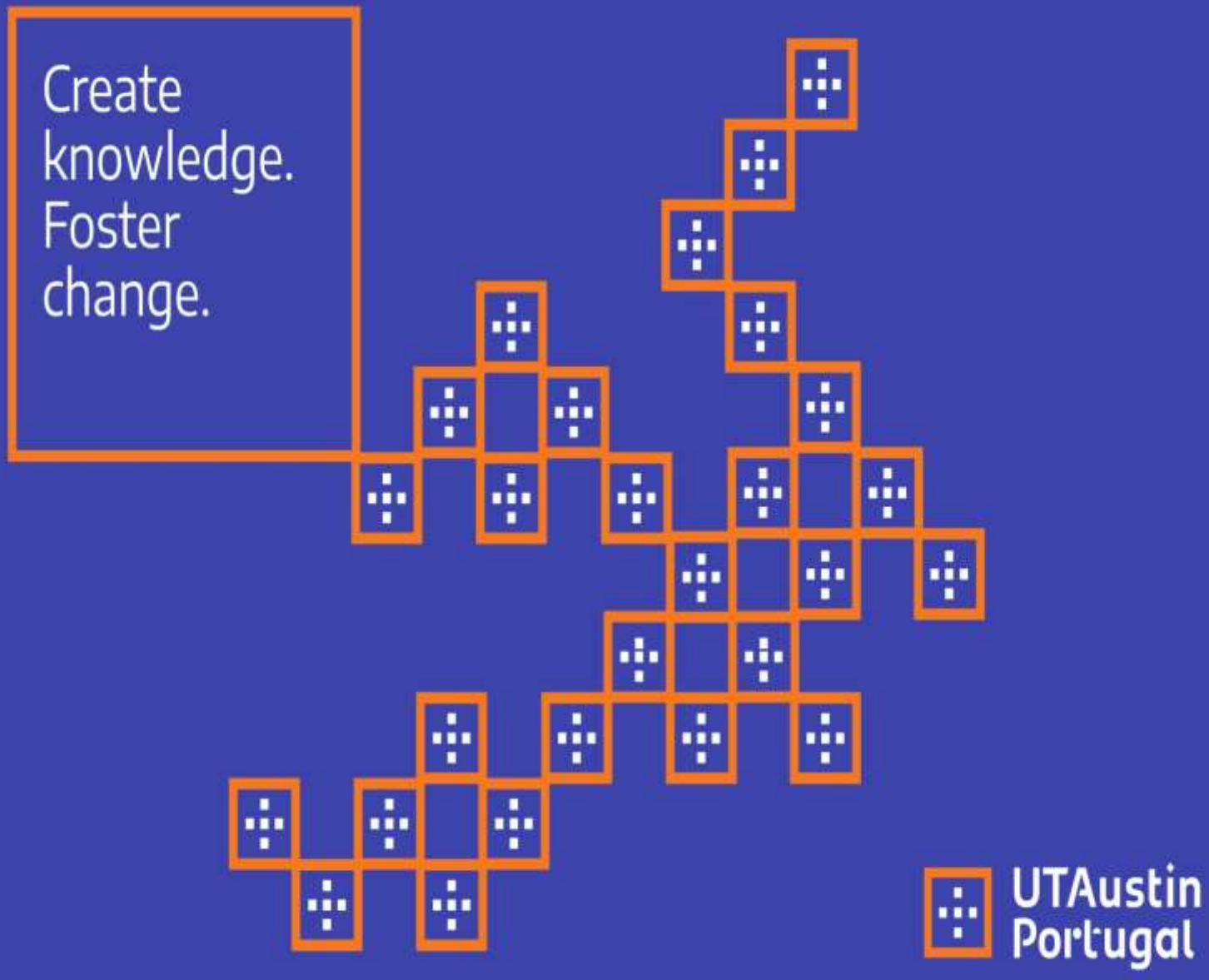

Create
knowledge.
Foster
change.
UTAustin
Portugal

Satellite-based Global Precipitation Data and Services at NASA GES DISC (Part I)

Zhong Liu

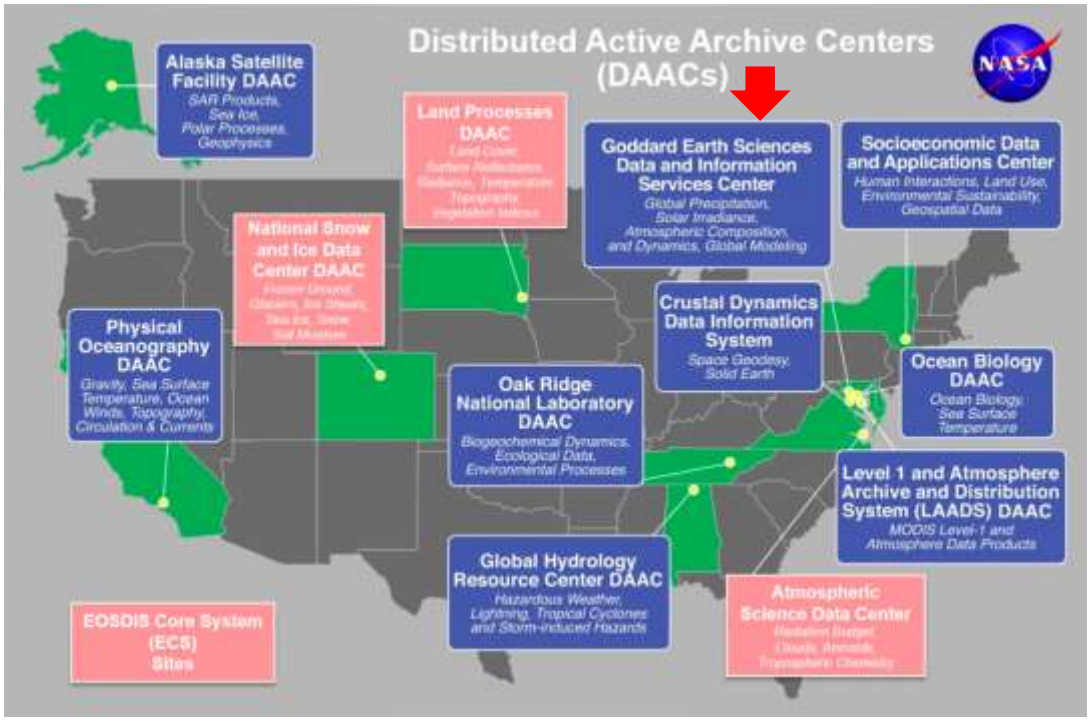
NASA Goddard Earth Sciences (GES) Data and Information Services Center (DISC)

CSISS, George Mason University

Outline

- A brief history of NASA GES DISC
- GES DISC data holdings
- Data services
- Giovanni (*easy-to-use online tool without downloading data and software*)
- Global and regional precipitation products at GES DISC
- Summary

About NASA GES DISC



The GES DISC, located in Greenbelt, Maryland, USA, is one of the **12 NASA ESDIS DAACs** that manage, archive and distribute Earth science data as part of the NASA's Earth Science Data Information Systems Program (ESDIS).

About GES DISC (cont.)

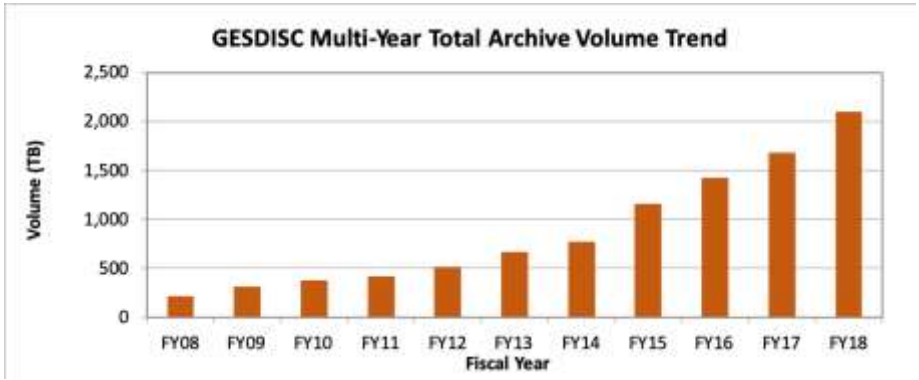
History:

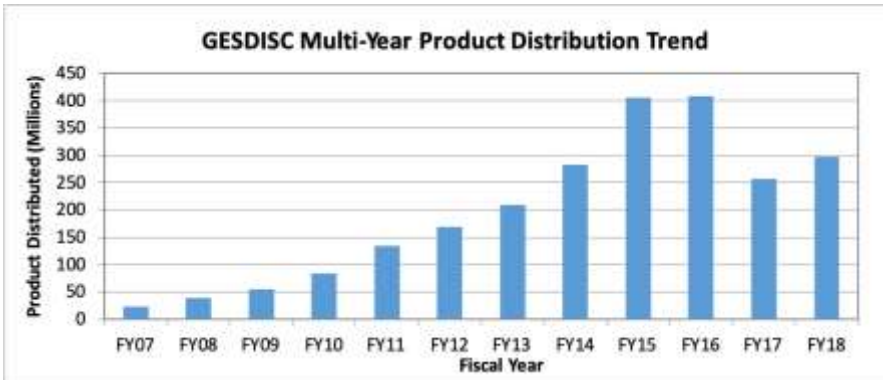
- Mid-1980's - one of two original DAACs (with Langley) - "Goddard DAAC"
- 1990's Version 0 era
  - AVHRR pathfinder
  - TOVS pathfinder
  - SeaWIFS
  - UARS
- 1997 - TRMM (first EOS launch)
- 2000/2002 - Terra/Aqua MODIS
- 2005/2006 - EOSDIS evolution - split Goddard DAAC:
  - GES DISC - atmosphere/hydrology/climate
  - Level 1 and Atmospheres Archive Distribution System (LAADS) - MODIS instrument
  - Ocean Biology DAAC - ocean biology

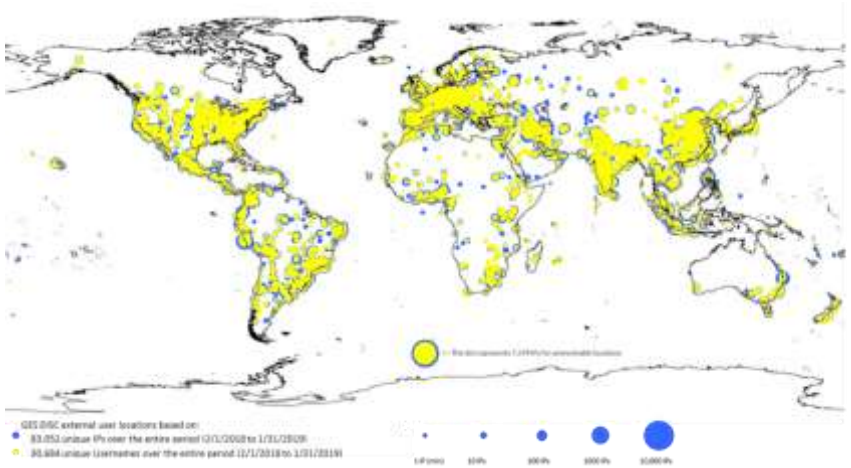
About NASA GES DISC (cont.)

- Archives total volume > **2.3 Petabytes** consisting of >**100 million data files** covering >**3000 public and restricted collections**.
- Multi-disciplinary data holdings include observations and model data of:
  - **atmospheric composition**
  - **water/energy cycles**
  - **climate variability**
- Through various available tools and services, the GES DISC provides users with **multi-sensor and model visual comparisons** and data access for a number of **projects spanning several disciplines**.

About NASA GES DISC (cont.)







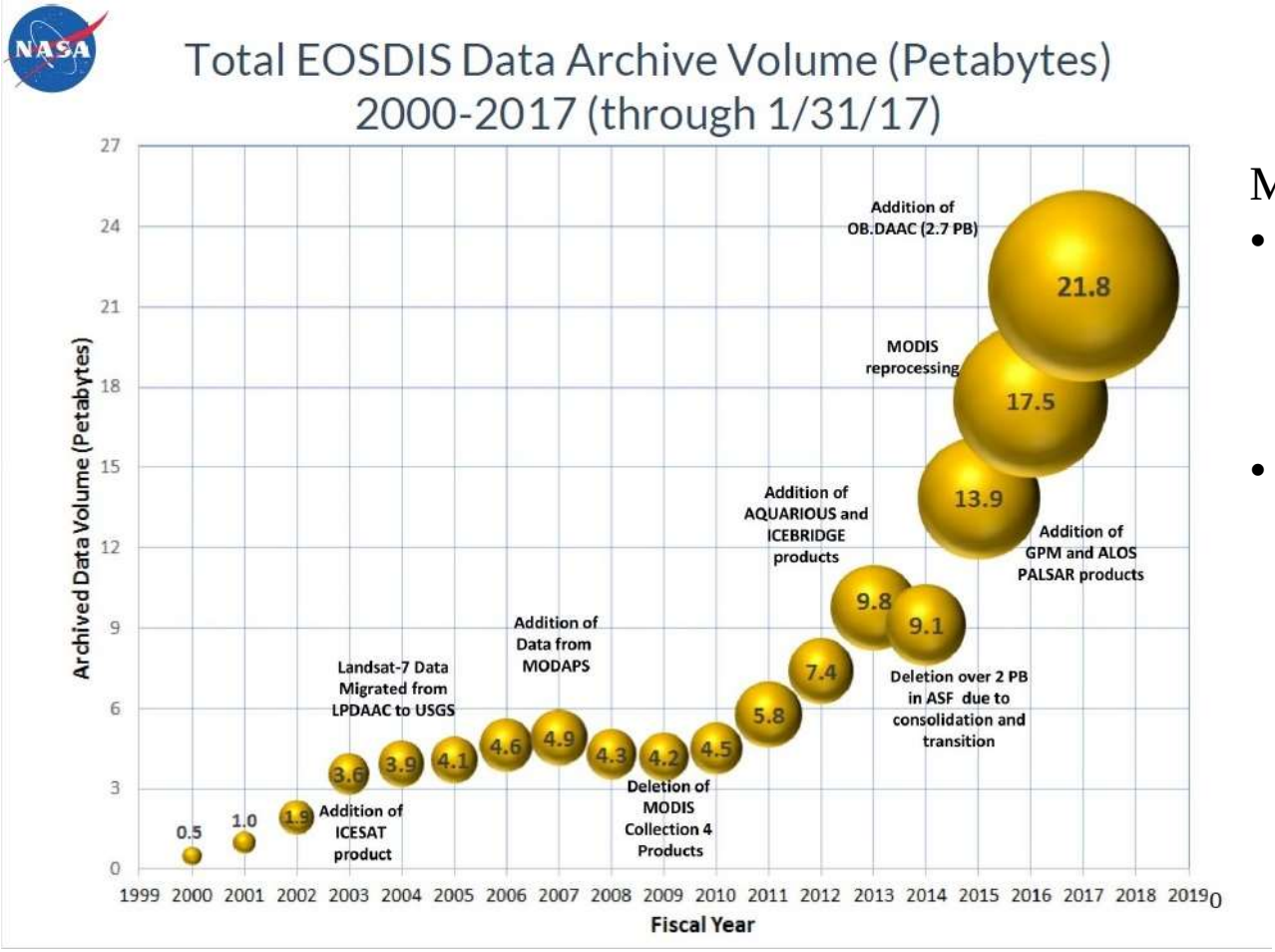
User locations from 2/1/2018 to 1/31/2019
83,052 unique IPs over the entire period
30,684 unique Usernames over the entire period

Archive Size: **2,296.372** TB
Archived Data Files: **117,565,233**
(Single copy does not include backup copies)

Files Distributed*: 2,446,913,954
Data Volume Distributed*: 23,480.012 TB

As of 02/20/2019
** Since 2010*

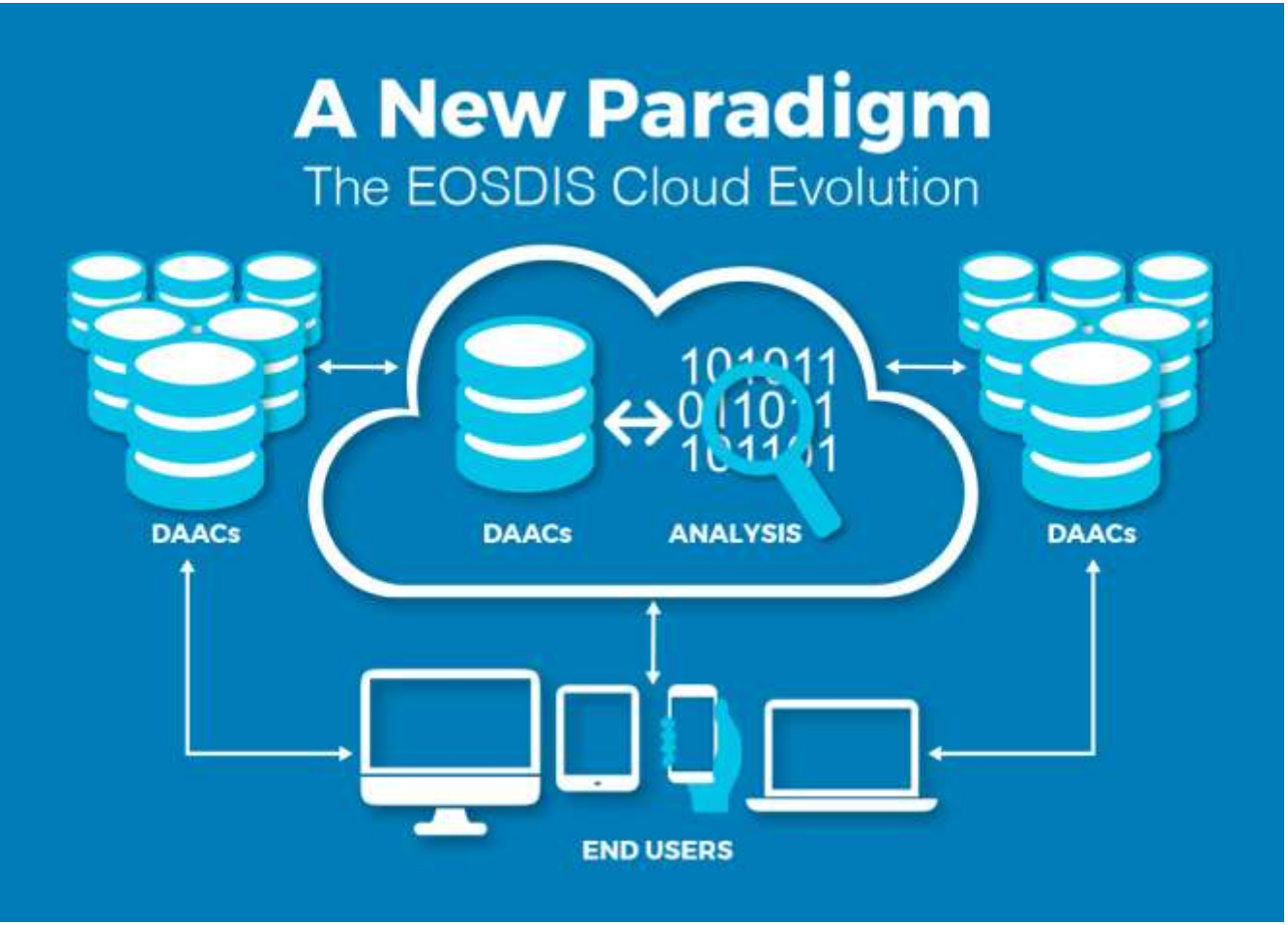
About NASA GES DISC (cont.)



Many **challenges** such as:

- What can we do with the increasing data volume and variety (e.g. data discovery, access)?
- How can we do interdisciplinary research with data archived and distributed across the 12 DAACs?

About NASA GES DISC (cont.)



A primary feature of NASA EOSDIS Cumulus is a cloud-based framework for data ingest, archive, distribution, and management, which are the primary activities of the discipline-specific Distributed Active Archive Centers (DAACs).

Source: Earth Science Data in the Cloud: The EOSDIS Cumulus Project (https://earthdata.nasa.gov/eosdis-cumulus-project)

About NASA GES DISC (cont.)

- The GES DISC is a **certified trusted repository** as a Regular Member of the International Council for Science (ICSU) World Data System (WDS)
- We provide the support for the archive and distribution of the data for **over 35** multiple satellite sensors, ground measurements, field campaigns, models; as well as data developed by science community members.
- **Multi-disciplinary archive** in the 5 of 6 NASA Earth science focus areas of atmospheric composition, weather and atmospheric dynamics, climate variability and change, water and energy cycle, and carbon cycle.
- Archive over **2.3 PB** of data, **2500 data products** and have disseminated over **23 PB** of data, including precipitation products from NASA missions/projects (GPM, TRMM, MERRA-2, NLDAS, GLDAS, FLDAS, GPCP, etc.)
- Follows data publication process and ESDIS standards for metadata, format and citation recommendations including **Digital Object Identifiers (DOIs)**

GES DISC Data Holdings

1200+ data collections being curated

Atmospheric composition missions:
- Nimbus 1-7* BUV, SBUV, TOMS
- Shuttle SBUV*
- UARS*
- Aqua AIRS
- Aura HIRDLS*, OMI, MLS
- ACOS*
- SNPP Sounder, OMPS
- JPSS-1 Sounder, OMPS
- OCO-2
- Copernicus Sentinel 5P
- TOVS Pathfinder*

Water cycle/precipitation missions:
- TRMM*
- GPM
- SMERGE

Climate variability/solar missions:
- SORCE
- TCTE
- TSIS
- CAR

Model data:
- MERRA*/MERRA-2
- NLDAS, GLDAS, FLDAS, NCA-LDAS

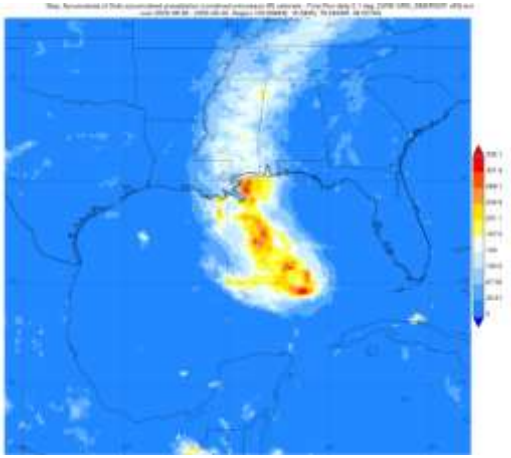
Research-derived data:
- MEaSUREs
- CMS

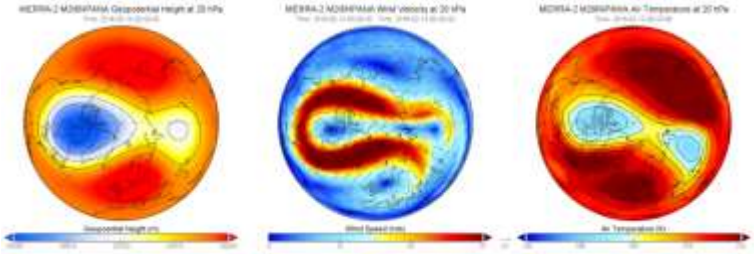
Near-real time:
- AIRS
- MLS
- **TMPA**
- **IMERG**

Future assigned missions:
- OCO-3
- TROPICS
- Copernicus Sentinel 6
- GeoCarb

** end-of-mission/project*

Hurricane Katrina (GPM IMERG)





polar vortex from MERRA-2

Data Services and Support

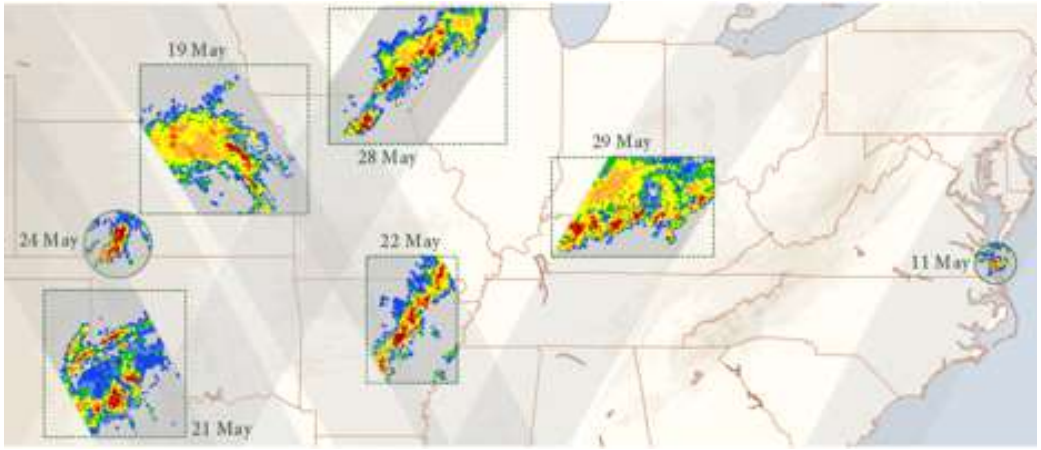
- Metadata support, documentation, metrics:
  - Assignment of DOIs
    - Includes recommended data set citation, hosting of data set landing pages, documentation
  - Generation of metadata records, publication to the EOSDIS Common Metadata Repository (CMR)
  - Publication of data **distribution metrics** to the EOSDIS Metrics System (EMS)
- Web-based discovery and access to products
- Value added services on data
  - Giovanni
  - Sub-setting, reformatting and re-gridding
  - Access protocols (e.g., OPeNDAP)
- User Services – provide tiered support in data access and use:
  - GES DISC User Services (first tier)
  - GES DISC science data specialist (second tier)
  - Collaboration with science team subject matter experts (third tier)
- Community Engagement:
  - Workshops and webinars on the use of data and relevant services
  - Conference participation, publications, news releases
    - Engagement with Applications Community
      - Applied Remote Sensing Training Group (ARSET), Disasters Working Group, Heath and Air Quality Applied Sciences Team (HAQAST), Land and Atmospheres near real time Capabilities for EOS (LANCE).

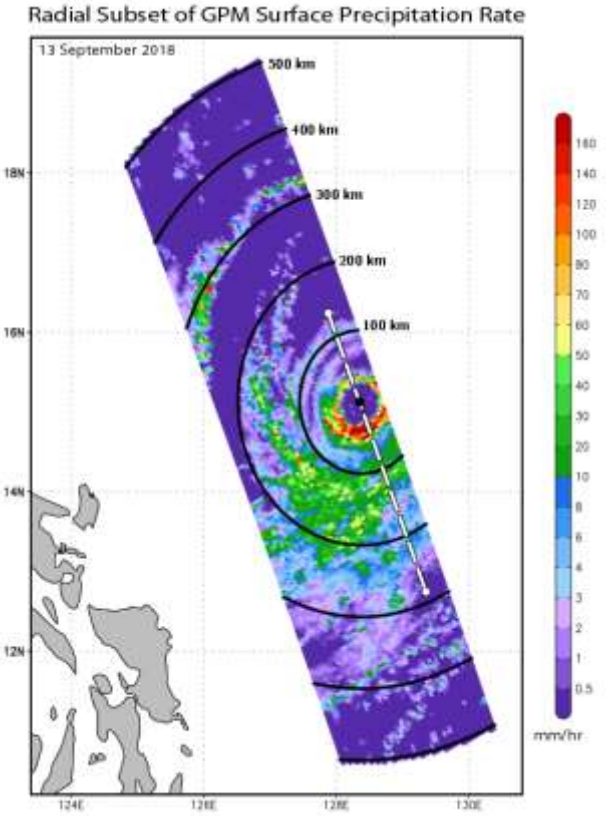
Tools and Services

GES DISC spatial and reformatting services for L2 and L3/4 data allow users to create subsets of the data to reduce download volume and get only what they need for their research, including:

- Spatial sub-setting
- Temporal search
- Temporal sub-setting
- Variable sub-setting
- Vertical sub-setting
- Calculate daily means
- File format conversion
- Re-grid L3/4 data from native grid to user-specified grid

Tools and Services

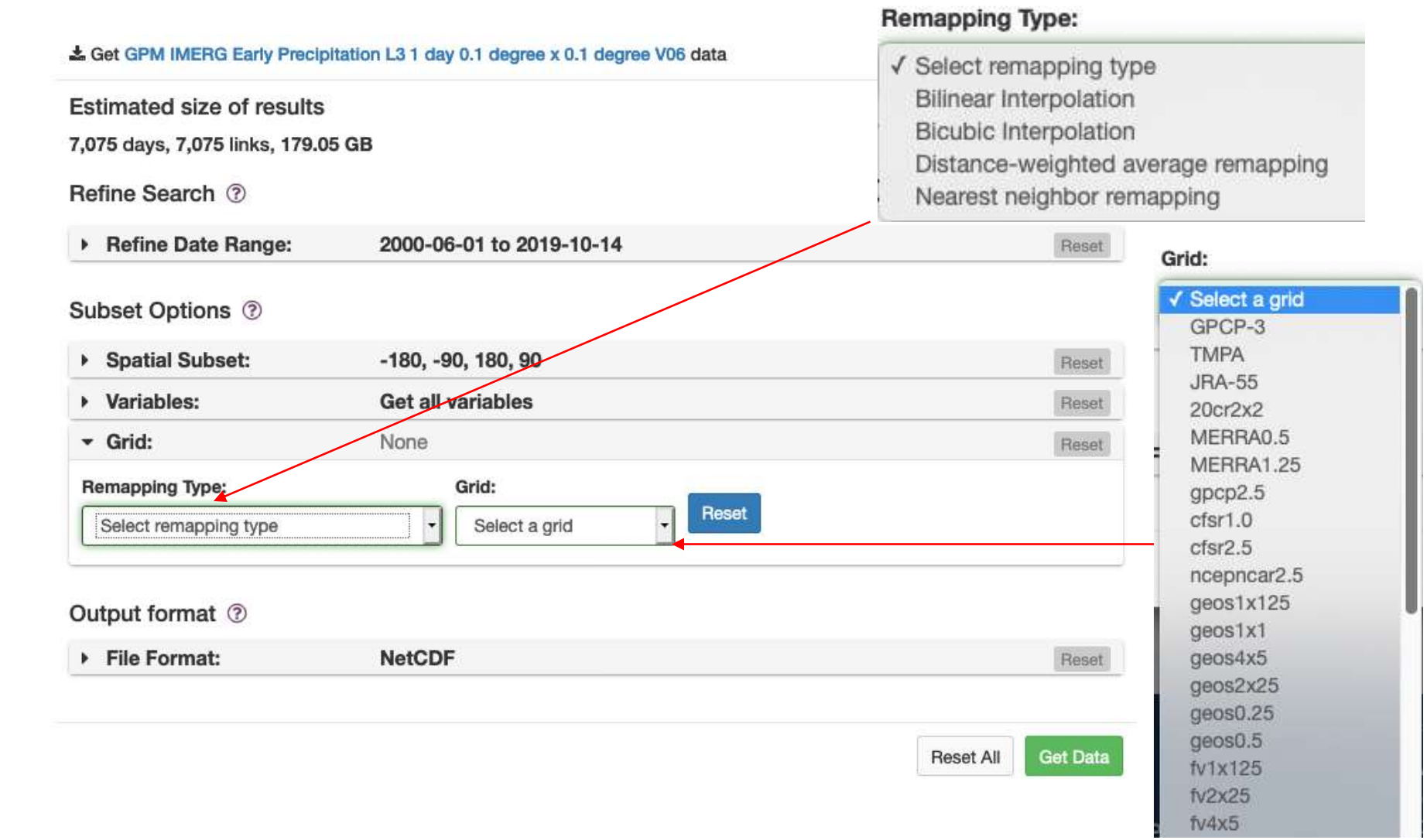




Top Left: GPM Dual-Frequency Precipitation Radar (DPR) observed occurrences of tornado outbreaks in the Midwestern and Eastern United States in May 2019. The image shows extreme rainfall accompanying the tornadoes reported on the dates shown. Red indicates rain rates greater than 25 millimeters (~1 inch) per hour. The light grey regions show the entire swath over the geographical area; darker grey regions containing precipitation contours show the subsetted portions of the full swaths. The data from May 19, 21, 22, 28, and 29 use a box subset, and the data from May 11 and 24 use a point/radius search subset.

Top Right: GPM_2ADPR Near-Surface Precipitation Rate ("/NS/SLV/precipRateNearSurface") subset within 500 km of the eye of Typhoon Mangkhut on 13 September 2018.

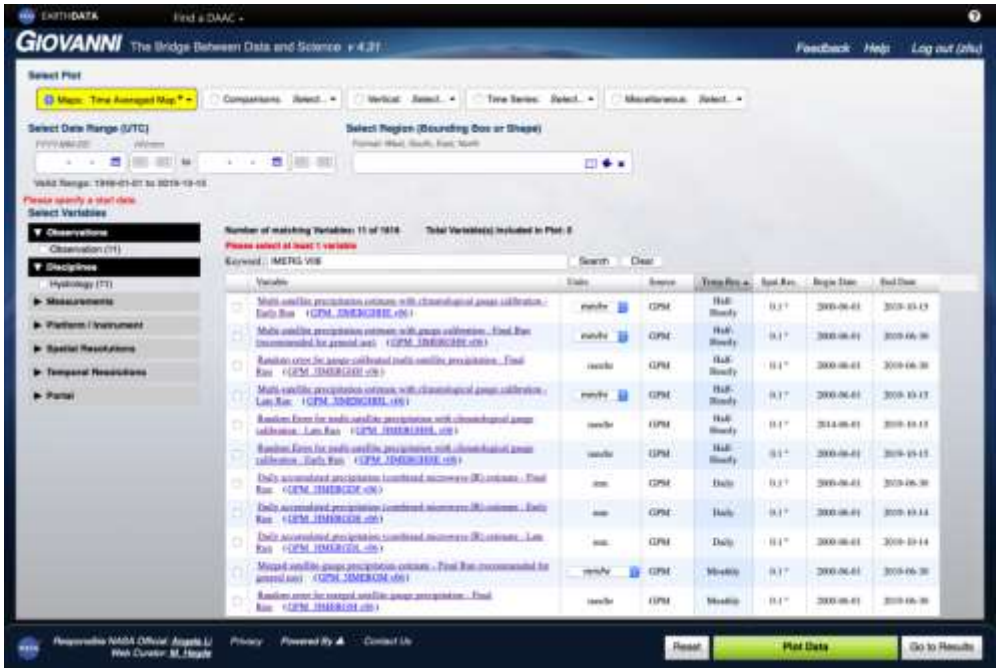
Tools and Services



NASA GES DISC Giovanni

The GES DISC Interactive Online Visualization and Analysis Infrastructure (Giovanni) provides the means to perform 22 visualizations on ~2000 variables from six different DAACs.

https://giovanni.gsfc.nasa.gov/giovanni/



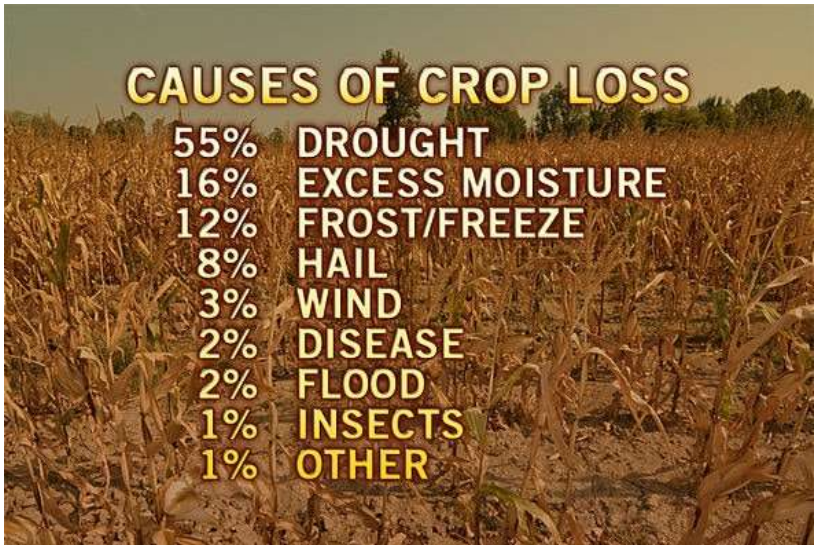
Global Precipitation Products

- Introduction
- Overview of precipitation products at GES DISC
- Issues in satellite-based precipitation products

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 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/

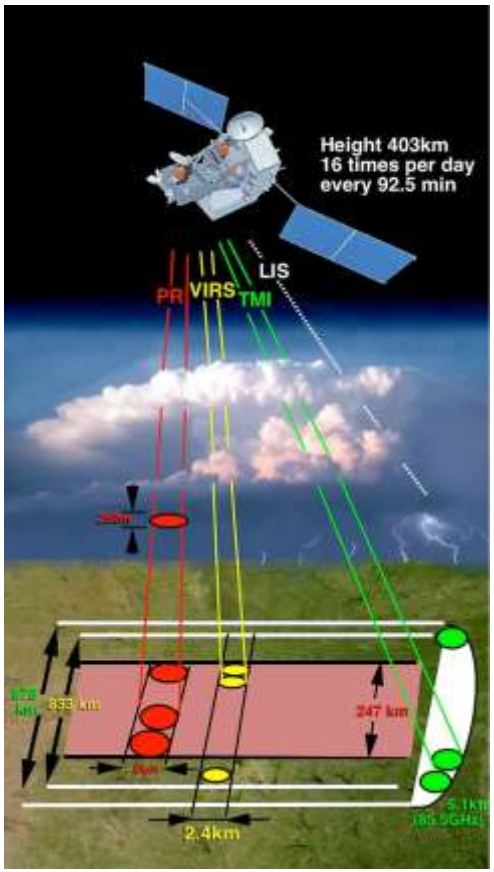
Source: International Water Management Institute, 2010, Issue 10.

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).

TRMM (Tropical Rainfall Measuring Mission)

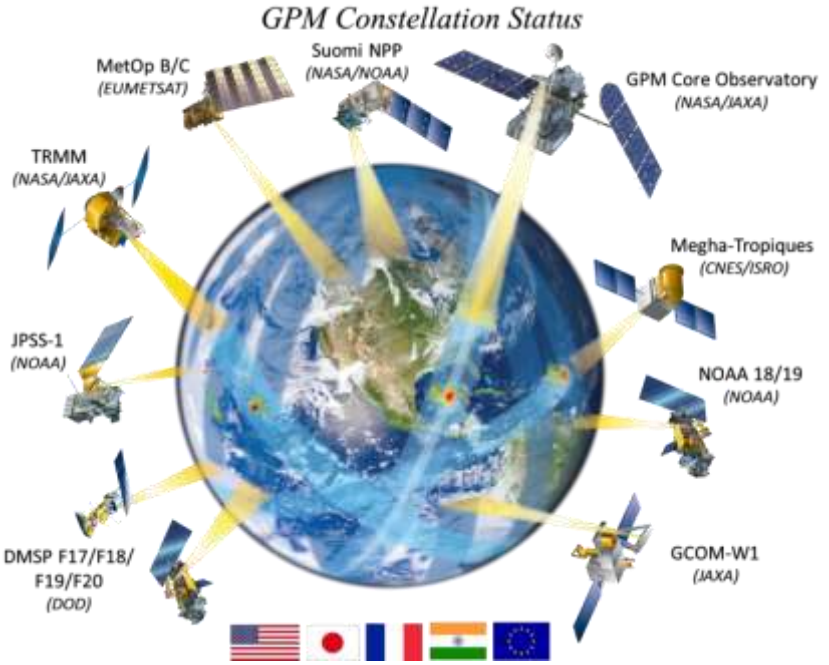
- NASA/JAXA mission (Nov. 1997 – Apr. 2015) to monitor and study tropical rainfall
- Precipitation related instruments (TMI, PR, LIS, VIRS)
- Orbital and gridded datasets
- Single sensor, multi-sensor, multi-satellite datasets.



Source: trmm.gsfc.nasa.gov

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.



Source: pmm.nasa.gov

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) – to be retired soon (Dec. 31, 2019)
- Integrated Multi-satellitE Retrievals for GPM (IMERG, NRT and research, 0.1-deg., 0.5-hr, monthly, 06/2000 – present), Version 06
- GPCP (Global Precipitation Climatology Project). Version 3.0 (1983 – 2016)
- 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)

TRMM Version 8 Status

- Beginning with TRMM Version 8 (V8) reprocessing, TRMM and constellation data became part of the GPM data suite, with **GPM algorithms** used for reprocessing. The TRMM data format, as well as the file naming conventions, are now consistent with those of GPM.
- Thus, the TRMM data is now fully incorporated into the Global Precipitation Measurement (GPM) data processing stream. Products are exclusively in GPM HDF5 format.
- The mapping between the New and Legacy TRMM data products is available.

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.

Some contents from: http://trmm.chpc.utah.edu/

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

Acknowledgements:

We thank scientists and engineers at GES DISC for their contributions to data management, distribution, and development of data services. We also thank scientific investigators and many users for their feedback and suggestions that improve our data services. GES DISC is funded by NASA's Science Mission Directorate.

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**