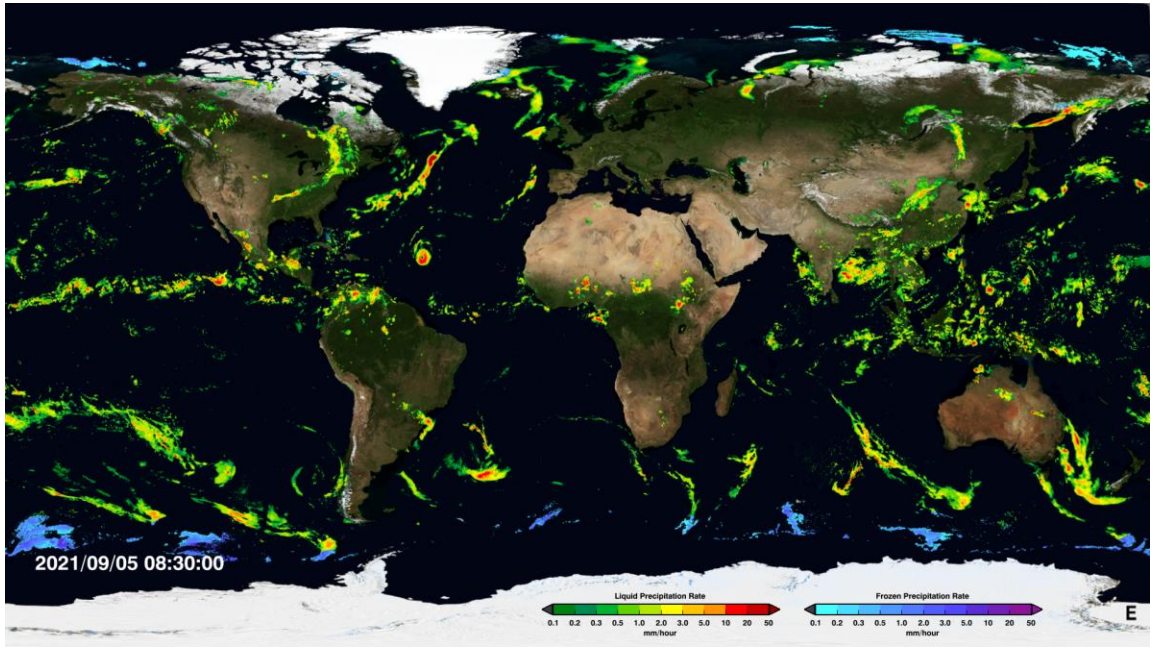
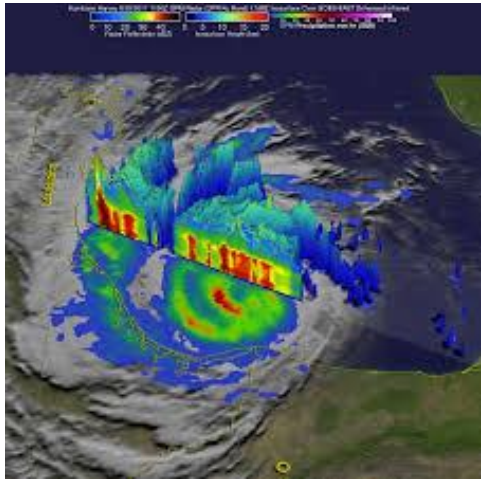
Joint GPM-IPWG Applications Training

Part 2: GPM Precipitation Data Applications





Today's Training Conveners:
Andrea Portier, NASA GSFC- SSAI
Amita Mehta, NASA GSFC-UMBC-JCET

15 September 2021

Session 2 Objectives

- Become familiar with GPM resources and learn how to access GPM data
- Description of GPM's IMERG data record, data access, analysis, and visualization
- View examples of GPM precipitation applications, highlighting a case study of GPM and Google Earth Engine

GPM-IPWG Training: Session 1 Recap

Session 1

September 8th

Introductory session on the International Precipitation Working Group (IPWG):

- Focused on operational and research satellite based quantitative precipitation measurement issues and challenges
  - Validation, research, applications, data assimilation, scattering
  - Data access:

http://ipwg.isac.cnr.it/data/datasets.html

GPM-IPWG Training: Session 1 Recap

Session 1

September 8th

- Overview of Precipitation Measurement Missions (PMM)

Past and Current Missions:

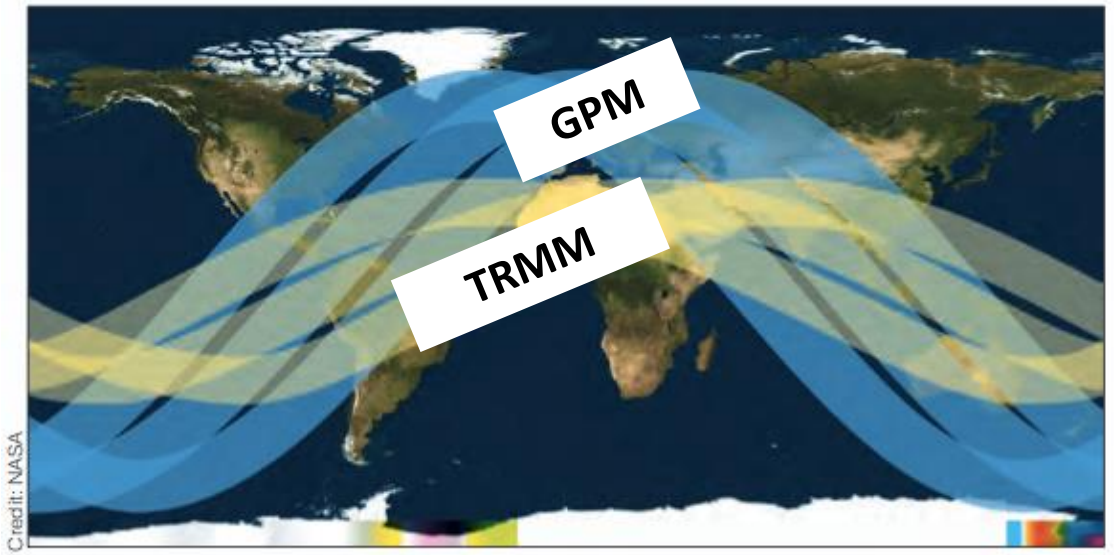
TRMM: Tropical Rainfall Measuring Mission	11/1997 – 04/2015
GPM: Global Precipitation Measurement Mission	02/2014 – present

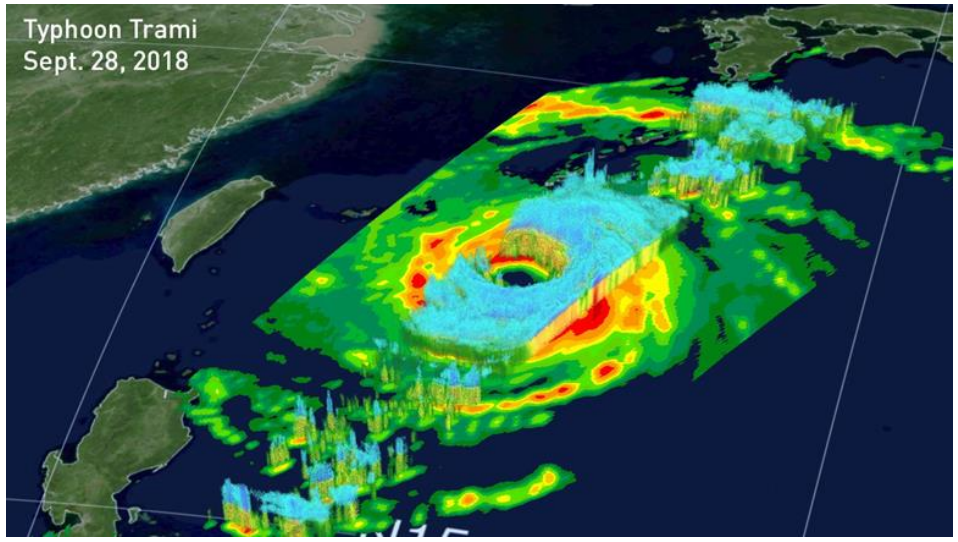
- Data Products (e.g., Integrated Multi-satellitE Retrievals for GPM (IMERG))

Overview: Global Precipitation Measurement (GPM) Mission

https://gpm.nasa.gov/

- Core satellite launched Feb 27, 2014
  - Non-polar, low-inclination orbit
  - Altitude: 407 km
- TRMM to GPM
  - TRMM was designed to measure heavy to moderate rainfall in the tropics and subtropics
  - GPM can measure everything from light rain to heavy rain and falling snow
- Sensors:
  - GMI (GPM Microwave Imager)
  - DPR (Dual Precipitation Radar)
- An consortium of international satellites contribute measurements to GPM mission
  - GPM has a revisit time of 2-4 hrs. over land





Overview: GPM Multi-satellite Product, IMERG Version 6 Data

- GPM Core satellites are used to calibrate microwave observations from a constellation of national and international satellites
- Multiple runs for different user requirements for latency and accuracy
  - "Early" – 4 hr. (flash flooding)
  - "Late" – 14 hr. (crop forecasting)
  - "Final" – 3 months (research)
- Time intervals are half-hourly , daily and monthly (final only)
- 0.1º global grid
- Extends from June 2000 to present
- Overall calibration is provided by TRMM and GPM Combined Radar-Radiometer Algorithm. TRMM June 2000-May 2014, GPM thereafter.

https://gpm.nasa.gov/science/precipitation-algorithms#multi-satellitealgorithms

GPM Application Activities

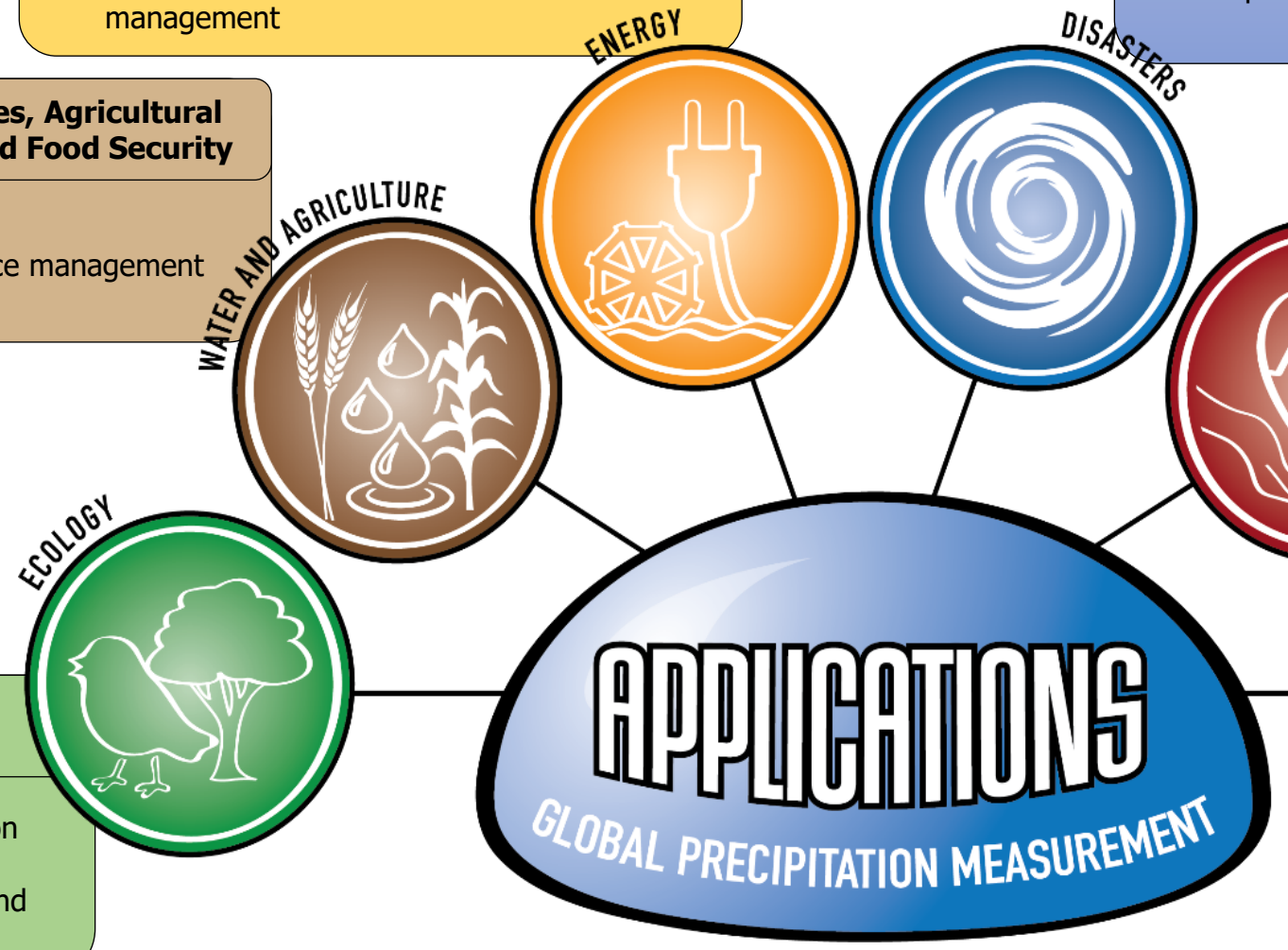
Applications = innovative uses of mission data products in decision-making activities for societal benefit.

- Mission Applications take a satellite's data products and expand them into areas where they can help inform policy or decisions.

*GPM precipitation products help advance societal applications by addressing the needs of end users and to support decision-making.

*GPM precipitation observations can be quickly and easily accessed via various data portals.

GPM Societal Benefit Areas



Energy Infrastructure and Management

- Energy infrastructure and management
- Alternative energy development/ management

Disasters and Risk Management

- Flooding
- Landslides
- Tropical Cyclones
- Re-insurance
- Wildfires
- Disaster Response

Water resources, Agricultural Forecasting, and Food Security

- Drought
- Water resource management
- Food security

Development and Public Health

- Disease Tracking
- Transportation

Ecological Management

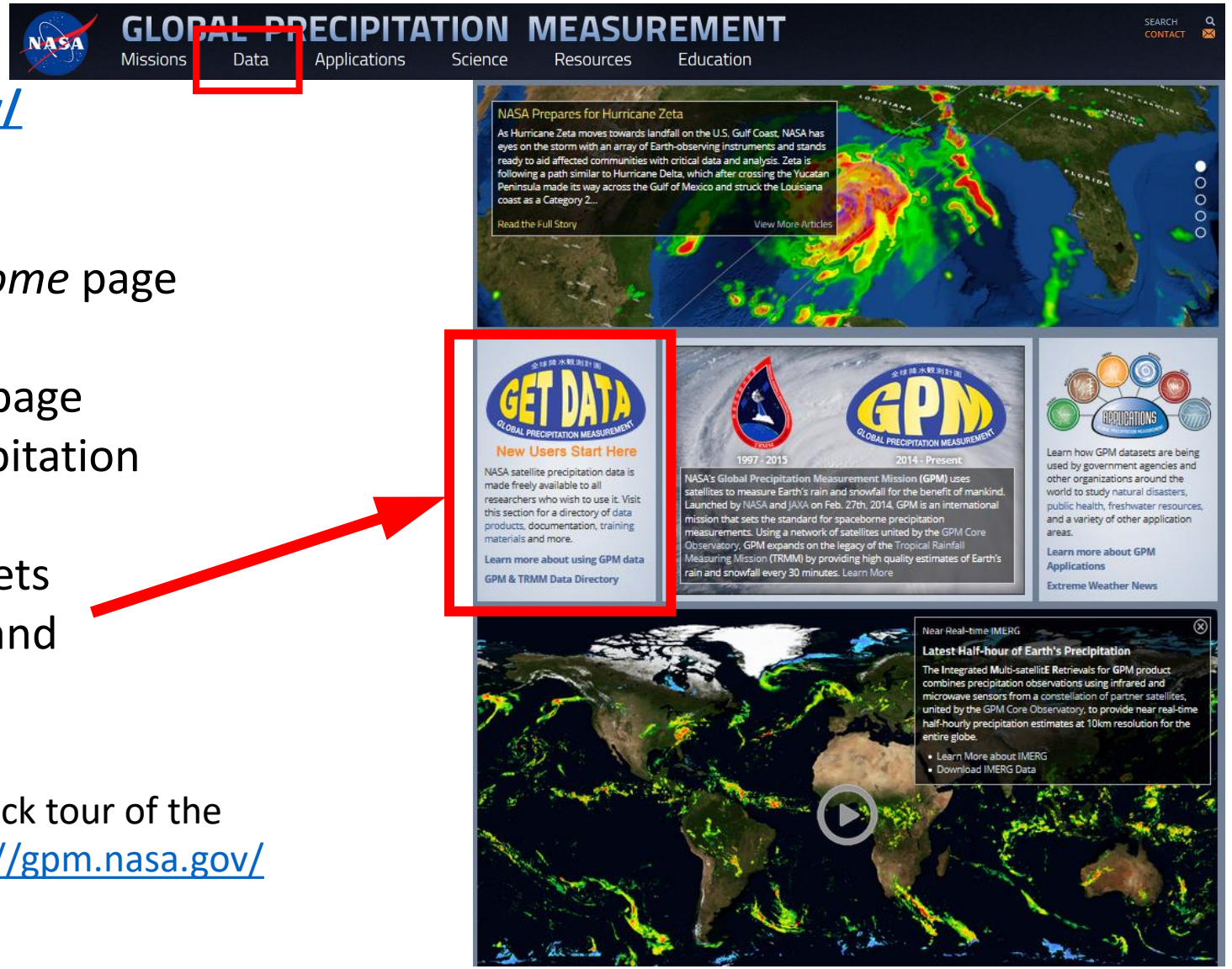
- Animal Migration
- Ecological Management and Sustainability

Weather, Climate, and Land Surface Modeling

- Numerical Weather Prediction
- Climate variability and change
- Land Surface Modeling

GPM Webpage and Data Resources

- GPM Webpage: https://gpm.nasa.gov/
- Mobile friendly layout
- Handful of resources on the GPM *Home* page
  - Latest GPM coverage stories
  - Direct link to GPM Applications page
  - Latest Half-hour of Earth's Precipitation
  - Upcoming Events
  - Latest @NASA Atmosphere Tweets
  - Direct access to data resources and downloads

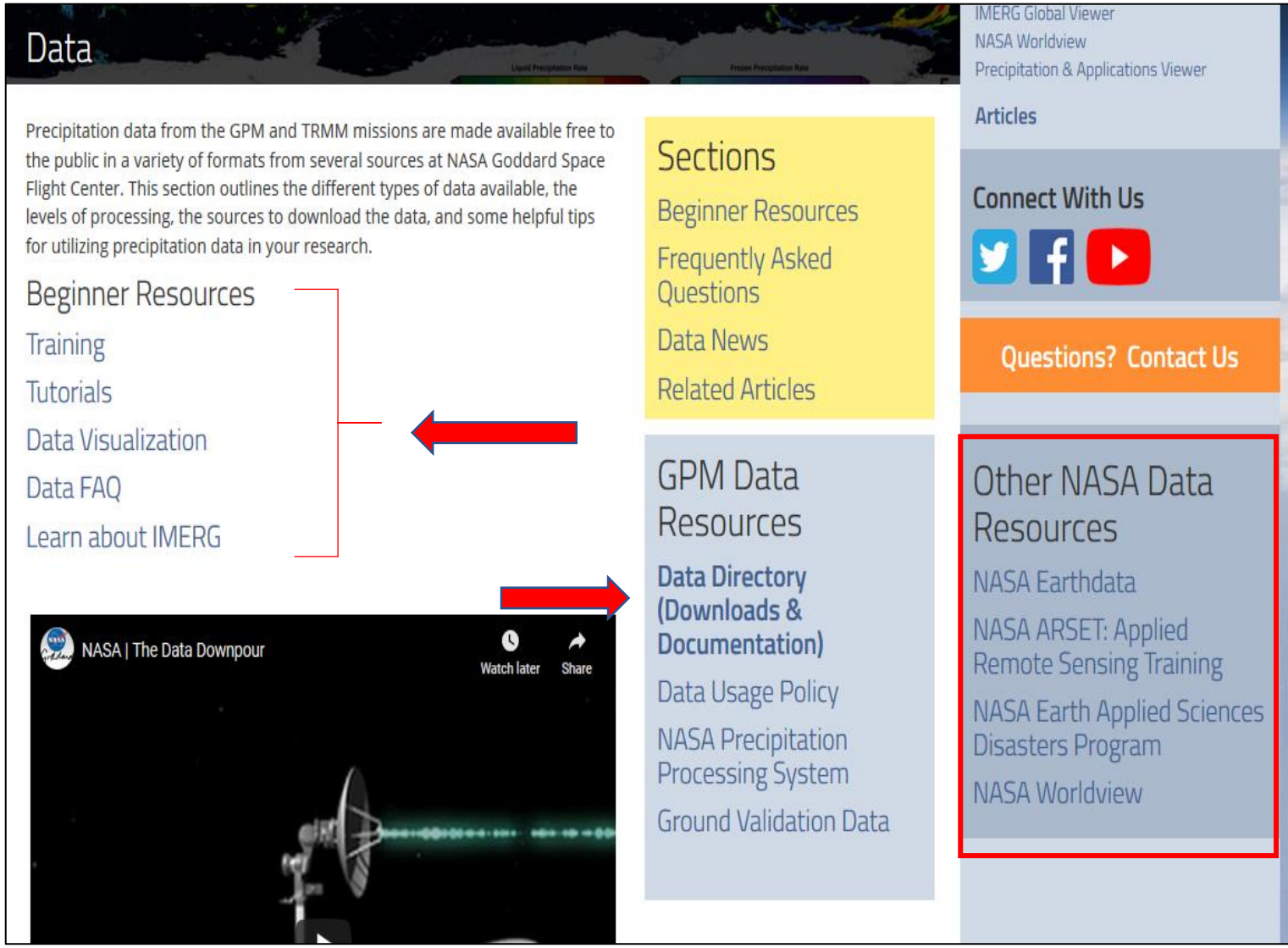


Let's take a look…. A quick tour of the NASA GPM Page, https://gpm.nasa.gov/

GPM Data Portal

https://gpm.nasa.gov/data

- Multiple data access sources for GPM
  - Beginner resources: trainings, tutorials, data visualization, FAQ
  - Data directory (downloads), https://gpm.nasa.gov/data/directory
  - Link to other key NASA resources



GPM Beginner Resources: Trainings

https://gpm.nasa.gov/data/training

- Beginner Resources
- Training
- Tutorials
- Data Visualization
- Data FAQ
- Learn about IMERG

Training

Beginner Training Sessions

Overview of Global Precipitation Measurement (GPM) Mission, Data Products and Data Access Tools

Topics Covered:

- Learn about the GPM Core Observatory satellite: Orbital Configuration, Sensors (GMI, DPR) GPM Constellation Satellites
- Learn about GPM precipitation data products: Level-2 to Level-3 Data Sets from GMI, DPR and Combined GMI-DPR, IMERG Filename Conventions, Formats Spatial and Temporal Resolutions and Coverage Data Search and Access Web-tools Data Quality Potential Data Applications

Training Resources:

- View a recording of the webinar
- Download the webinar slides (pdf)

Introductory Webinar: Overview and Applications of Integrated Multi-Satellite Retrievals for GPM (IMERG) Long-term Precipitation Data Products

Topics Covered:

- Become familiar with the TRMM / GPM Missions, GPM data products, and GPM applications
- Understand IMERG and the strengths and caveats of the long-term IMERG data record
- Find previous training webinars related to GPM precipitation
- Learn to access, analyze, and visualize IMERG precipitation data using NASA web-tools

Recent Training Sessions

(2017 - 2020)

Expand All

- Advanced Webinar: Applications of GPM IMERG Reanalysis for Assessing Extreme Dry and Wet Periods +
- Introductory Webinar: Overview and Applications of Integrated Multi-Satellite Retrievals for GPM (IMERG) Long-term Precipitation Data Products +
- Using NASA Earth Observations to Predict and Monitor Vector-borne and Water-related Diseases - Advanced Level +
- Using NASA Earth Observing Data for Monitoring and Response to Vector-borne and Water-borne Diseases +
- GPM Agricultural Applications Workshop +
- Status of Global Precipitation Measurement (GPM) Mission Data Products and Applications +
- NASA Remote Sensing for Flood Monitoring and Management +

Older Training Sessions

(2015 - 2016)

GPM Beginner Resources: Tutorials

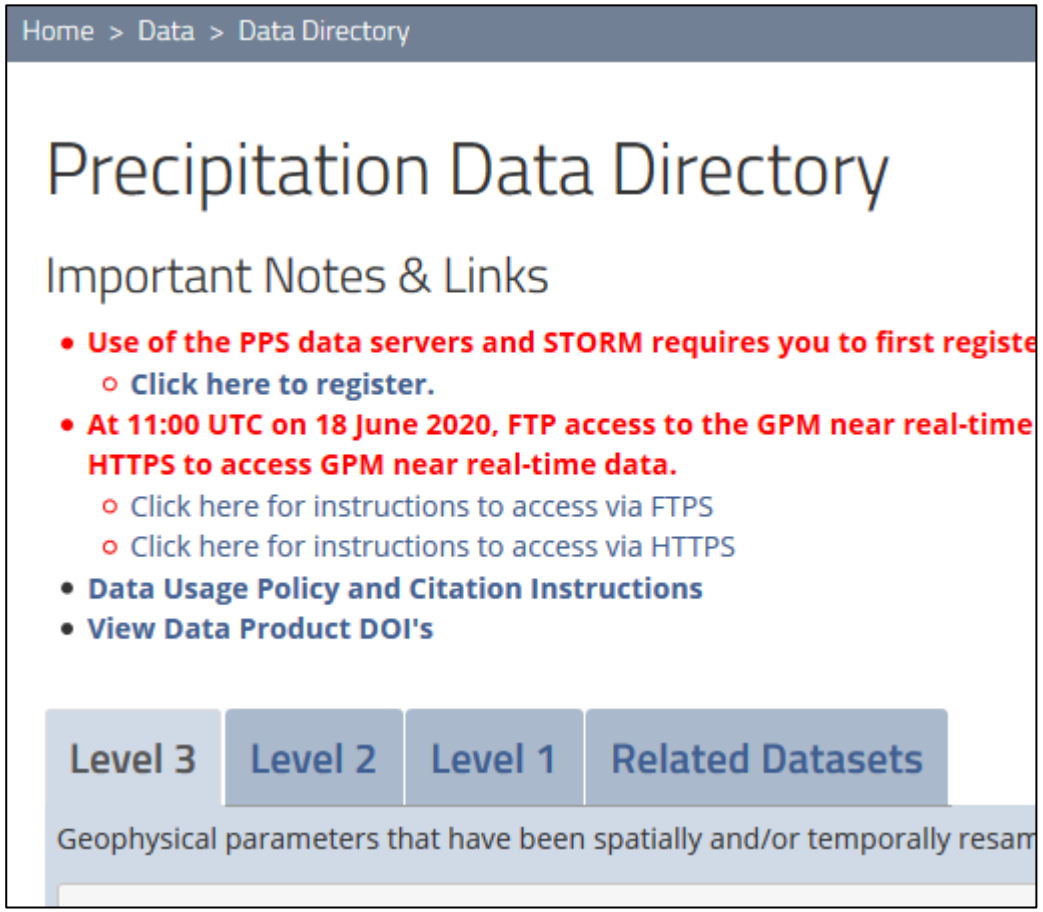
https://gpm.nasa.gov/data/tutorials

- Beginner Resources
- Training
- Tutorials
- Data Visualization
- Data FAQ
- Learn about IMERG

- Visualize GPM Precipitation Radar Data in 3D Using STORM Virtual Globe
- Create a Map or Graph of Rainfall Totals for a Specific Date Range and Location Using GES DISC Giovanni
- Read GPM IMERG Data Using Python
- Display GPM / TRMM HDF Data Files Using THOR
- Import Gridded GPM / TRMM Data in NetCDF Format into ArcGIS

GPM Data Access

https://gpm.nasa.gov/data/directory



GPM Data Directory

- Access to all 3 GPM product levels (geolocated data to gridded precip products)
- Each product level provides information:
  - Description of product
  - Dates covered
  - Latency
  - Resolution
  - Technical documentation

Data Processing Levels

https://gpm.nasa.gov/data/directory

Level 0 Raw Instrument Data

↓

Level 1 Geolocated and Calibrated

↓

Level 2 Geophysical Data Product Derived from L1 Data

↓

Level 3 Composites Of Level 2 Data Products

Level 1 and 2 Orbital Data
Highest spatial/temporal resolution

Precipitation Data
L-2 and L-3

Level 3 Gridded Data
Lower spatial/temporal resolution but gridded and may be available at multiple spatial/temporal resolutions

Level-2 Data

https://gpm.nasa.gov/data/directory

Level 3 | Level 2 | Level 1 | Related Datasets

Derived geophysical parameters at the same resolution and location as those of the Level 1 data.

As of the GPM Version 6 reprocessing cycle, the radars on both the TRMM and GPM satellites have their data products written in the HDF5 file format. Also as of Version 6 the research products are stored in the same FTP archive for both satellites, ftp://pps.gsfc.nasa.gov/. The FTP archive is organized into directories whose names are "yyyy/mm/dd/radar/" where yyyy, mm, and dd are the four-digit year and the two-digit month and day of month, respectively. In prior reprocessing cycles, TRMM and GPM data products were stored in different FTP archives. As of May 2020, PPS distributes near-realtime GPM data via FTPS and HTTPS rather than FTP. A similar switch is expected to occur with research data products later in 2020.

2B Combined
- Single-orbit rainfall estimates from combined radar/radiometer data (GPM GMI & DPR, TRMM TMI & PR)

2A Radar
- Single-orbit radar rainfall estimates for GPM DPR, Ka, Ku and TRMM PR

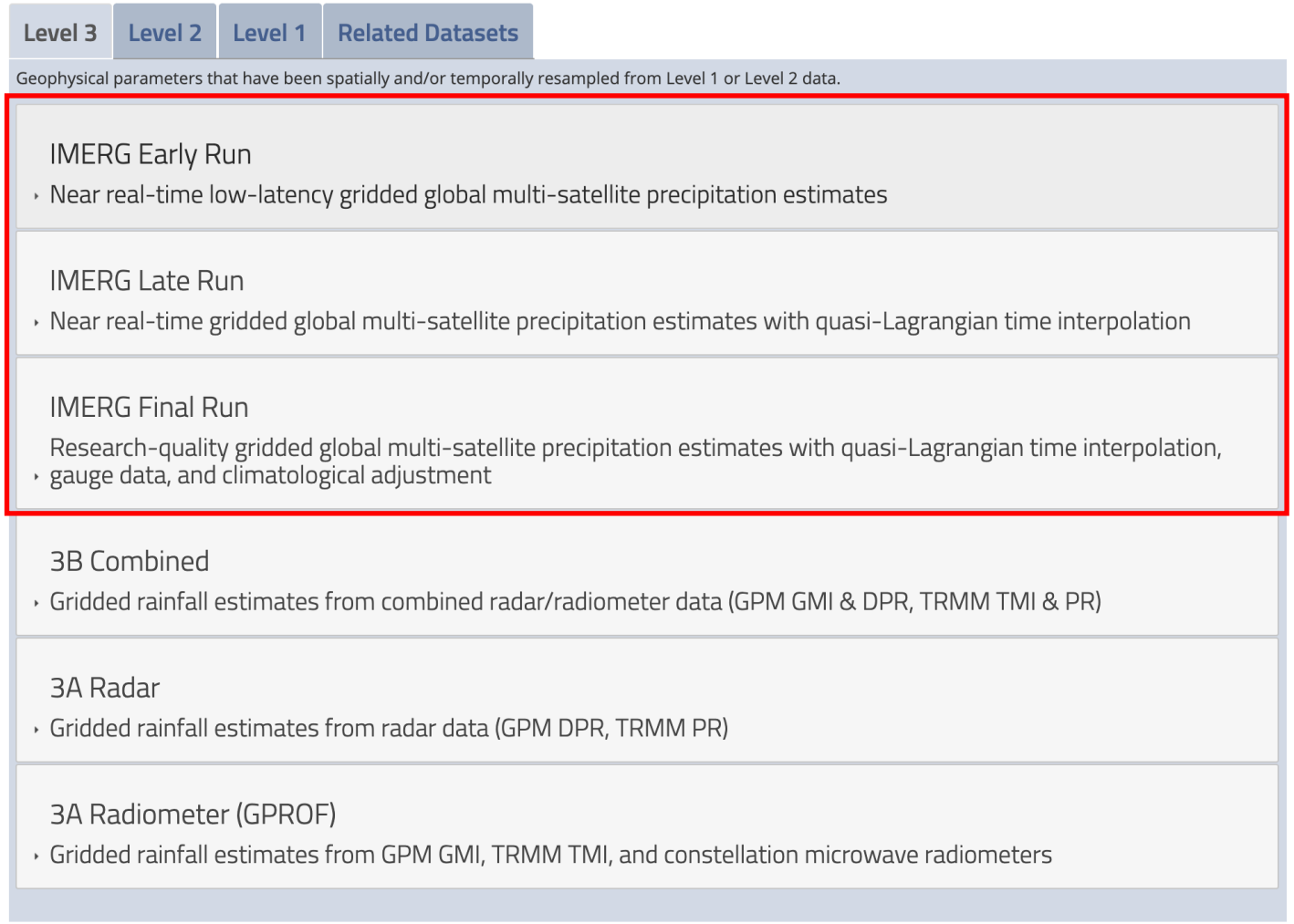
2A Radiometer (GPROF & PRPS)
- Single-orbit radiometer rainfall estimates from GPM GMI, TRMM TMI, and constellation microwave radiometers

Three Algorithms and Products:

- Dual Precipitation Radar
- Microwave Radiometer
- Combined Radar & Radiometer

Level-3 Data

https://gpm.nasa.gov/data/directory



Uniformly Gridded Products:

- Radar, Radiometer, and Combined Level-3 data

- IMERG: Multi-satellite Merged Algorithm and Data product
  - Long temporal coverage combined with TRMM data
  - Widely used for a variety of applications

GPM Data Access

https://gpm.nasa.gov/data/directory

- Multiple ways to view and analyze data
- Each product provides:
  - Data source (GPM downloaded from two NASA primary data archive servers, GES DISC and PPS)
  - Option to download in format of your choice

Data Source	Instruments	Primary Unit / Variable	Data Format(s)	Temporal Resolution	Instructions / Notes	Download URL
GES DISC	Multisatellite	Precipitation Rate (mm/hr) / precipitationCal	Visualization, GeoTIFF, HDF5, NetCDF, OPeNDAP	30 Minute, 1 Day, 1 Month	• On GES DISC site, see gray "Data Access" box in top right for download links • To generate data visualizations, click the blue "Giovanni" button • Allows for data subsetting	30 Minute: https://disc.gsfc.nasa.gov/datasets/GPM_3 1 Day: https://disc.gsfc.nasa.gov/datasets/GPM_3IME 1 Month: https://disc.gsfc.nasa.gov/datasets/GPM_3I
PPS Research	Multisatellite	Precipitation Accumulation (mm)	GeoTIFF	30 Minute, 1 Day, 1 Month	• Click here to register for PPS data access • Read documentation for using IMERG GeoTIFF + Worldfiles • Files located in ./[yyyy]/[mm]/[dd]/gis/ • 30 minute, 1 day and 1 month files are all available in the same directory, with the timespan indicated within the filename (e.g.3B-**DAY**-GIS.MS.MRG.3IMERG.20170101-S000000-E235959.0000.V06B.zip is a 1 day file) • 1 month files are located in the folder corresponding to the first day of each month. • Precipitation values are scaled by a factor of x10 (0.1mm) for 30 minute and 1 day files, and are scaled by a factor of x1000 (.001mm) for 1 month files. • When you download and unzip the *.zip files of Final IMERG GIS, you will find *.tif files that contain precipitation accumulations and other *.tif files that contain precipitation averages.	ftp://arthurhou.pps.eosdis.nasa.gov/gpmdata/

Let's take a look…. A quick tour of the GPM Directory page, https://gpm.nasa.gov/data/directory

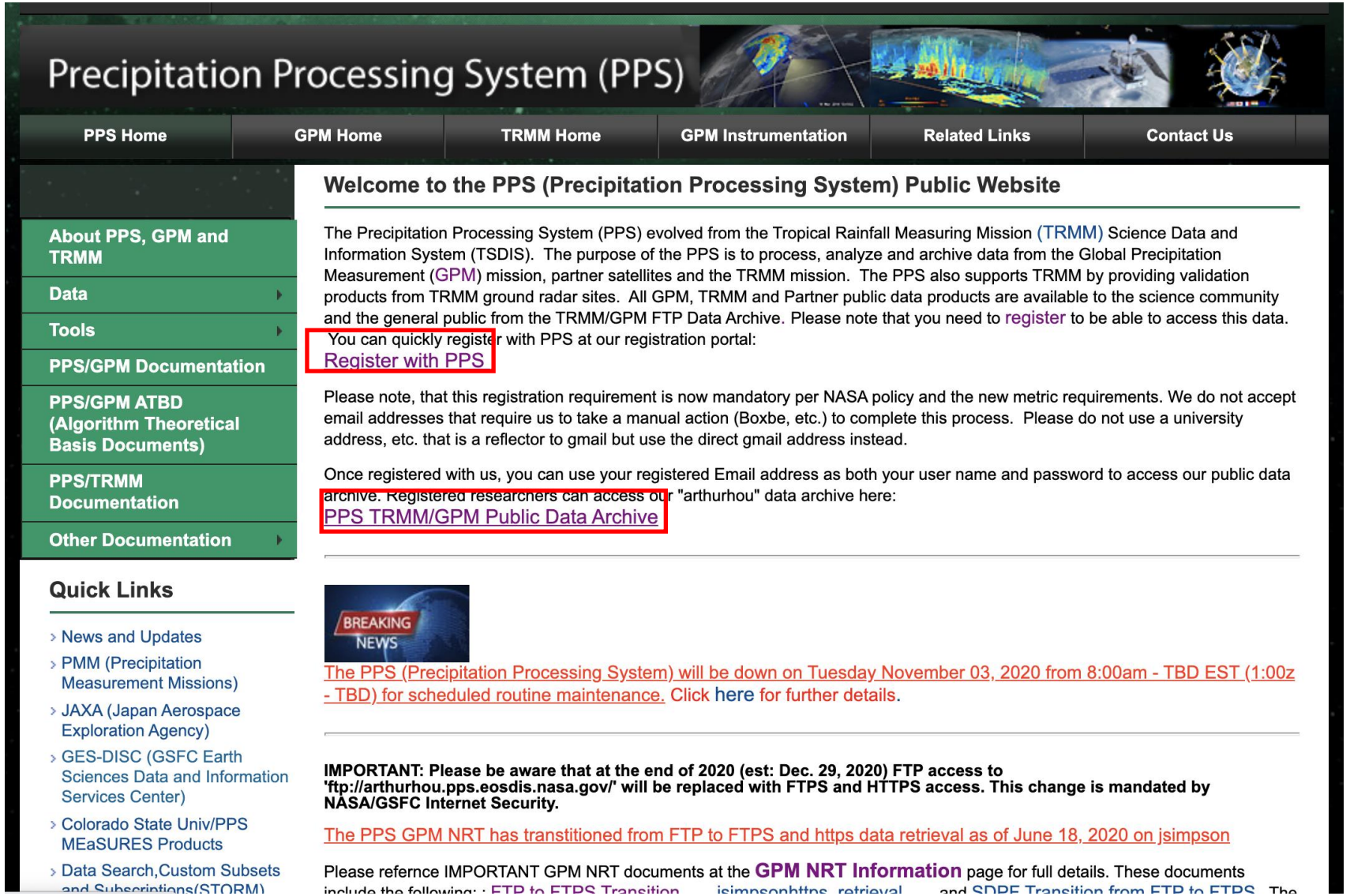
IMERG Data Access

https://gpm.nasa.gov/data/sources

PPS Near Real-time and Research	Bulk Data Download
GES Disc	
Giovanni	Analysis and Visualization
PPS Storm	Visualization
Worldview	Visualization

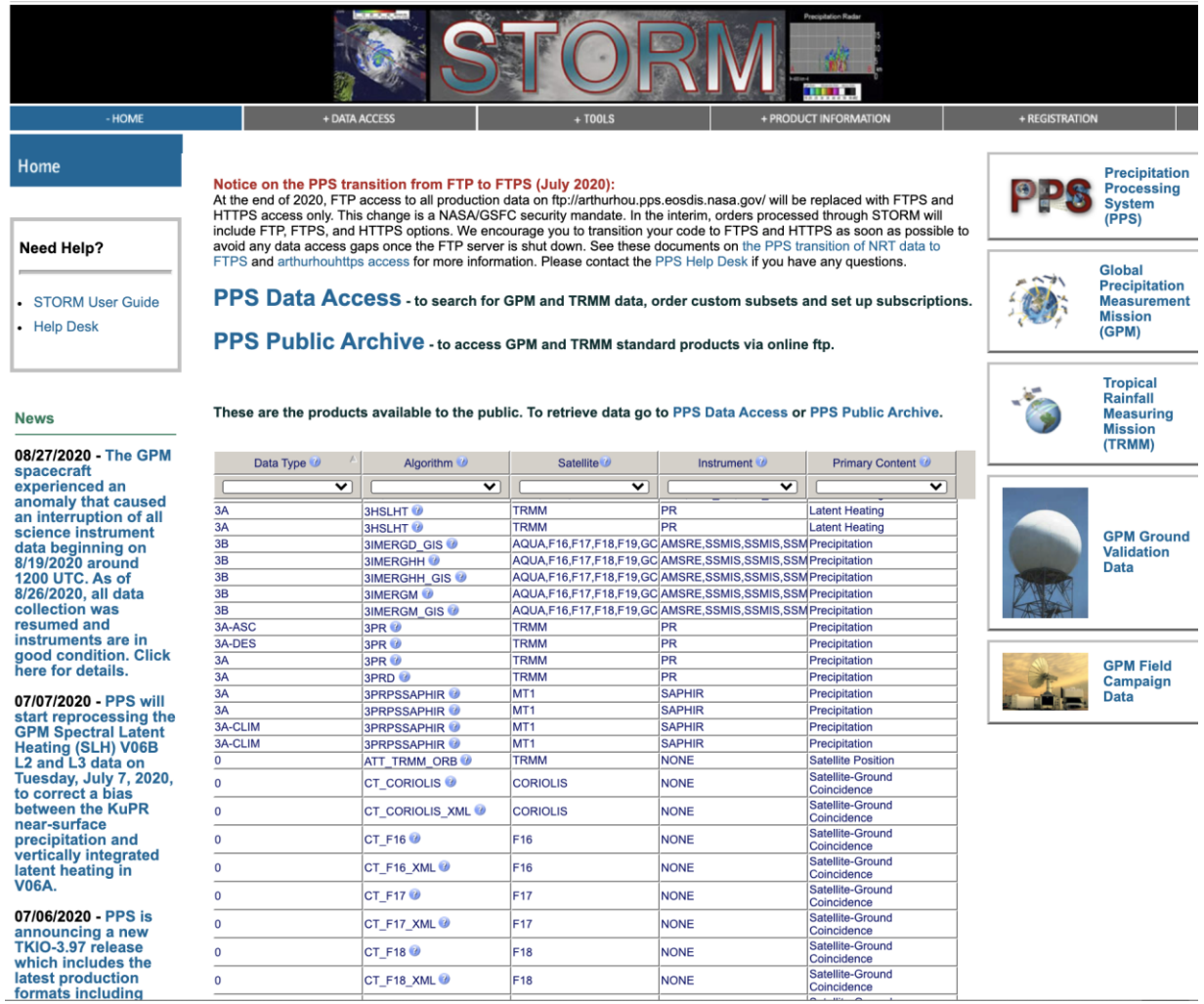
Demonstration: Precipitation Processing System

PPS Near Real-time and Research



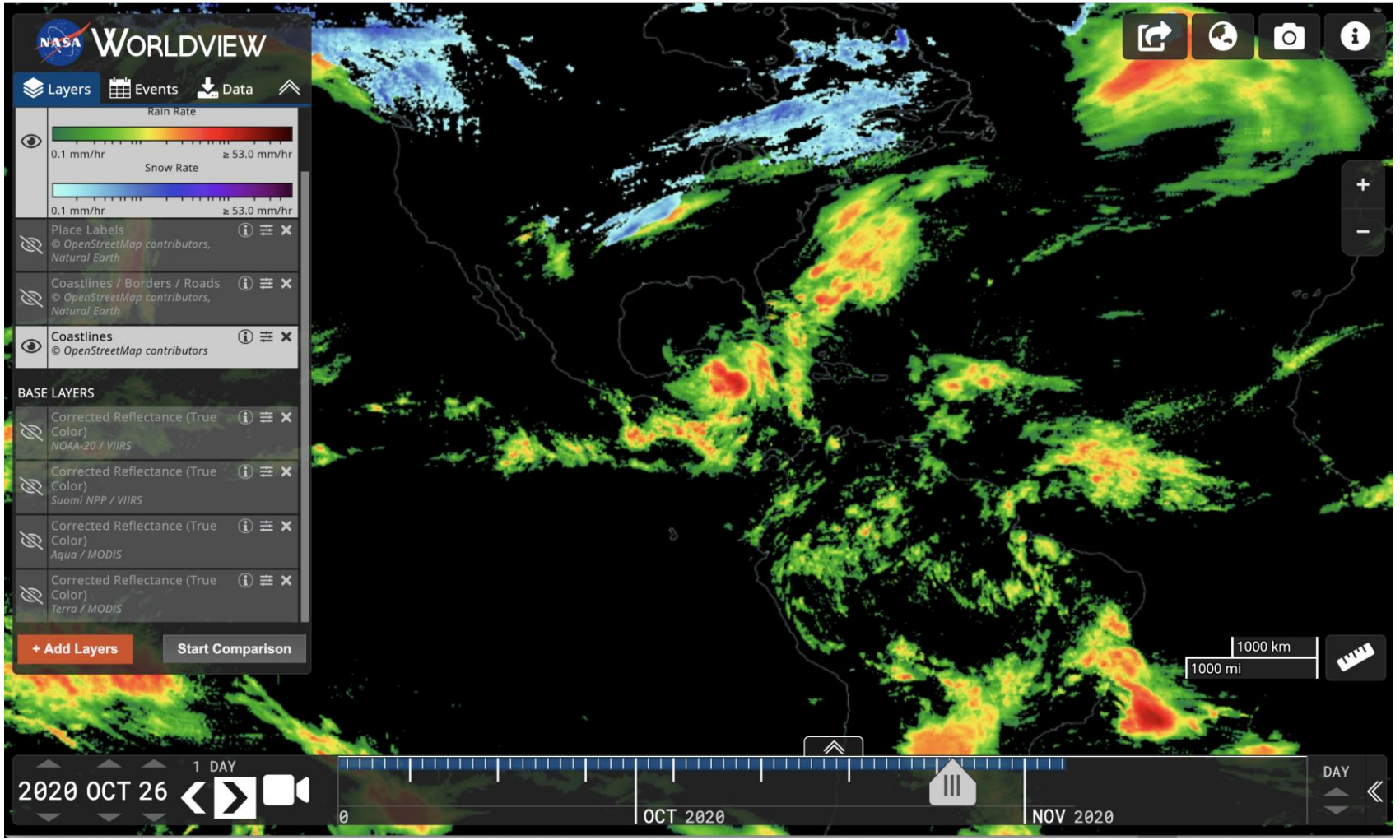
Demonstration: Precipitation Processing System Science Team On-Line Request Module (STORM)

https://storm.pps.eosdis.nasa.gov/storm/



Demonstration: Worldview

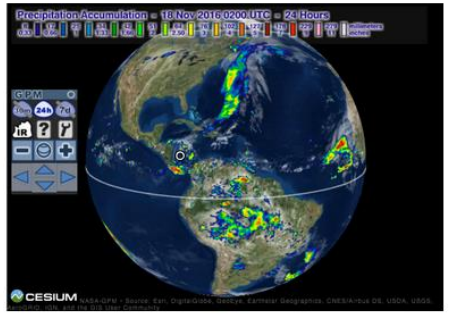
https://worldview.earthdata.nasa.gov/



GPM Beginner Resources: Visualizations

Quick ways to view GPM data

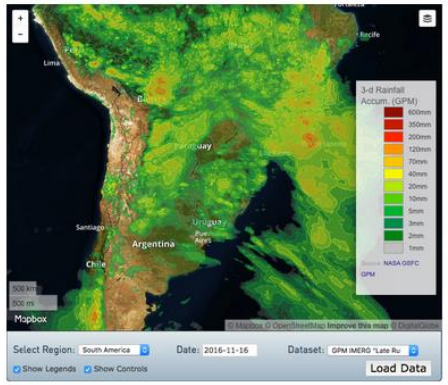
- Beginner Resources
- Training
- Tutorials
- **Data Visualization**
- Data FAQ
- Learn about IMERG



IMERG Global Viewer

View the latest near-realtime GPM IMERG global precipitation datasets (30 minute, 1 day, 7 day) on an interactive 3D globe in your web browser.

IMERG Global Viewer: View the latest IMERG global precipitation accumulations on an interactive 3D globe

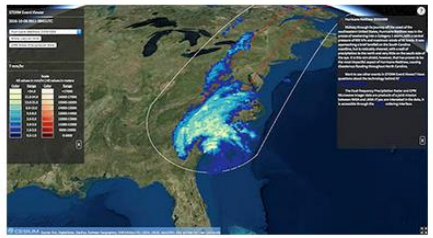


Precipitation & Applications Viewer

View and download various precipitation and applications datasets from the past 60 days (30 minute, 1 day, 3 day, 7 day precipitation, floods nowcast, landslides nowcast). Download datasets in various popular formats (TIF, SHP, arcJSON, geoJSON, topoJSON) and learn how to directly access the data via the PMM Publisher API.

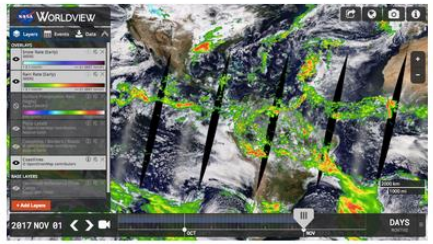
Precipitation & Applications Viewer: Download datasets in various popular formats (TIF, SHP, arcJSON, geoJSON, topoJSON) and learn how to directly access the data via the PMM Publisher API.

- **STORM Event Viewer:** View latest extreme weather events on an interactive globe.
- **NASA Worldview:** Browse global, full-resolution satellite imagery and then download the underlying data, including data from GPM.
- **GIOVANNI:** view, analyze, and download multiple Earth science datasets (including GPM) from within your web browser.



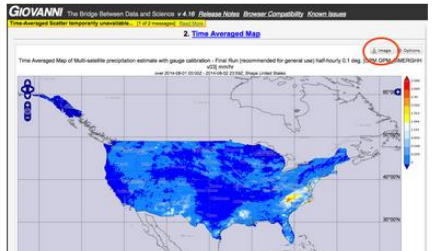
STORM Event Viewer

View 2D GMI and 3D DPR data from the latest extreme weather events on an interactive 3D globe in your web browser. (click here for mobile version)



NASA Worldview

This tool from NASA's Earth Observing System Data and Information System (EOSDIS) provides the capability to interactively browse global, full-resolution satellite imagery and then download the underlying data, including data from the Global Precipitation Measurement Missions.



GES DISC Giovanni

This website from the NASA GES DISC provides a powerful tool for viewing, analyzing, and downloading multiple Earth science datasets (including TRMM and GPM) from within your web browser. This tools is capable of generating custom time averaged maps, animations, multi-variable correlations, regional subsetting, and much more.

Click here for a tutorial on creating precipitation maps

https://gpm.nasa.gov/data/visualization

GPM Application Examples

Using GPM to inform decision-making that direct impacts society

Utilizing GPM in the U.S. Army Streamflow Prediction Tool

Statement of the Problem:

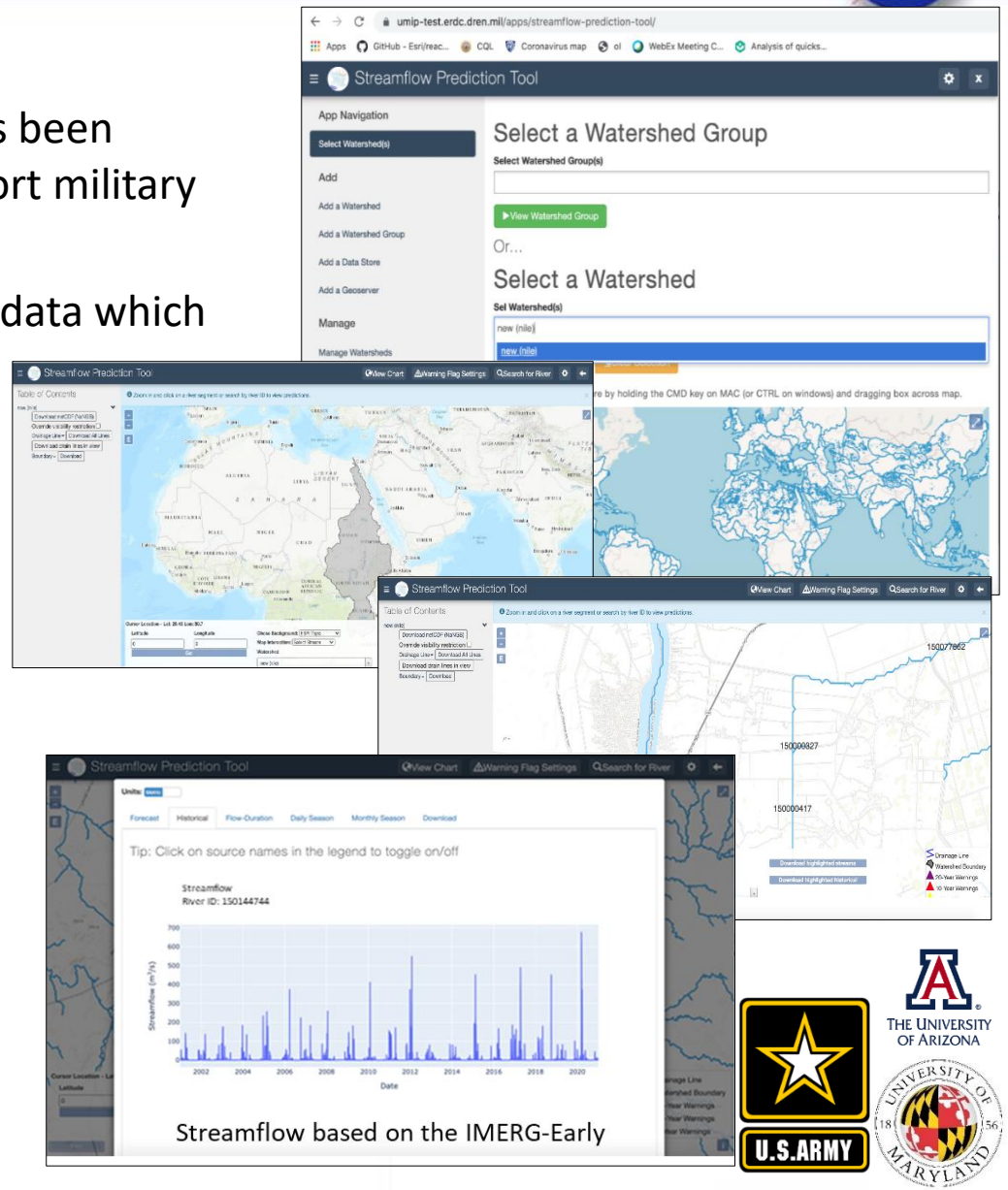
- The U.S. Army Engineer Research and Development Center (ERDC) has been maintaining and developing Streamflow Prediction Tool (SPT) to support military costumers and first responders.
- The SPT framework for flood prediction is lacking NASA observational data which can enhance the SPT capability to predict real-time streamflow and flood mapping simulations.

Use of GPM data:

- IMERG is the key source of global precipitation data that can be used for near real-time flood simulation at high spatiotemporal resolution.

Outcomes:

- IMERG was successfully integrated into SPT system to produce streamflow prediction at very high resolution needed by Army.
- Developed interactive map-based web interface to make the hydrologic information easily accessible and comprehensible for decision making.
- IMERG Final produces reasonable streamflow simulations, but IMERG early and late show overestimation in late winter and early spring.
- Efforts are underway to advance the system and make it more accessible by commanders.

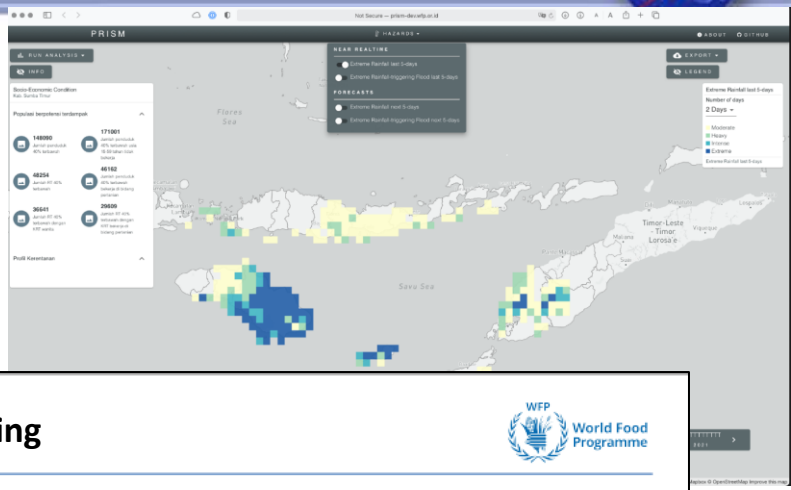


Text and image credit: Ahmad Tavakoly (ERDC/UMD)

Monitoring the Impacts of Climatic Hazards on Food Security with GPM

- Representatives from World Food Programme Indonesia and BMKG (Met agency) are utilizing IMERG within the Platform for Real-time Impact and Situation Monitoring (PRISM).
- IMERG half-hourly and daily products are used to provide daily precipitation information including precipitation extremes.
- This information is then used to assess the potential risk and forecasts the impact of climate hazards, especially droughts and floods on food security in the most vulnerable communities throughout Indonesia, in order to design risk reduction activities and target disaster responses.

Screenshot of the PRISM prototype on extreme rainfall monitoring during Tropical Cyclone Seroja



Flowchart of IMERG at WFP Indonesia for decision-making

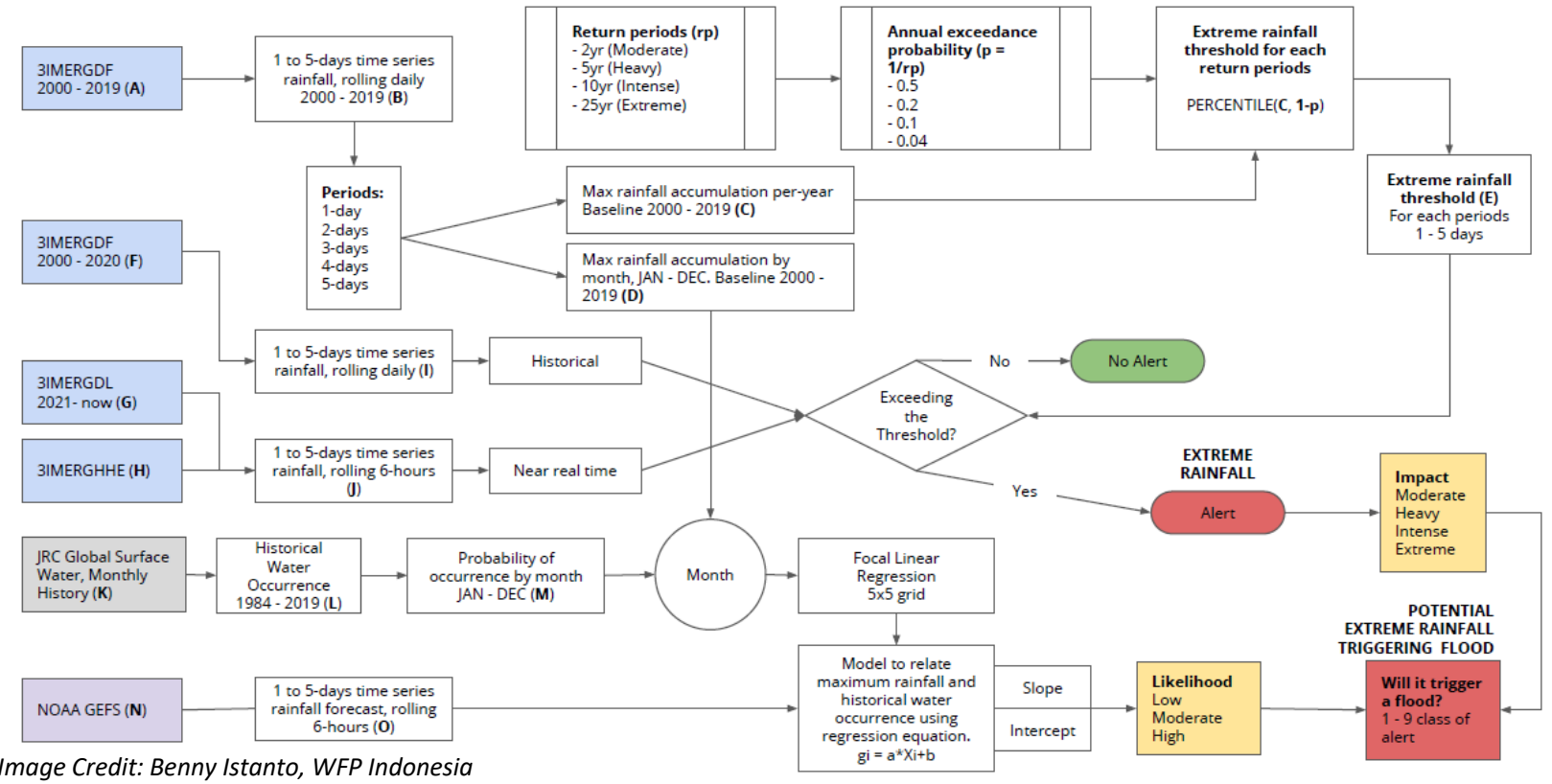
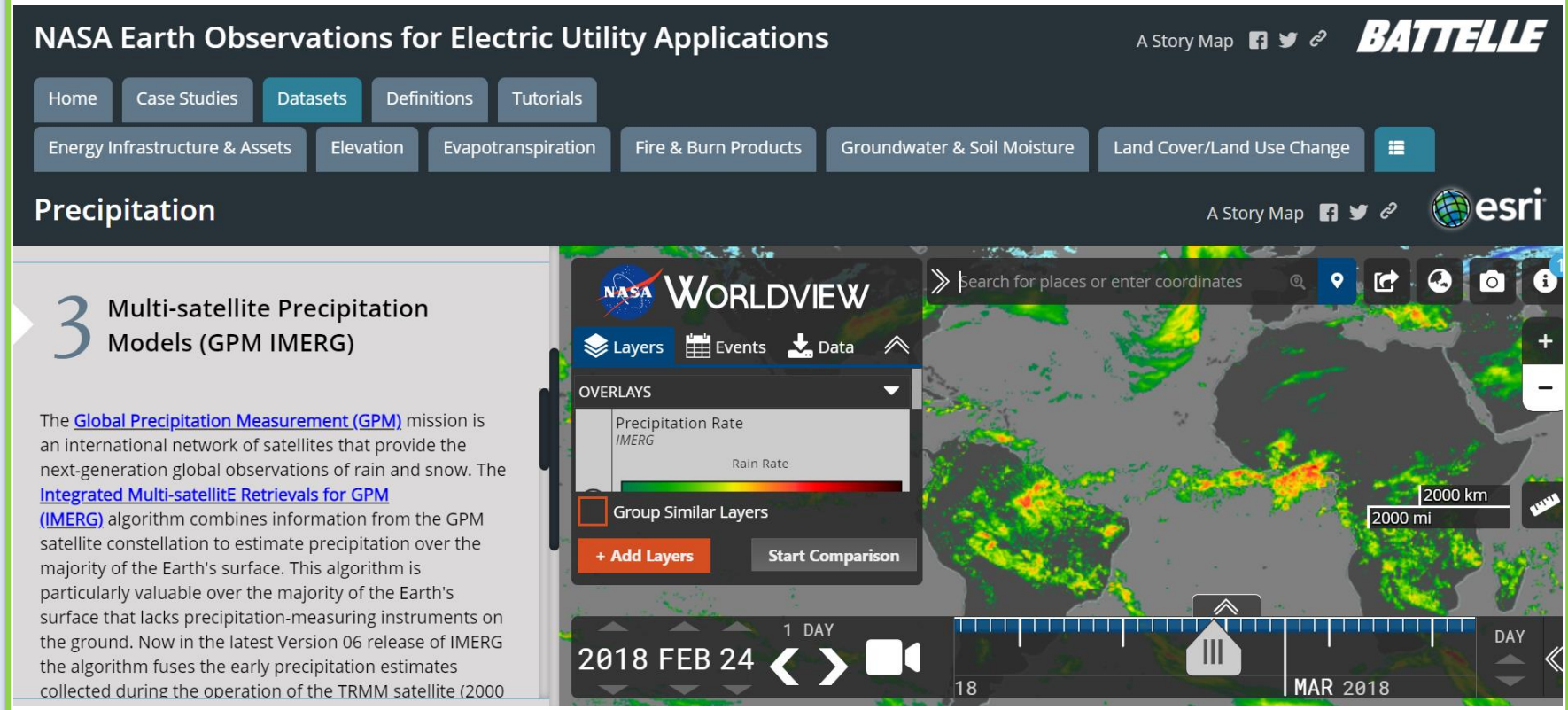


Image Credit: Benny Istanto, WFP Indonesia

Supporting Electric Utility Applications with GPM

- To make NASA EO data more accessible for electric utility end user needs, Battelle developed a StoryMap to directly support energy applications.
- GPM data, products and tutorials are provided to support these electric utility end users.
- This StoryMap was designed to offer actionable information on applications for electric utility end user needs; including third party or private sector organizations providing related services to utilities within the U.S. and internationally.
- Check out the StoryMap HERE!



Screenshot of the StoryMap Portal highlighting GPM tools that are available for stakeholders to use for electric utility applications.

Building Climate Resilience with Satellite Data

The Earth observing satellite data from NASA is used to determine whether a client will receive a payout from a climatic event (such as drought or excess rainfall). This data is processed in real-time in order to allow objective, transparent and efficient payouts. **-Iker Llabres, MiCRO**

MiCRO, a reinsurance company, is increasing climate resilience to extreme events among 20K+ individuals and small and micro-entrepreneurs throughout Central America with the help of NASA satellite data.

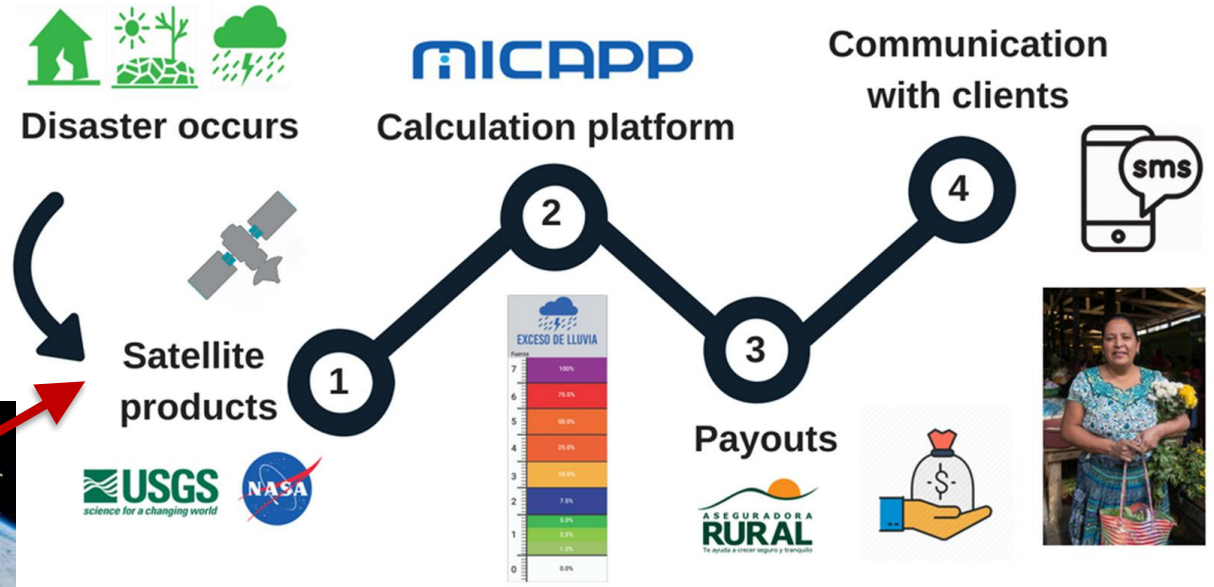
Through data modeling, MiCRO develops index-based insurance products that are based on analysis of environmental parameters. As such, NASA GPM precipitation data was used to create a reliable and credible index on which to trigger a policy and client payouts when severe drought or excess precipitation occurs.

MiCRO
Microinsurance Catastrophe Risk Organisation

MiCRO
Microinsurance Catastrophe Risk Organisation

FROM SPACE TO MICROINSURANCE

Increasing the resilience to natural disasters of the most vulnerable



MiCRO's flow chart depicting how they determine the amount of a payment to insured clients when a disaster strikes: NASA satellite data (1) is used to design payout triggers (2). When disasters occurs and depending on its severity, payment is determined (3) and clients are informed via text (4).

Image credits: Iker Llabres on behalf of MiCRO (www.microrisk.org).

GLOBAL PRECIPITATION MEASUREMENT

Flood Forecasting Validation using GPM

Climacell, a weather technology company, routinely uses GPM IMERG data for model validation and calibration for their global urban flood forecasting operations. Climacell is also exploring the use of IMERG as input into their Global Urban and Flash Flood Forecasting (CGUFF) System. Their forecasts help communicate flooding severity for a given area where severity levels from level 1 (common) to 8 (severe) are communicated to the public through an app and online broadcasts. This system is used to communicate potential flooding events throughout the world (900+ cities), helping hundreds of millions across Asia, South America and Africa.

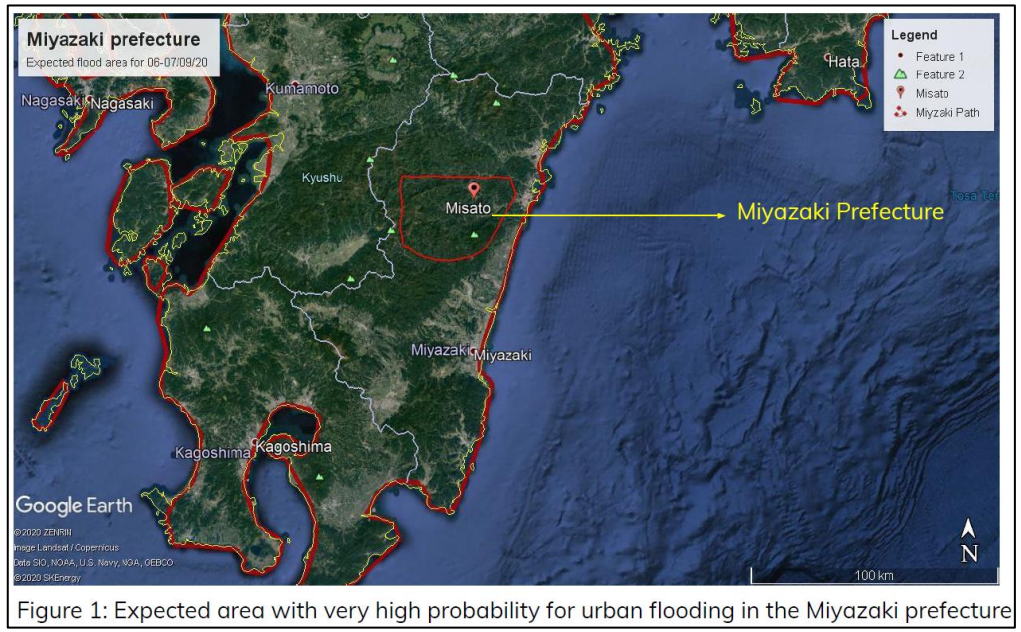


Figure 1: Expected area with very high probability for urban flooding in the Miyazaki prefecture

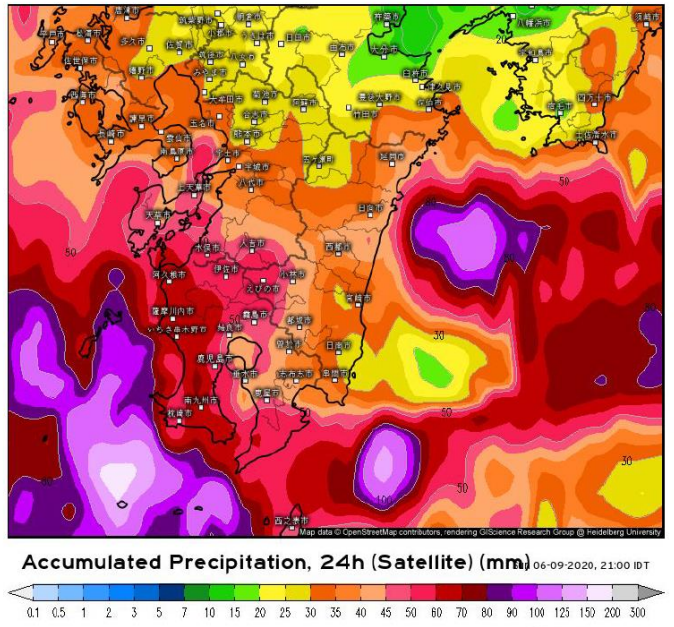


Figure 3: Observed 24h accumulated precipitation for Typhoon Haishen, the Miyazaki Prefecture, Japan

Climacell example: Typhoon Haishen made landfall in southern Japan on Sept. 6-7, 2020. The precipitation forecasts that fed Climacell's flood model projected rainfall estimates between 250-500 mm in 24hr around the Miyazaki Prefecture (image left). The observed precipitation was much lower, around 70-80 mm, and IMERG corroborated these rainfall totals within the Miyazaki Prefecture (image right). Images provided by Amir Givati, Climacell, www.climacell.co/urban-flooding-forecast/.

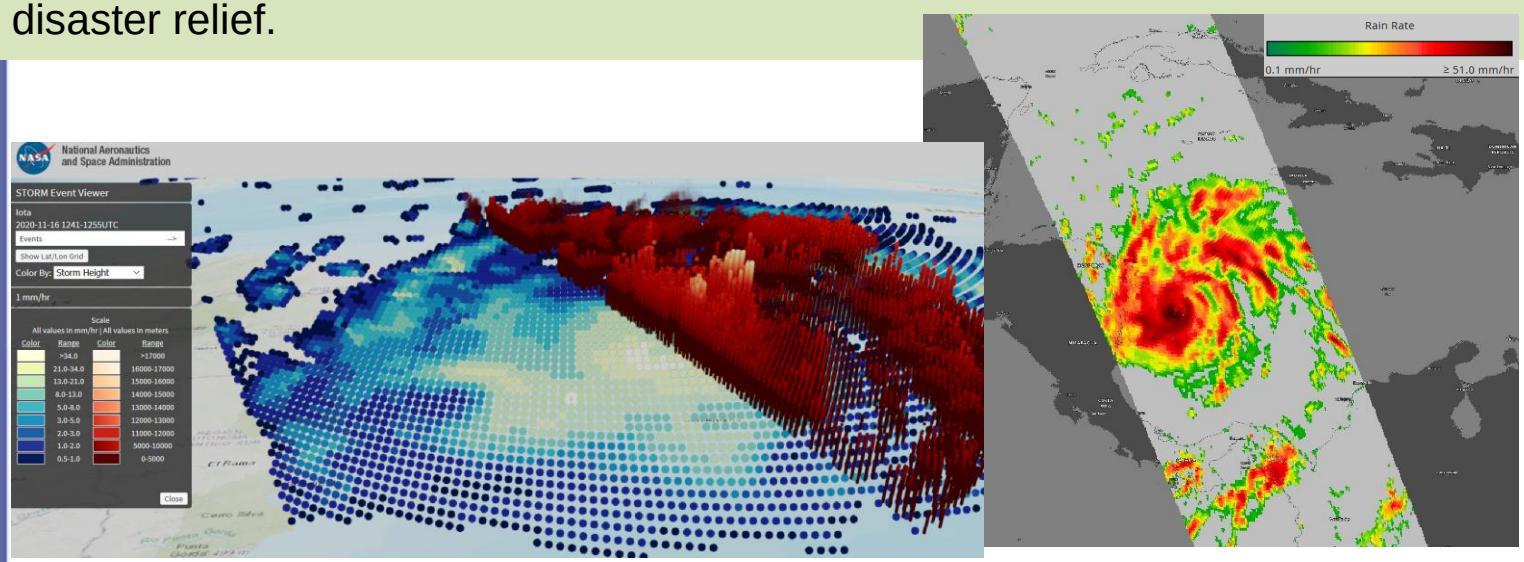
GLOBAL PRECIPITATION MEASUREMENT

Using GPM Data to Help Coordinate Disaster Relief for Hurricane Iota

On November 16, 2020, Iota made landfall as a Category 4 hurricane bringing torrential rains and strong winds along the NE coast of Nicaragua. Hurricane Iota's landfall location was approximately 15 miles (25 km) south of where Category 4 Hurricane Eta made landfall on November 3.

GPM flew over Hurricane Iota shortly after it had intensified to a high-end Category 4 hurricane. The GPM's GMI and DPR instruments observed rainfall rates greater than 1.8 inches (46 mm) per hour and measured a hot tower just shy of 15 kilometers high, indicative of deep convection.

The Pacific Disaster Center (PDC) used the GPM IMERG data product to distribute information about the storm's impact across Central America. This information is being used to coordinate efforts for humanitarian assistance and disaster relief.

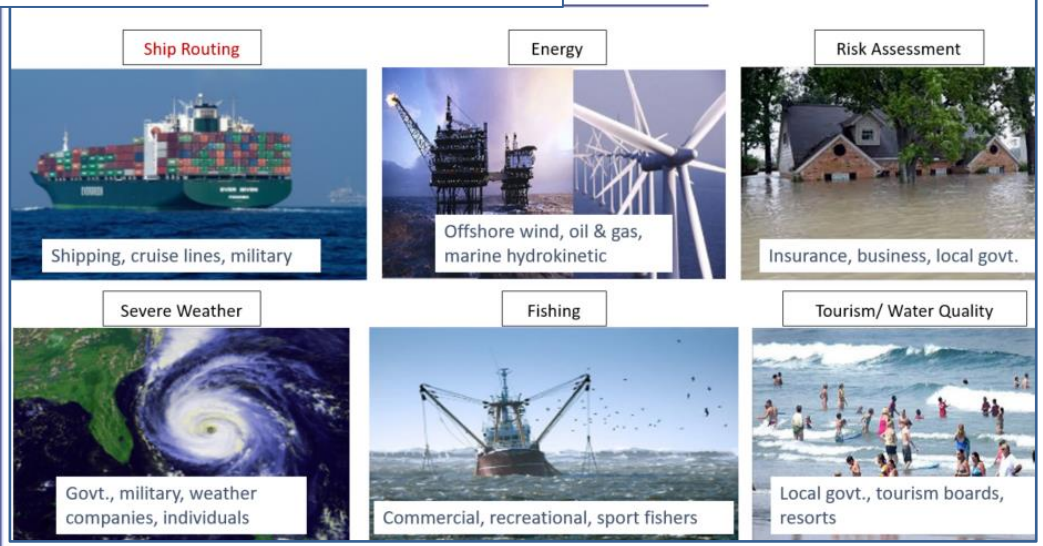


GPM's GMI (right) and DPR (red, left) can be used to view rainfall rates and internal structure of the storm. Credit: Andrea Portier (GSFC/ SSAI), extracted from NASA Worldview (right) and NASA STORM Viewer tool (left).

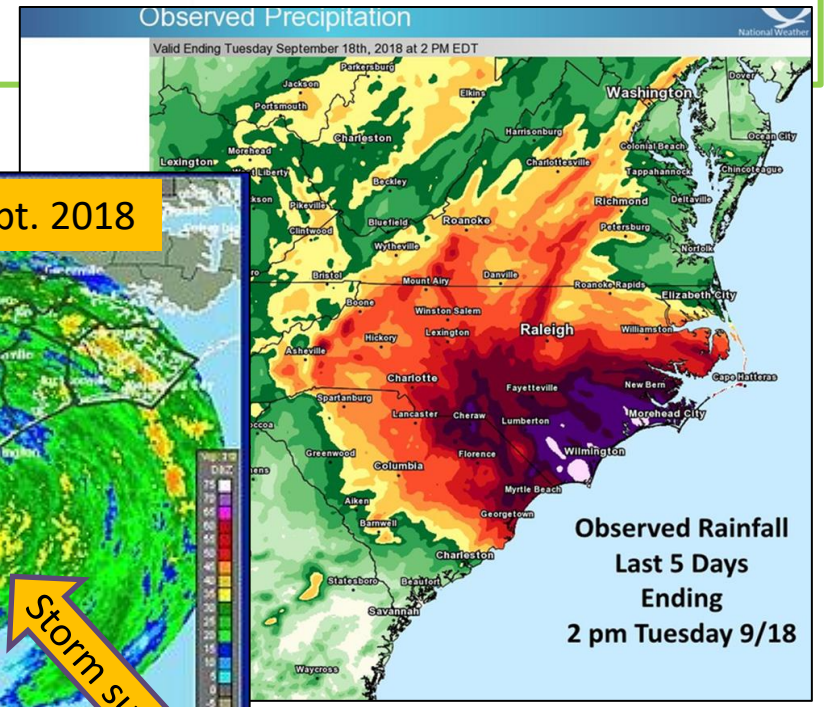
The PDC Twitter account shows their efforts using GPM IMERG to show rainfall accumulation (right) as well as the NASA LHASA (landslide model) that uses GPM as input to communicate risks throughout Central America.

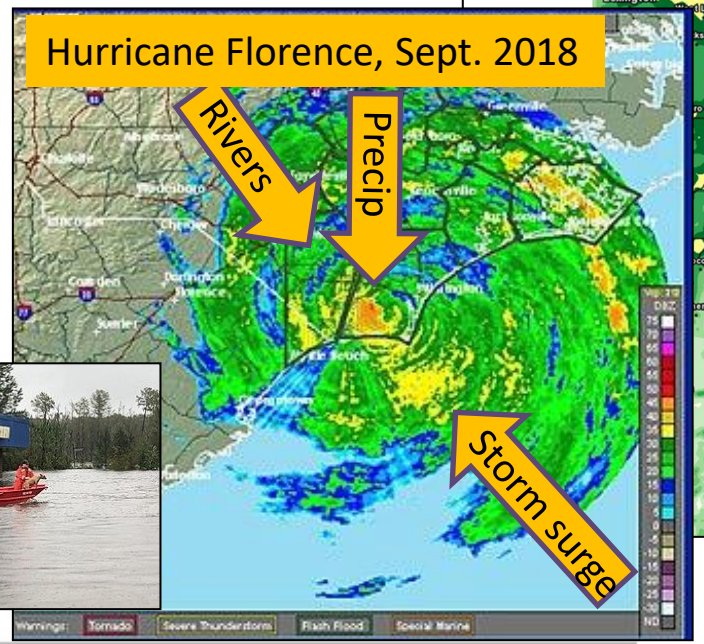
Using GPM Data at Fathom Science

Sectors Fathom Science Serves



- Fathom used GPM data to model the arrival of Hurricane Florence and forecast **compound flooding** in N.C. in Sept. 2018.
- Compound flooding = local precipitation + storm surge + increased river runoff
- *The area around Wilmington, NC received over half its annual rainfall in 5 days, leading to major compound flooding.
- Forecasts of events like this are of critical importance to local governments and other users to minimize the risk to life and property.





- ❖ Reps from Fathom Science participated at the 2020 GPM-ACCP Transportation Workshop.
- ❖ Fathom's proprietary system ingests real-time observations, including satellite data, into their coupled marine environment model covering U.S. coastal oceans, Gulf of Mex. and Caribbean.

For the full Fathom Science presentation and recording:
https://gpm.nasa.gov/science/meetings/2020-transportation-workshop

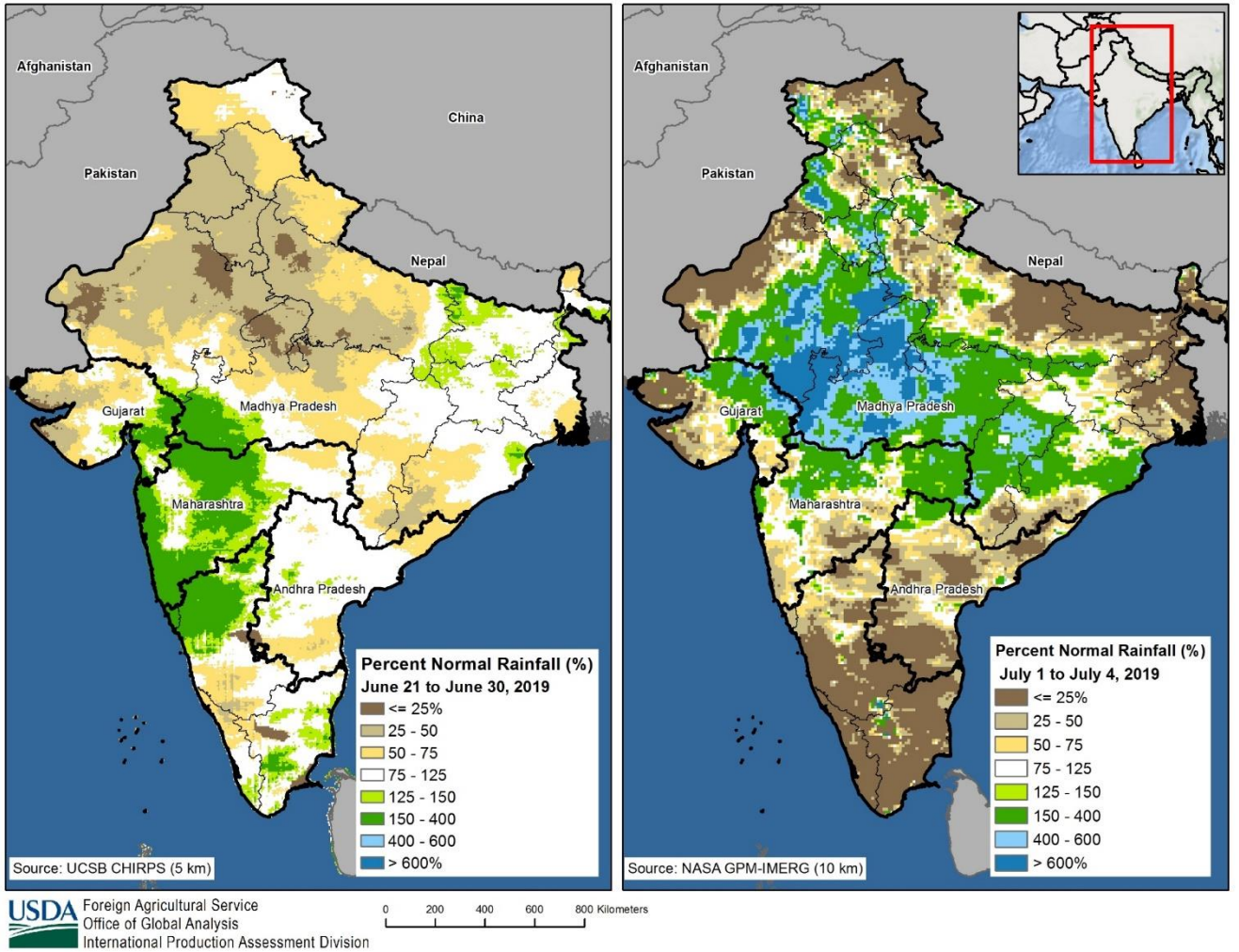
Images courtesy of Fathom Science

The Use of GPM data at USDA FAS

While CHIRPS and World Meteorological Organization (WMO) station data serve as primary precipitation data sources for the USDA Foreign Agricultural Service (FAS), GPM IMERG data have supported FAS operations in multiple ways:

- IMERG estimates are routinely evaluated against WMO station data used by USDA FAS above 50˚N latitude for consensus to produce crop assessments in those regions.
- USDA evaluates crop production estimates monthly. At this time, handful of countries and agricultural commodities are chosen for further evaluation, and quick turnaround of products is necessary. IMERG estimates have provided a timely precipitation product for this evaluation. See example at right and comment below.

> *"IMERG was able to provide a timely product where we didn't have a 10-day product from the CHIRPS data stream yet."*



Previous CHIRPS and then IMERG estimates that corroborate reports of heavy rains after a prolonged drought in the Madhya Pradesh region in 2019. Credit: Justin Blackburn, USDA FAS

GLOBAL PRECIPITATION MEASUREMENT

GPM Case Study

A video and presentation from NASA Scientist, Amber McCullum, highlighting her use of NASA data for decision-making

Questions?
Comments?

Thank you!