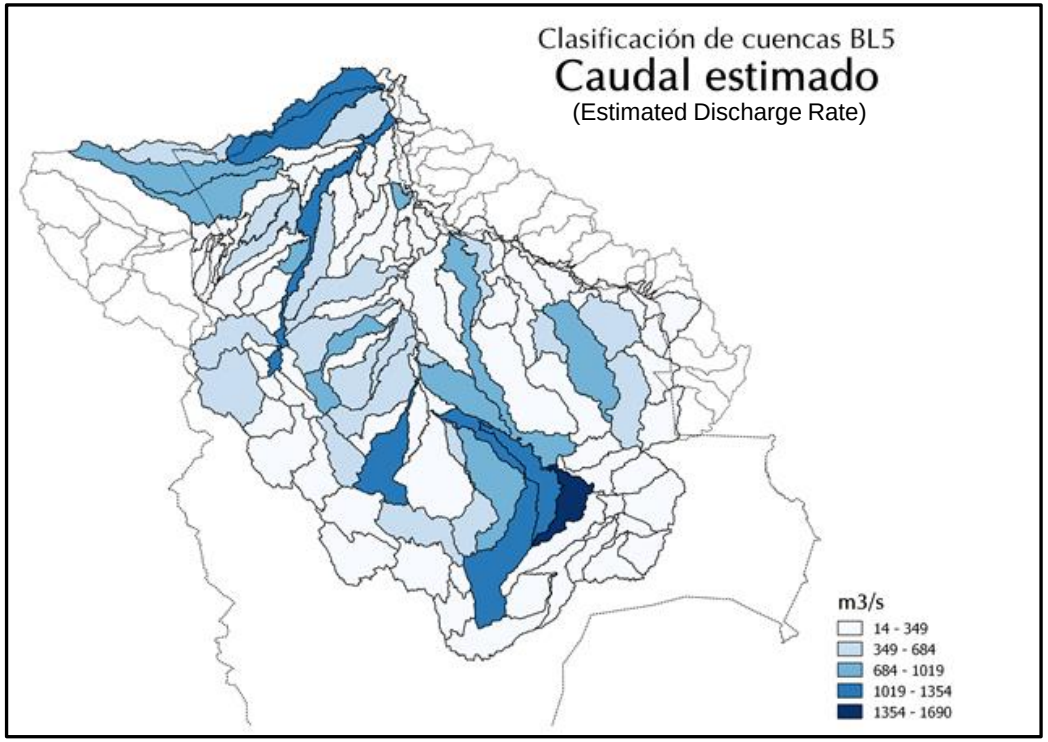
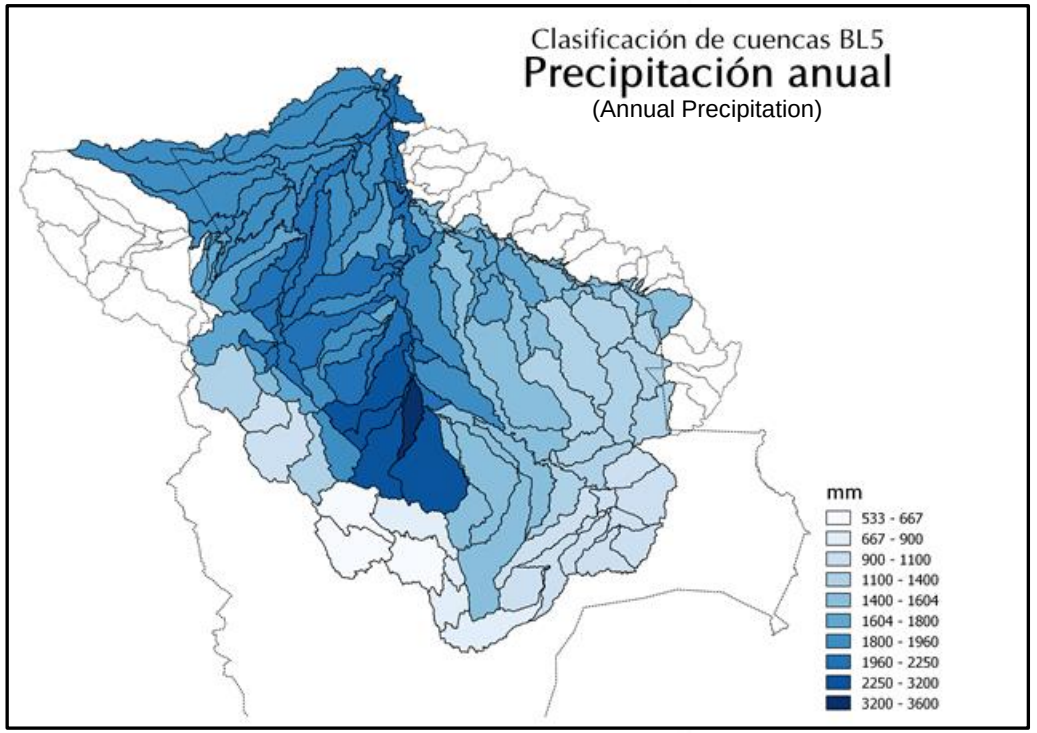
Strengthening the Mitigation Hierarchy in the Amazon with NASA Rainfall Data

The large-scale development of agriculture, mining, oil & gas, hydroelectric dams, timber and fisheries in the Amazon have set the stage for large-scale environmental research, planning and management of aquatic ecosystems. To address this issue, the Wildlife Conservation Society (WCS) in Bolivia are using over 17 years of precipitation data (1998-2015) from NASA's Tropical Rainfall Measuring Mission (TRMM) and Global Precipitation Measurement Mission (GPM) to collect rainfall totals and estimate potential discharge rates throughout the Bolivian Amazon. This information will enable WCS Bolivia to identify endangered river basins, which will then provide decision makers a useful framework to implement a mitigation hierarchy approach. This approach will be a useful guide to limit negative impacts on biodiversity such as dam implementation in Bolivia.

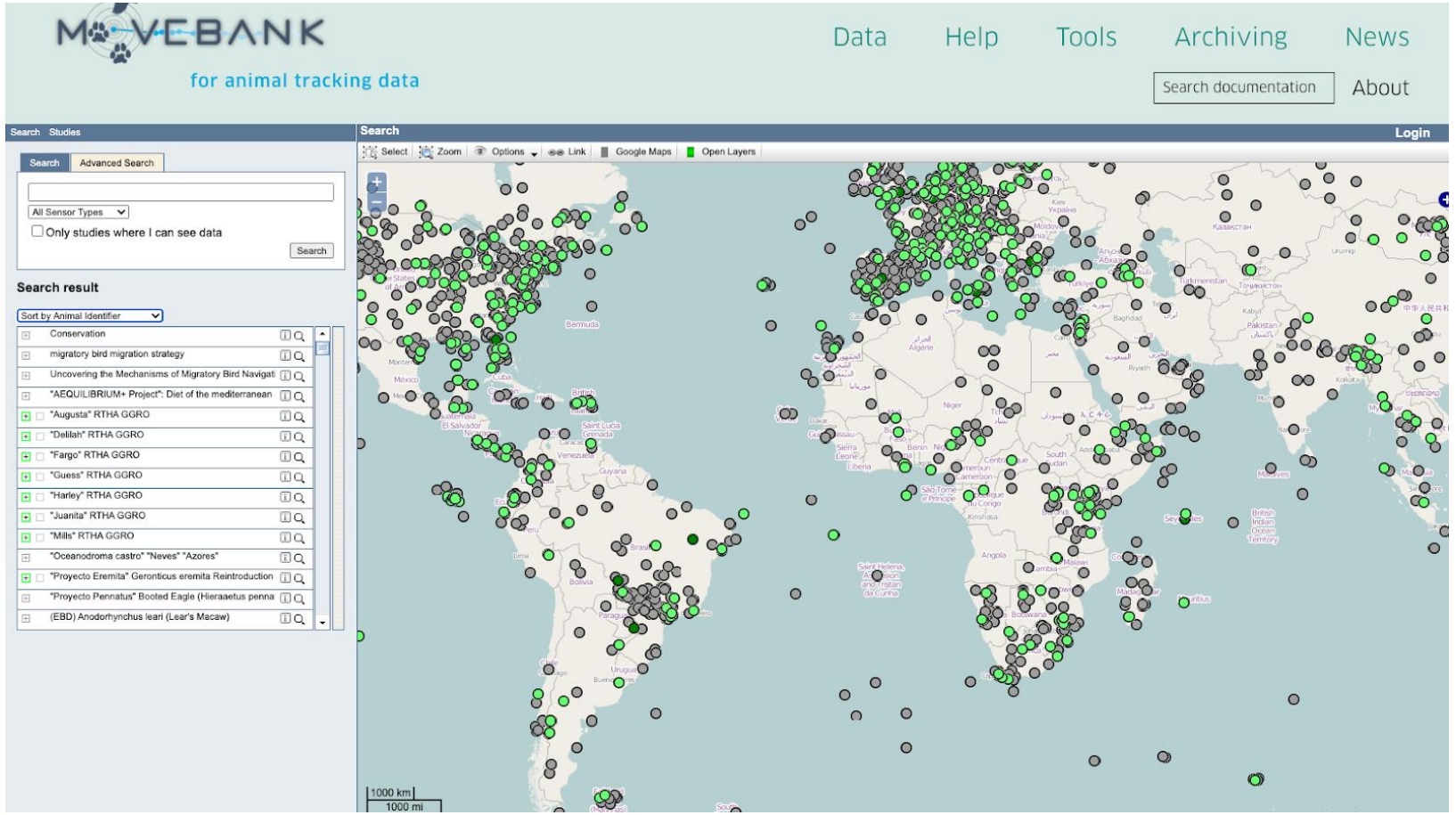




Miranda G. (gmiranda@wcs.org), Molina J, Sanjinés D & Painter L. in prep. (WCS Bolivia) (above images)

Movebank's Env-DATA System Provides Easy Access to GPM Data

- Movebank's Env-DATA System includes a set of free online tools which help ecologists link animal movement data with information from Earth observing satellites, such as GPM!
- Using this system enables ecologists to investigate the questions about how animal movement and migrations are impacted by the environment around them.



https://www.movebank.org/cms/movebank-main

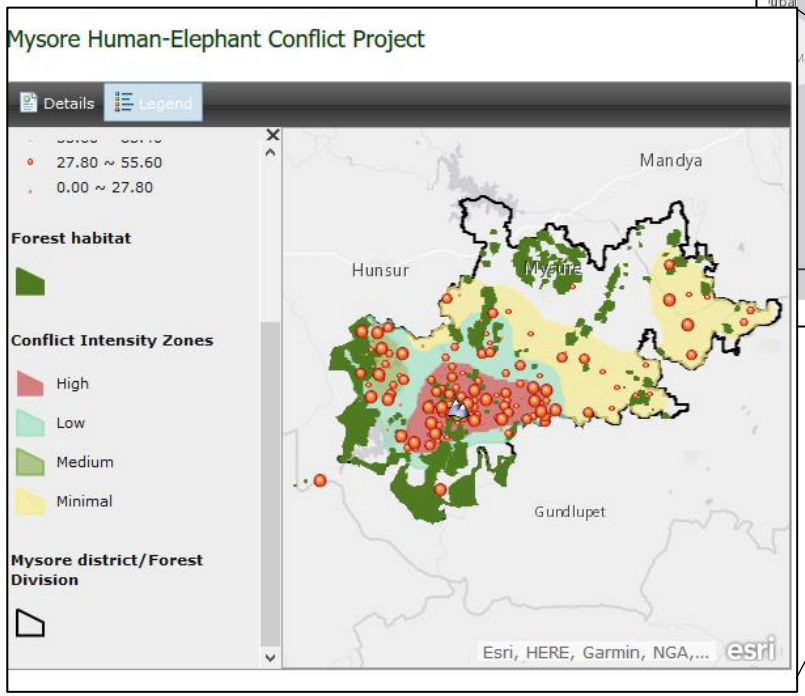
- Scientists around the world are better able to address new ecological questions and can combine datasets in order to test theories related to ecological patterns, evolutionary processes, and disease spread.

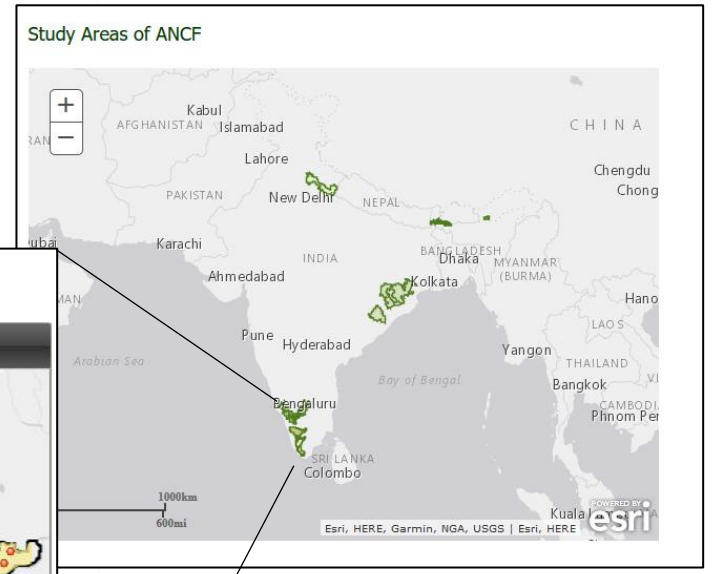
More Info HERE!

Tracking Human-Elephant Conflict using NASA Rainfall Data in India

Changes in temperature and rainfall can impact the degree of forest fragmentation and loss of habitat, which has led to increasing conflicts between humans and Asian elephants. Elephants can raid crops, and cause property damage, injuries and deaths to humans. The Asian Nature Conservation Foundation (ANCF) is conducting detailed investigation of the status and patterns of conflict.

ANCF is collaborating with the Centre of Ecological Sciences (CES) at the Indian Institute of Science to determine potential relationships between precipitation, change in forestry, and human-elephant conflict using NASA's rainfall data (TRMM and GPM). Understanding these relationships could help local authorities to devise management action plans to mitigate this hazard in districts of southwest India.

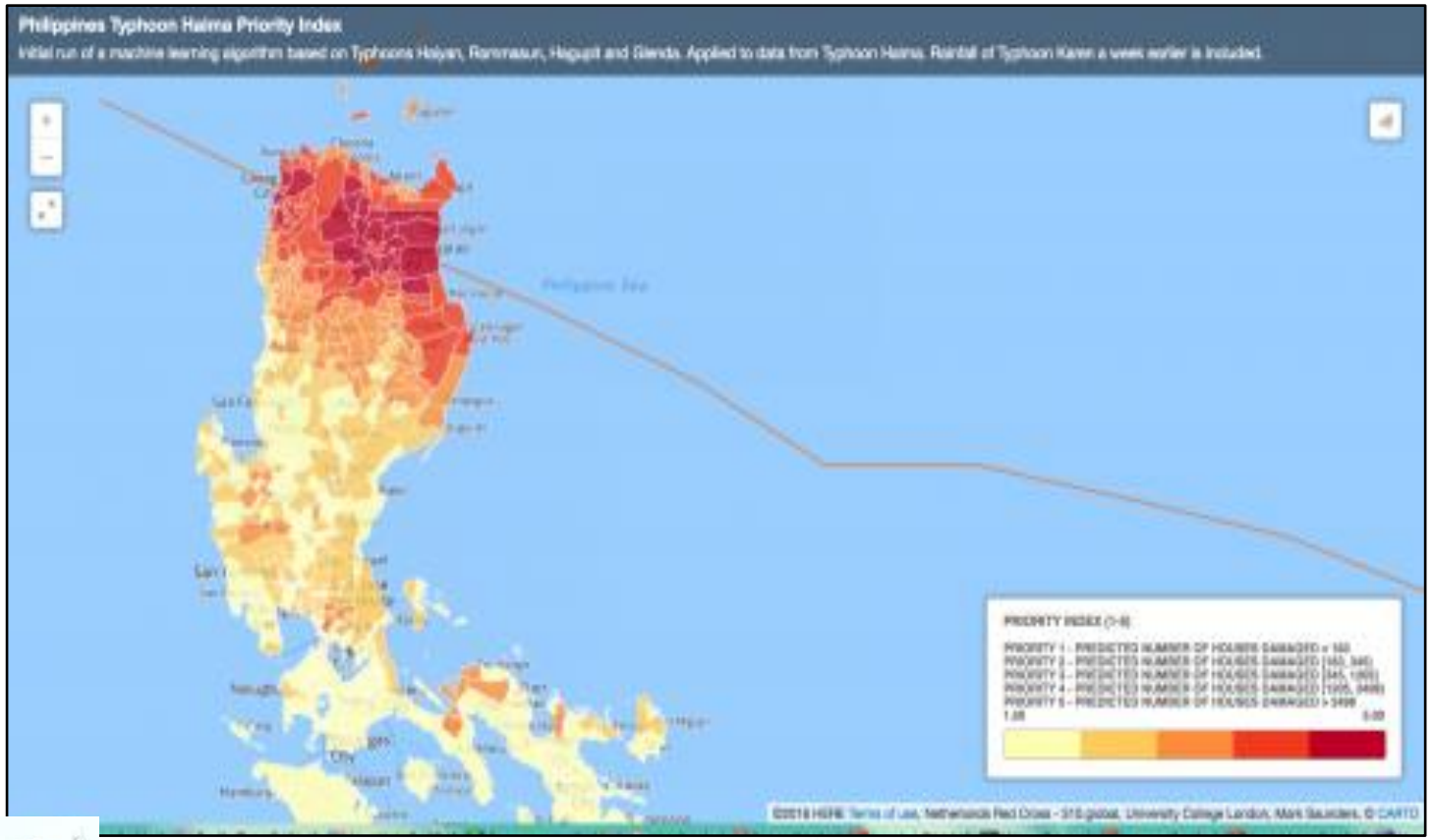




ANCF: http://www.asiannature.org/gis/mysore-human-elephant-conflict-project (right)

Precipitation Data Used to Assess Typhoon Damage in the Philippines

The Netherlands Red Cross used GPM IMERG rainfall accumulation data coupled with maximum wind-speed measurements for a prediction model to help explain differences in damage between municipalities in the wake of Typhoon Haima. Haima made landfall in the Philippines as a Category 4 event on October 19, 2016 (right). This information was then shared with the Philippine Red Cross and United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA) to give an estimation of damage per municipality within one day of the typhoon passing.

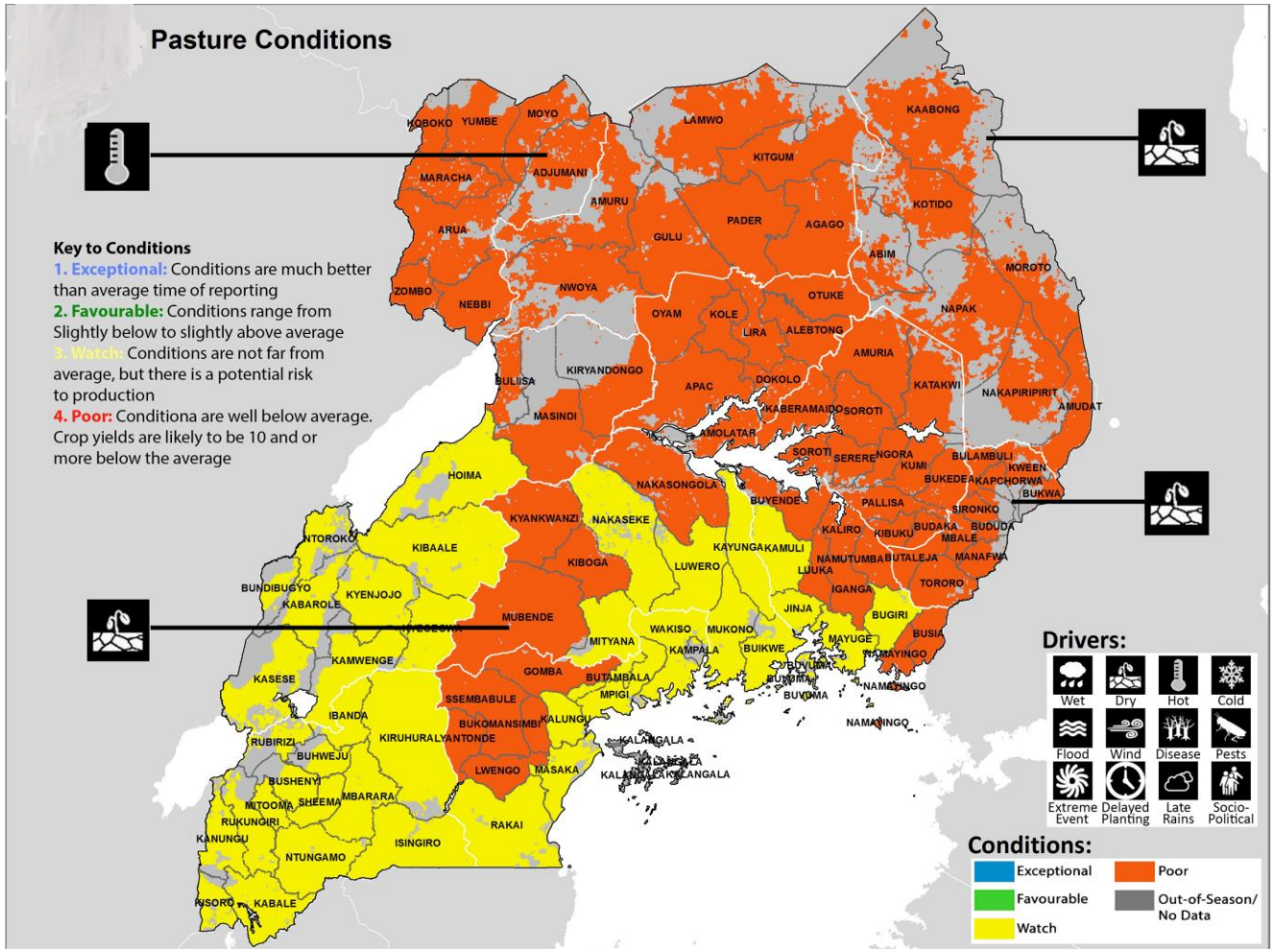


"We use the [GPM] data with other natural disasters, such as hurricane Matthew in Haiti. We then simply collect the data and combine it with wind speed in a composite index to quickly give an insight into spatial distribution of the intensity"
–Jannis Visser, NL Red Cross

GLOBAL PRECIPITATION MEASUREMENT

NASA's Rainfall Data used to Monitor Crop Conditions throughout Uganda

The National Emergency Coordination and Operations Centre (NECOC), with the support of United Nations Development Programme (UNDP), is Uganda's central facility for early warning and the coordination of emergency and crisis response and recovery action. NECOC provides publicly available monthly bulletins, U-NIEWS (Uganda National Integrated Multi Hazard Early Warning System), to understand crop and pasture conditions, food insecurity, weather/climate forecast and to determine anticipated disasters while providing disaster management and humanitarian aid information.

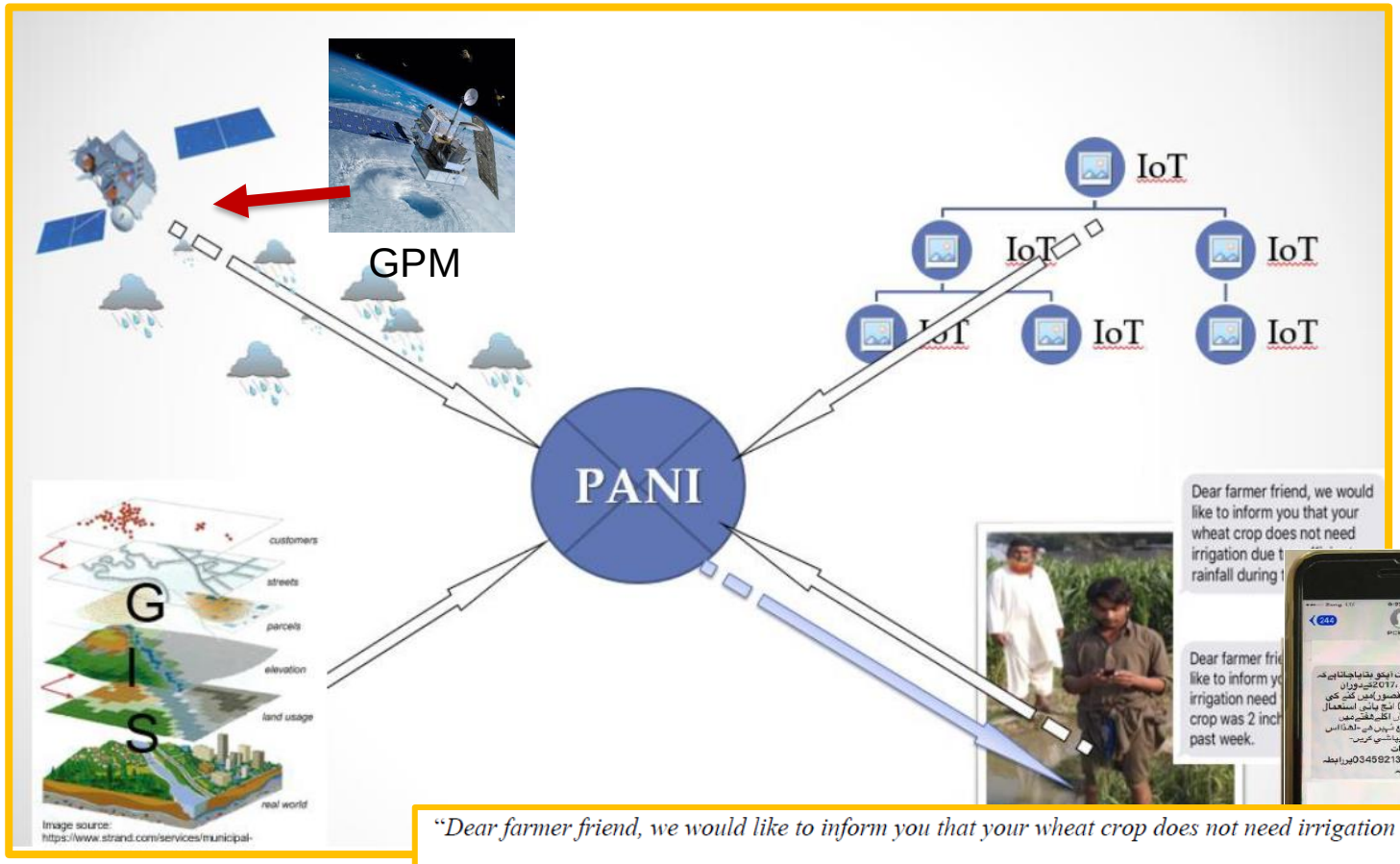


Each month, NASA rainfall data are combined with soil moisture, temperature, and evapotranspiration data to analyze crop and pasture conditions of Uganda at the national and sub-national level to determine crop production risks. This information enables NECOC and UNDP to determine probability of food insecurity and other disasters to issue warnings and alerts. The data is analyzed and shared among government departments, parliament ministers, diplomatic missions, academics, development partners, UN Agencies, NGOs, farmer organizations, and the public via emails.

**To view U-NIEWS' monthly bulletins: http://www.necoc-opm.go.ug/bulletins.php

Empowering Small Farmers with Satellite Data in India

Building on the successful development of an operational irrigation advisory system based on satellite and weather model data for farmers in Pakistan, a pilot project termed Provision of Advisory for Necessary Irrigation (PANI) system was developed and implemented in India.



"*Dear farmer friend, we would like to inform you that your wheat crop does not need irrigation due to sufficient rainfall during the past week.*"

The PANI concept, combining satellite and weather model data (upper left) with finer resolution geographic data (lower left) and personalized farm data (upper right) to generate irrigation advisories via cellphones.

PANI is enabling conservation of water and nationwide smart-farming practices!

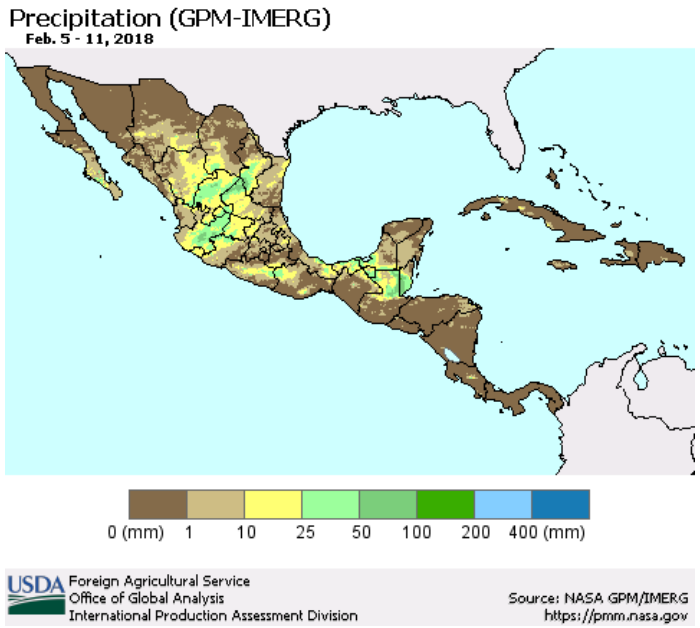
Check out more information at SASWE.net

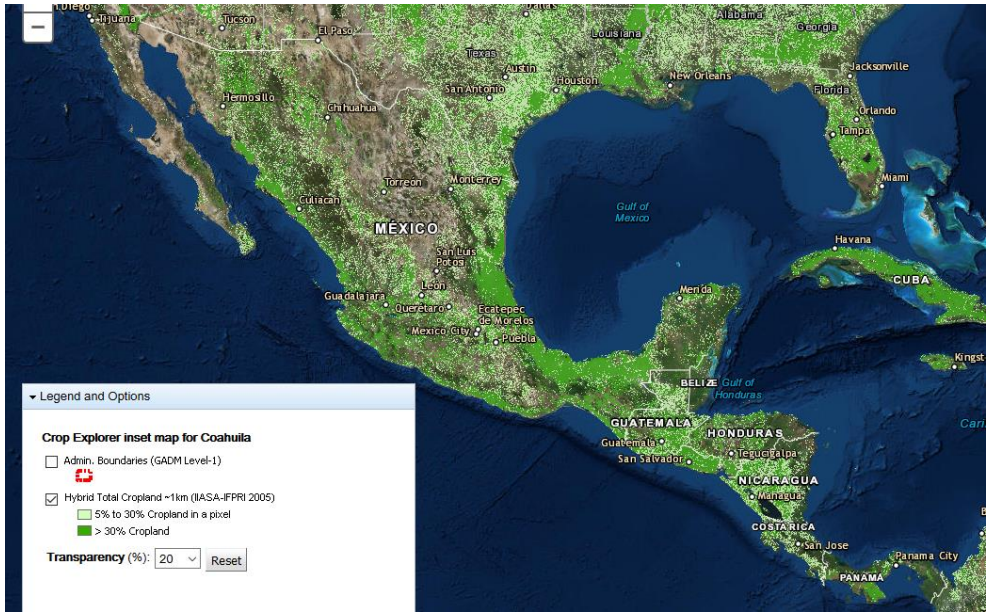
- The PANI enables farmers to receive real-time information on water resources in their area to know when and how much to water their crops.
- Information is customized to each plot of land and communicated via cellphones.

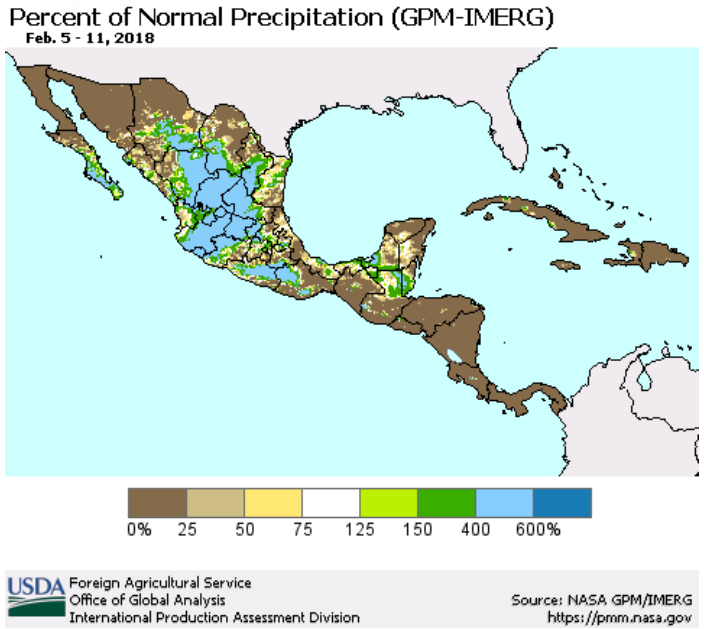
Image and text resources provided by Faisal Hossain (UW CEE)

Using NASA's Precipitation Data for Global Crop Production Analysis

NASA's precipitation products have been incorporated into USDA Foreign Agricultural Service's global crop production analysis to determine impacts on agricultural yields and vegetation health. Due to high resolution of the data, GPM (IMERG) products are used as a precipitation reference data source to develop weekly, 10-day, monthly, and 3-month precipitation data sets at USDA/FAS/IPAD.







Google Crop Explorer from USDA/FAS IPAD (above images)
https://ipad.fas.usda.gov/cropexplorer/imageview.aspx?regionid=ca&startdate=12%2f21%2f2017&imenddate=12%2f31%2f2017&ftypeid=23&fattributeid=1&stypeid=23&sattributeid=2

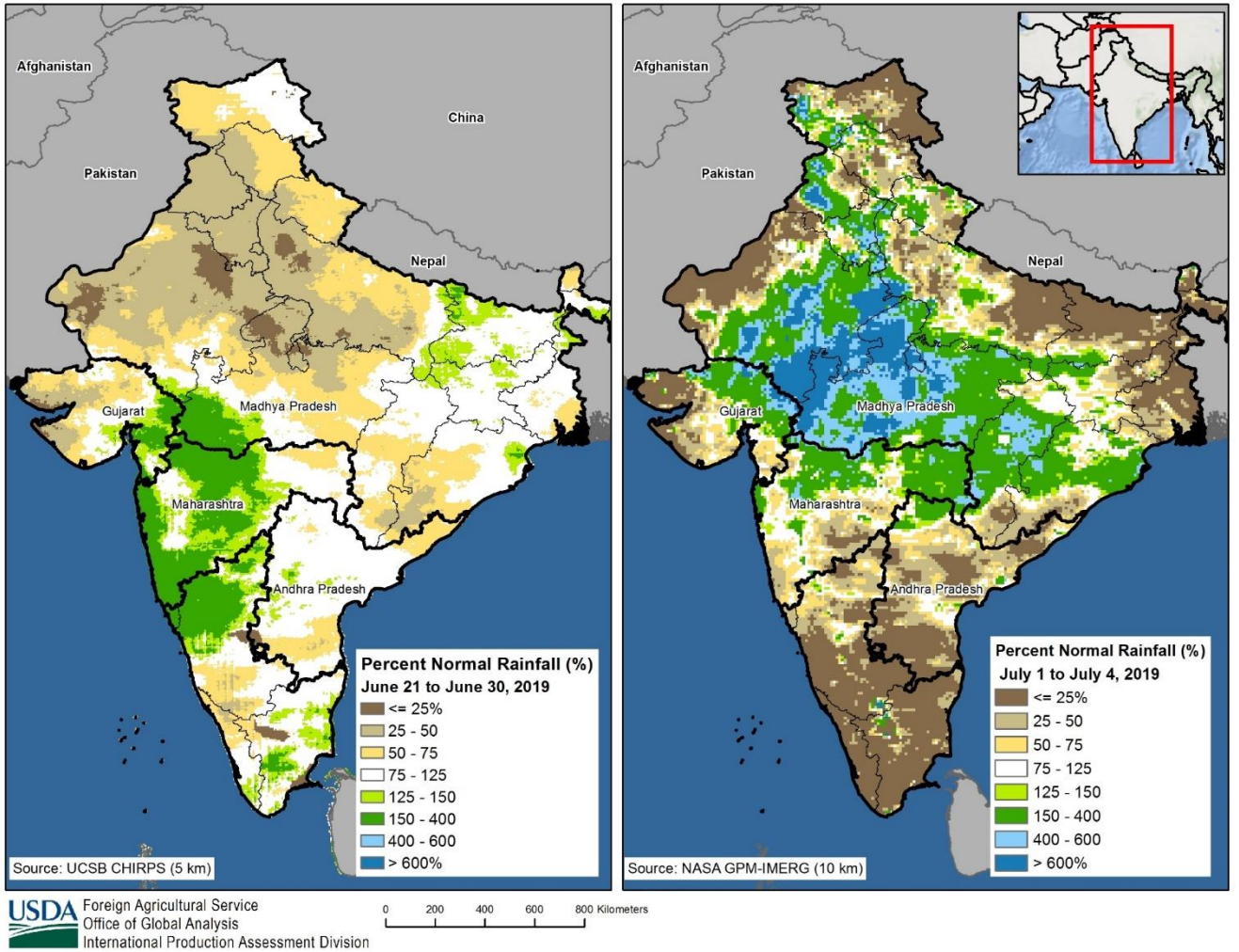
The International Production Assessment Division (IPAD) of FAS provides global agricultural production outlook and the conditions affecting food security. IPAD assessments are an integral component of the monthly crop assessments issued by USDA's World Agricultural Outlook Board - a primary source for agricultural information worldwide (*USDA FAS).*

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."*

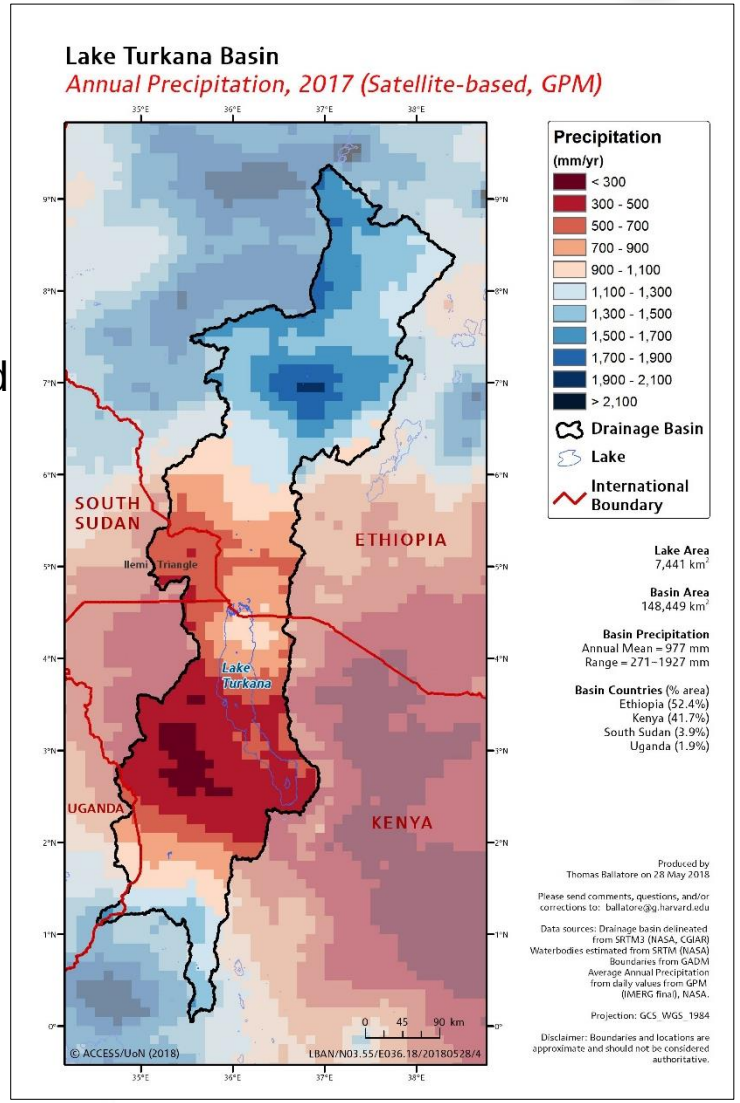


Previous CHIRPS and then IMERG estimates that corroborate reports of heavy rains after a prolonged drought in the Madhya Pradesh region in 2019. Credit: Justin Blackburn, USDA FAS

GPM used to empower the DAFNE Project

Ethiopia's hydropower development upstream from Lake Turkana altered the natural flow and sediment regime of the Omo-Turkana basin, thus leading to changes in the temporal and spatial water availability in the Lower Omo Valley and Lake Turkana, the inflow of which largely depends on the Omo River. The DAFNE project, an EU-funded project which explores the water-energy-food Nexus in complex transboundary water resource systems of fast developing countries, is identifying sustainable solutions analyzing the trade-offs among the key water uses for hydropower, irrigation and the environment around Lake Turkana. To support this effort, GPM monthly and annual GPM precipitation maps are used to assess the region's water budget.

Tom Ballatore, director and founder of the Lake Basin Action Network (LBAN), develops precipitation maps not only for the DAFNE Project, but produces multiple precipitation maps for several organizations and research projects for lake basin management activities. He also teaches how to access GPM and apply the data for water and agriculture applications across Africa. The DAFNE Project is just one example of many of Ballatore's works being used for decision-making for water resource issues.

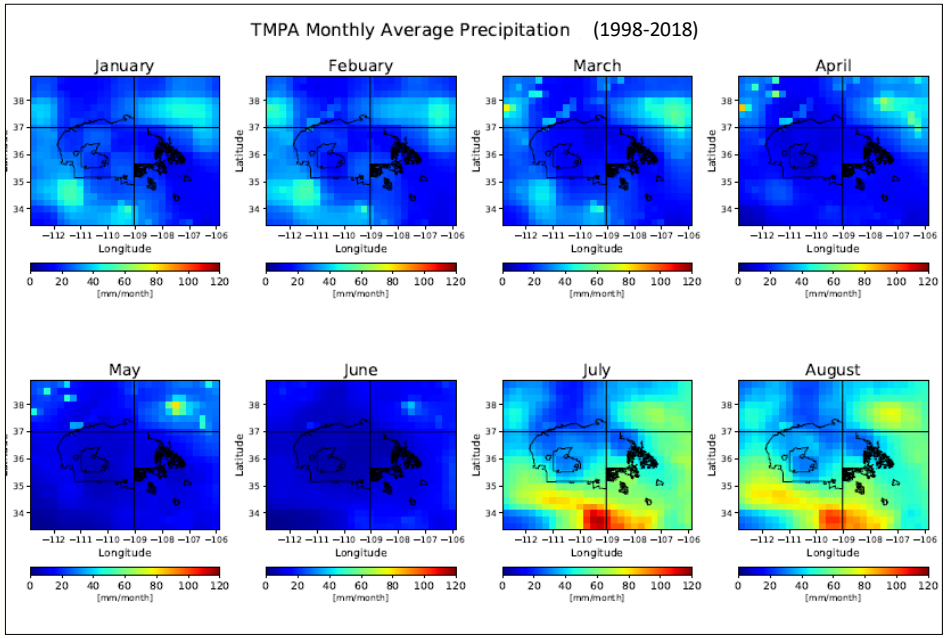


Lake Turkana 2017 monthly (left) and annual (right) precipitation using GPM IMERG Final. Maps were used for the DAFNE General Assembly in October 2018. Credit: Tom Ballatore, LABN, http://www.lakebasin.org/.

Assessing the Water Budget for the Navajo Nation

The Navajo Nation, located in the Four Corners Region of the United States, is suffering from limited freshwater resources as a result of climate, insufficient infrastructure, and contamination. The lack of reliable freshwater resources directly impacts the Navajo's energy, water, and food nexus (EWFN), which is expected to be further impacted in the future by climate change. In a region where surface observations of precipitation are sparse, the integration of satellite-derived precipitation products, such as TMPA, and other NASA data will be utilized to create precipitation climatologies and water budget assessments. Satellite-derived precipitation climatologies will shed light on the region's hydroclimate vulnerability and aid in the assessment of potential freshwater resource mitigation strategies, such as rainwater harvesting. This work using NASA satellite-derived precipitation data aims to improve freshwater resource security for the Navajo Nation to enhance the synergistic relationships between sectors of the EWFN.

Credit: http://www.navajo-nsn.gov/



(Left) Monthly average of precipitation (in mm/month) and (right) seasonal averages of precipitation (in mm/month) from 1998-2018 using TMPA. The figures show the Four Corners Region with the Navajo Nation Reservation outlined. The figures also show the lack of precipitation in the region. The North American Monsoon that brings a majority of the annual rainfall to the southwestern United States is evident in the figures, particularly in the months of July and August. Interestingly, the climatological spatial extent of the monsoon rainfall is south of the Navajo Nation, posing water resource replenishment and security challenges for the community.

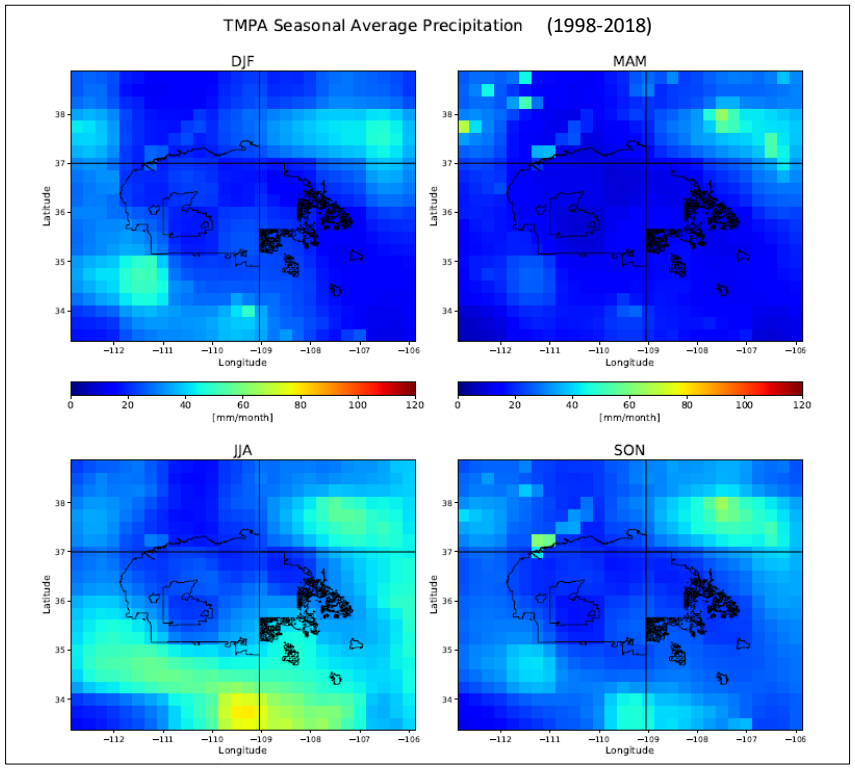


Image and text credits: (Katherine) Ansley Long, University of Georgia, kalong@uga.edu

GLOBAL PRECIPITATION MEASUREMENT

GPM used for Agricultural Forecasting in Africa

VanderSat, a Dutch satellite data analysis service company, is using NASA's satellites (GPM and SMAP) and other satellites to develop precipitation, vegetation and temperature products for the agriculture sector. Working with over 5,000 registered users including insurers, agriculture companies, governments, and the Red Cross, VanderSat produces products for agricultural forecasting, predicting the weather, and performing predictive analysis.

NASA's rainfall and soil moisture data enables VanderSat within the Partners for Water Program to collaborate with Tongaat Hulett, a large sugar cane company, to improve the water use efficiency and water productivity in a large scale open irrigation system of the Tongaat Hulett Xinavane Sugar Estate, Mozambique. Using satellite data, researchers can determine the different water fluxes (evaporation) and states (soil moisture) within the plantation. This information is then used by local operators to determine when to irrigate the fields.

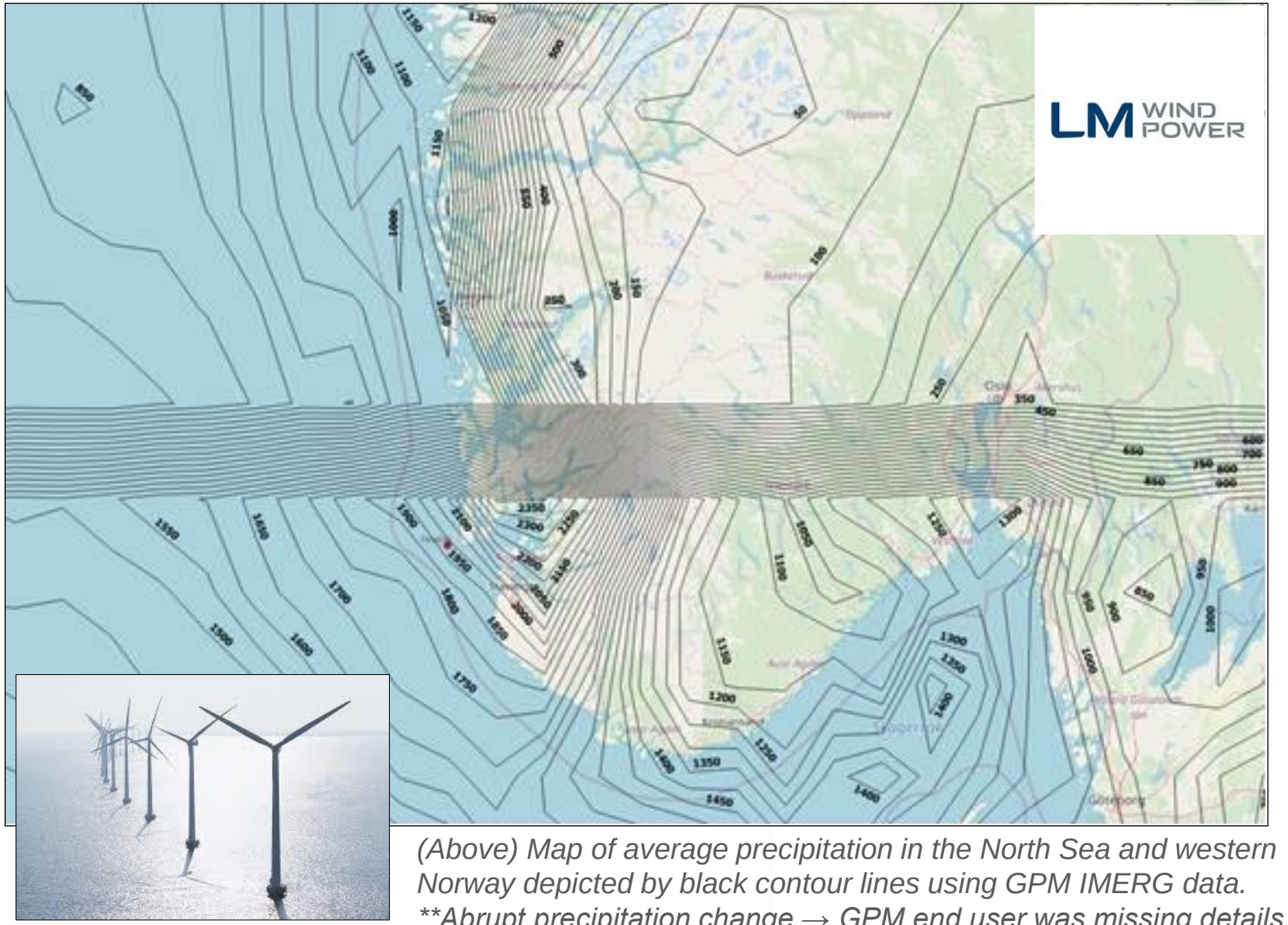
"With our high resolution satellite products based on microwave observations including GPM-GMI we are able to manage water resources in a water stressed area more efficiently. The sugarcane plantation in southern Mozambique is a clear example of a significant water user along the Incomati riverbank. By boosting their water efficiency using valuable satellite information about soil moisture, and evaporation, sustainable expansion is possible and surrounding local farmers can meet their water needs" **- Richard de Jeu, VanderSat Founder**

VanderSat

GLOBAL PRECIPITATION MEASUREMENT

GPM IMERG Data Used for Wind Energy

Individual components of wind turbines, especially the rotor blades, are expected to have an operational life span of 20 years while facing environmental extremes such as precipitation. These extremes can lead to corrosion on the leading edges of the blades and reduce the overall efficiency of converting wind into energy. To understand how weather impacts wind turbine blades throughout the world, LM Wind Power (a supplier of wind turbine blades worldwide) is using GPM IMERG data to develop contour precipitation maps and determine average precipitation at existing and potential wind turbine site locations. This information will help LM Wind Power gather information on blade reliability and performance to satisfy their customers.

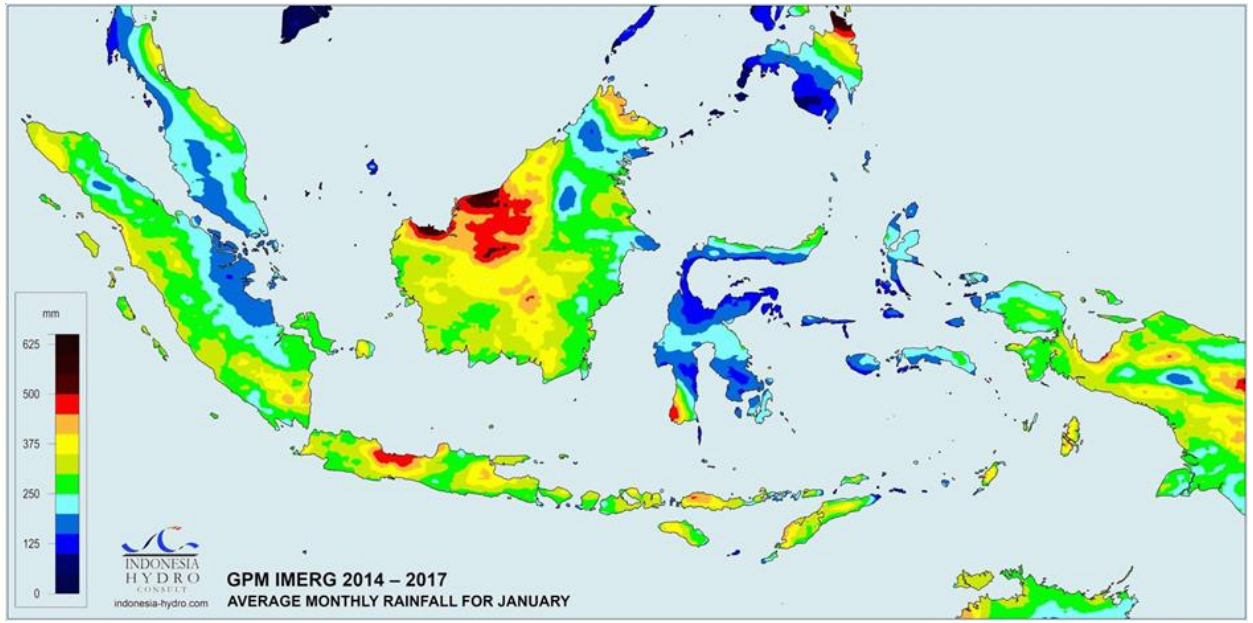


LM Wind Power, www.lmwindpower.com.

*(Above) Map of average precipitation in the North Sea and western Norway depicted by black contour lines using GPM IMERG data. **Abrupt precipitation change → GPM end user was missing details and will revise.*
Image credits: (Central) Laurids Andersen

Driving Hydropower Generation in Indonesia using GPM IMERG

Availability of river flow is an important factor in the planning and the development of a hydropower plant to estimate its capacity and energy production. A hydro engineering consulting service company in Indonesia, INDONESIA HYDRO™ CONSULT, is using NASA's TRMM and GPM precipitation data to better understand the potential for hydropower projects throughout Indonesia. These data are particularly relevant where rivers are either ungauged or the quality of records from the gauging stations are unreliable. This company provides hydrological modeling consulting services for hydro developers, leveraging satellite precipitation data along with river discharge, slope, vegetation, and evapotranspiration to characterize potential opportunities for hydropower plant construction.



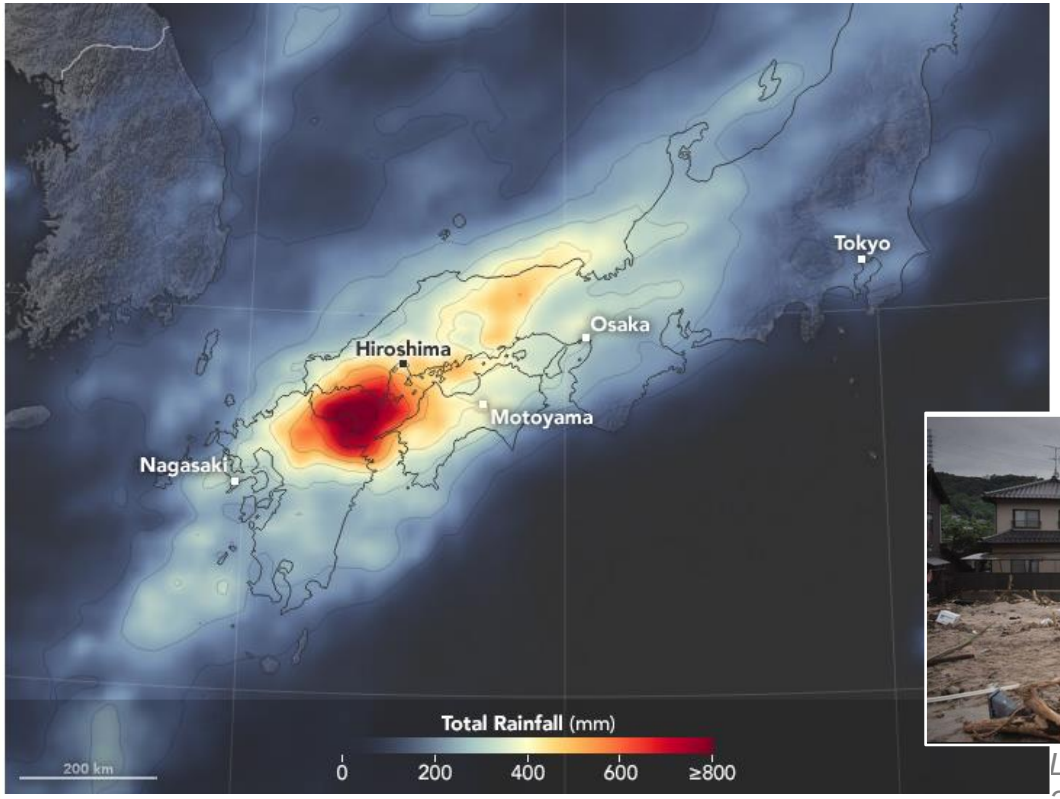
Average annual rainfall in Indonesia for January, 2014 – 2017, GPM IMERG (INDONESIA HYDRO™ CONSULT)

INDONESIA HYDRO™ CONSULT project locations throughout Indonesia (above).

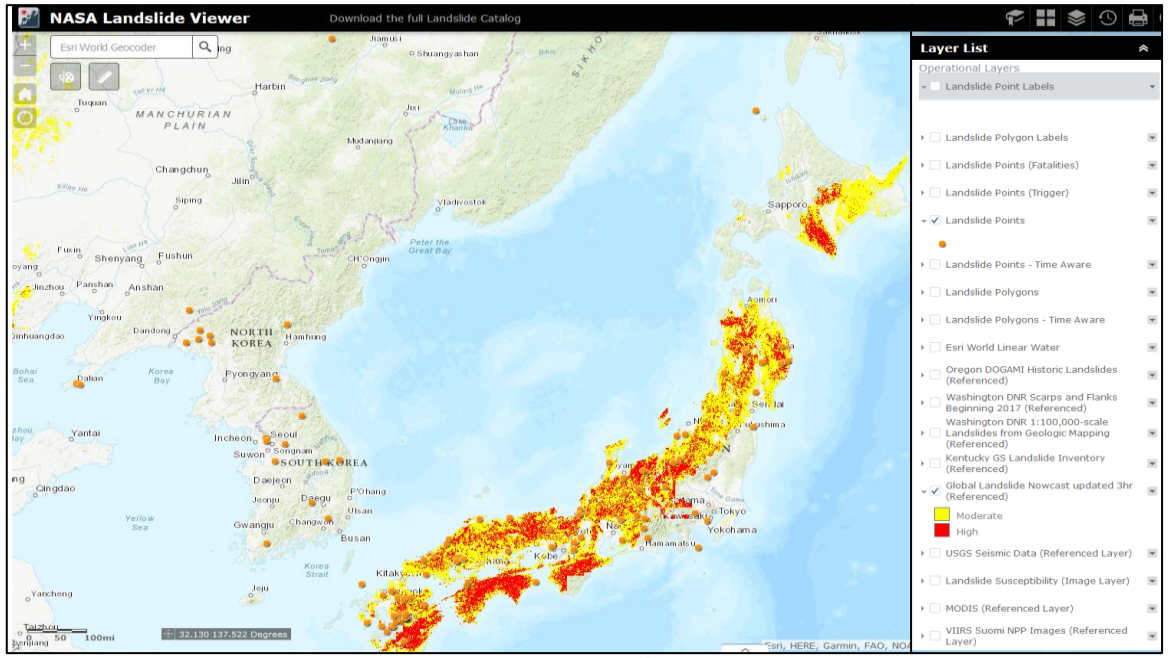
Kincang Hydropower Project; Location: Banjarnegara, Central Java, Indonesia (INDONESIA HYDRO™ CONSULT) (right)

Aftermath of Typhoon Prapiroon across Japan

At least 155 people have died in floods and landslides triggered by Typhoon Prapiroon in Japan. GPM IMERG estimates showed upwards of 20.2 inches (512 mm) of rain in areas across the country from July 2 to July 9, 2018 (*below*). These heavy rains led the Japanese Meteorological Survey to issue landslide warnings for southern Japan that affected millions of people.



Total rainfall (IMERG) from July 2 to July 9, 2018 in Japan (above). Image Credit: Joshua Stevens, NASA Earth Observatory.



NASA Landslide Viewer showing "nowcast" of landslides in Japan on July 10, 2018. Landslide Viewer: (https://science.gsfc.nasa.gov/600/citizen-science/landslides/index.html)

Landslide on Sunday, July 8, 2018 in Hiroshima (Getty Images).

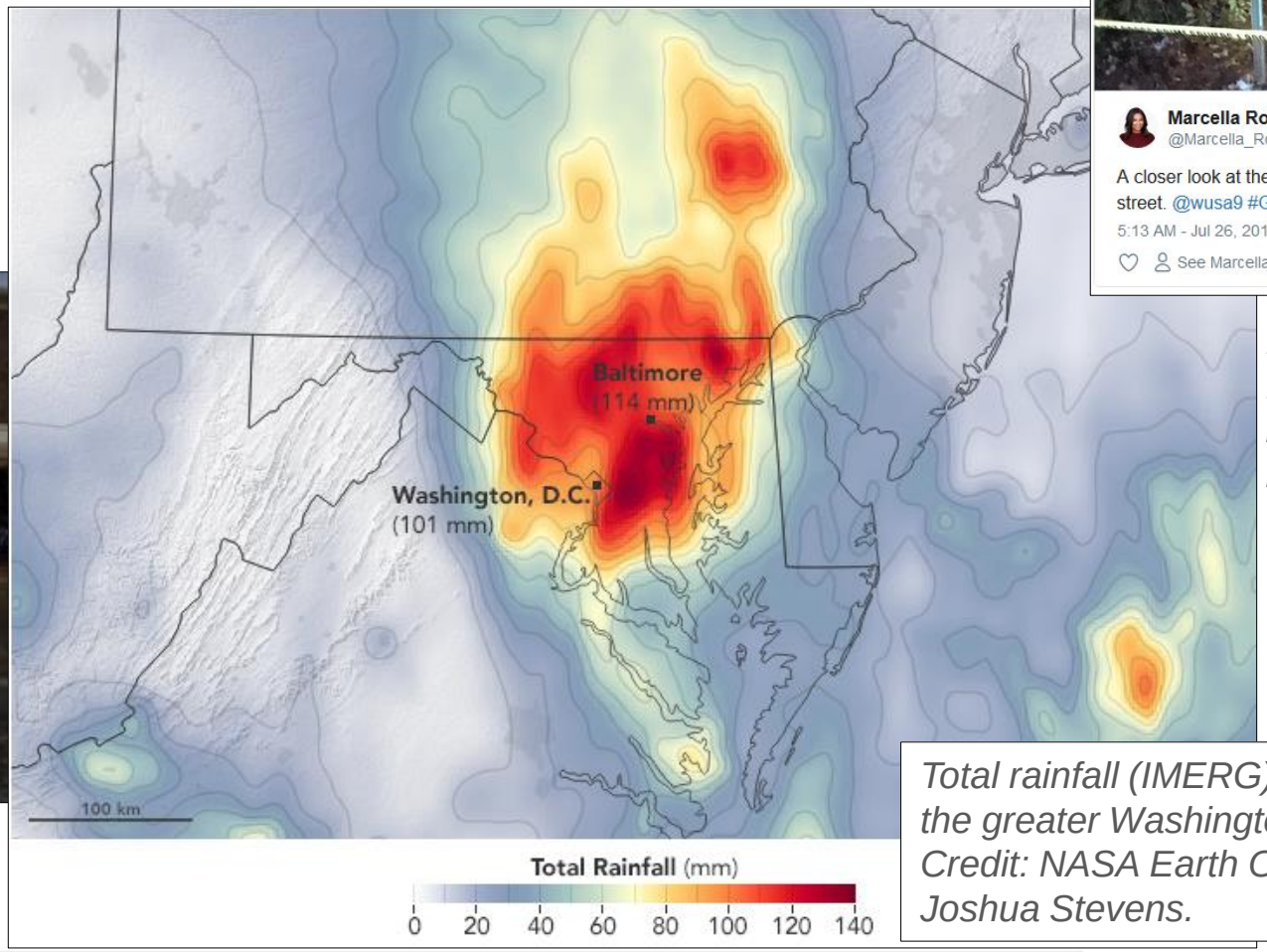
NASA's Landslide Viewer tool enables the public and researchers to pinpoint potential landslide activity in near real-time. Areas that are highly susceptible to landslides from Prapiroon are seen throughout southern Japan (*above*). The tool is based on a model that considers susceptibility with GPM rainfall.

Adding up the Rain in D.C. using GPM IMERG

Over the past several days, rounds of torrential rainfall have pounded the greater Washington metro area triggering flash floods, road closures, downed trees, and several water rescues. GPM IMERG estimates captured this rainfall accumulation between July 20 and July 23, 2018. IMERG data indicate that about 4 inches (101 mm) of rain fell in D.C. and about 5 inches (120 mm) south of Baltimore. These heavy rains have caused the Baltimore area alone to have their wettest July on record (13.26 inches total), pushing past its previous record of 11.03 inches from 1889 (*Capital Weather Gang via Washington Post*).

D.C. journalist, Marcella Robertson, shows the impact of the storms in northern D.C. on Twitter via @Marcella_Rob.

Part of King Street near City Marina floods in Alexandria, Va. Credit: Calla Kessler/The Washington Post.

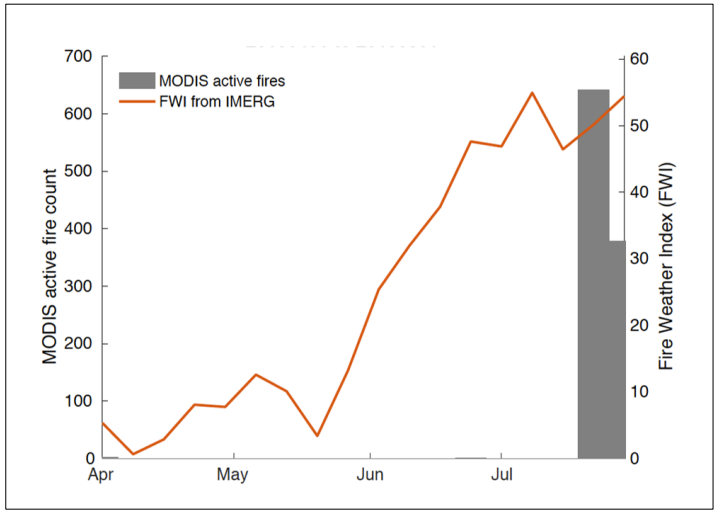


Total rainfall (IMERG) from July 20-23, 2018 in the greater Washington D.C. metro area (left). Credit: NASA Earth Observatory image by Joshua Stevens.

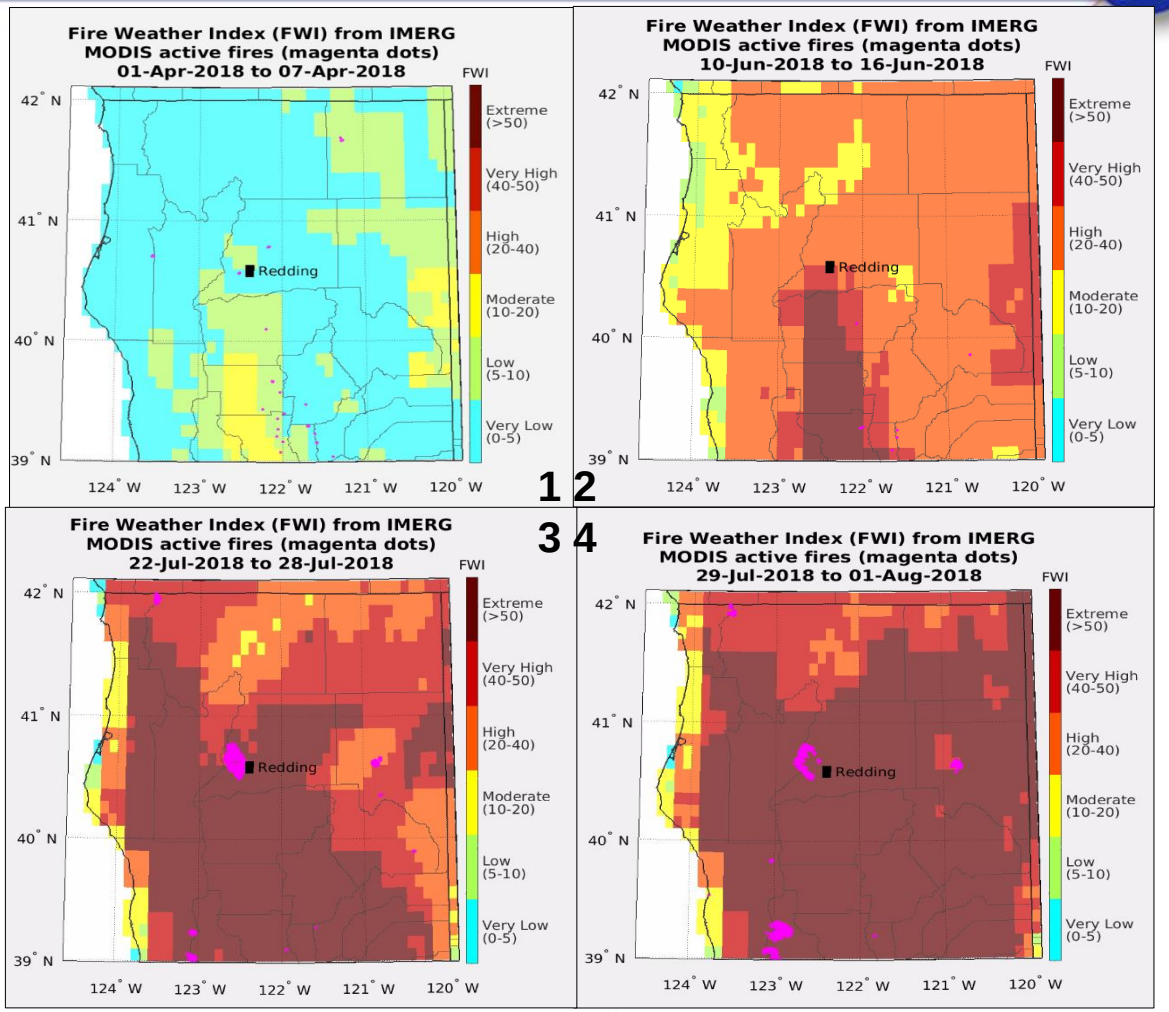
Monitoring California's Carr Fire

The Carr Fire in Northern California erupted on July 23, 2018 and covered over 195 miles (~127,000 acres) by August 2. Hot, dry and windy conditions combined with an extraordinarily high fuel load in the area have transformed the low, local burn into an expansive blaze. More than 4,300 fire personnel have been assigned to the blaze. To help understand and monitor areas for fire danger such as the Carr Fire, NASA's Global Fire WEather Database (GFWED) is used which integrates different weather factors, including daily GPM IMERG precipitation estimates, influencing the likelihood of a vegetation fire starting and spreading.

GFWED provides a globally consistent fire weather dataset for fire researchers and managers to apply locally.
Data are available via the Global Fire Weather Database: https://data.giss.nasa.gov/impacts/gfwed/.



Weekly FWI and MODIS active fire totals over the Carr fire region from April through July, 2018.



Figures 1-4: Evolution of weekly FWI and MODIS active fires over northern California from April 1 to August 1, 2018. Low FWI in April, then FWI increased in June, and was consistently at Very High or Extreme levels through July. FWI is computed using local 12:00pm surface temperature, relative humidity and wind speed from NASA GMAO's GEOS-5 model, and daily IMERG precipitation estimates.

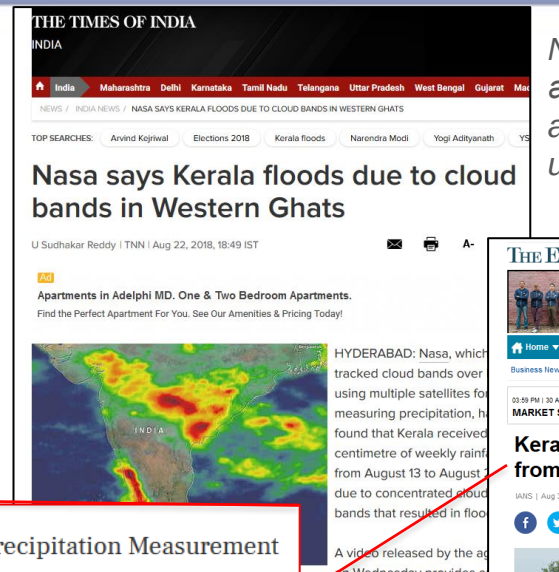
Image and caption credits: Robert Field, robert.field@columbia.edu

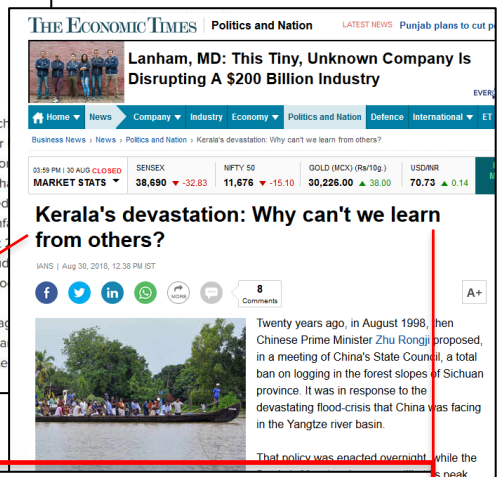
GLOBAL PRECIPITATION MEASUREMENT

GPM in the News

Torrential rain to intense storms have impacted thousands of people throughout the world just within August 2018, resulting in flooding, landslides, canceled flights, damaged infrastructure, and multiple fatalities. The GPM Core observatory along with GPM's constellation of international satellites were able to pass over these devastating precipitation events to estimate rainfall accumulation and capture the storm's structure and intensity. GPM's products, including its visuals, are used by multiple organizations and media outlets to communicate before, during, and after a disaster strikes.

News outlets throughout India are highlighting GPM's products and importance to understanding disaster impacts.





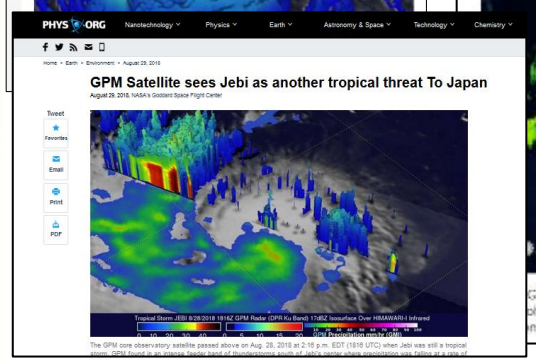
Kerala, After The Flood: Dam expert blames lack of sound reservoir management system for disaster

"To decide upon opening and closing of dam gates, it is now a global norm to use Global Precipitation Measurement Mission data provided by NASA about rainfall. It does not seem such data was used in Kerala," he said.

Above Credit: FIRSTPOST

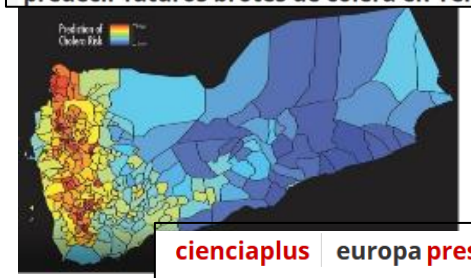
Is there way out?

There are numerous examples and initiatives to learn from and to participate in. The Global Precipitation Measurement (GPM) mission of NASA and the Japan Aerospace Agency predicted the Kerala floods just a few days in advance. Collaboration with GPM and initiating disaster management measures "just-in-time" could still would have helped.



News outlets use GPM IMERG, GMI and DPR data to communicate to the public about current tropical cyclones from phys.org (left), EurekAlert (upper left), to Atlanta's local news on CNBC (above right).

La NASA utiliza por primera vez sus satélites para predecir futuros brotes de cólera en Yemen

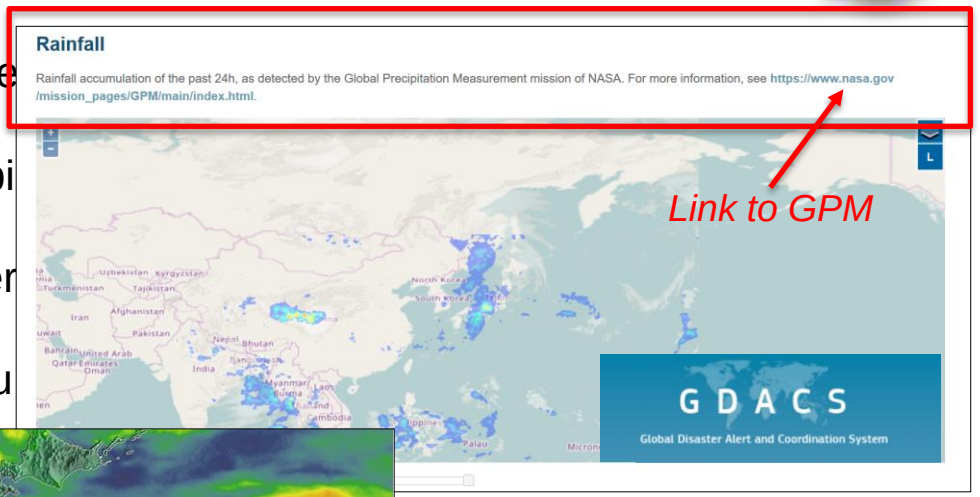


GPM data and products are not only highlighted for disaster applications but are used as inputs in models for disease forecasting and publicized through multiple international media outlets including the *Europa Press (left)* and *Medical Xpress (upper left)*.

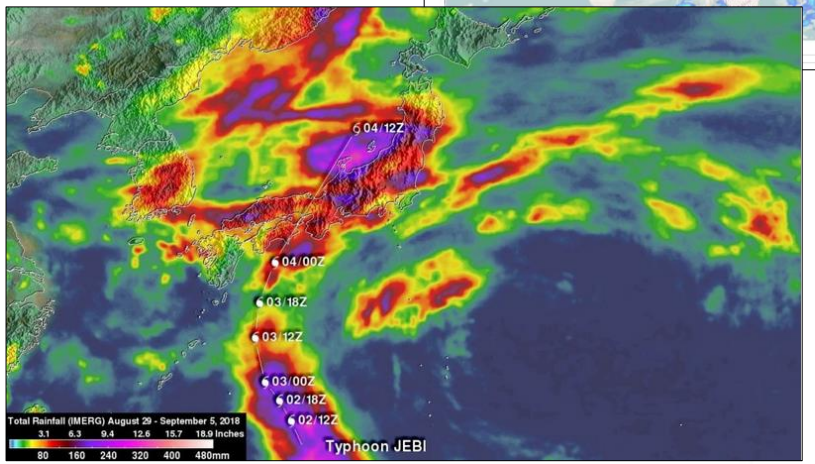
GLOBAL PRECIPITATION MEASUREMENT

GPM helps track Jebi's Staggering Rainfall Totals

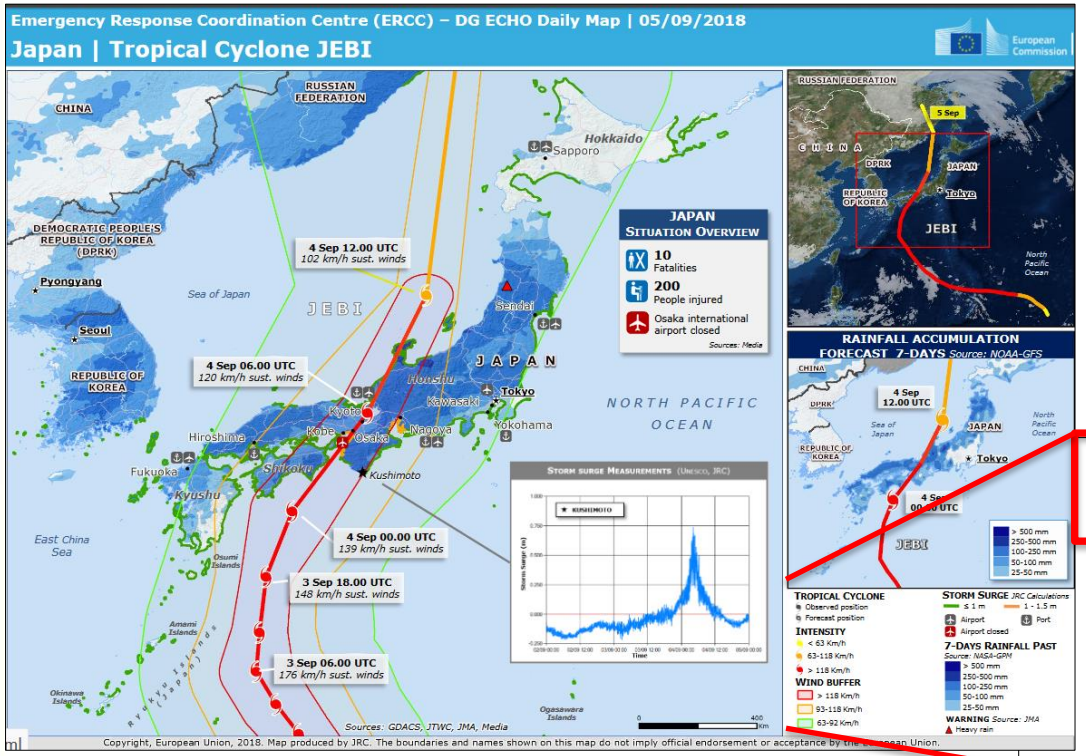
Typhoon Jebi brought torrential rain and strong winds across southern Japan, causing major flooding, landslides, airport closures, and overturn cars within the first week of September 2018. At least 11 fatalities and over 300 injuries were reported due to the storm's intensity. The GPM Core Observatory captured Jebi before making landfall and continued to capture the storm as it brought heavy rain to the country. GPM IMERG data was used to make rainfall estimates over Japan and the surrounding region for the 1-week period from August 29 to Sept. 5. More than 4 inches of rain covered main island of Honshu and Shikoku in the south.



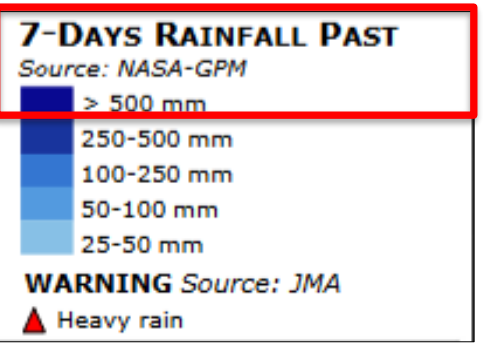
GDACS Disaster Alert Map crediting GPM for rainfall totals for Typhoon Jebi (above). Credit: http://www.gdacs.org/Cyclones/report.



Total rainfall (IMERG) from 8/29 to 9/05, 2018 in Japan (left). Credit: Hal Pierce (SSAI/NASA GSFC).



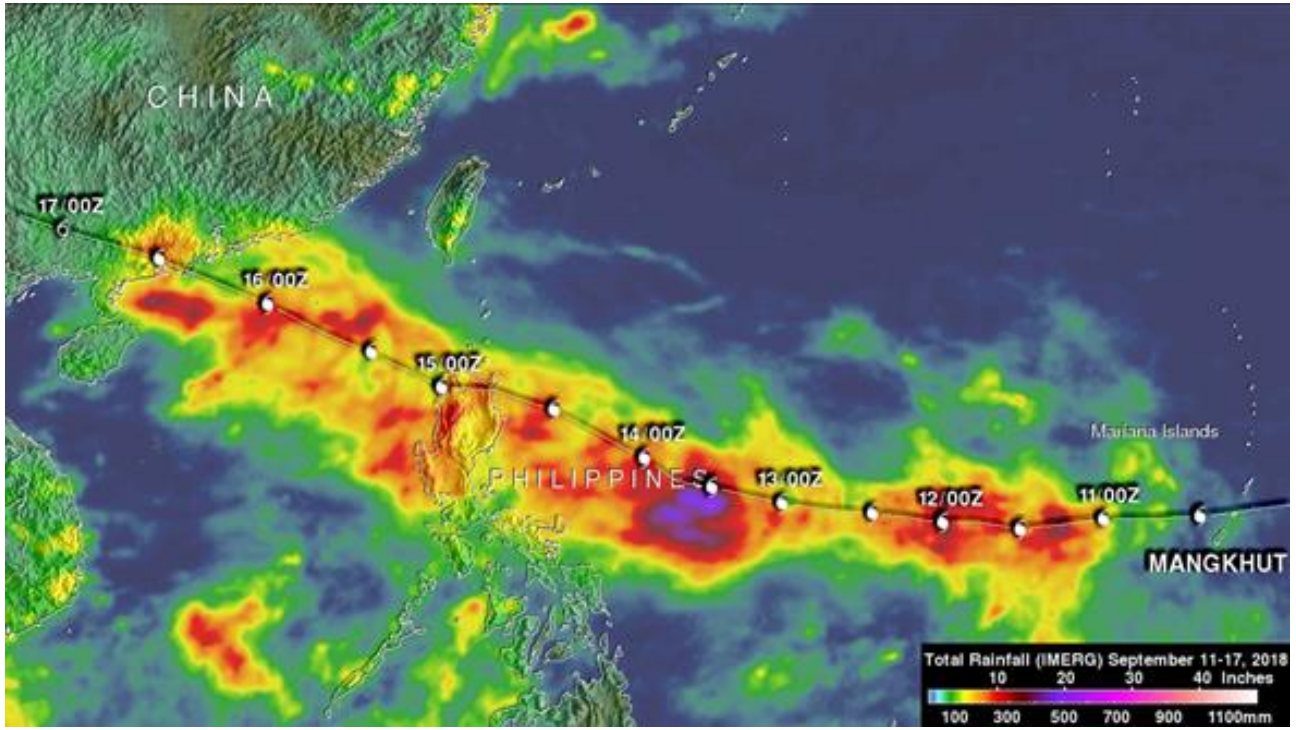
ECHO Daily Map for Jebi on 09/05/2018 using data from GPM. Credit: https://erccportal.jrc.ec.europa.eu/Maps/Daily-maps



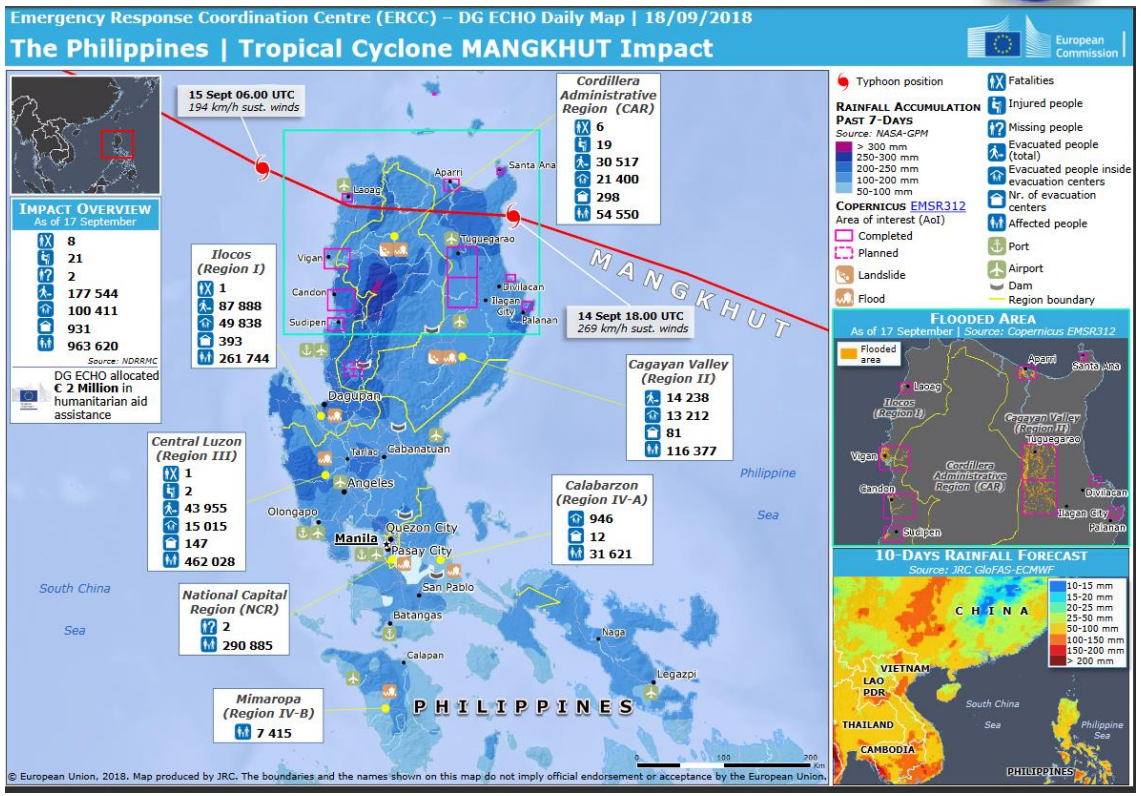
The EU's ERCC and the GDACS used GPM rainfall estimates to communicate real-time rainfall information to multiple relief organizations and the government of Japan. This information is being used to prepare and plan for proper disaster response and relief throughout the country for Typhoon Jebi.

Adding Up Typhoon Mangkhut's Rainfall with GPM

From September 14-17, 2018, Typhoon Mangkhut brought torrential rains and strong winds across the Philippines, mainland China, and Hong Kong. Over 175,000 people were evacuated from their homes in the Philippines alone. GPM IMERG data was used to show accumulated rainfall as the storm traced across the Philippines and made landfall in China. More than 4 inches of rain stretched from Manila to the northern tip of Luzon triggering landslides and flooding. The *New York Times* even highlights the storm's intensity with GPM data before making landfall.



Total rainfall (IMERG) from 9/11 to 9/17, 2018 for Typhoon Mangkhut. Credit: Hal Pierce (SSAI/NASA GSFC).



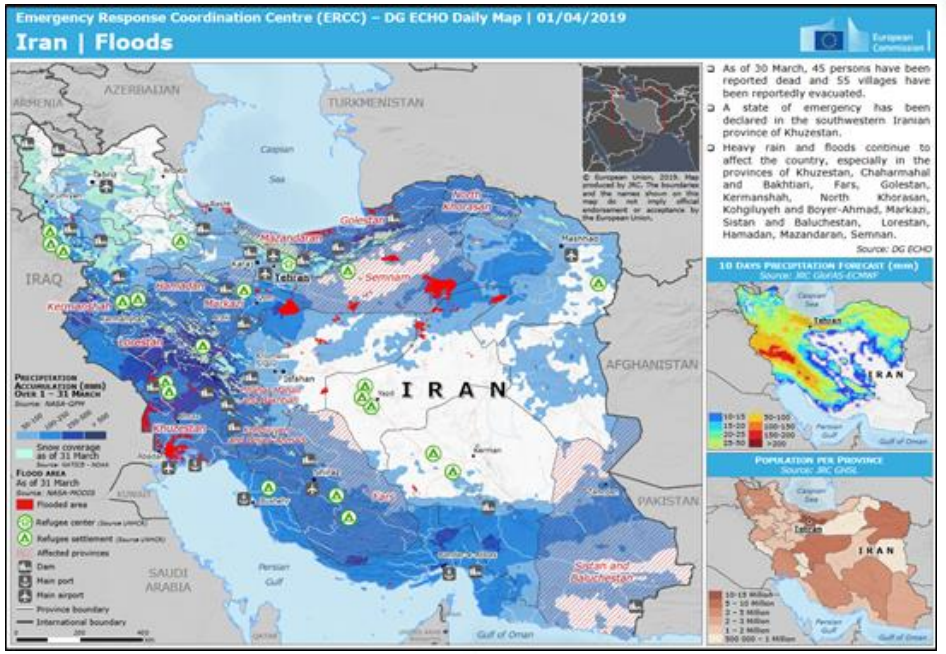
GDACS Emergency Response Map for Mangkhut on 09/18/2018 using data from GPM. Credit: https://erccportal.jrc.ec.europa.eu/Maps/Daily-maps

The Global Disaster Alert and Coordination System (GDACS) used GPM IMERG data to distribute information about the storm's impact across the countries. In turn, GDACS' data was used by several relief organizations to provide humanitarian aid where needed.

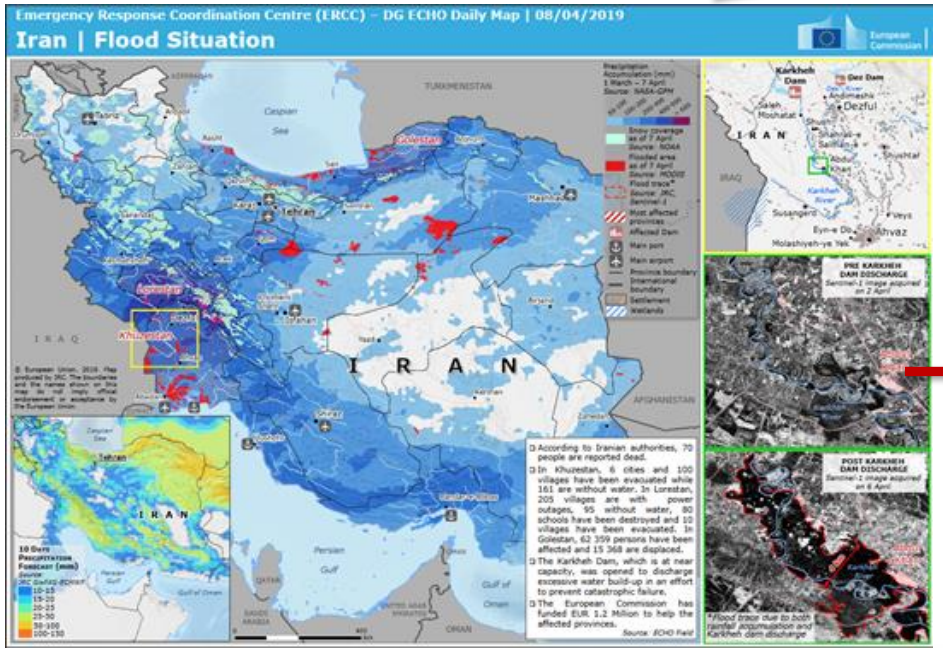
GLOBAL PRECIPITATION MEASUREMENT

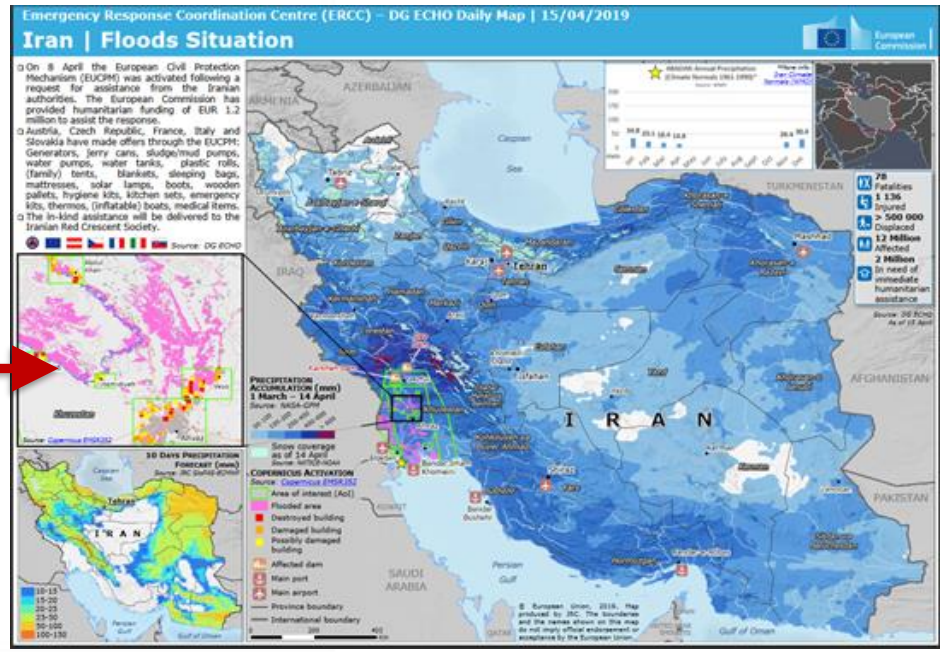
GPM Helps ERCC in Disaster Communication

To support disaster response in a timely and efficient manner and meet the needs of the population effected, Emergency Response Coordination Centre (ERCC) collects and analyses real-time information on disasters, monitors hazards, prepares plans for the deployment of experts, teams and equipment, and works with Member States to map available assets and coordinate the EU's disaster response efforts by matching offers of assistance to the needs of the disaster-stricken country. Part of the ERCC strategy is to develop and provide maps to the public of real-time information for a disaster which includes socioeconomic and earth observation data, where GPM IMERG accumulation rainfall data is continuously used to as a precipitation data source.



The ERCC maps to the right show how GPM data were used to communicate the April 2019 flooding disaster in Iran. The maps were updated regularly for the public. Rains not only caused flooding but displaced thousands of people and killed over 70 throughout the country.





GPM used within the ERCC for Disaster Communication

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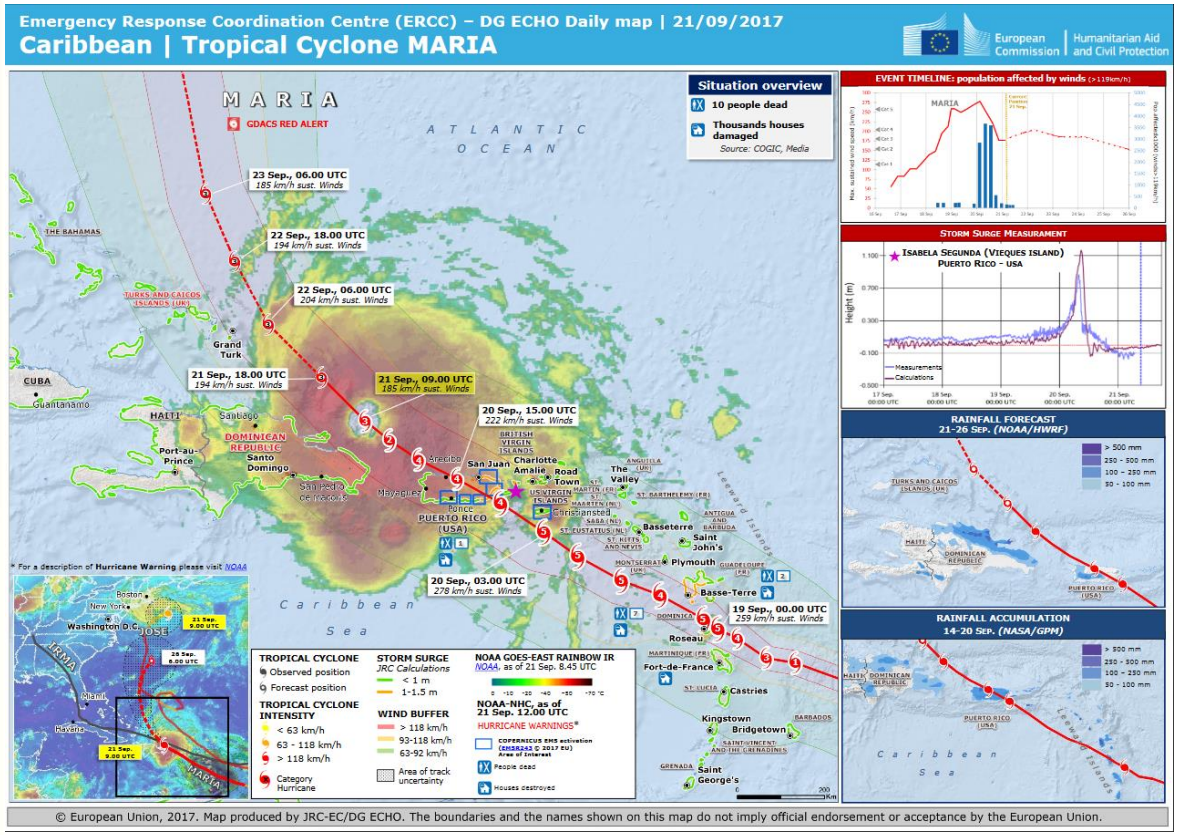

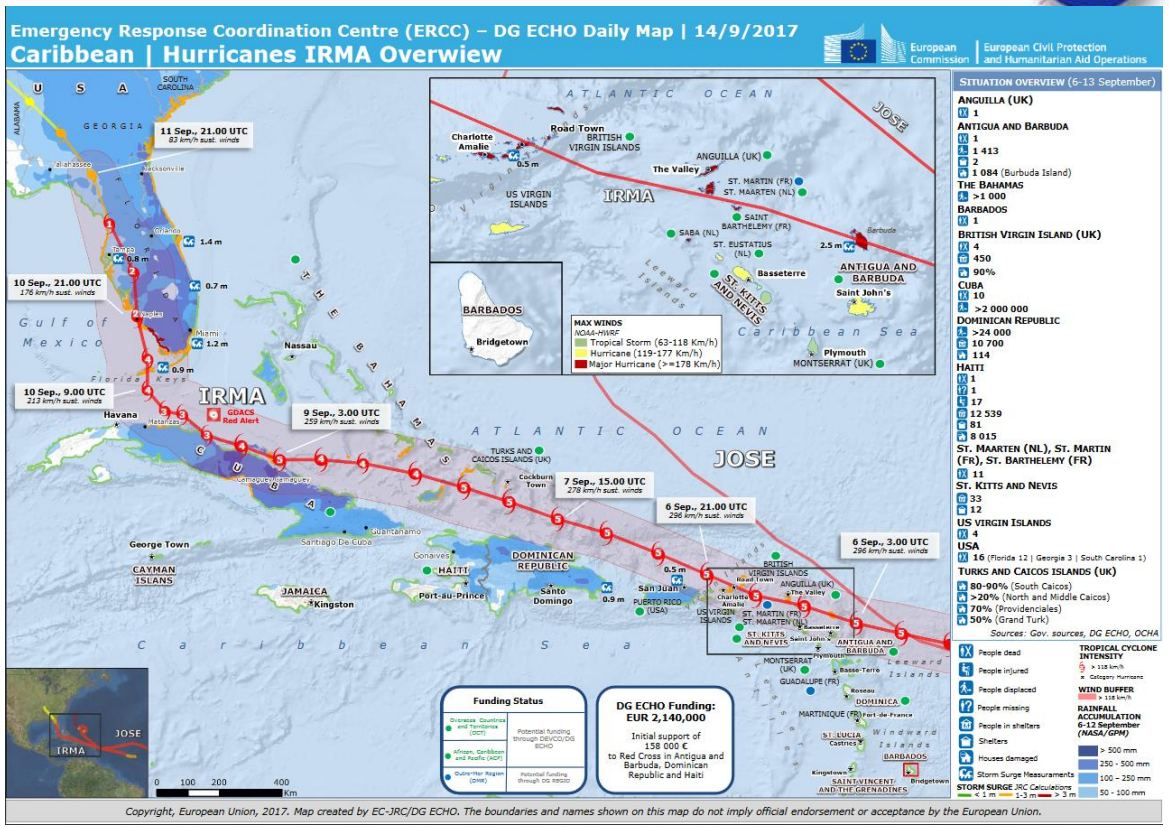

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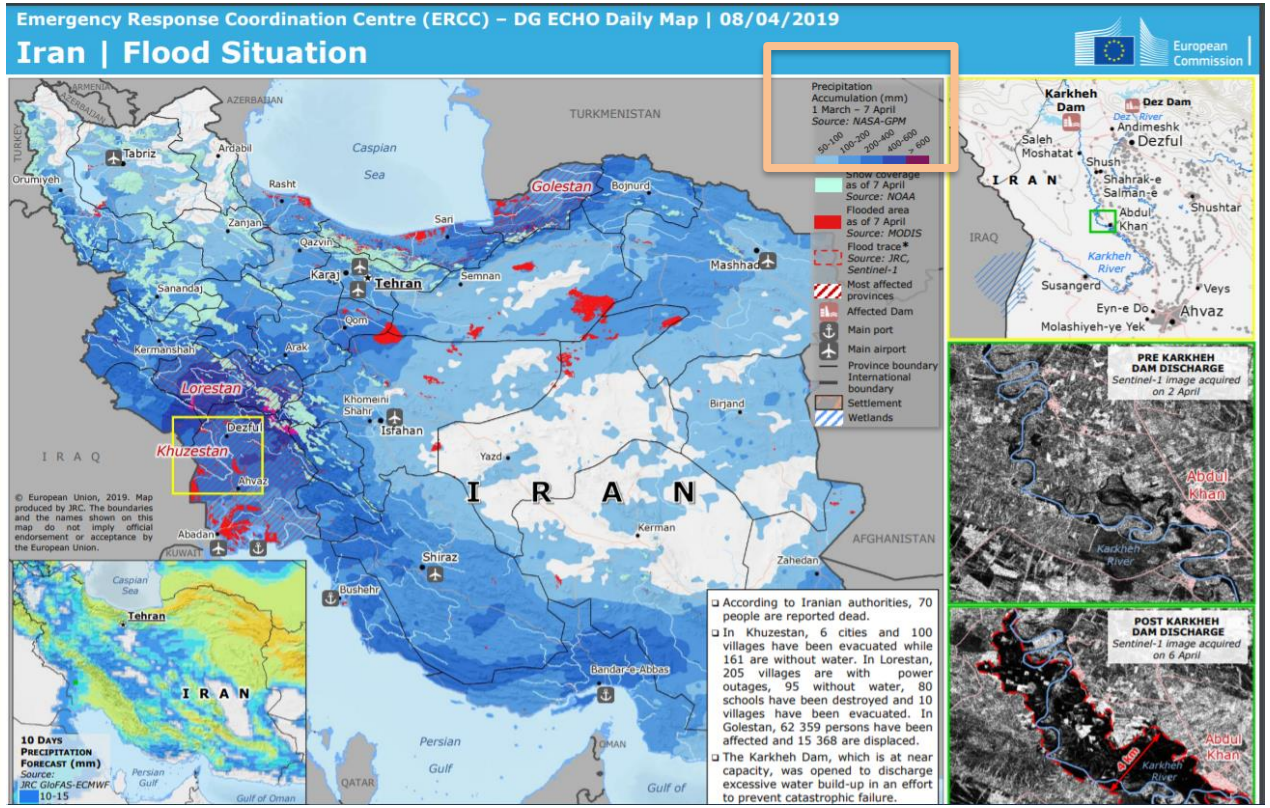
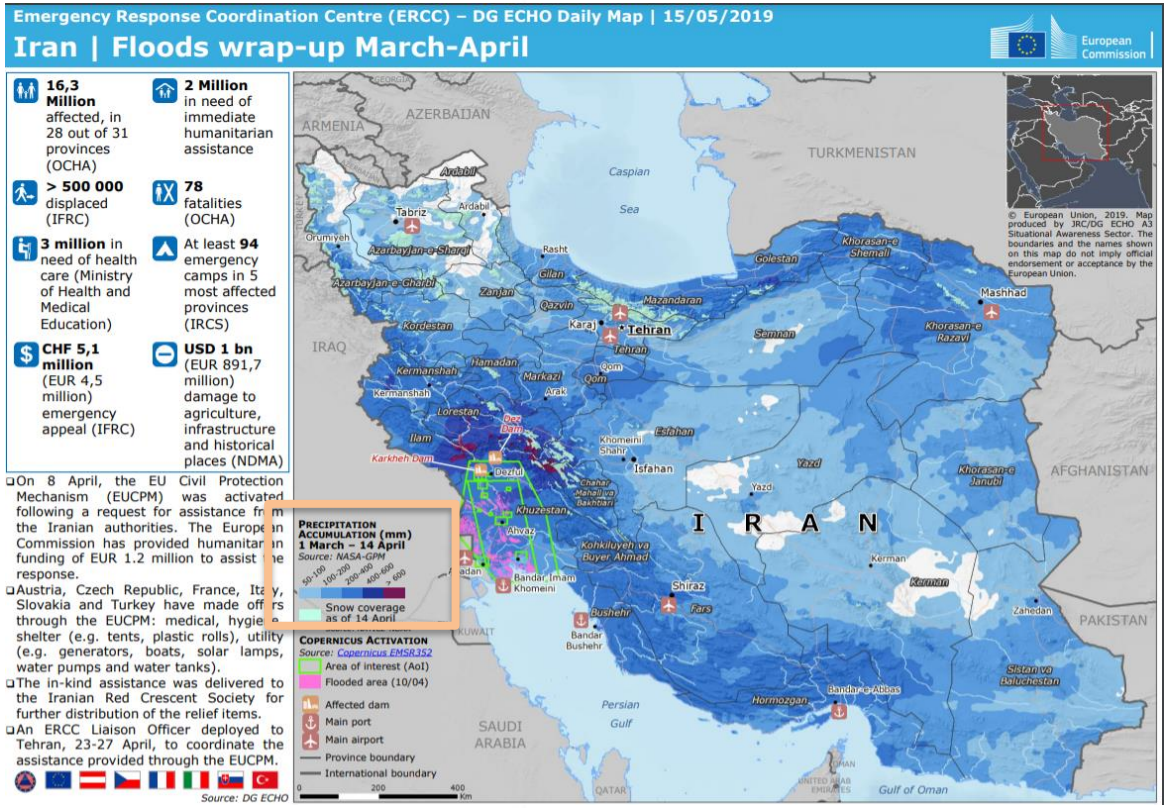
The ERCC used GPM IMERG data to distribute information about the storm's impact across the countries. In turn, ERCC's data was used by several relief organizations to provide humanitarian aid where needed.

GLOBAL PRECIPITATION MEASUREMENT

Map of EU humanitarian assistance in response to 2019 March-April floods

https://erccportal.jrc.ec.europa.eu/ECHO-Products/Maps#/maps/latest



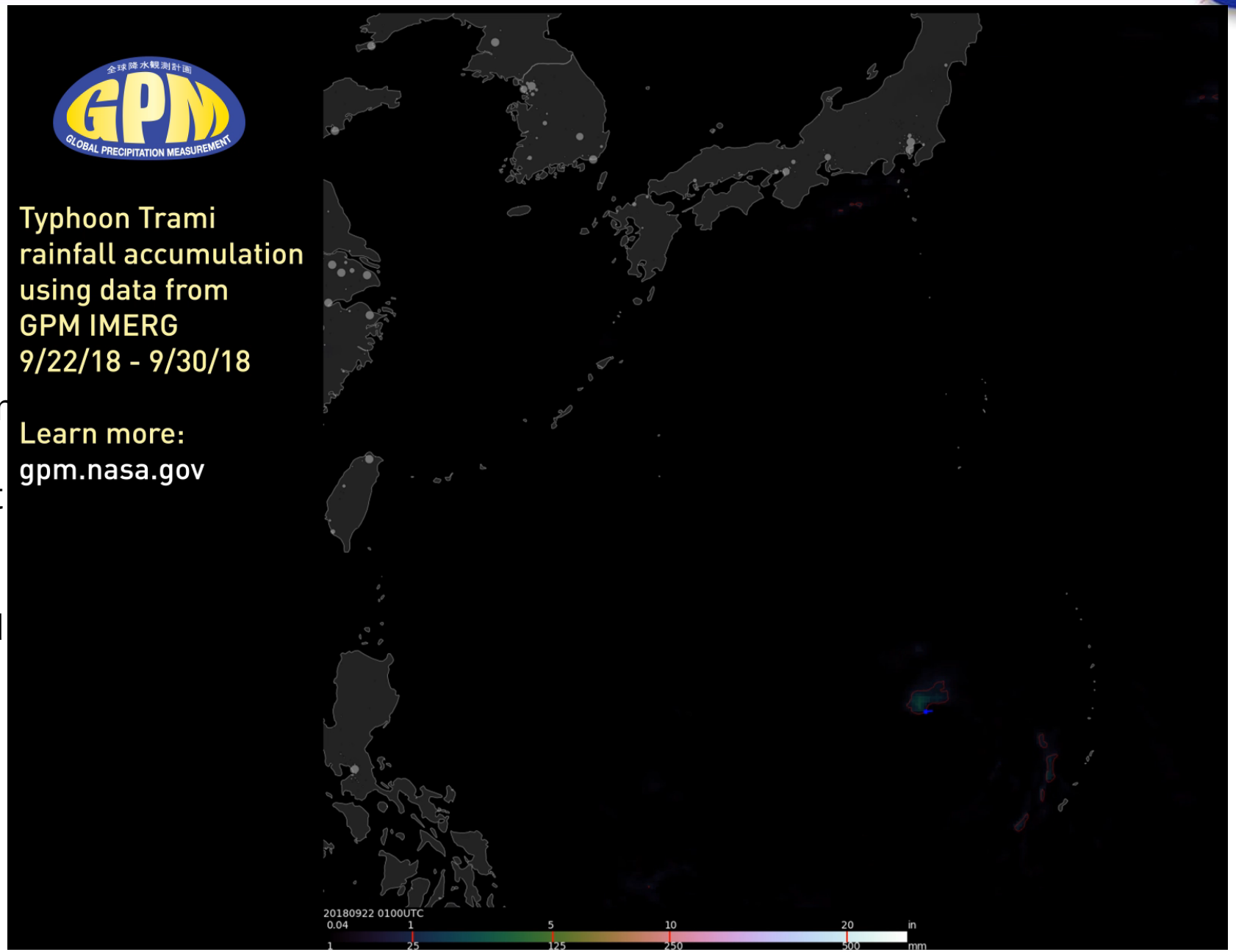


- Emergency Response Coordination Centre (ERCC) collects and analyses real-time information on disasters, monitors hazards, prepares plans.
- ERCC maps show how GPM data were used to communicate the April 2019 flooding disaster in Iran. The maps were updated regularly for the public. Rains not only caused flooding but displaced thousands of people and killed over 70 throughout the country.

Multiple Perspectives of Typhoon Trami using GPM Data

This rainfall accumulation analysis was derived from the GPM IMERG multi-satellite dataset. This analysis shows IMERG rainfall accumulation estimates along Trami's track during the period from becoming a tropical depression in the western Pacific until it passed off the southeast coast of Japan. IMERG rainfall accumulation data indicated that Trami frequently produced rainfall totals greater than 10 inches (254 mm) along it's track.

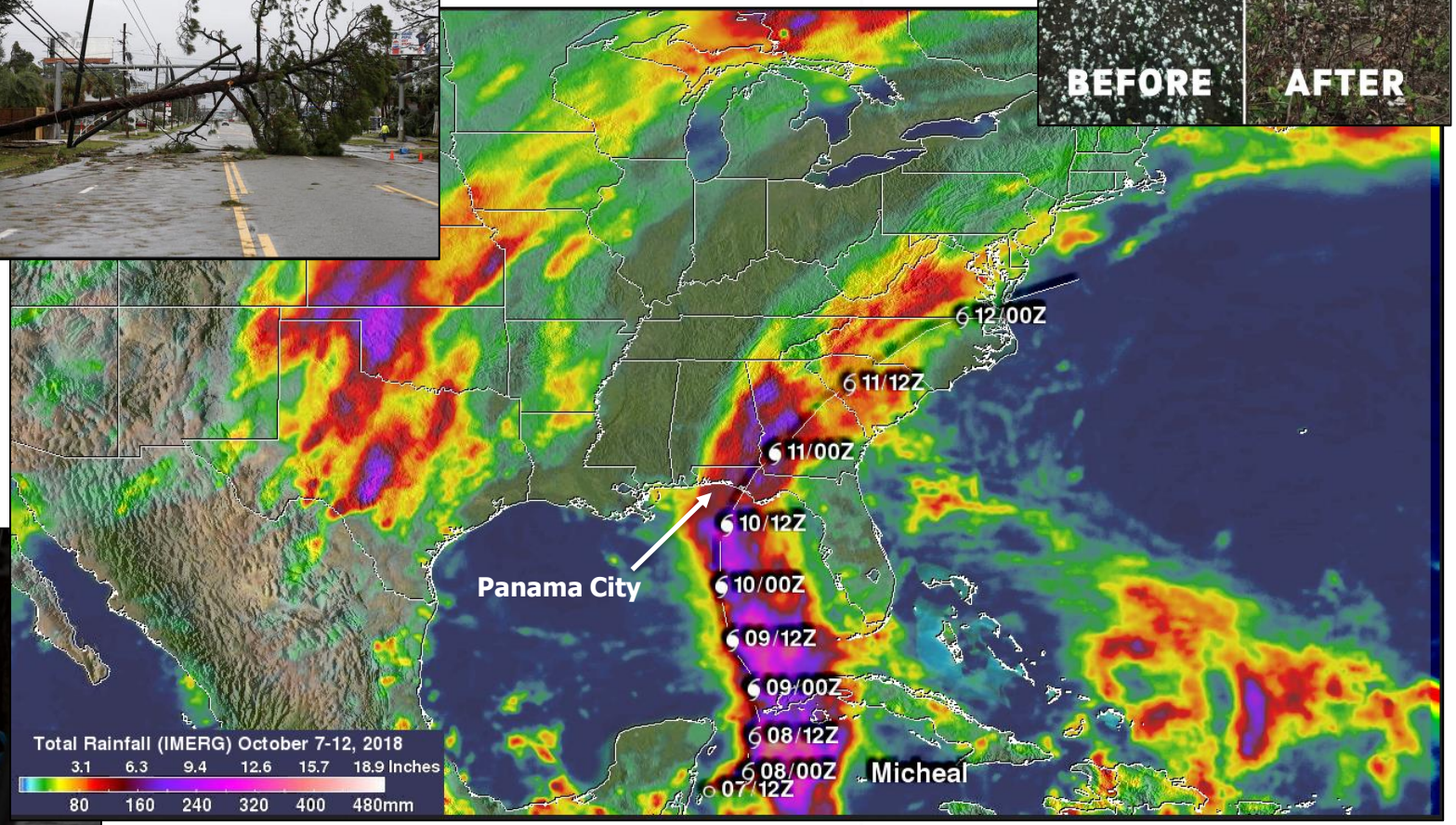
Visualization Credit: Matt Lammers and Owen Kelley (NASA GSFC)



Hurricane Michael's Heavy Rainfall Measured with GPM IMERG

On October 10, 2018, Hurricane Michael made landfall in the Florida panhandle as a category 4 storm and continued a destructive path northeastward through Virginia. As a result of the strong winds, storm surges and heavy rains that Michael produced, over 19 deaths and billions of dollars in damage to crops and livestock have been recorded, and at least 250,000 people are still without power as of Monday, October 15.

GPM IMERG data were used to calculate estimates of precipitation totals along Michael's track from October 7-12, 2018, the period from Michael becoming a tropical depression fourteen off the coast of the Yucatan Peninsula until it passed off the East Coast. IMERG data indicated that Michael frequently produced rainfall totals greater than 10 inches (254 mm) along it's track with the heaviest rainfall accumulation occurring off the Yucatan where over 20 inches (512 mm) were estimated.



Floodwaters of Panama City, FL on 10/10/18.Credit: Jabin Botsford/ The Washington Post via Getty Images.

(Above)Total rainfall using IMERG from Oct. 7-12, 2018 in southeastern US from Michael, credit: Hal Pierce (SSAI/NASA GSFC), see IMERG Accumulation Animation. (Top left) Downed trees and power lines in Panama City on 10/10, credit: Reuters via CBS News. (Top right) Images from Georgia Grown showing before (10/10) and after (10/11) the storm passed through cotton field in Georgia, credit: Georgia Grown via Facebook.

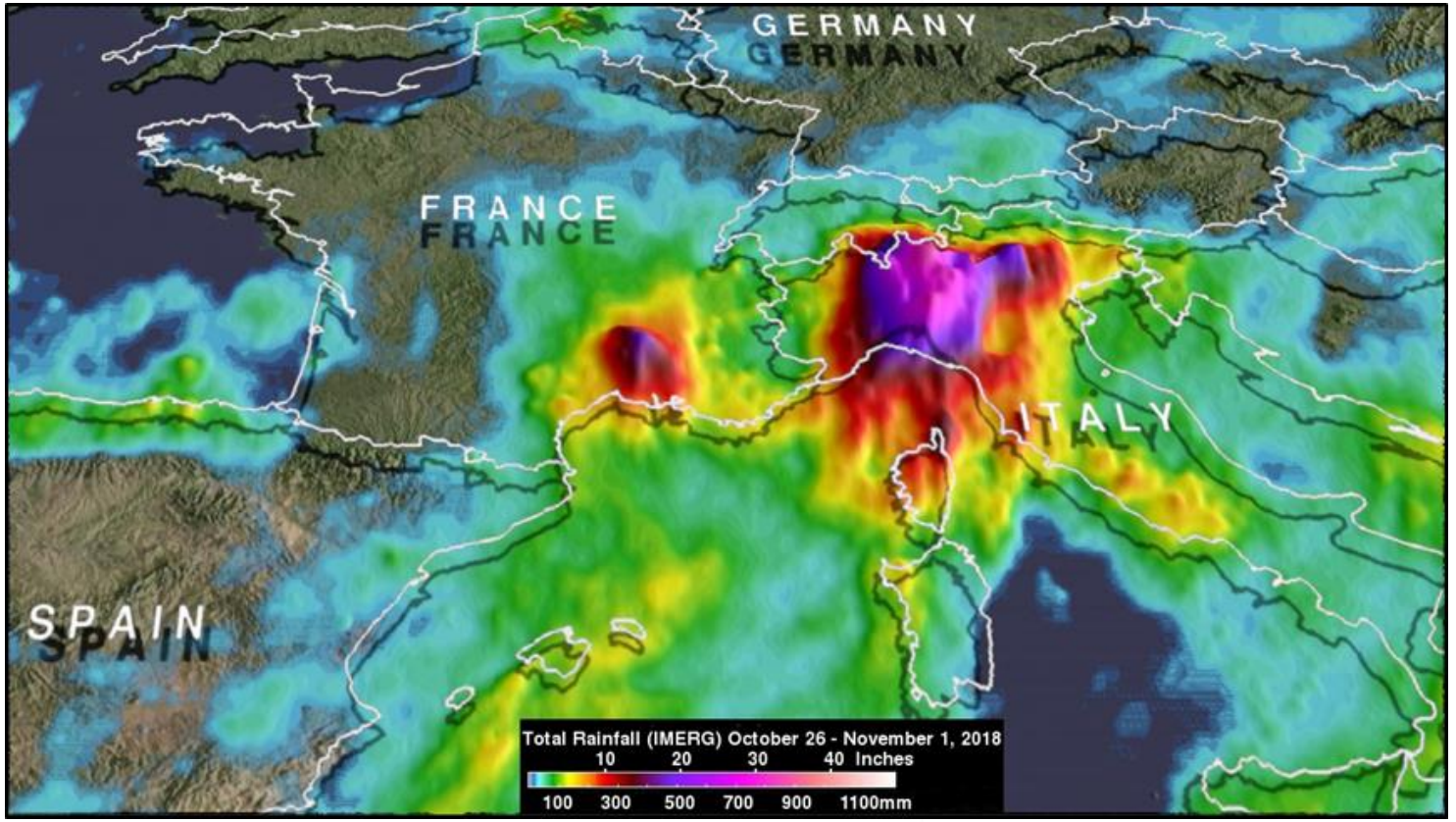
GLOBAL PRECIPITATION MEASUREMENT

Adding up the Rain in Italy using GPM IMERG

Torrential rainfall from a strong low-pressure system moving through southern Europe drenched Italy triggering landslides, flooding throughout Venice, infrastructure damage to historic buildings, and several deaths in late October and early November, 2018. GPM IMERG estimates captured this rainfall accumulation between October 26 and November 1, 2018. IMERG data revealed that the most extreme rainfall in southern Europe was concentrated in northern Italy. IMERG indicated that storms inundated that area with rainfall totals often greater than 508 mm (20 inches).

People cross the flooded St. Mark's Square on a raised walkway Monday. Credit: Miguel Medina (Getty Images) via CNN.

Heavy rains have caused landslides in the region of Liguria (NW Italy). Credit: BBC News.

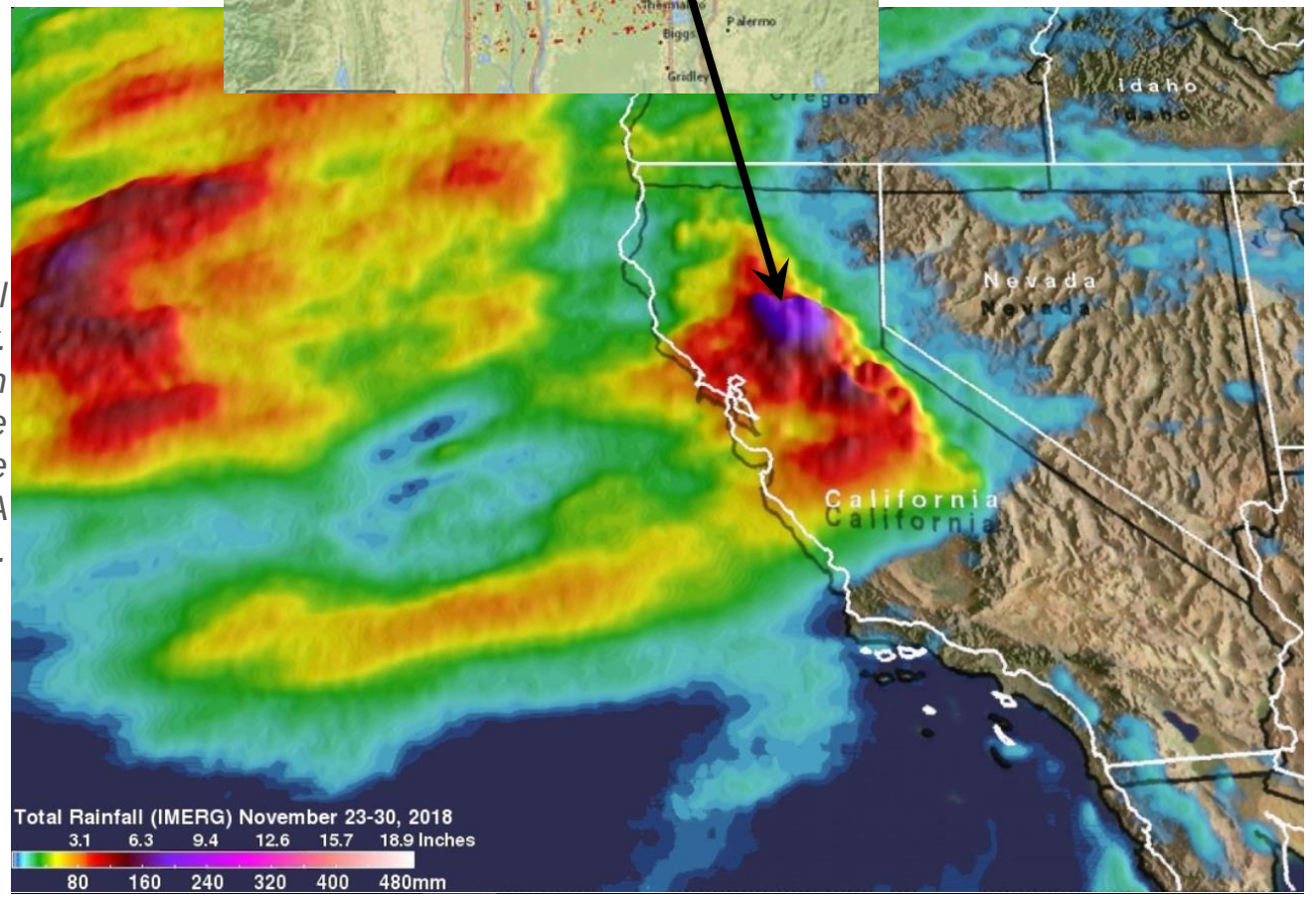


Total rainfall (IMERG) from Oct. 26-Nov. 1, 2018 in Italy. Credit: Image Credit: Hal Pierce (SSAI/NASA GSFC).

GPM Captures Rainfall in California Wildfire Areas

Heavy precipitation hit areas of California that were recently devastated by deadly wildfires during the last week of November 2018. Flooding triggered by the heavy rain resulted in evacuations in burn scarred areas such as Butte County where the deadly Camp Fire hit. Flash floods, debris flows and mudslides were observed in areas where the wildfires stripped away vegetation. GPM IMERG estimates captured this rainfall accumulation from November 23-30, 2018. IMERG data revealed that the most extreme rainfall was concentrated in central-northern California. IMERG indicated that parts of Northern California received upwards of 7.8 inches (200 mm) of rain.

Red line delineating affected area of the Camp Fire. Image captured from NASA Disasters Mapping Portal, https://maps.disasters.nasa.gov/arcgis/apps/MapSeries/index.html?appid=8014e6c744a945baa8700797ccffccf6.



(Right)Total rainfall (IMERG) from Nov. 23-30, 2018 in California. Image Credit: Hal Pierce (SSAI/NASA GSFC).

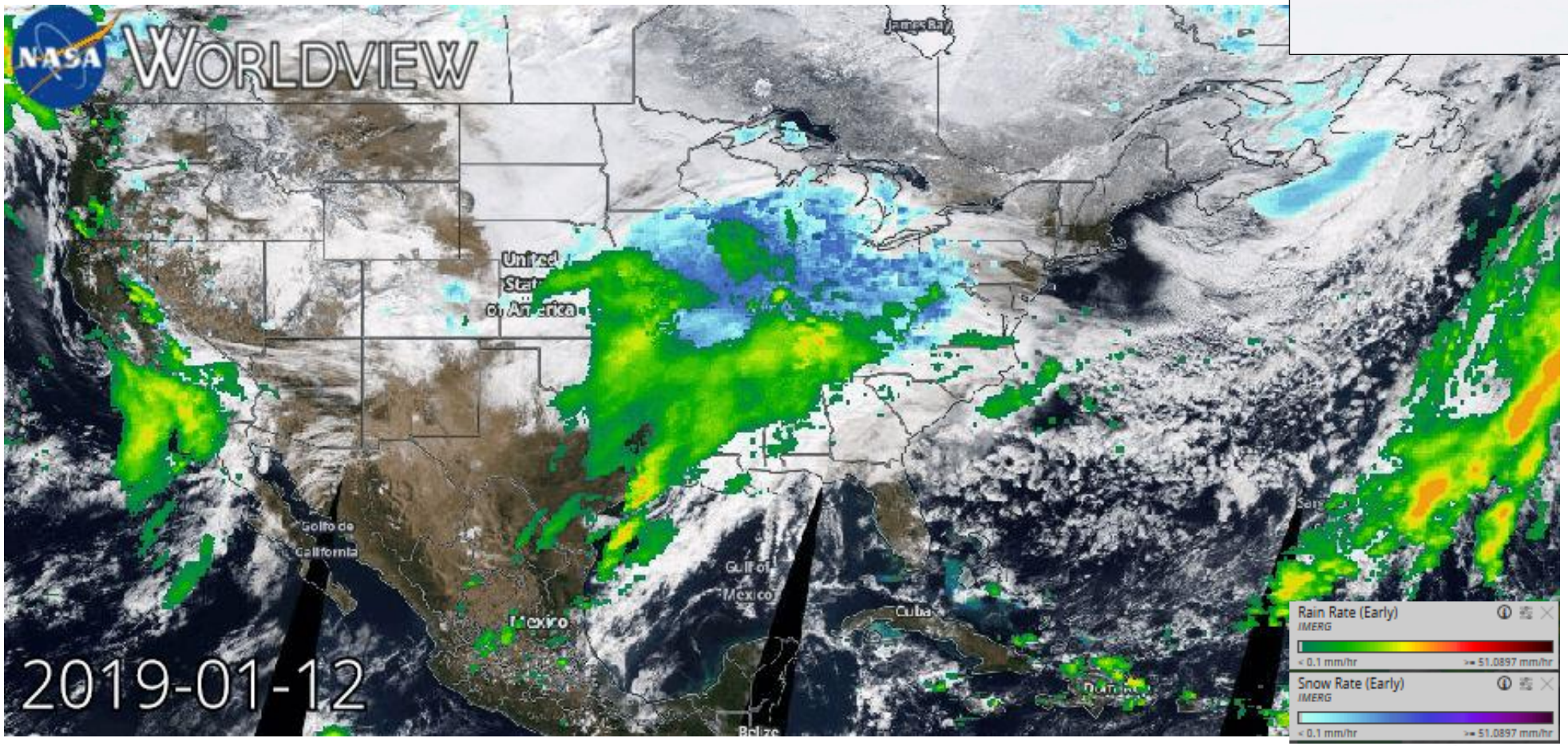
Flooded street in Chico, California (near Camp Fire area) on Thursday, Nov. 29, 2018. Image Credit: AP Photo/Rich Pedroncelli) via The Weather Channel.

GLOBAL PRECIPITATION MEASUREMENT

GPM Captures First Snow of 2019

The first major snowstorm of 2019 hit the greater DC metro area on January 13, bringing with it multiple school closures, icy road conditions, and delayed flights. GPM IMERG estimates captured rain and snowfall accumulation as this snowstorm made its way eastward across the United States from January 12 through January 14, 2019. On the ground, most places within the DC metro area reported nearly half a foot of snow.

A local DC resident shared a shot of snow covering the U.S. Marine Corps War memorial in Arlington, VA on 1/13/2019 with "Washington's Top News" (Courtesy of Monica Rojas).

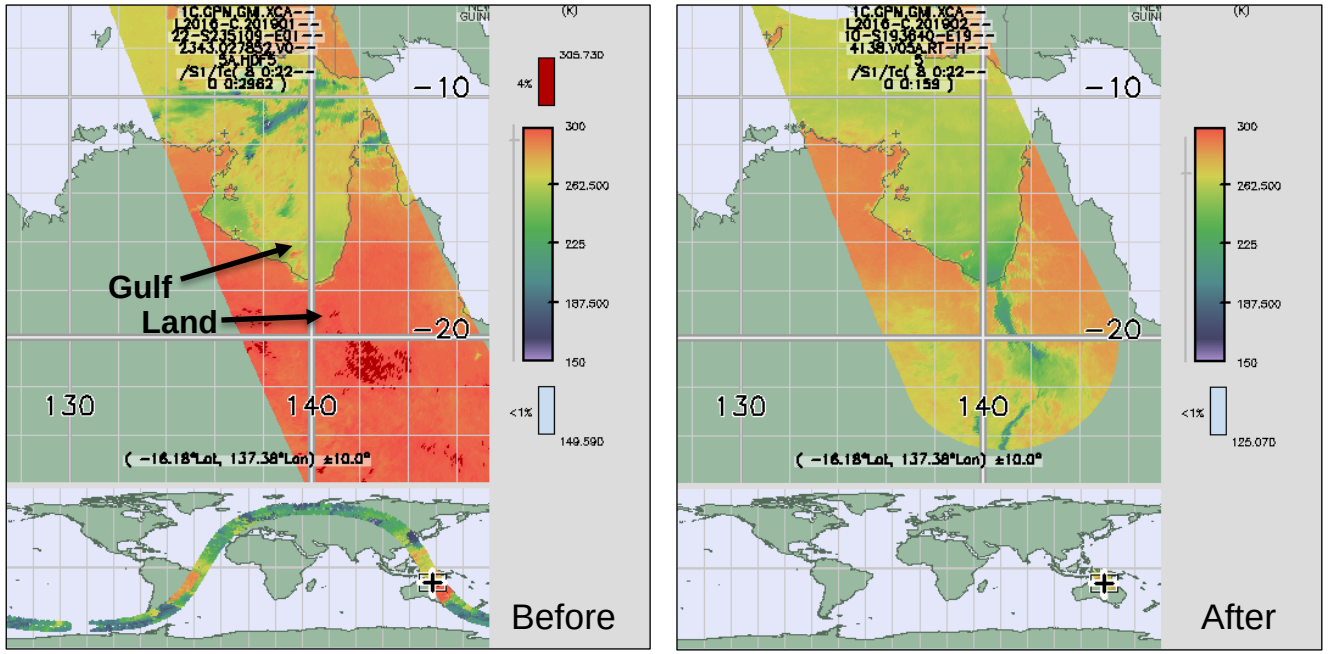


NASA Worldview animation of total rain and snowfall accumulation across the United States using GPM IMERG from 1/12/2019 to 1/14/2019 (Credit: Andrea Portier, SSAI/ NASA GSFC).

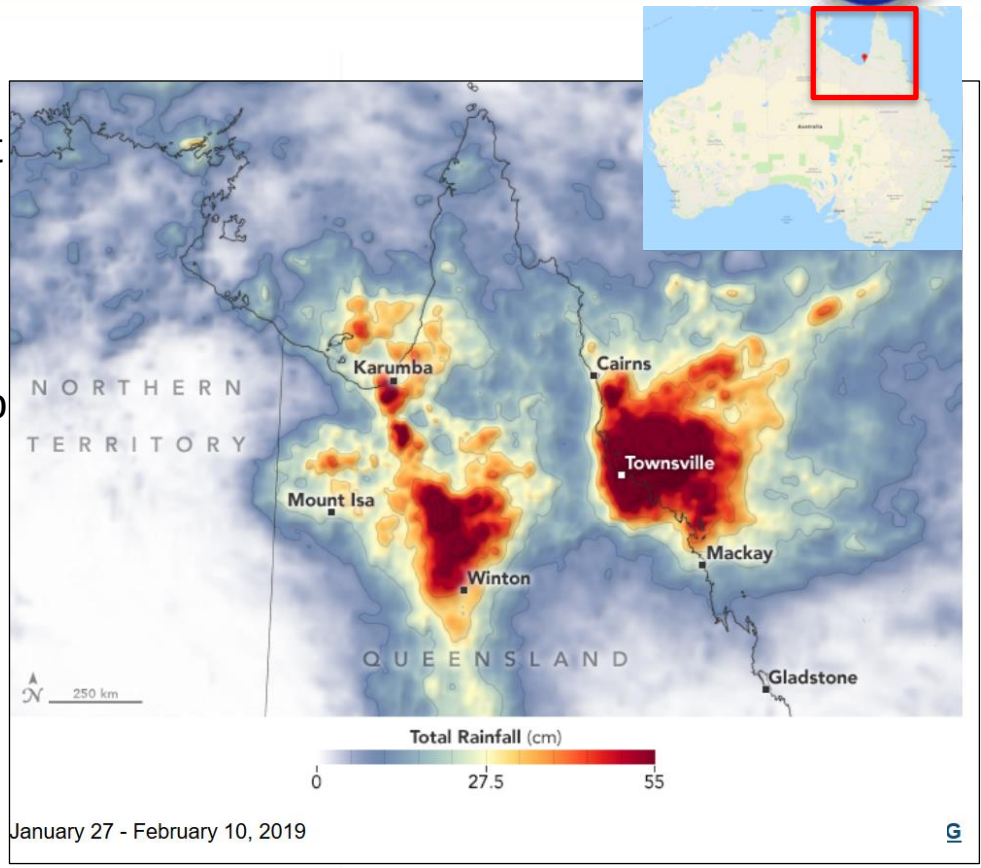
GLOBAL PRECIPITATION MEASUREMENT

GPM Shows Flooding in Queensland

Heavy rains pounded Queensland for several weeks in January and February 2019 causing widespread flooding across the Australian state. Floods led to massive loss of livestock and infrastructure just weeks after some of the hottest recorded temperatures in the country. Two overpasses from GPM's GMI captured before and after imagery of severe inundation in Northern Queensland (see below). In the before image, it is clear where the Gulf of Carpentaria ends and the hot, dry land begins, while in the after image, flood waters have created a 40-mile wide arm stretching hundreds of miles south into the Outback.



GPM GMI overpass in Northern Queensland on 1/22/2019 prior to rainfall (above left) and on 2/10/2019 after rainfall inundated areas (right). We can see this contrast because the emissivity of water is less than that of dry land, so open water and wet soil appear cooler than dry land in clear-sky overpasses of GMI. Image Credit: Matt Lammers (NASA/ GSFC).

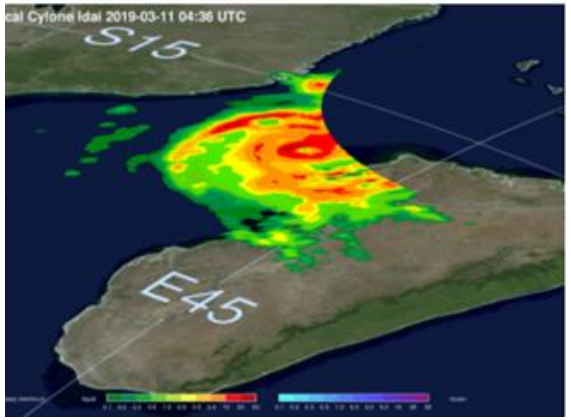


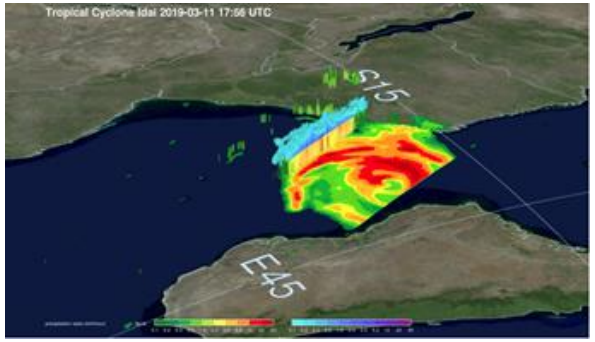
Total rainfall (IMERG) from Jan. 27 to Feb. 10, 2019 in Queensland, Australia (above). Image Credit: Joshua Stevens, NASA Earth Observatory.

Rainfall accumulation estimates were derived from the GPM IMERG multi-satellite dataset to show another perspective of the tremendous amount of rain that fell around the Mount Isa and Townsville areas from January 27 to February 10 (above). Estimates showed upwards of 22 inches (550 mm) in places.

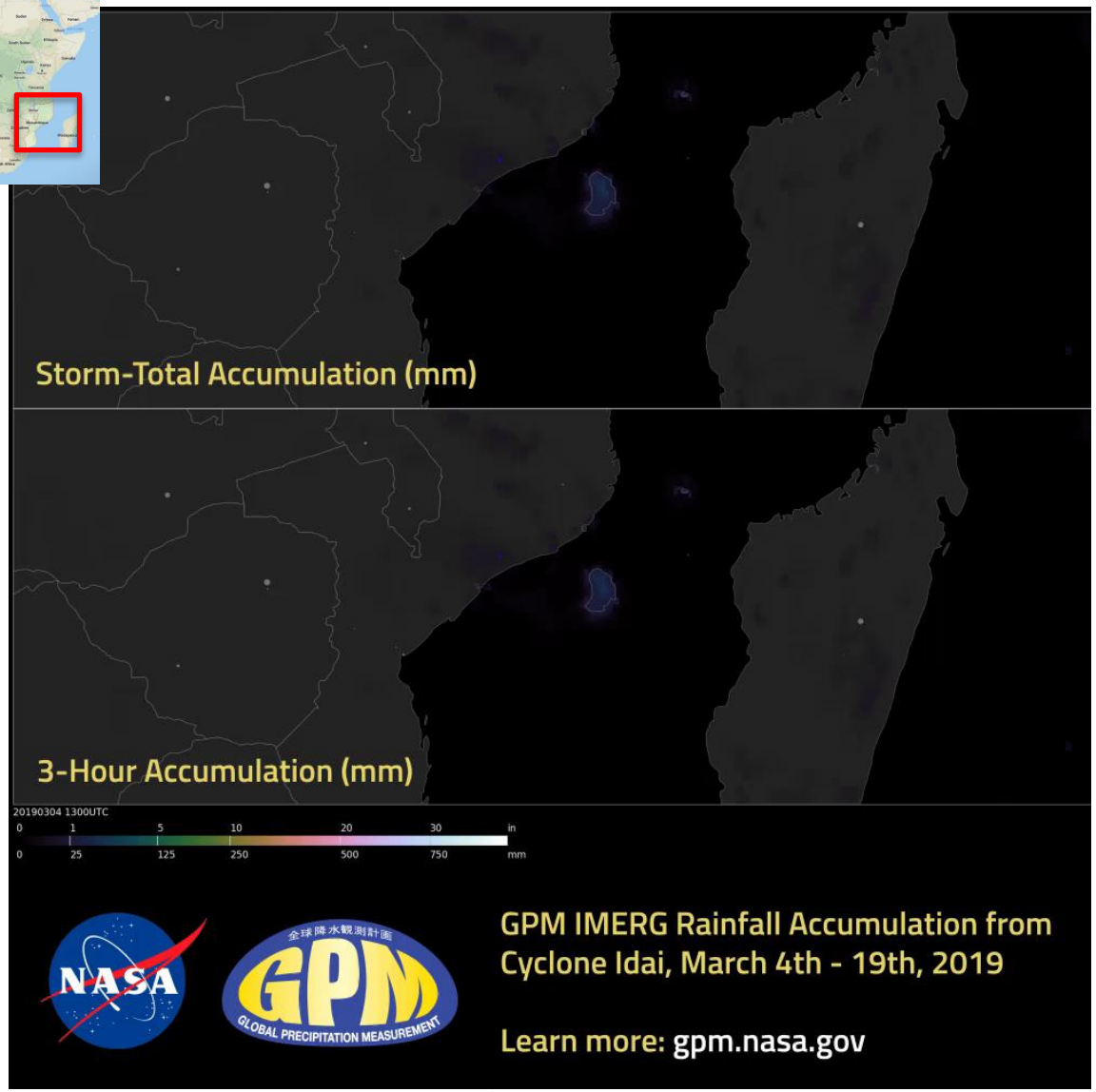
Tropical Storm Idai Measured with GPM

Tropical Cyclone Idai brought torrential rain and strong winds across Mozambique, causing major flooding, landslides, and damaged infrastructure from March 4 to 19, 2019. Early stages of the storm saturated the ground which made flooding much worse. The GPM satellite captured the cyclone with both the GPM Microwave Imager (GMI) and the Dual-frequency Precipitation Radar (DPR) on March 11 in the morning and afternoon when the storm was in the middle on the Mozambique Channel. The DPR captured a well-developed eye, seen at the center of the image (below left). It flew over the storm once again measuring increased precipitation rates (below right). Idai then made landfall for the second time on March 15. GPM was also able to calculate estimates of precipitation totals along Idai's entire storm track using IMERG data. IMERG data indicated that areas of Mozambique received upwards of 500 mm (20 inches) of rain (right).





GPM's GMI/ DPR provides a view of Idai's precipitation, showing heavy precipitation over a large area on 3/11/2019. Credit: Jacob Reed (Telophase / NASA GSFC)

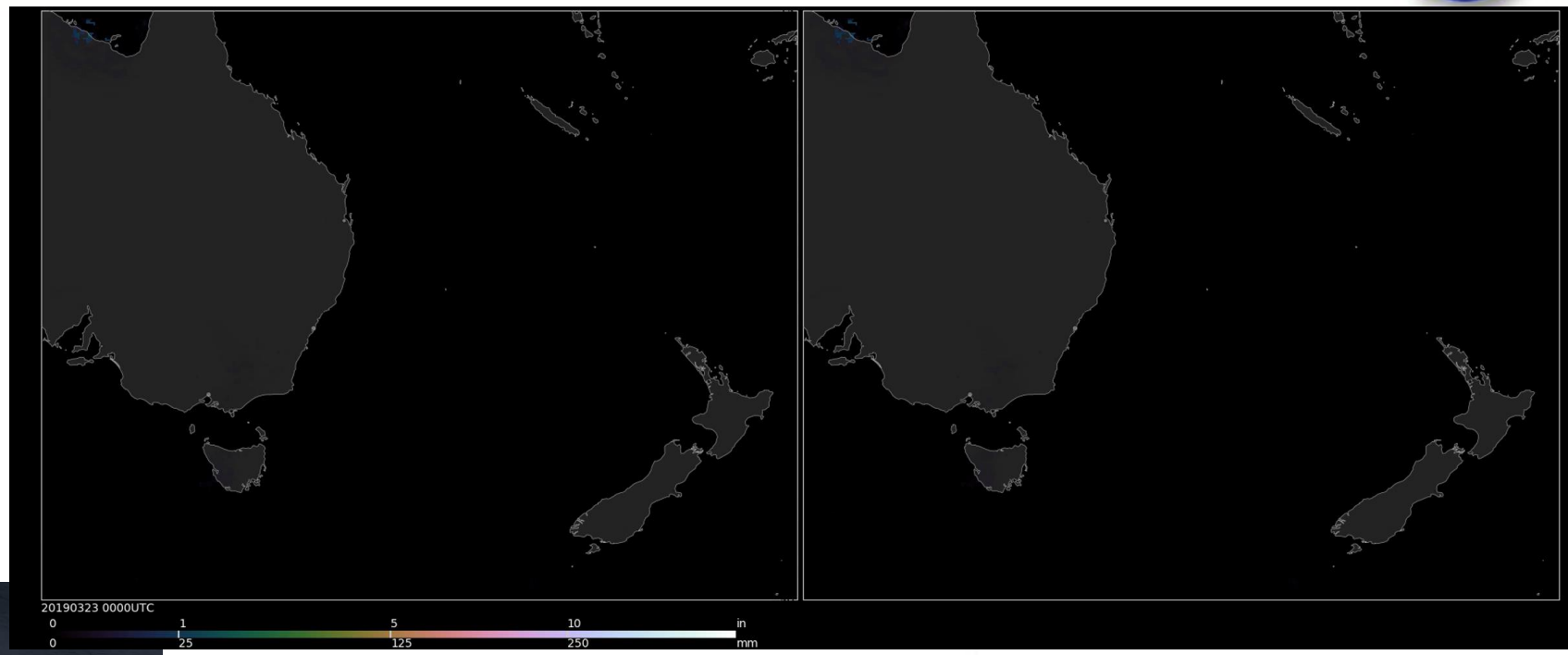


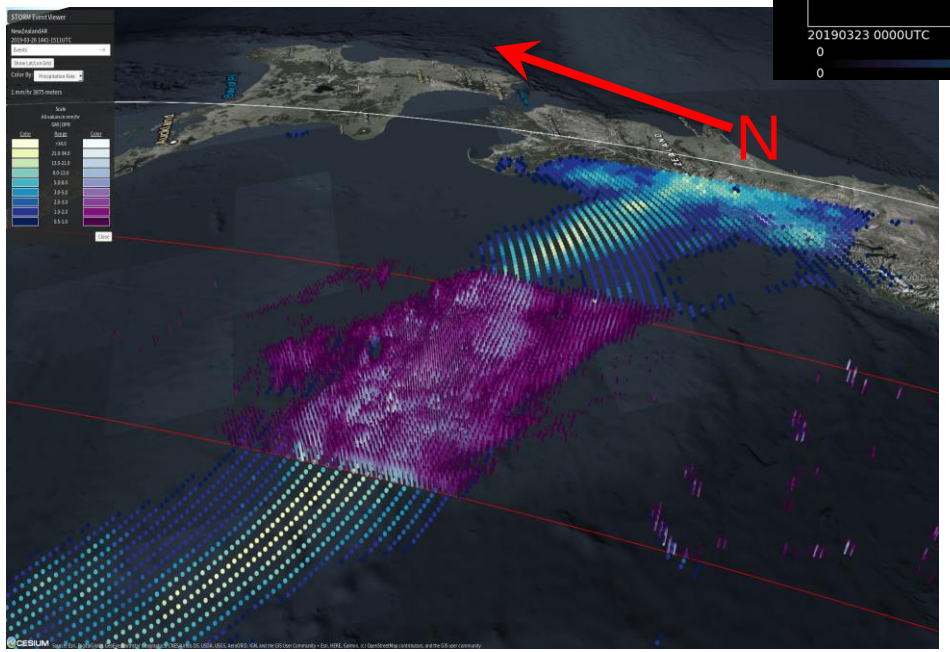
GPM IMERG accumulation from Cyclone Idai, March 4-19, 2019. Visualization Credit: Matt Lammers and Owen Kelley (NASA GSFC).

GPM Captures New Zealand Atmospheric River Event

On Tuesday, March 26, 2019 Westland, New Zealand declared a state of emergency after an atmospheric river event brought torrential rains causing flooding, record river levels, and closed roads, and prompting evacuations throughout the region.

GPM's GMI/ DPR provides a view of the atmospheric river event hitting NZ's South Island on March 26, 2019. Visualization was produced using Event Viewer. Credit: Matt Lammers and Owen Kelley (NASA GSFC).

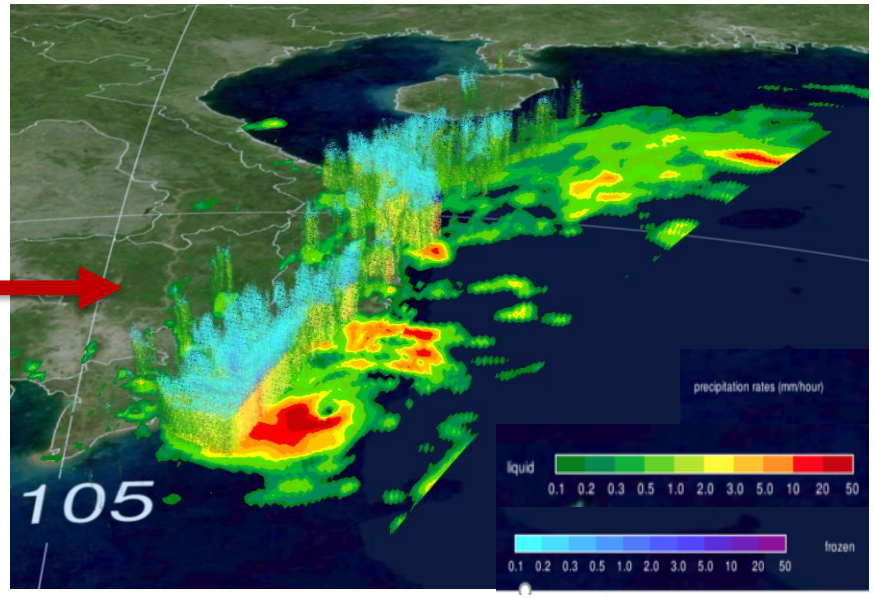




GPM IMERG accumulation over Westland, New Zealand from March 23- 27, 2019. (Left) IMERG Storm-total accumulation (mm). (Right) Three-hour storm accumulation (mm). Visualization Credit: Matt Lammers and Owen Kelley (NASA GSFC).

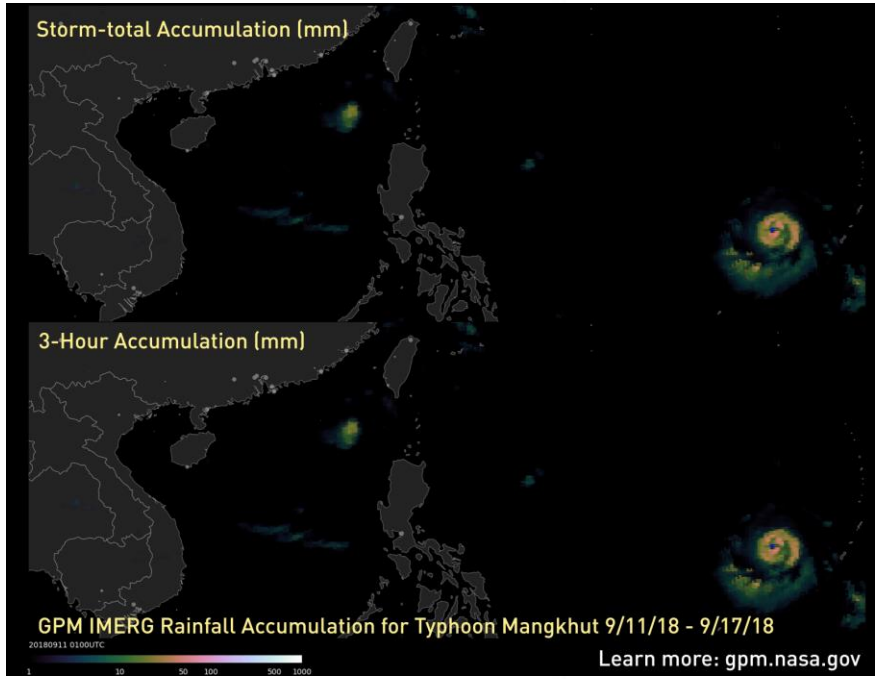
GPM's GMI and DPR captured the moisture tendril impinging upon the South Island (left). The moisture source was TC Trevor, which eventually meandered over the Australian outback, where a trough pulled moisture southward across the Tasman Sea and over to New Zealand. Rainfall accumulation estimates using GPM IMERG revealed areas on the South Island receiving greater than 500 mm (~20 inches) of rain (above).

Capturing Storms in and around Vietnam using GPM



TS Usagi brought heavy rainfall and damaging winds when it hit Vietnam's southern coast on 11/23/18. GPM IMERG data (above) was used to show accumulated rainfall from 11/19-11/26 as the storm moved across the South China Sea into SE Asia. GMI/DPR (top right) captured the location and intensity of the storm as it hit S. Vietnam. The analyses show that Usagi often dropped more than 240 mm (9.4 inches) of precipitation over S. Vietnam. Credits: Hal Pierce and Jacob Reed (NASA).

Imagery of storms that impacted Vietnam in 2018 captured by GPM. Data collected by GPM can be viewed in multiple formats using GMI, DPR, and IMERG data products.

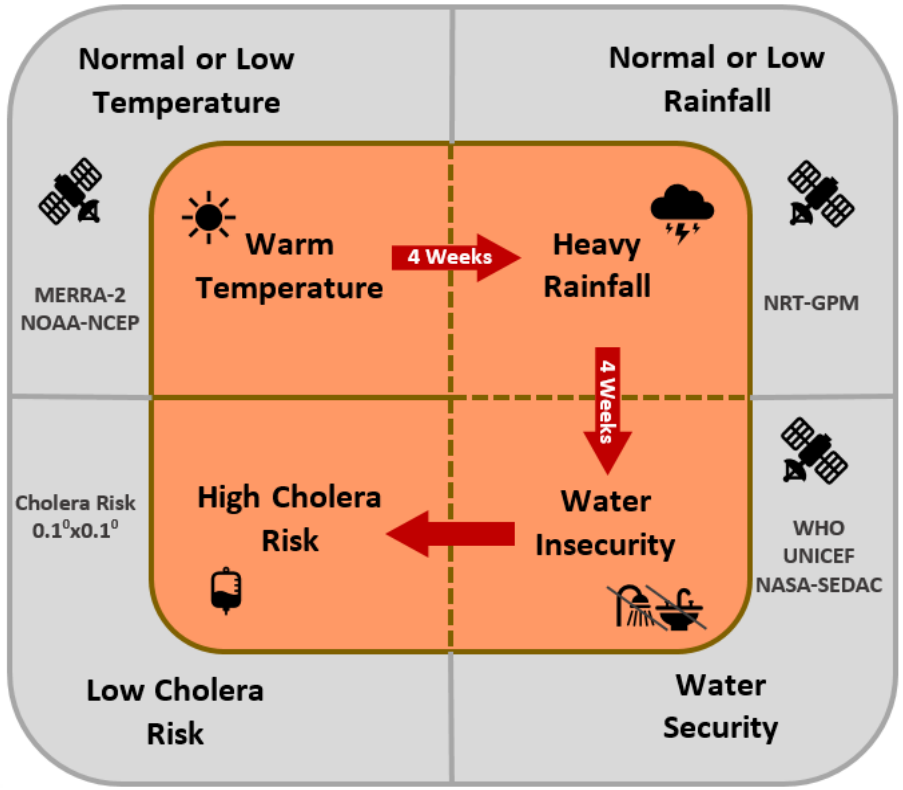


GPM IMERG data was used to show Typhoon Mangkhut's (Cat. 5 storm) rainfall accumulation as it made its way across the Philippine Sea from 9/12/18-9/13/18 affecting several countries. Credit: Matt Lammers and Owen Kelley (NASA GSFC).

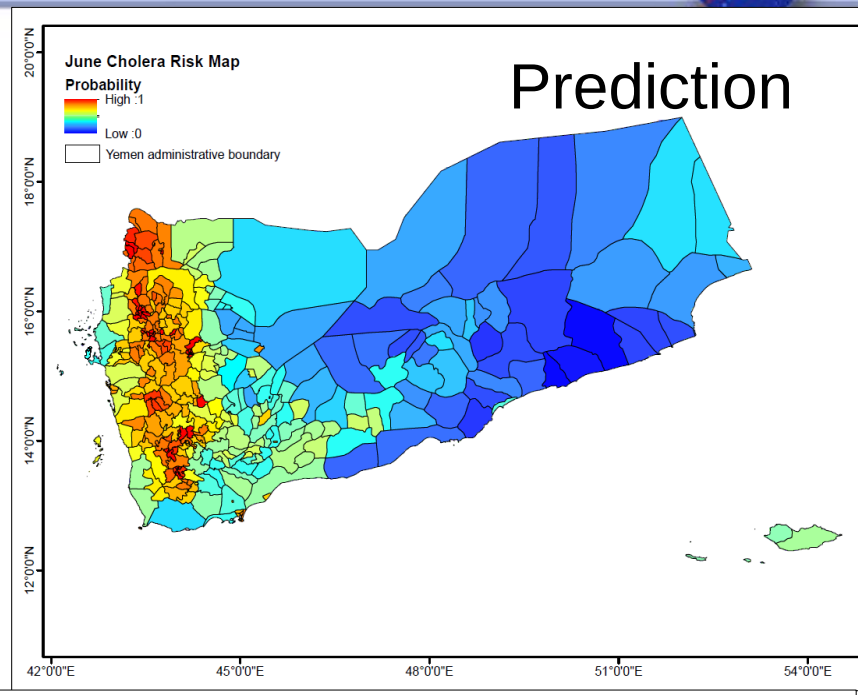
GLOBAL PRECIPITATION MEASUREMENT

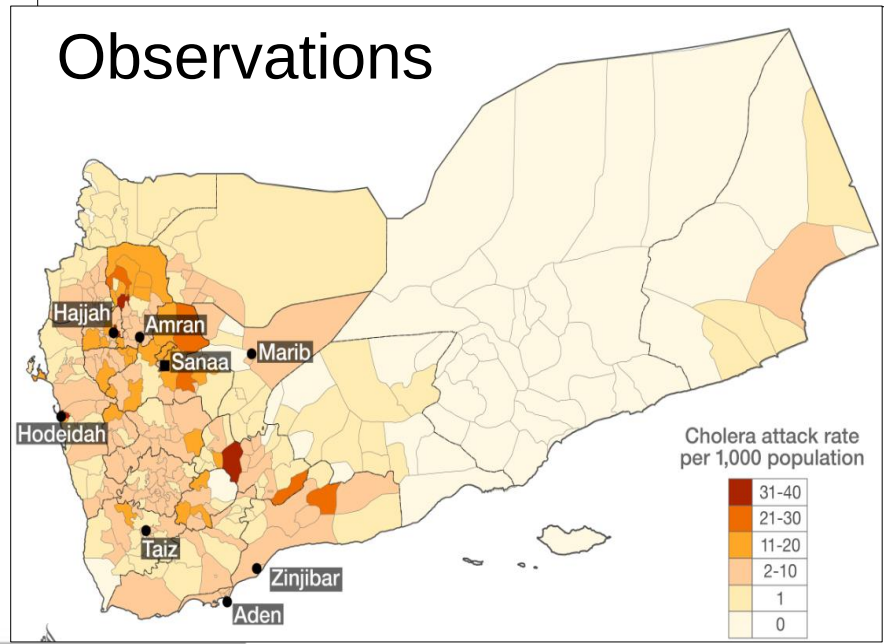
Predicting Cholera using NASA Satellites

- Predicting favorable conditions for cholera infection relies on identifying areas of above average temperatures and rainfall, poor water infrastructures and changes in land use.
- Scientists are using precipitation from GPM and air temperature from MERRA to develop forecasts for the risk of a cholera outbreaks across countries such as Yemen, Haiti, South Africa and Bangladesh.
- Project findings are being used to map unsafe water sources, prepare warnings related to water quality, and predict the potential of disease outbreaks.



Flow chart to determine areas at high cholera risk using satellite data (left). Real-time cholera risk prediction map for Yemen in June 2017 (top right). Areas in red have the highest risk of cholera outbreak. In-country records that a cholera epidemic occurred in June 2017(left). Content and image credits: Antar Jutla, U. of Florida & Rita Colwell, U.of Maryland.



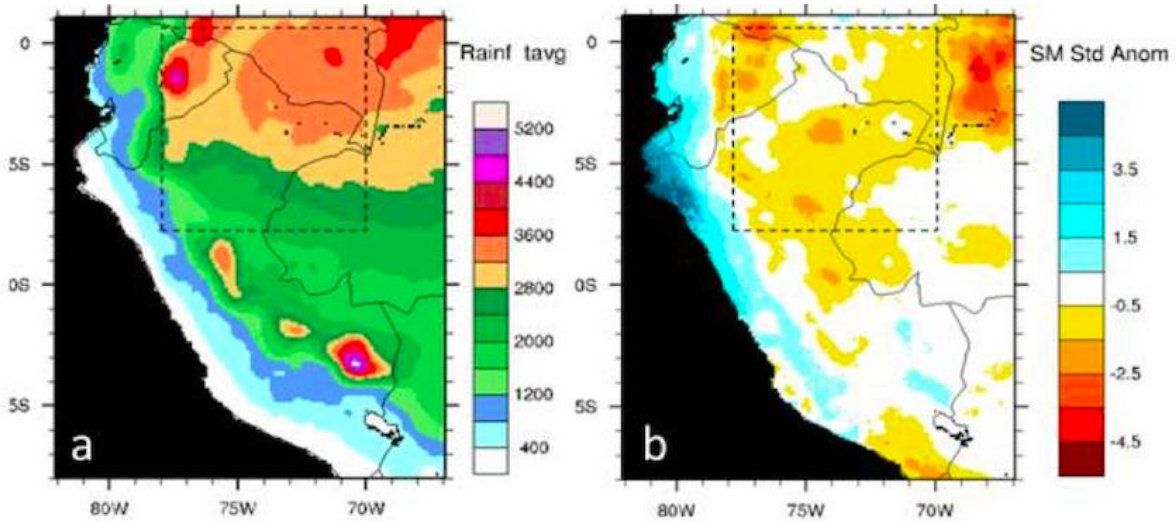


Using NASA Satellite Data to Predict Malaria Outbreaks

In the Amazon Rainforest, few animals are as dangerous to humans as mosquitos that transmit malaria. Predicting favorable conditions for mosquito breeding and survival relies on identifying areas with warm air temperatures and calm waters, such as ponds and puddles. To tackle this problem, group of researchers are using a range of NASA satellites, including GPM, SMAP, Landsat, Terra and Aqua, to identify human and environmental events that typically precede an outbreak. With funding from NASA's Applied Sciences Program, they are working in partnership with the Peruvian government to develop a system that uses satellite and other data to help forecast outbreaks at the household level months in advance and prevent them from happening.

JOHNS HOPKINS UNIVERSITY

A map showing the rivers the Peruvian Amazon and surrounding areas.
Credits: NASA's Scientific Visualization Studio



Long-term mean annual precipitation for Peru and Ecuador based on TMPA data (1998-2013) (left) and an example of a monthly standardized soil moisture anomaly for March 1998 (right). The dashed box shows the approximate location of the western Amazon focus region.

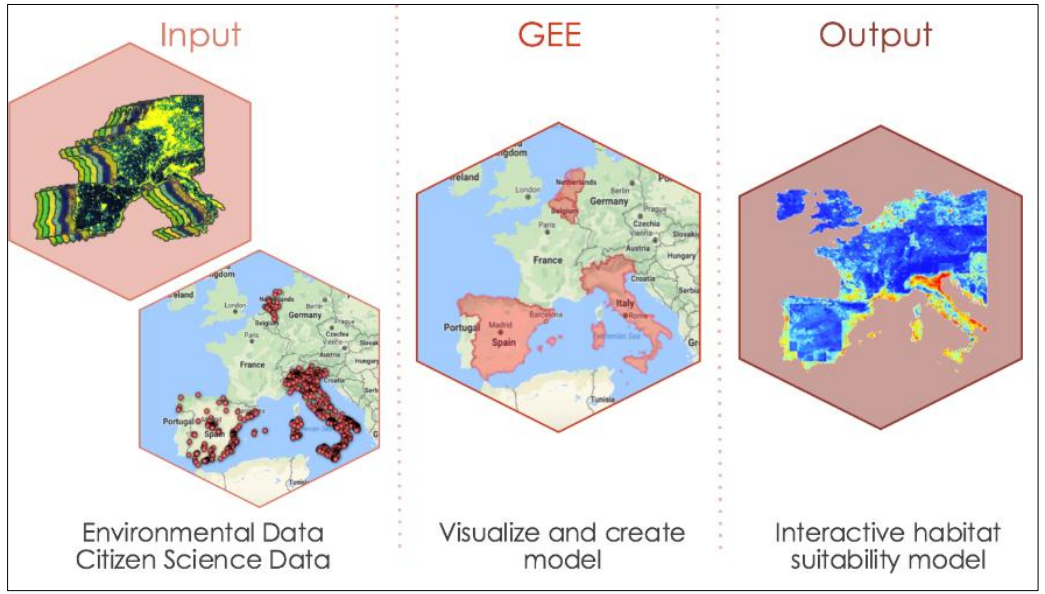
"We use TRMM/GPM to monitor rainfall conditions in data scarce regions of the western Amazon basin. The rainfall data drive a water balance model that is used to predict conditions favorable for mosquito breeding and survival, which in turn informs our malaria transmission risk estimates."

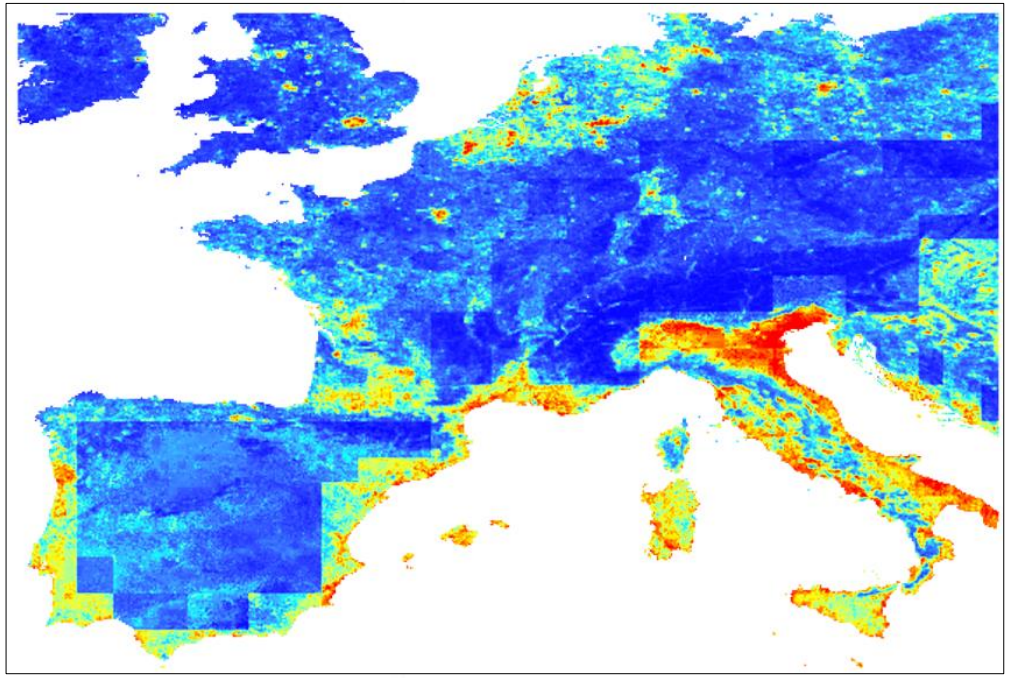
-Ben Zaitchik, John Hopkins University

GLOBAL PRECIPITATION MEASUREMENT

Integrating NASA Earth Observations with Citizen Science Data

The NASA Develop program is working with multiple organizations to integrate NASA Earth observations with citizen science data from Western Europe to understand the location and timing of disease outbreaks and improve outbreak predictions.



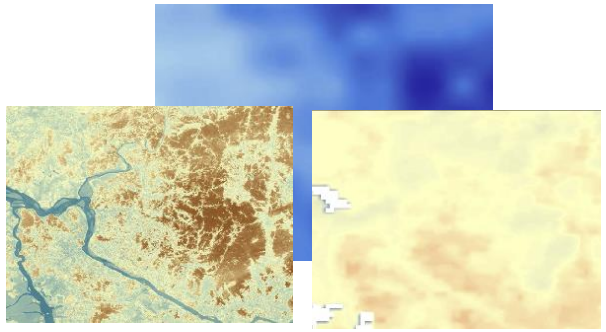


NASA and partners are working towards a shared, coordinated platform and protocol to leverage citizen science for the global surveillance and control of disease-carrying mosquitoes. Specifically, data from citizen science and environmental data from NASA Earth observations, including precipitation (from GPM IMERG), elevation, humidity, land cover, soil moisture, and land surface temperature will be used as parameters for a mosquito habitat suitability model and incorporated into a open-source interactive map. The tool will assist policy makers and public health officials in identifying environmental factors associated with mosquito outbreaks and deciding where to focus disease mitigation efforts.

Using NASA Derived Environmental Data to Predict Dengue Spread in Cambodia

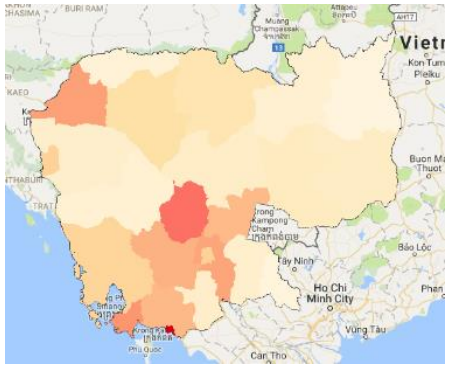
NASA satellite products have been incorporated into US Army Corps ERDC-GRL's vulnerability assessment software, Spatial Analytics for Force Health and Readiness (VAST-SAFHR), to predict the occurrence of dengue outbreaks in Cambodia.

CHIRPS Precipitation (5km)



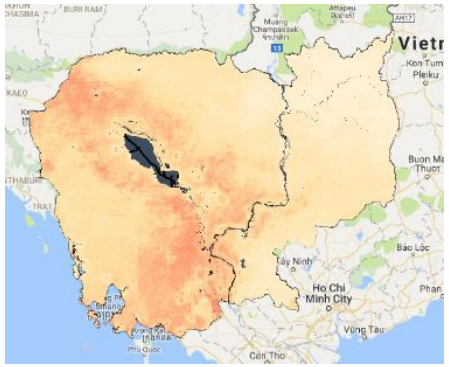
NDVI (30m) **LST (1km)**

Step 1: Combine NASA products into uniform pixel size

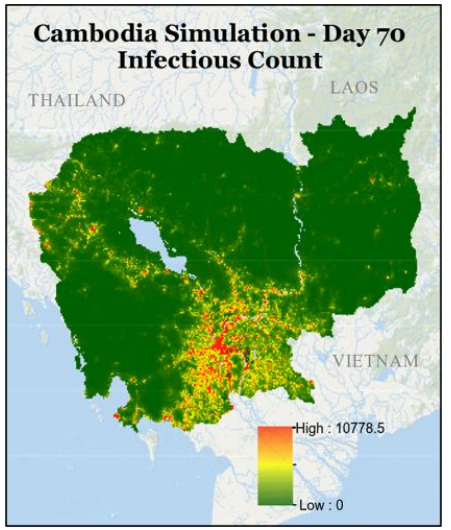


Provincial-Level Dengue Incident Rates*

Step 2: Downscale Provincial-Level Disease Data



Downscaled Pixel-Level Dengue Incident Rates



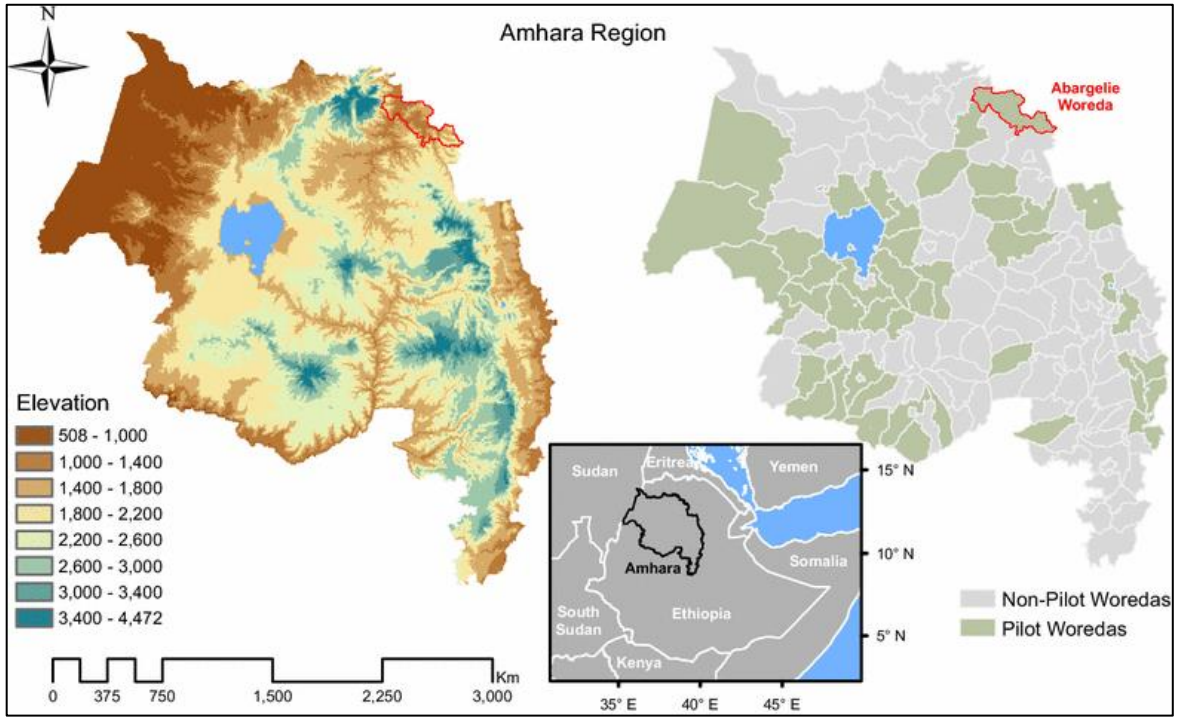
Step 3: Stochastic Simulation of Vector-Borne Disease

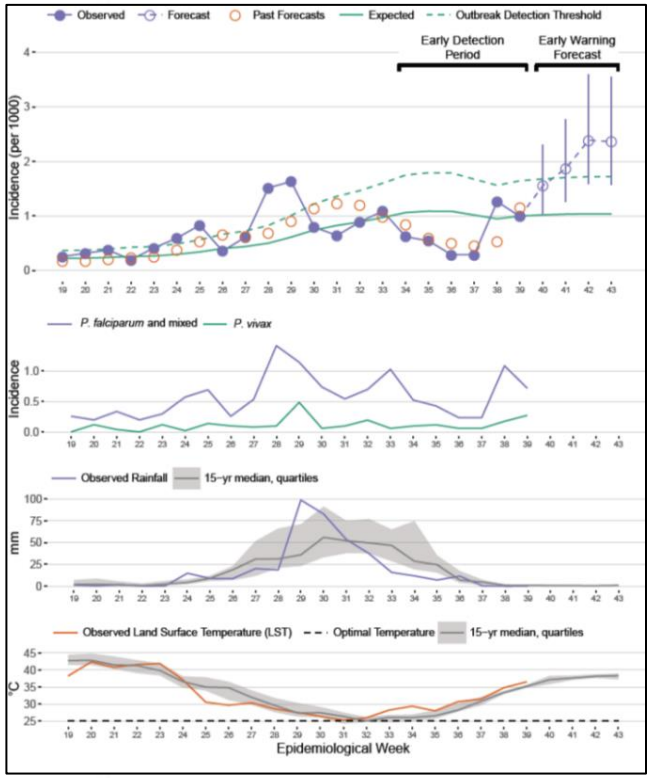
The purpose of VAST-SAFHR is to develop a computational framework to model, map and predict the spatial and temporal movement of dengue within Cambodia. The movement of dengue is highly dependent upon mosquitoes and their environment, which can be modeled with NASA derived products of Normalized Difference Vegetation Index (NDVI), land surface temperature (LST), and precipitation data using NASA sensors MODIS Terra and Aqua and TRMM/GPM. These environmental variables plus population density are used to calculate pixel level dengue incident rates which are then used to predict the occurrence of dengue outbreaks in Cambodia.

Malaria Early Warning in the Amhara Region of Ethiopia

A collaboration between South Dakota State University (SDSU) scientists and public health stakeholders are using NASA satellite data as input variables for a web-based malaria informatics system for epidemiological and environmental data acquisition and harmonization. Specifically, GPM precipitation, MODIS land surface temperature, and MODIS surface reflectance are used for environmental data sources to develop malaria forecasts in the Amhara Region of Ethiopia.

Study Area: The Amhara region of Ethiopia, including 47 pilot woredas (districts) that were selected to encompass the most malaria-prone parts of the region.





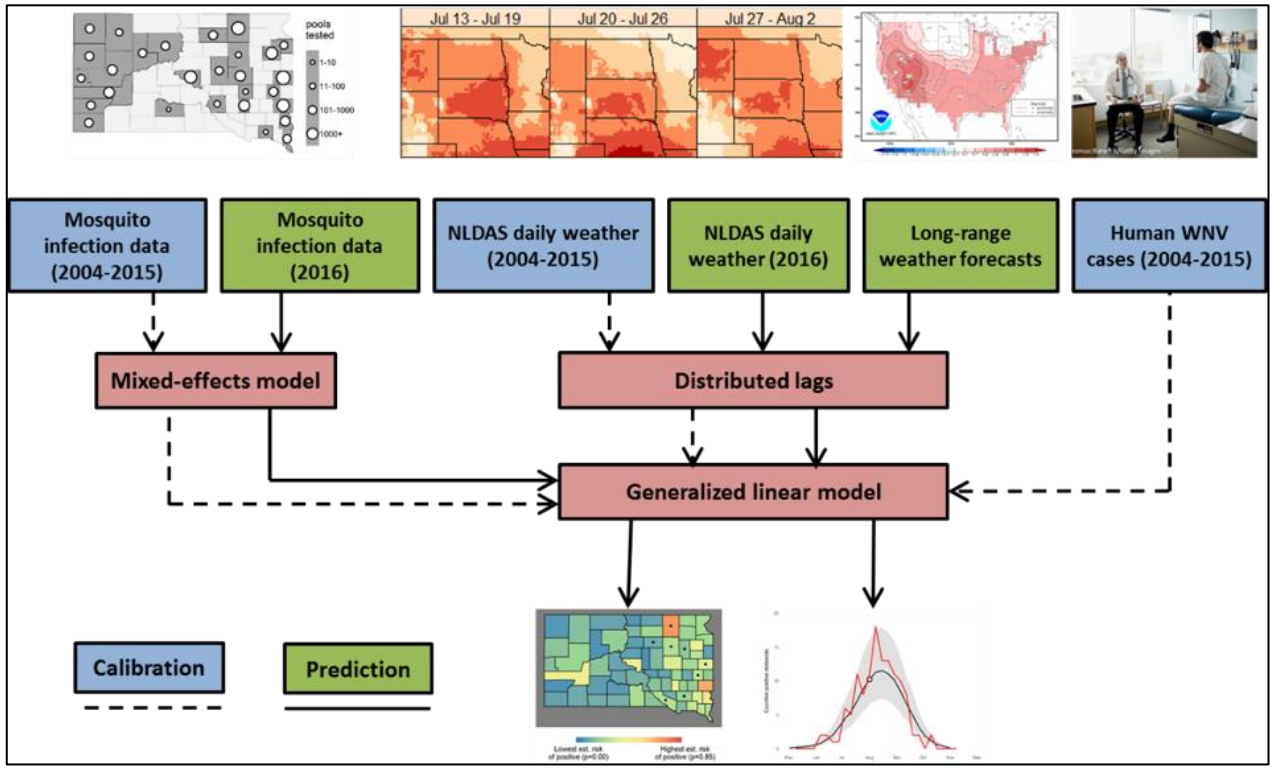
Example malaria forecasts generated for Abargelie districts in October 2016

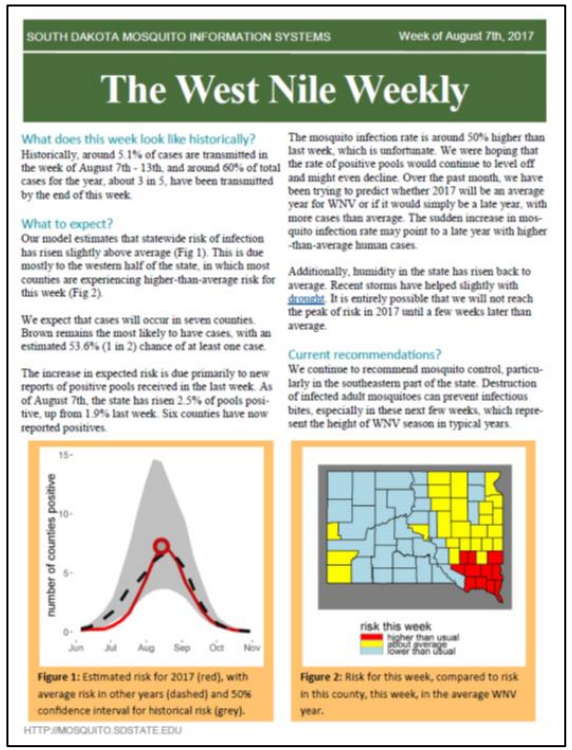
Michael C. Wimberly (michael.wimberly@sdstate.edu), Geospatial Sciences Center of Excellence, South Dakota State University/ Supported by NIH-NIAID (R01AI079411, PI: Wimberly)/ See Merkord et al. (2017), Malaria Journal for more information

West Nile Virus Forecasting and Risk Mapping in the Northern Great Plains

South Dakota State University (SDSU) scientists are using a web-based informatics system to integrate mosquito surveillance data with environmental data to predict outbreaks of West Nile virus in the Northern Great Plains of the United States. West Nile virus risk forecasts are generated using models that incorporate precipitation (GPM), temperature, and humidity from the North American Land Data Assimilation System (NLDAS) with recent infection rates from mosquito surveillance. These forecasts are then disseminated as weekly reports on the project website at http://mosquito.sdstate.edu/.

Schematic of West Nile virus forecasting using the South Dakota Mosquito Information System (SDMIS) illustrating data flows for calibration and prediction.




SOUTH DAKOTA MOSQUITO INFORMATION SYSTEMS — Week of August 7th, 2017

The West Nile Weekly

What does this week look like historically?

Historically, around 5.1% of cases are transmitted in the week of August 7th - 13th, and around 60% of total cases for the year, about 3 in 5, have been transmitted by the end of this week.

What to expect?

Our model estimates that statewide risk of infection has risen slightly above average (Fig 1). This is due mostly to the western half of the state, in which most counties are experiencing higher-than-average risk for this week (Fig 2).

We expect that cases will occur in seven counties. Brown remains the most likely to have cases, with an estimated 53.6% (1 in 2) chance of at least one case.

The increase in expected risk is due primarily to new reports of positive pools received in the last week. As of August 7th, the state has risen 2.5% of pools positive, up from 1.9% last week. Six counties have now reported positives.

The mosquito infection rate is around 50% higher than last week, which is unfortunate. We were hoping that the rate of positive pools would continue to level off and might even decline. Over the past month, we have been trying to predict whether 2017 will be an average year for WNV or if it would simply be a late year, with more cases than average. The sudden increase in mosquito infection rate may point to a late year with higher-than-average human cases.

Additionally, humidity in the state has risen back to average. Recent storms have helped slightly with drought. It is entirely possible that we will not reach the peak of risk in 2017 until a few weeks later than average.

Current recommendations?

We continue to recommend mosquito control, particularly in the southeastern part of the state. Destruction of infected adult mosquitoes can prevent infectious bites, especially in these next few weeks, which represent the height of WNV season in typical years.

Figure 1: Estimated risk for 2017 (red), with average risk in other years (dashed) and 50% confidence interval for historical risk (grey).

Figure 2: Risk for this week, compared to risk in this county, this week, in the average WNV year.

HTTP://MOSQUITO.SDSTATE.EDU

West Nile virus forecast report from August 2017.

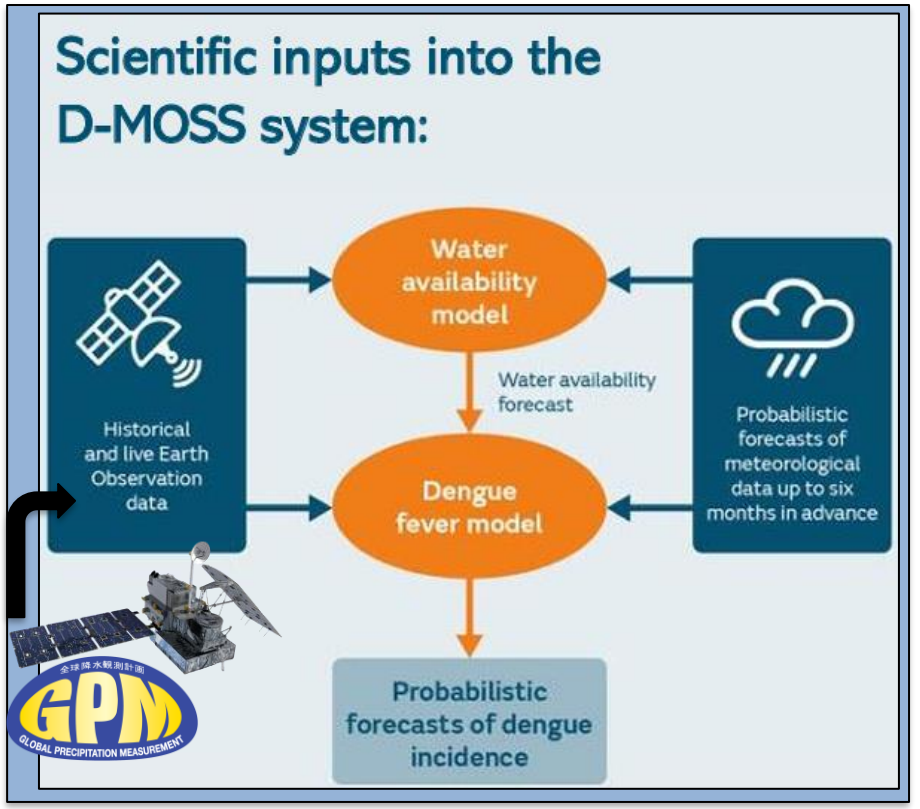
Michael C. Wimberly (michael.wimberly@sdstate.edu), Geospatial Sciences Center of Excellence, South Dakota State University/ Supported by NASA (NNX15AF74G, PI: Wimberly)/ See Davis et al. (2017), PLOS Currents: Outbreaks for more information

GPM utilized in the Dengue forecasting MOdel Satellite-based System

The Problem: Half the world's population is estimated to be at risk from dengue fever.

The Solution: HR Wallingford is leading the development of the Dengue forecasting MOdel Satellite-based System (D-MOSS), a system that uses EO data and seasonal climate forecasts to give **early warning for dengue fever outbreaks in three South and South-East Asian countries** at admin levels 1 and 2.

One significant EO data **input is precipitation using GPM IMERG Early** into the water availability model, which simulates the total water accumulation in a river catchment, and to the dengue fever forecasting model as a direct covariate. D-MOSS team uses **IMERG due to its continuity, latency, and sufficient spatial and temporal resolution.** IMERG is aggregated to total daily rainfall amount.

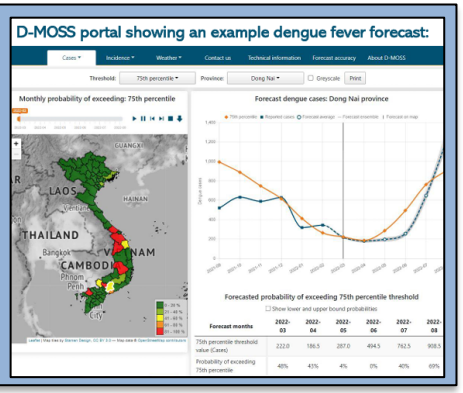


Benefits of D-MOSS:

- Up to six months advance warning of likely outbreaks of dengue fever, allowing local communities to eliminate mosquito-breeding sites and reduce the incidence of dengue.
- Seasonal forecasts of water availability, at a catchment scale.
- Built in capability to replicate anywhere in the world and for a variety of other diseases.

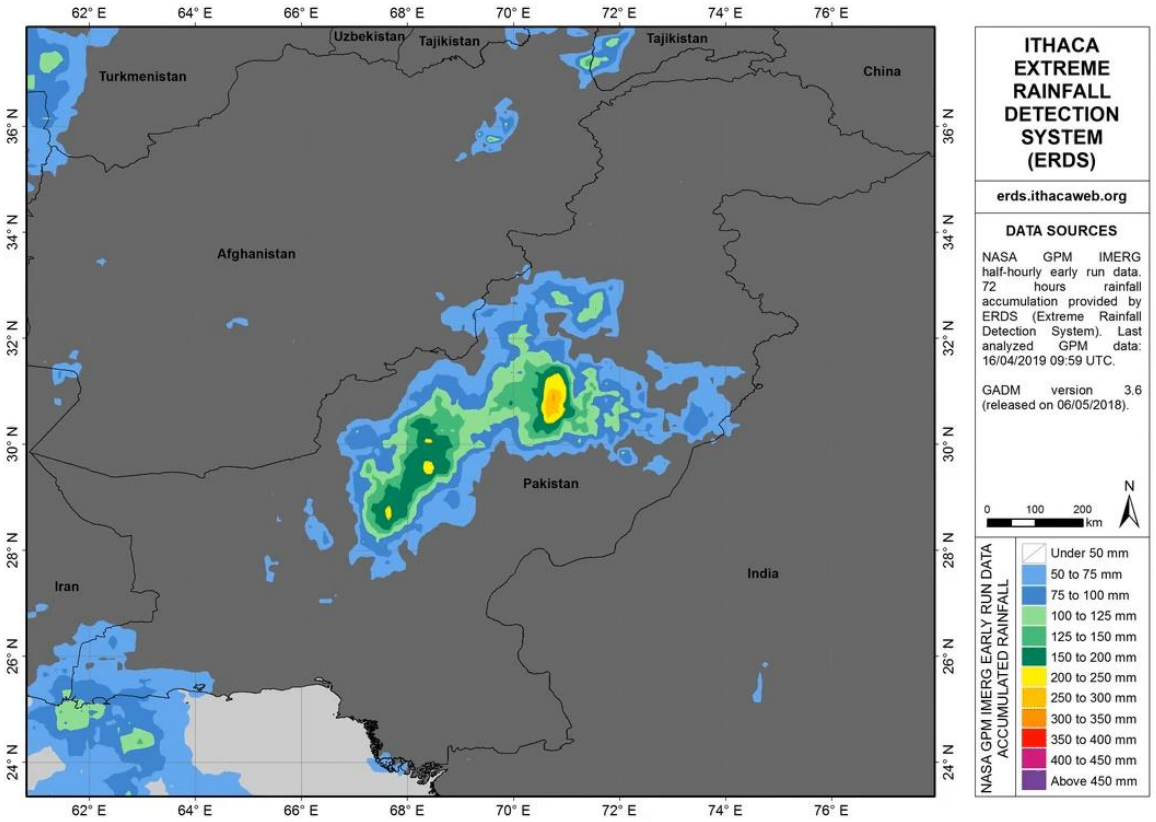
"We have found GPM data to be important in developing and applying dengue fever forecasting models. There is a known link between incidence of dengue fever and available water and the GPM data provides the necessary precipitation information to train the leading edge models in D-MOSS and to keep the forecast running."

- Dr Quillon Harpham, Technical Director, HR Wallingford.

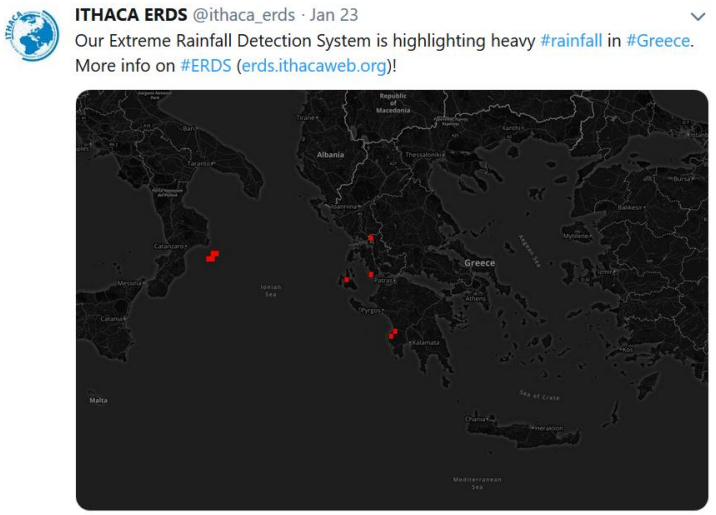


GPM Data Used to Provide Early Warning of Extreme Rainfall Events in Developing Countries

GPM IMERG data is used as an input within the Extreme Rainfall Detection System (ERDS) to provide immediate information about potential extreme hydrological events throughout the world.



ERDS visual communicating the severe rainfall over Pakistan in April 2019 using IMERG data. This was posted on the ERDS Twiiter account, @Ithaca_erds.



ERDS web application highlighting rainfall in Greece in January 2019. Credit: http://erds.ithacaweb.org/ via @Ithaca_erds.

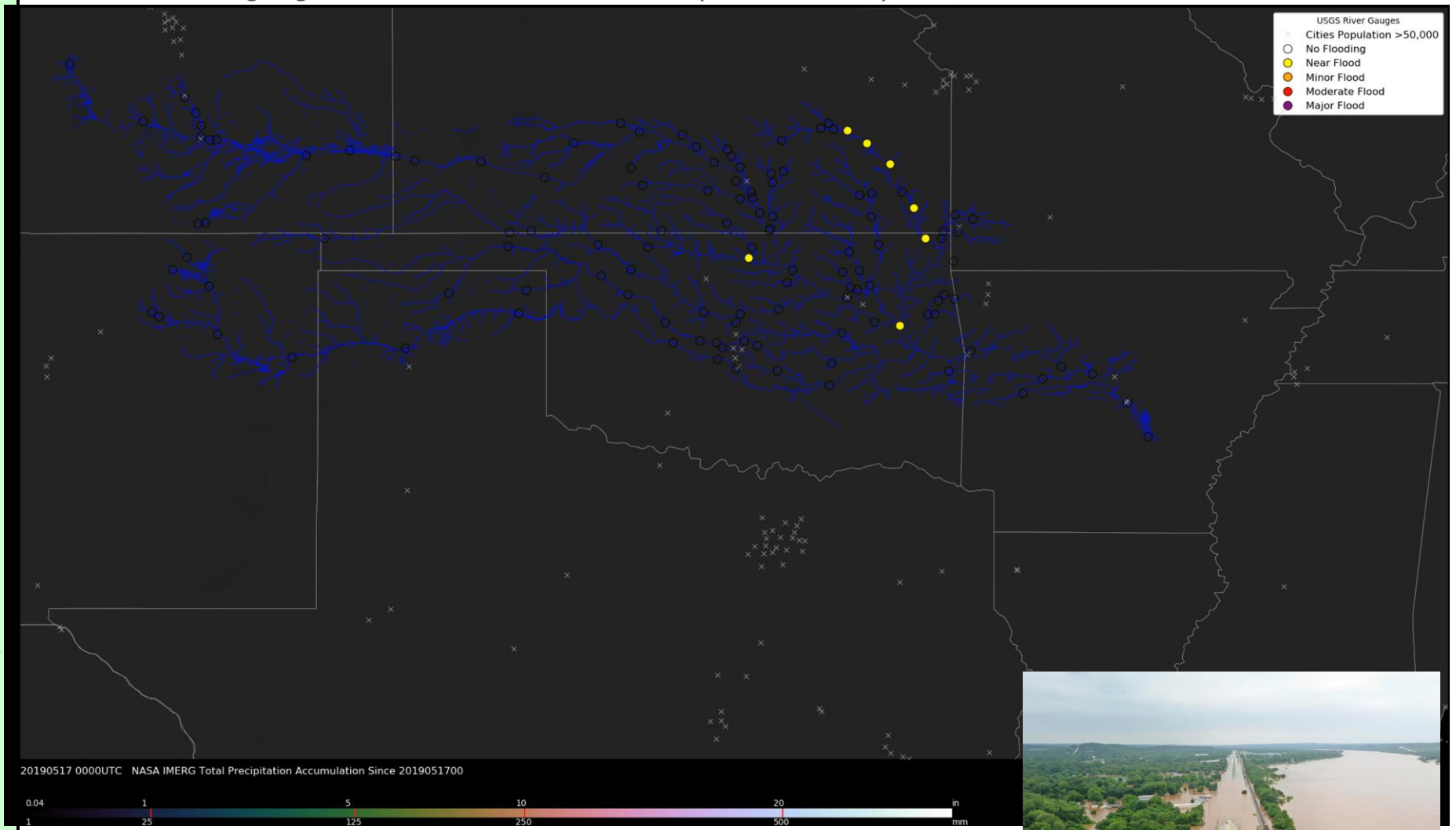
- ERDS is a web GIS applications service for monitoring and forecasting extreme rainfall events- http://erds.ithacaweb.org/.
- ERDS is developed and implemented by the Information Technology for Humanitarian Assistance, Cooperation, and Action (ITHACA) - http://www.ithacaweb.org/ - and used by the UN World Food Programme (WFP) Emergency Preparedness Unit and multiple emergency management service organizations.
- ERDS Twitter account, @Ithaca_erds, has multiple examples how GPM IMERG data has been used for disaster response and preparation in over 20 countries!

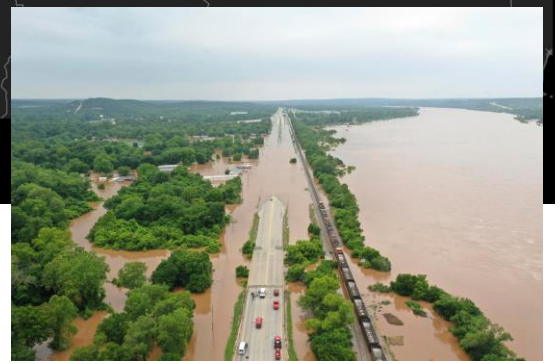
GLOBAL PRECIPITATION MEASUREMENT

Capturing Arkansas Flooding with GPM IMERG

Southern and Central US were pummeled with heavy rains throughout May 2019. Towards the end of the month, Oklahoma declared a state of emergency and evacuations were under effect for areas along the Arkansas River where flood waters overtopped levees. Rainfall accumulation estimates derived from GPM IMERG were used along with USGS river gauge flood data to illustrate the extensive flooding of the Arkansas River over the past few weeks. Estimates showed upwards of 30 inches of rain (>700mm) fell in Oklahoma.

(Below) Animation of the Arkansas river flooding from 5/17/2019 to 6/03/19 using NASA's GPM IMERG and USGS river gauge data. Credit: Matt Lammers (NASA/ GSFC).





(Right) Flooded highway along Arkansas River in Sand Spring, OK. Credit: DroneBase via AP, cbsnews.com/news/arkansas-river-flooding-fort-smith-floods-threatening-thousands-tulsa-oklahoma/

GLOBAL PRECIPITATION MEASUREMENT

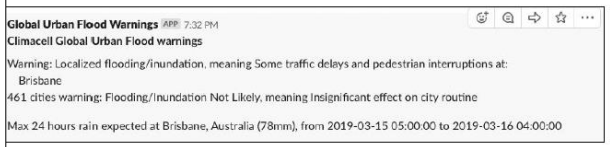
Climacell Plans to Use GPM

Climacell, a weather data company, is planning to incorporate GPM data into their Global Urban and Flash Flood Forecasting (CGUFF) System. Satellite precipitation data (soon to include GPM) is used as input in their precipitation forecasts. These forecasts are then converted into 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 flood events throughout the world (900+ cities), helping hundreds of millions across Asia, South America and Africa. Check out these multiple case studies where Climacell has been applied and validated.

Forecasting Urban Floods Brisbane March 15, 2019

"A MASSIVE band of wild storms stretching from the Sunshine Coast down to Byron Bay has dumped up to 105mm of rain in just one hour, causing widespread commuter chaos and power outages"

- Source: couriermail



Forecasting Urban Floods in Kolkata, Feb 26, 2019

Forecasting Urban Floods in Pakistan, Feb 20, 2019

Torrential rains lashed several cities in Pakistan on Thursday, triggering flash floods and leaving at least 26 dead across the country, many swept away by the waters or killed when their roofs collapsed before dawn, authorities said.

Source - QUETTA, Pakistan (AP)

CGUFF Cities affected:

Islamabad, Lahore, Abbottabad, Rawalpindi

NEWS / ASIA

Death toll from Pakistan flash floods, rains rises to 26

Officials say 26 people have died across Pakistan, while winter storm also affected northern India and Afghanistan.

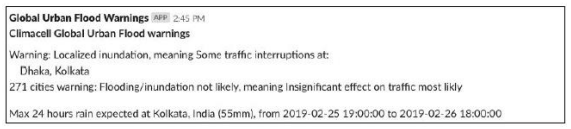
21 Feb 2019

Forecasting Urban Floods in Bangladesh, Feb 25, 2019

ClimaCell Warning:
Localized inundation
Some traffic interruptions

Cities affected:

Dhaka



उत्तर भारत में यह लगातार चौथा हफ्ता है जब अनेक इलाकों में एक साथ बारिश देखने को मिल रही है। इसकी शुरुआत सोमवार को ही हो गई थी, जब दिल्ली, नोएडा और गाजियाबाद सहित उत्तर भारत के मैदानी और पर्वतीय इलाकों में कई जगह पर बारिश हुई।

इस समय एक सक्रिय पश्चिमी विक्षोभ जम्मू कश्मीर को प्रभावित कर रहा है। इसके कारण विकसित हुआ चक्रवाती हवाओं का क्षेत्र हरियाणा और पंजाब के ऊपर हवाओं में बना है। साथ ही एक टफ गंगा के मैदानी इलाकों पर विकसित हो गई है।

Forecasting Urban Floods Davao City March 19, 2019

Multiple case studies showing Climacell's early flooding warning system being applied to a given city prior to a flood event and the aftermath showing the effects of the flood on the ground. Credit: Climacell.

GLOBAL PRECIPITATION MEASUREMENT

Coffee Growers Interested in GPM Data

Nedcommodities India, the sister company of the major coffee trader Nedcoffee, is interested in using NRT GPM data along with other satellite data as input to produce coffee yield forecasts for coffee farms throughout India. The forecasts will then play a major role in the company's policy- and decision-making where arriving at precise and close to accurate production numbers will be beneficial for the entire supply chain and the company's success.

(Right) Photos taken from Nedcommodities highlighting their production products and local farmers. Credit: http://www.nedcoffee.com/india/.

S&D NEDCOFFEE

Ned commodities (a 100% subsidiary of Amtrada Holding B.V and a group company of Nedcoffee B V) is a private limited company established in 2000 and has a processing factory in Kushal Nagar of Kodagu district. It intertwines sustainable standards and traceability in order to enhance value for the producers. It is a sourcing agency for the parent company operating from the Amsterdam market. It is now the third largest exporter of green coffee from India. It uses a sophisticated technology driven system of traceability from farm level to end product. This company adopts Utz certification and encourages small growers adopt the same so that they would be able to benefit from it. In 2009, the Company facilitated the organisation of producers so that they would be able to enhance quality

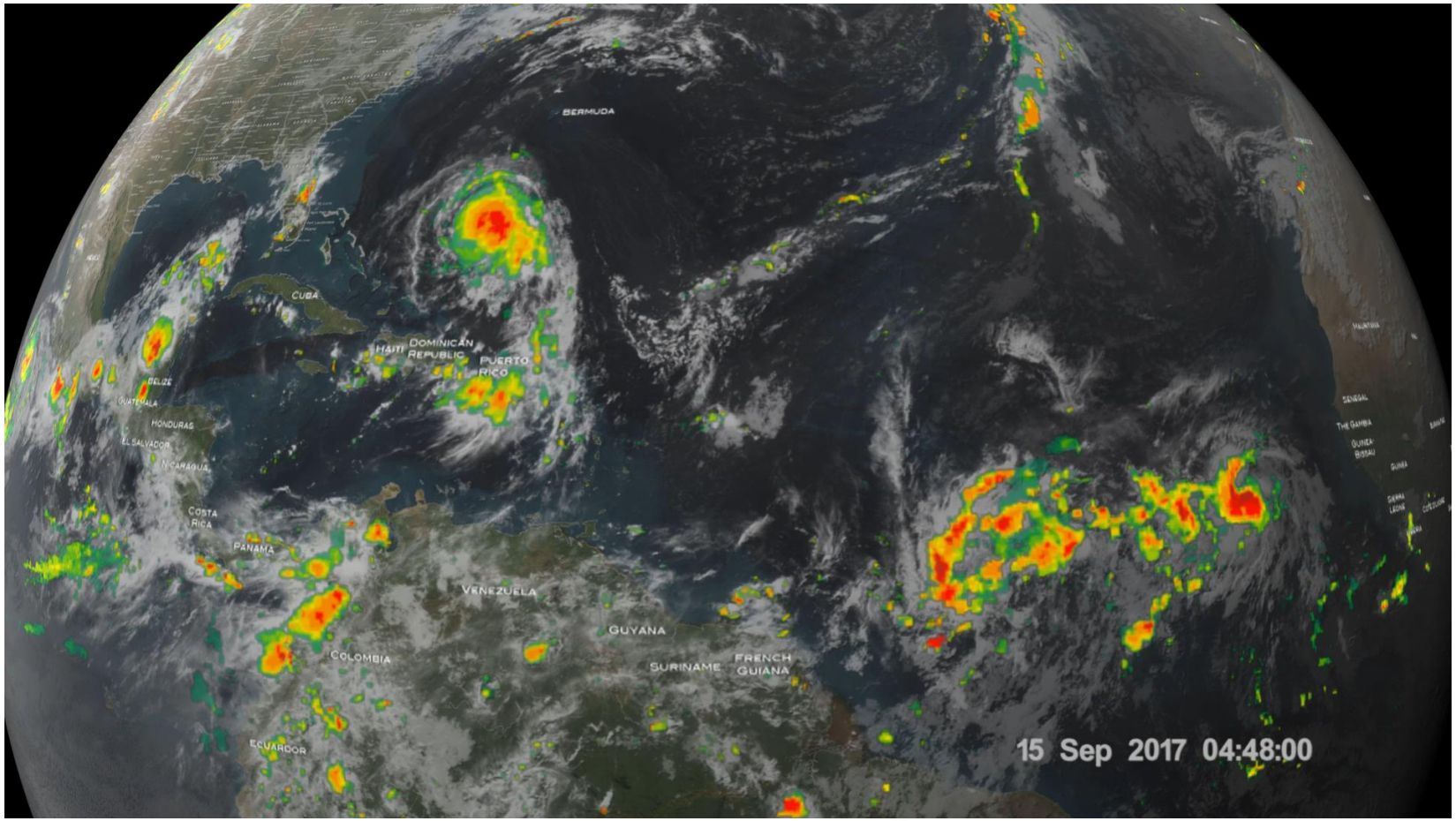
eing

Currently there are over 150 small growers who are part of this programme. Field facilitation is being carried out by a Bangalore based NGO, Prakruthi for this initiative

(Above) Excerpts from India's National Research Programme on Plantation Development Discussion Paper. Ned commodities is a major coffee exported from India who is interested in using satellite data to support decision-making needs and works with over 150 farmers who in turn will rely on data to produce high coffee yields. Credit: http://cds.edu/wp-content/uploads/2014/07/NRPPD15.pdf.

GPM Sees Hurricanes Maria and Jose

GPM passed over both Hurricane Maria and Hurricane Jose on September 18th, 2017, capturing rainfall distribution for the two major storms churning in the Atlantic and Caribbean basins. The visualization shows an image of Hurricane Jose as the storm was moving due north at 9 mph well off shore from the coast of North Carolina. The GPM image estimated areas of very heavy rain on the order of 75 mm/hr (~3 inches per hour). The GPM CO satellite also had an excellent view of Hurricane Maria when it passed almost directly above the hurricane on September 17, 2017 at 1001 PM AST (September 18, 2017 0201 UTC). GPM's Microwave Imager (GMI) and Dual-Frequency Precipitation Radar (DPR) showed that Maria had well defined bands of precipitation rotating around the eye of the tropical cyclone. GPM's radar (DPR Ku band) found rain falling at a rate of over 6.44 inches (163.7 mm) per hour in one of these extremely powerful storms northeast of Maria's eye. Intense thunderstorms were found towering to above 9.7 miles (15.7 km). This kind of chimney cloud is also called a "hot tower" (as it releases a huge quantity of latent heat by condensation). These tall thunderstorms in the eye wall are often a sign that a tropical cyclone is becoming more powerful. Maria rapidly intensified following this view to a Category 5 storm on September 19th.



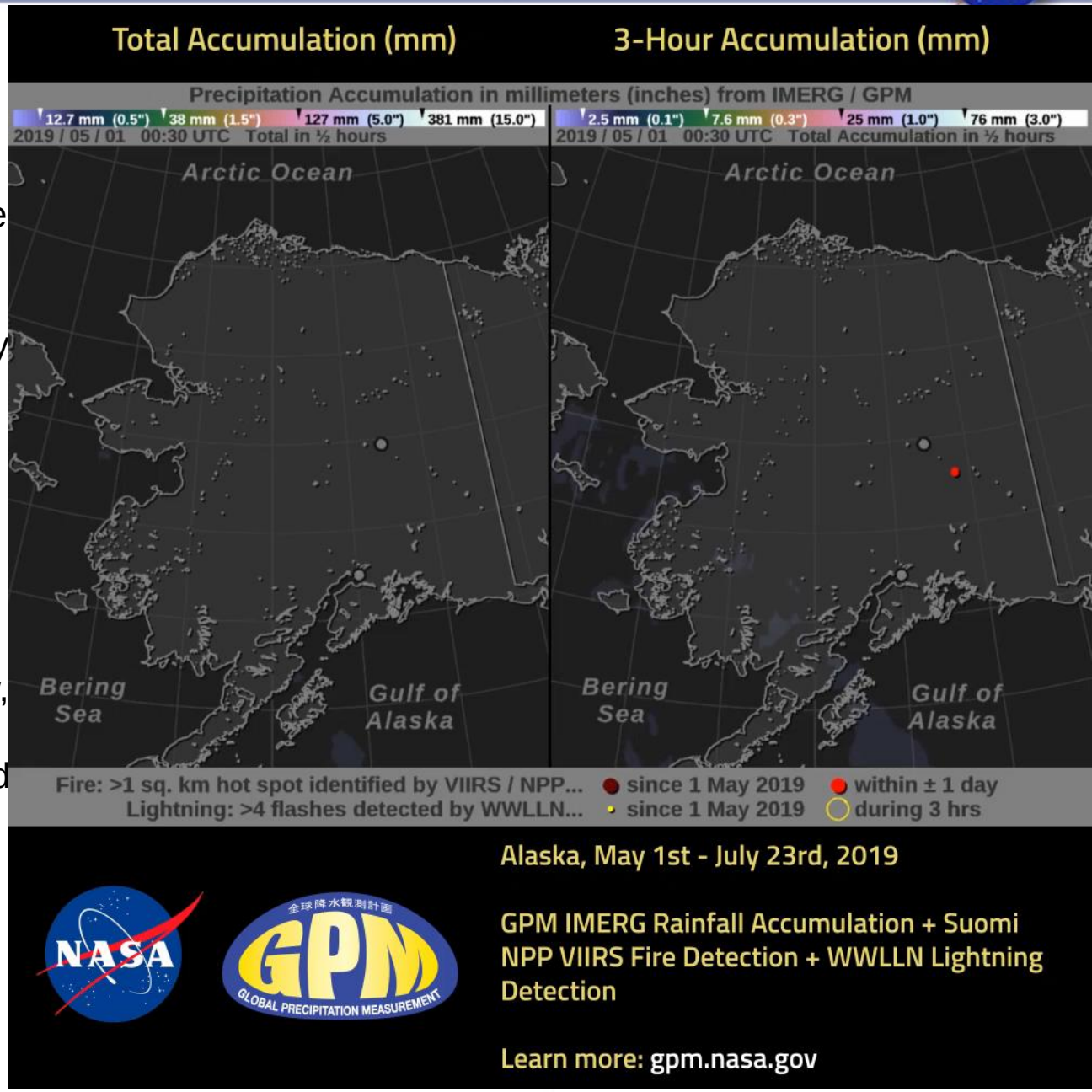
Credit: NASA SVS

GLOBAL PRECIPITATION MEASUREMENT

Rain Patterns Captured by GPM During the 2019 Alaska Wildfires

Wildfires occur in Alaska each summer, but July 2019 is shaping up to be a particularly active month. Few rain gauges exist in the large tracts of Alaskan wilderness, but wildfires unchecked can spread to populated areas within the state. Satellite-based precipitation estimates are particularly valuable here because of precipitation's relationship to wildfire hazard.

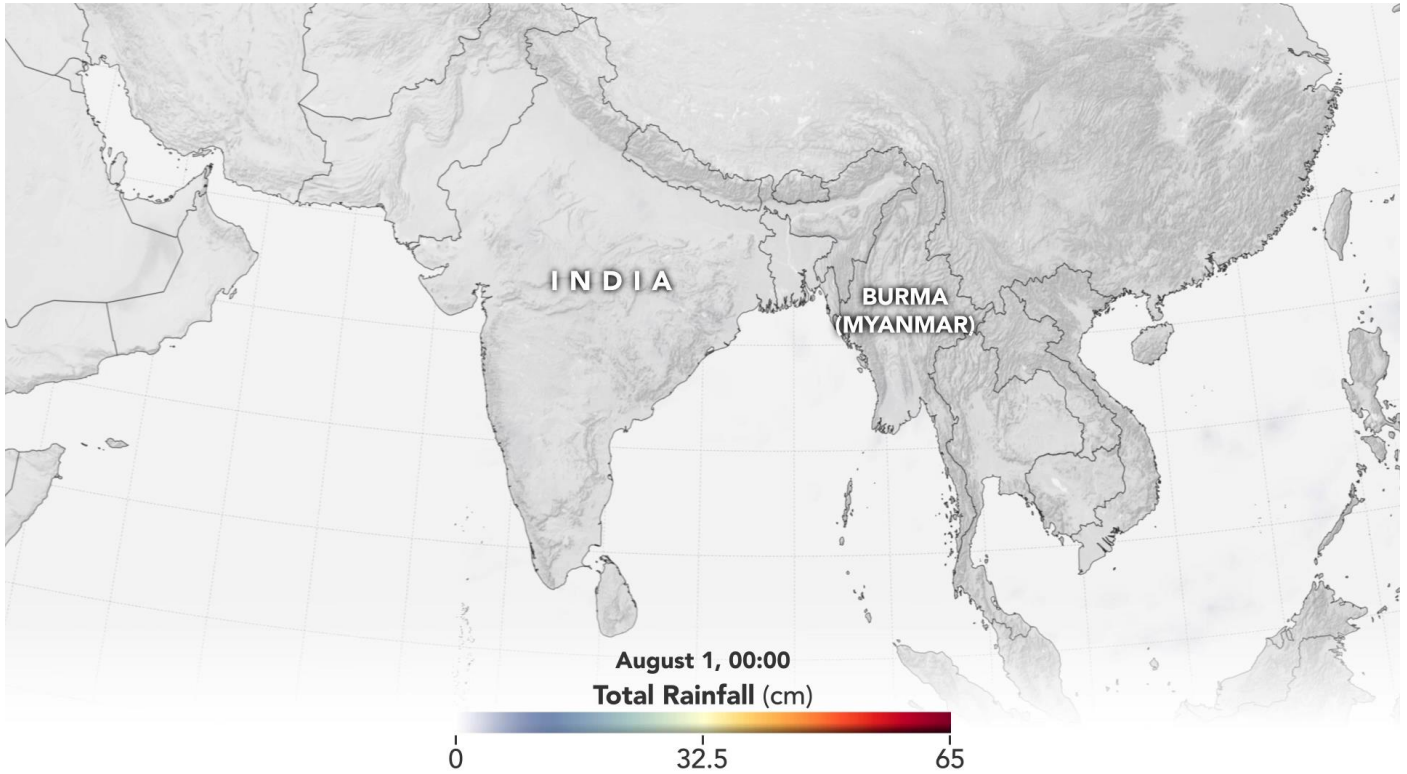
The movie shows GPM IMERG precipitation estimates for May 1- July 18, 2019. The total accumulation since May 1 is shown in mm (in.) on the left half, while the accumulation during a 3-hour period is shown on the right half. The locations of likely fires are shown in red, based on thermal anomalies observed by the VIIRS instrument on the Suomi NPP polar-orbiting satellite. The VIIRS "hot spot" data has a resolution of approximately 0.25 square km and is based on IR brightness temperature. Locations of lightning strikes are shown in yellow, as detected by the network of ground sensors that make up the World Wide Lightning Location Network. A flash is detected when five or more WWLLN stations around the world detect a radio-frequency atmospheric signal from the same lightning flash. A gray circle along the southern coast or center of Alaska represents the cities of Anchorage or Fairbanks, respectively.

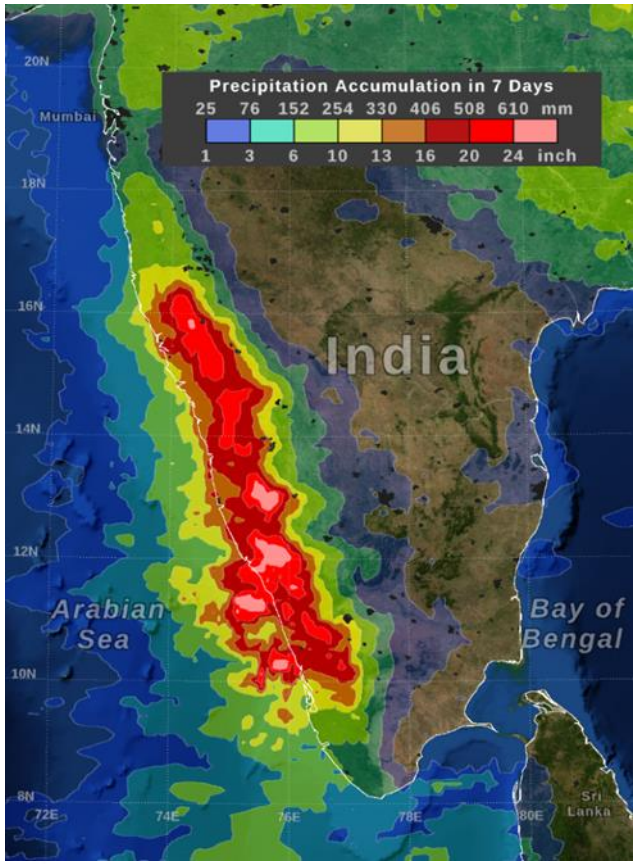


Visualization and text: Owen Kelley (NASA PPS) & Jacob Reed (Telophase / NASA GSFC)

Extreme Rainfall in Southern Asia

Extreme rainfall has overflown tributaries and destabilized hillsides in several regions throughout western India and Burma (Myanmar), causing flooding, landslides, and over 95 deaths in early August 2019. The animation on the left depicts satellite-based precipitation estimates using GPM IMERG from August 1–12, 2019. The darkest reds reflect the highest rainfall amounts, with many places receiving 60 cm (24 in) or more during this period. The image on the right shows the IMERG totals after 7 days (Aug. 5-11). The rainfall totals are regional, remotely-sensed estimates. Each pixel shows 0.1 degrees of the globe (about 7 miles at the equator), and the data are averaged across each pixel. Individual ground-based measurements within a pixel can be significantly higher or lower than the average. IMERG compiles precipitation estimates from passive microwave and infrared sensors on several satellites, as well as monthly surface precipitation gauge data, to provide precipitation estimates between 60 degrees N-S latitude.



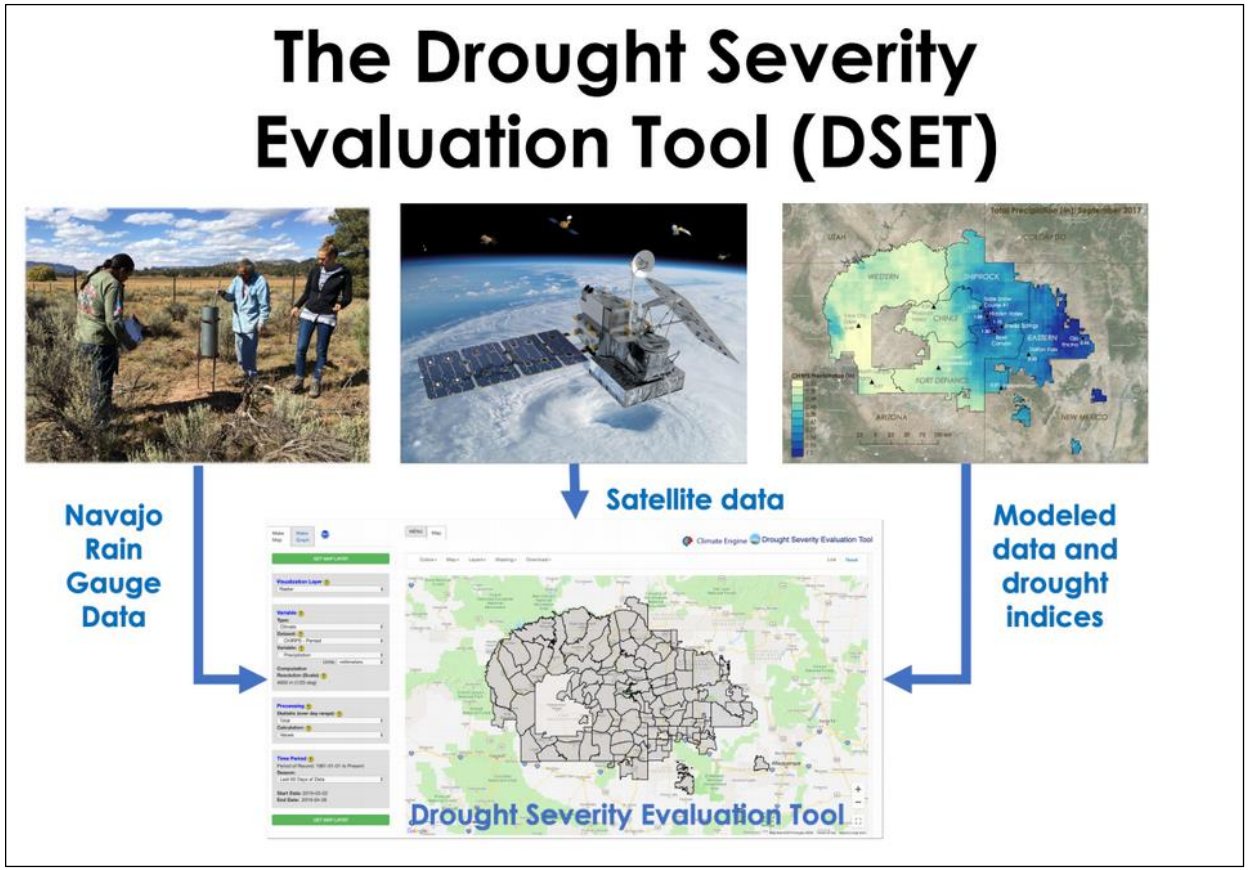


Caption and Image credit: Joshua Stevens (NASA GSFC) and Michael Carlowicz (NASA GSFC) (above/left) and Owen Kelley (NASA GSFC) (right).

Check out full articles at Earth Observatory and Extreme Weather News (https://earthobservatory.nasa.gov/images/145460/extreme-monsoon-rains-in-asia and https://pmm.nasa.gov/extreme-weather/imerg-measures-flooding-rainfall-india)!

Addressing Drought on the Navajo Nation

The Navajo Nation (NN) is the largest federally recognized tribe in land area, of over 70,000km^2, and faces challenges related to water management during long-term droughts. Currently, the Navajo Nation Department of Water Resources (NNDWR) reports on drought and climatic conditions through the use of regional Standardized Precipitation Index (SPI) values and a network of in-situ rainfall and climate data. However, these data sources lack the spatial detail and consistent measurements needed to provide a coherent understanding of the drought regime within the Nation's boundaries. The use of satellite-based remote sensing of precipitation, vegetation, and drought indices on the NN may improve upon the ability to monitor and report drought conditions. This project aims to create a cloud-based web application, the Drought Severity Evaluation Tool (DSET), for improved drought reporting that will include remotely-sensed, modeled, and in-situ data on the NN. This tool will harness the capabilities of Google Earth Engine (GEE), specifically through a partnership with the Desert Research Institute (DRI) and ClimateEngine.org, to conduct drought and land assessments. DSET connects NASA Earth Observations (e.g. TRMM, GPM, Landsat, MODIS), modeled climate data (e.g. CHIRPS and gridMET), and in-situ rain gauge data for on-the-fly analyses. DSET computing capabilities includes the generation of regional to field scale maps, time series figures, and reporting metrics that can assist in drought emergency declarations and the subsequent allocation of relief dollars across the NN.



Text and Image credit: Amber Jean McCullum[1], Justin Huntington[2], Britta Daudert[2], Carlee McClellan[3] ([1]Bay Area Environmental Research Institute/NASA Ames Research Center, [2]Desert Research Institute,[3]Navajo Nation Dept of Water Resources).

IMERG Estimates Hurricane Dorian's Rain

Hurricane Dorian is breaking records over the Bahamas as the most destructive hurricane to ever hit the Bahama Islands, with catastrophic rains and winds with gusts over 200 mph. In the early hours of Tuesday, September 3, 2019, Hurricane Dorian had been stationary over the island of Grand Bahama for 18 hours, most of the time as a category 5 hurricane. NASA IMERG estimates captured this heavy rainfall accumulation from August 28-September 3, 2019. IMERG data revealed that storm-total rain accumulation over parts of Grand Bahama and Abaco Islands have exceeded 24 inches.

*IMERG is an example of the research role that NASA has in hurricanes – developing observational tools and building computer models to better understand the behavior of tropical cyclones.

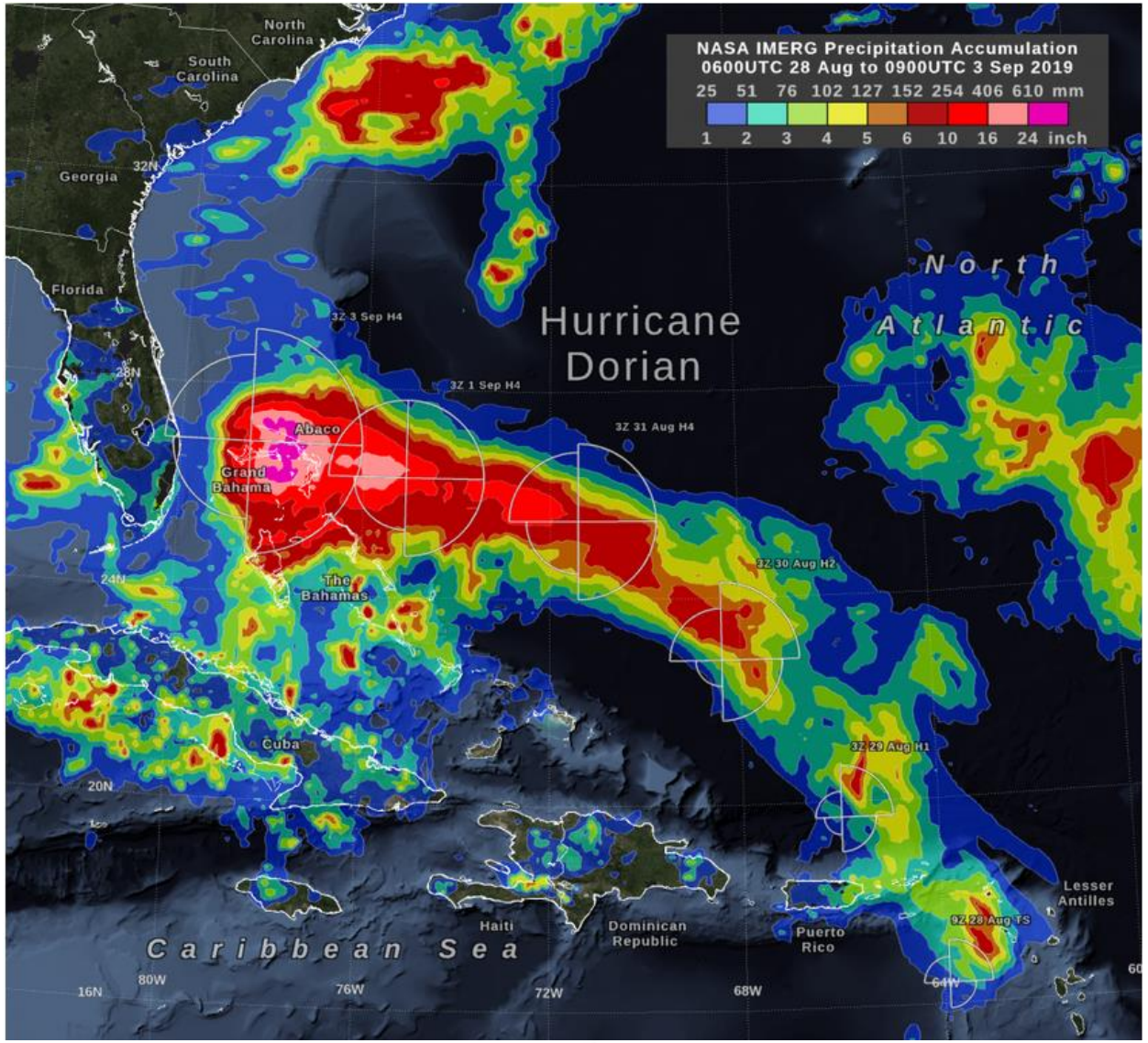


Figure (right): NASA's IMERG storm-total rain accumulation over parts of Grand Bahama and Abaco islands have exceeded 24 inches according to NASA IMERG estimates. The graphic also shows the distance that tropical-storm force (39 mph) winds extend from Hurricane Dorian's low-pressure center, as reported by the National Hurricane Center. The symbols H and TS represent a hurricane of various Saffir-Simpson categories or a tropical storm, respectively. Image Credit: NASA Goddard

Caption Credit: Courtesy of Owen Kelley via https://blogs.nasa.gov/hurricanes/tag/dorian-2019/

Check out full article and updates of Hurricane Dorian at https://blogs.nasa.gov/hurricanes/tag/dorian-2019/

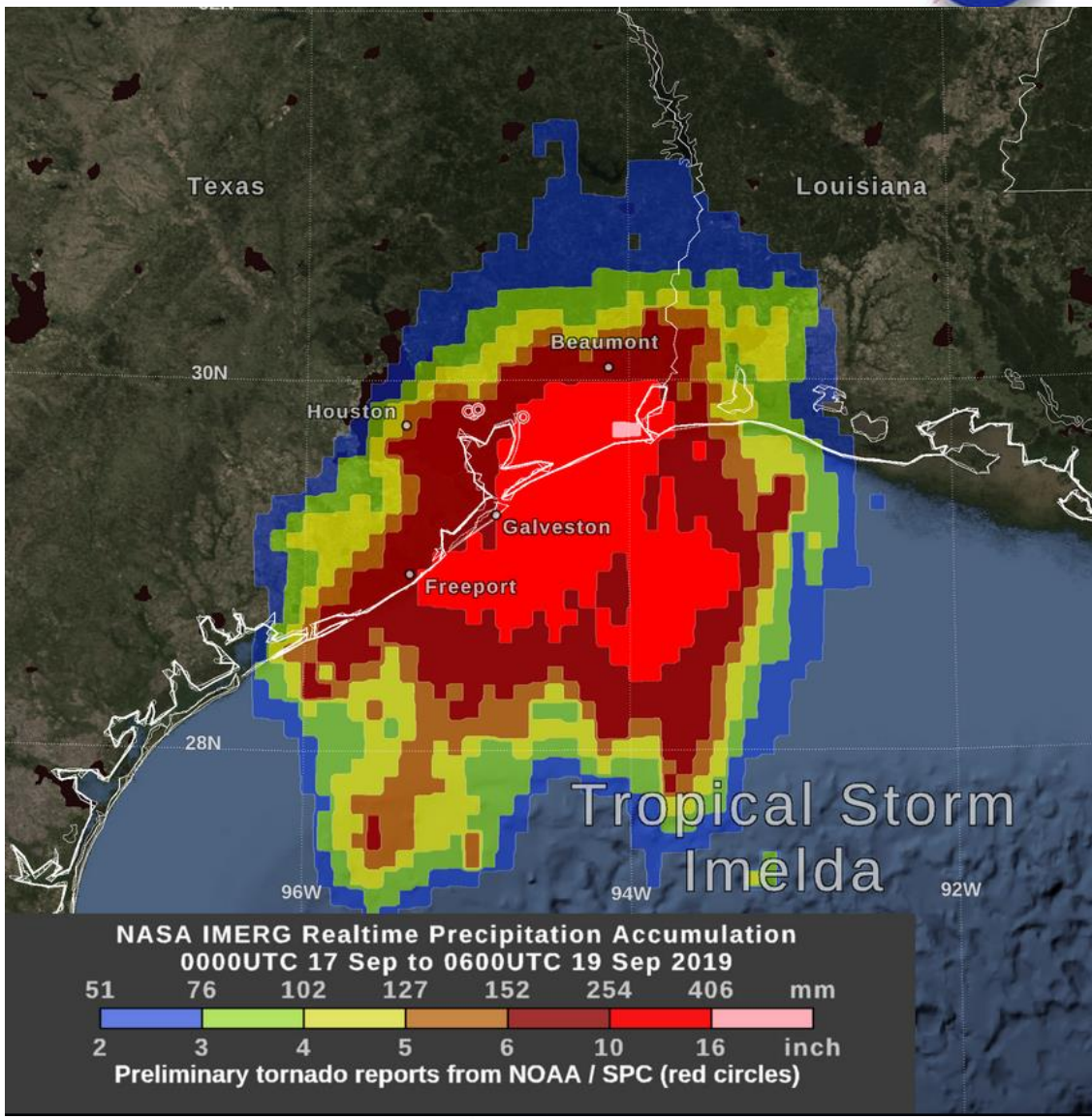
IMERG Estimates Tropical Storm Imelda's Rain

By Thursday morning, September 19, 2019, Tropical Storm Imelda had dropped over 10 inches of rain over a large area between Houston and Beaumont, Texas. This graphic shows precipitation that fell starting on Tuesday, September 17, the day that Imelda formed as a tropical depression in the Gulf of Mexico, intensified into a tropical storm, and made landfall in Texas, all within a few hours.

Rainfall accumulation estimates came from using GPM IMERG. The IMERG data was able to capture the narrow band of heavy precipitation (>6 inches) that fell overnight on September 17 along the Texas coast southwest of Galveston near Freeport. On the ground reports showed flooding throughout Freeport (image below) and several road closures. Flash flood warnings are in effect from Houston to Freeport to the Beaumont area.

Also, there were several preliminary reports of tornados on Wed. evening, September 18. Tiny red circles on the IMERG image (NW side of the storm) indicate the location of these tornado reports between Houston and Beaumont, Texas, as provided by NOAA's Storm Prediction Center.

A Freeport Police Department vehicle drives down a flooded S. Velasco Blvd. between west Fifth and Seventh streets, Wednesday, Sept. 18, 2019, in Freeport, Texas, as heavy rain from Tropical Depression Imelda falls. (Mark Mulligan/Houston Chronicle via AP)



Above image credit: Owen Kelley, NASA GSFC
Left Image Credit: Mark Mulligan/Houston Chronicle via AP via WJLA.com

GLOBAL PRECIPITATION MEASUREMENT

Capturing Tropical Storm Imelda's Rain with GPM IMERG

By Friday morning, Sept. 20, 2019, the rainfall from the remnant of TS Imelda had increased to over 24 inches in some areas near the Gulf of Mexico coast between Beaumont and Houston, TX since Tuesday, Sept. 17. This rainfall was in excess of what had been forecasted a few days earlier and was due to Imelda's forward motion ceasing for approximately 24 hours between Wednesday and Thursday afternoon. The image shows, with large "L" symbols, the location estimated by the National Hurricane Center for Imelda's low-pressure center of rotation at various times over the past three days.

GPM IMERG was used to capture Imelda's rainfall accumulation estimates. If one compares IMERG to that from a National Weather Service ground radar, one sees that IMERG correctly identified the large region of heavy rainfall near Beaumont, but IMERG failed to resolve an extremely narrow band of heavy rainfall along Galveston Island. Such good detection of large rain features in realtime would be impossible if the IMERG algorithm merely reported the precipitation observed by the periodic overflights of various agencies' satellites. Instead, what the IMERG algorithm does is "morph" high-quality satellite observations along the direction of the steering winds to deliver information about rain at times and places where such satellite overflights did not occur. Information morphing is particularly important over the majority of the world's surface that lacks ground-radar coverage.

On the ground reports showed severe flooding from Beaumont to Houston and several preliminary reports of Imelda-spawn tornados were recorded on Wednesday and Thursday, September 18-19.

Chambers County rescuers use an airboat to ferry people to drier ground near Winnie, TX on Thursday morning. Credit: Chamber's County Sherriff's Office via CNN.com

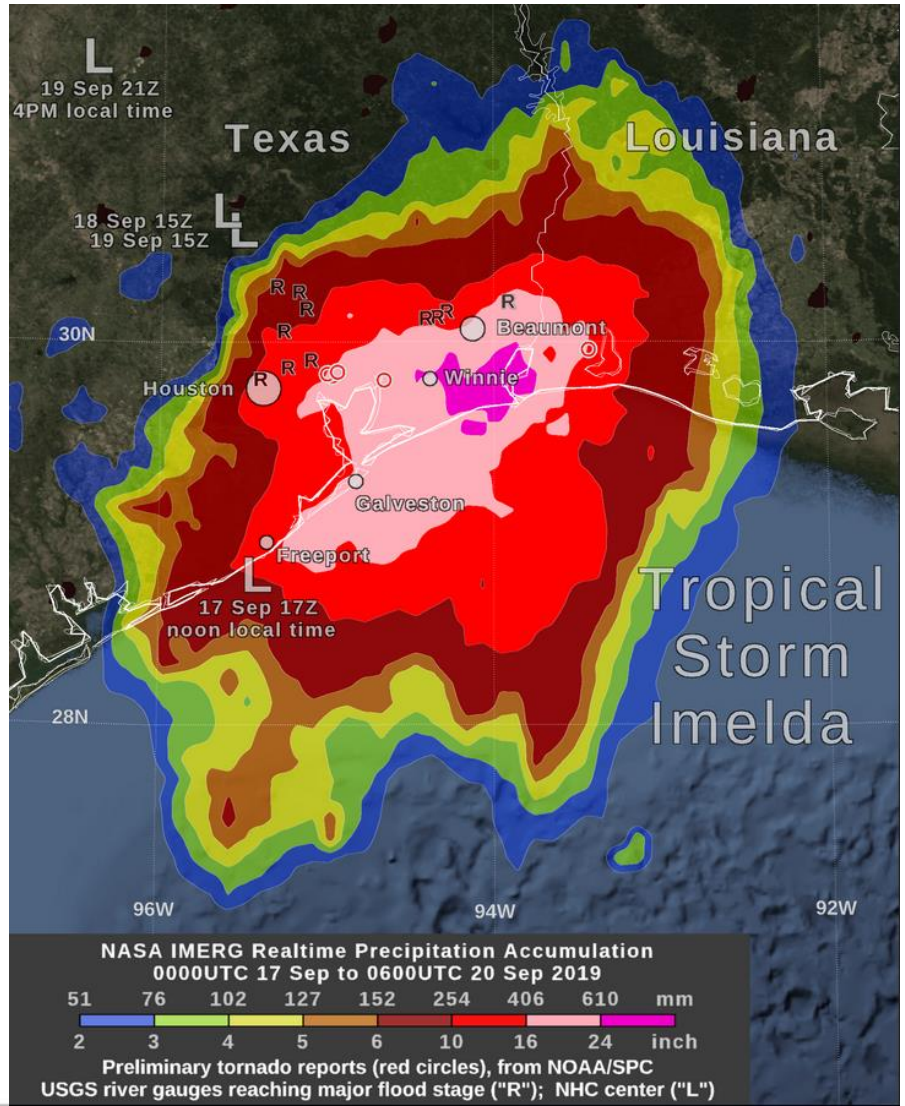


Image Right: TS Imelda's rainfall estimates using GPM IMERG. The red to pink shading show where the heaviest rainfall occurred and the "R" symbol indicates a place where the rainfall from the remnant of Imelda caused USGS river gauge to swell to "major flood" stage. "Major" flood generally means that nearby homes and roads were flooded. The river-gauge data shown here is intended merely to give a hint of what areas experienced flooding and is not intended to portray the complete extent of flooding. In addition, the tiny red circles indicate reports Tornado reports, as provided by NOAA's Storm Prediction Center.

Text and IMERG image credit: Owen Kelley, NASA GSFC

GLOBAL PRECIPITATION MEASUREMENT

Typhoon Hagibis brings heavy rains to Japan

Typhoon Hagibis made landfall in Japan over the weekend of October 12 and 13, 2019 bringing damaging winds, rough surf and flooding rains. Shown here are IMERG surface rainfall accumulations for the period of October 4 to 13 4 for Japan and the surrounding region from the time when Hagibis first formed until it became extratropical northeast of Honshu. In addition to several areas of heavy rain just off shore, IMERG shows rainfall totals exceeding 400 to 500 mm (~16 to 20 inches, shown in darker orange and red) over east-central Honshu near to where Hagibis made landfall with many areas receiving at least 200 mm (~4 inches, shown in light blue). Locally, over 3 feet of rain was reported in 24 hours southwest of Tokyo. All of this rain caused numerous rivers to overflow their banks as well as several mudslides. So far, Hagibis is being blamed for at least 72 fatalities in Japan.

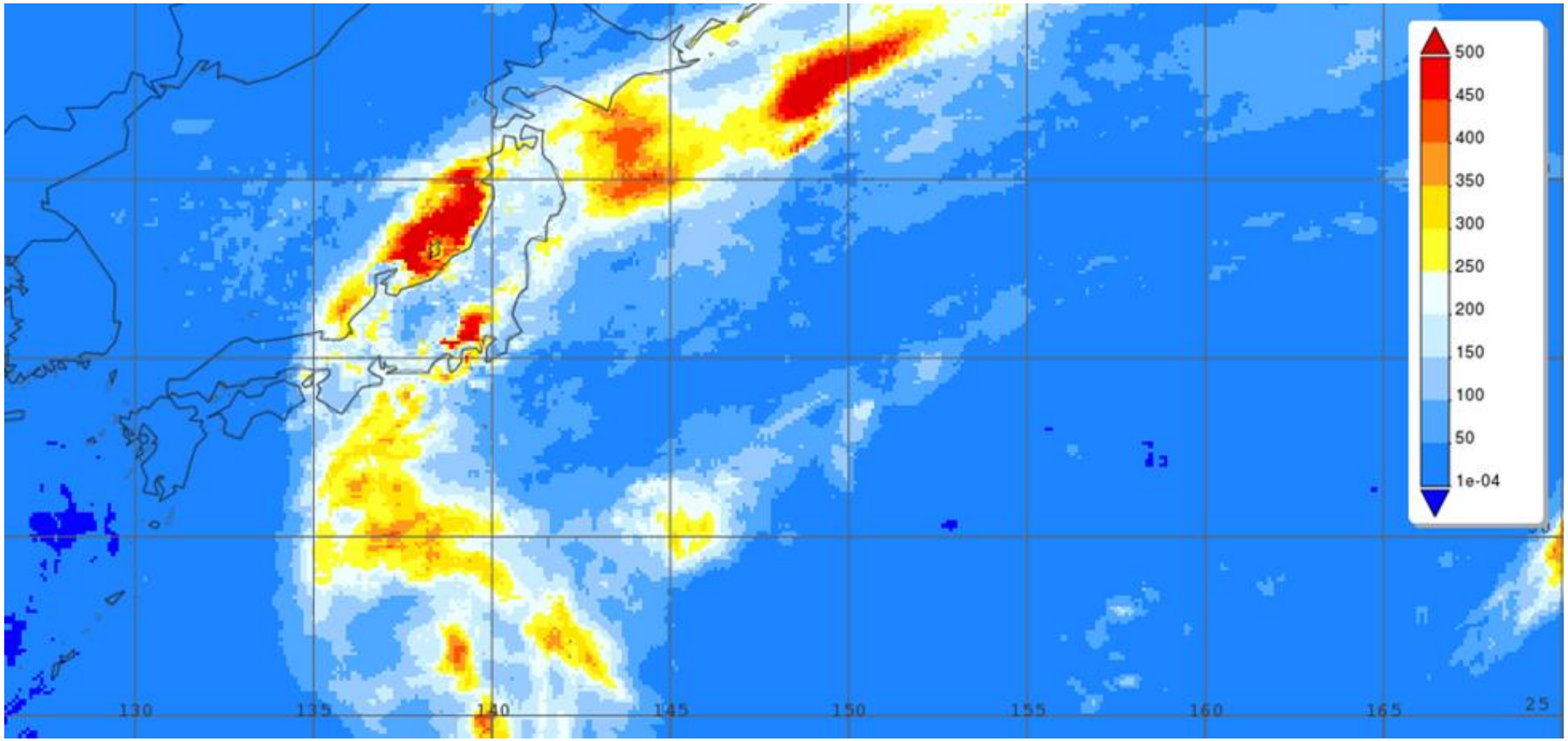
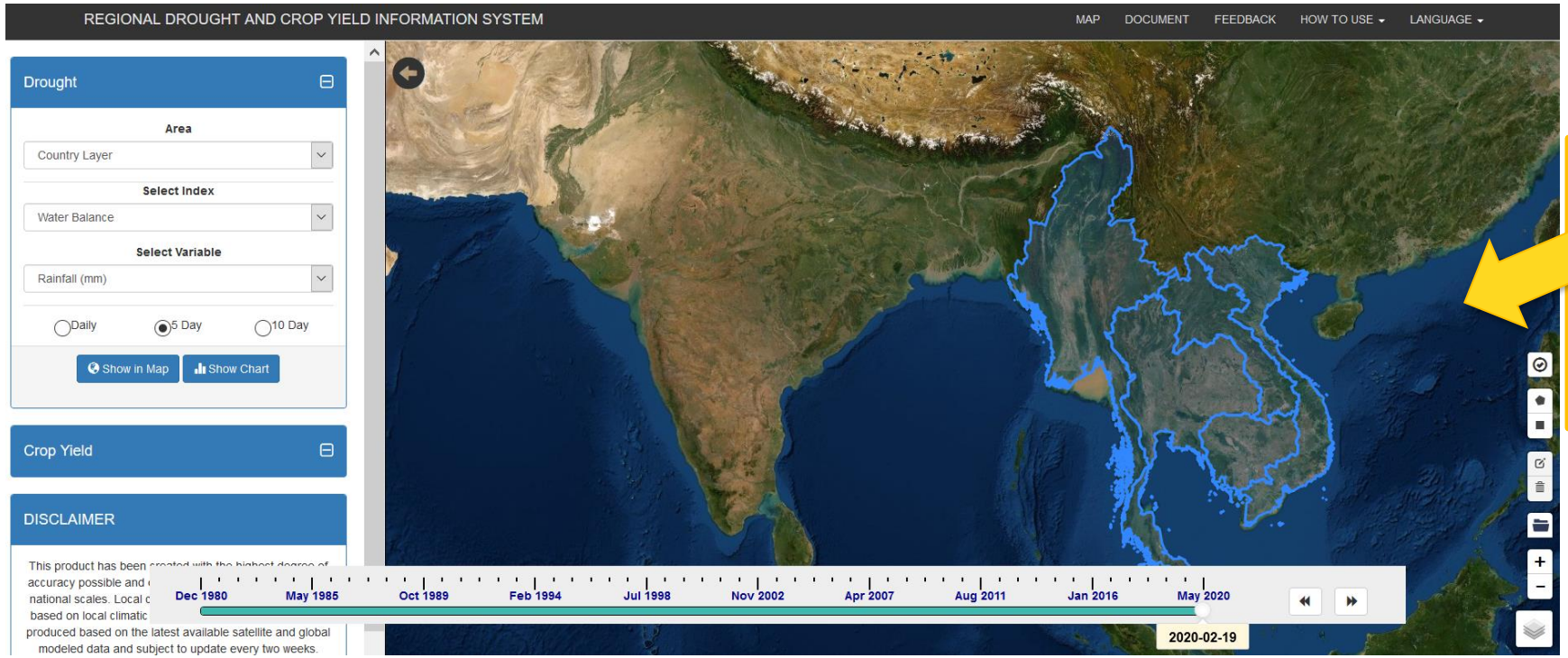


Image from NASA GSFC using IMERG data archived at https://giovanni.gsfc.nasa.gov/giovanni/. This image was produced with the Giovanni online and open data system, developed and maintained by the NASA GES DISC. Image credit: NASA GSFC/ SSAI

Assessing Drought in Vietnam

SERVIR Mekong and co-developers developed the Regional Drought and Crop Yield Information System (RDCYIS) to manage information needed to understand drought conditions and potential effects on crop yields at a provincial level in Vietnam.



RDCYIS (https://rdcyis-servir.adpc.net/map) which uses GPM and other satellite data and products

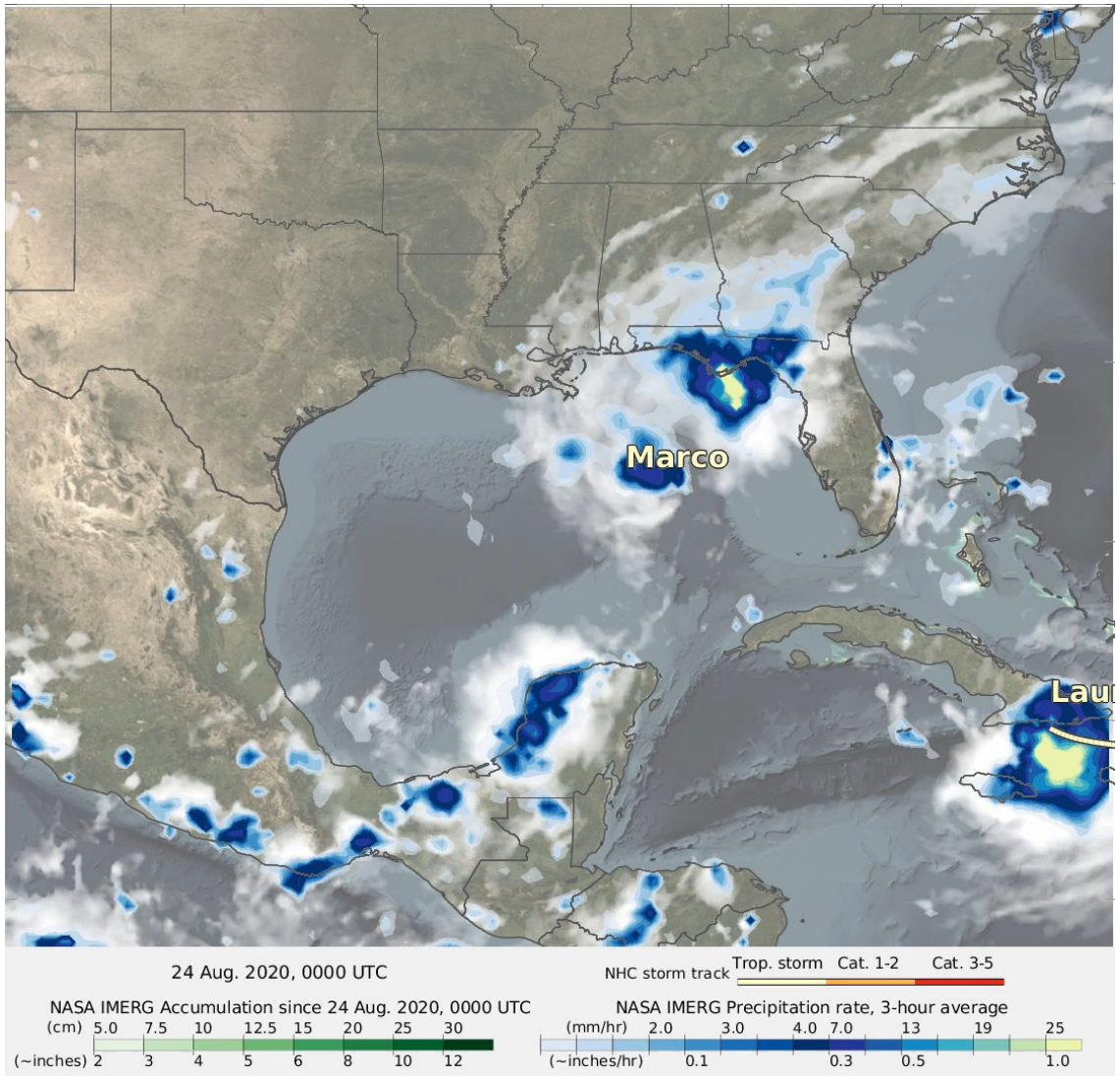
The system uses GPM and other satellite data products and is designed to generate drought and crop yield forecasts that will be used to inform better mitigative decision-making by Vietnam's Ministry of Agriculture and Rural Development, including salt-water intrusion, water allocation and distribution compensation, or other social welfare initiatives.

*For more information see https://servirglobal.net/ServiceCatalogue/details/5c3472f19ff7d708e49cc973

GLOBAL PRECIPITATION MEASUREMENT

Multiple Perspectives of Hurricane Laura using GPM Data

Hurricane Laura made landfall as a strong category 4 hurricane near Cameron, Louisiana shortly after midnight on August 27, 2020, bringing extreme rainfall, storm surge, and winds up to 150 mph.



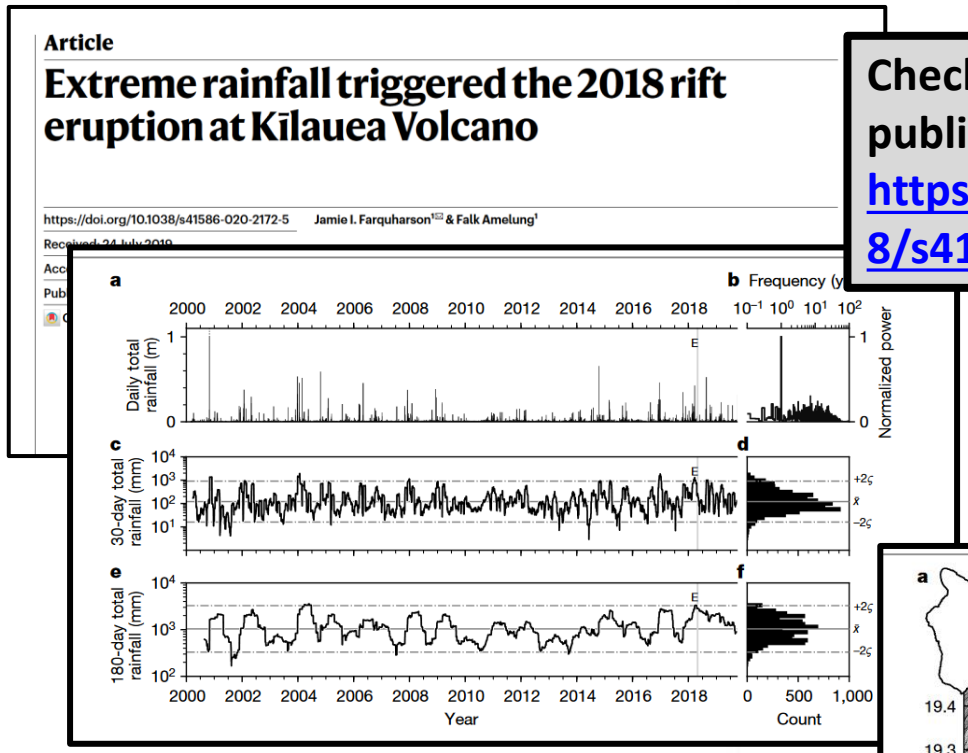
The GPM IMERG data product was used to estimate rain rates and total rainfall accumulation for Hurricane Laura from August 21-27, 2020.

- The GPM Core Observatory (CO) satellite flew over Hurricane Laura shortly before it made landfall at 10:00pm CT on Wednesday, August 26th, capturing the structure of Laura.
- The GPM CO flew over Laura again in the early morning of Thursday, August 27th when it was over land, retrieving precipitation data within the storm.
- Data collected by GPM can be viewed in multiple formats. GPM data and products, like this video to the left and images on the following slides, provide valuable information about Laura's structure and behavior that can be used for disaster preparation, response, ad recovery.
- Detailed coverage and information about Hurricane Laura by GPM is readily available at https://gpm.nasa.gov/.

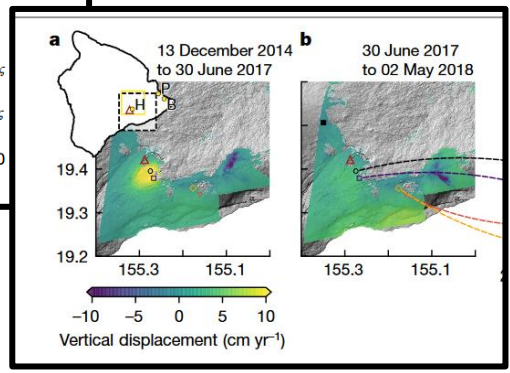
Using GPM to Explore Rainfall Patterns in Volcanic Environments

The May 2018 eruption of the Kilauea Volcano was a unique eruptive event sending lava flowing into streets and neighborhoods, yet the trigger to this eruption remained unknown. To explore the cause of this event, a team from University of Miami used NASA GPM data to understand how rainfall patterns could trigger the May 2018 eruption of Kilauea Volcano, Hawaii. Their research results were published in April 2020 in *Nature*.

- Previous studies have proposed that rainfall can modulate shallow volcanic activity.
- The event was preceded by several months of anomalously high precipitation.
- The Miami team used GPM data and other sensor data as input to model pore pressure changes in Kīlauea's edifice.
- They demonstrate that anomalous rainfall in late 2017/early 2018 facilitated the 2018 eruptive episode.
- This research adds a new factor of information when assessing volcanic hazards worldwide.



Check out the full published article at https://doi.org/10.1038/s41586-020-2172-5

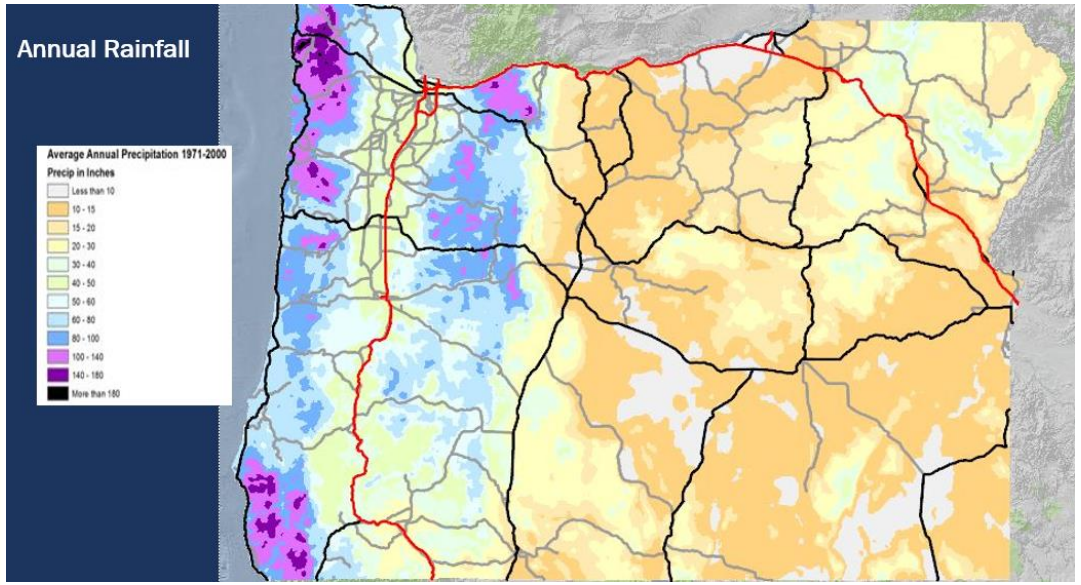


Screenshot of the team's results of daily rainfall over Kilauea using GPM data and gauge data (above) and study site (right).

"We show that immediately before and during the eruption, infiltration of rainfall into Kīlauea Volcano's subsurface increased pore pressure at depths of 1 to 3 km by 0.1 to 1 kilopascals, to its highest pressure in almost 50 years." – Farquharson & Amelung, 2020

Characterizing Data Needs at Oregon DOT

- Oregon Department of Transportation (ODOT) participated at the 2020 GPM-ACCP Transportation Workshop
- ODOT precipitation, weather, and climate effects/ concerns for highway design and operations:
  - Culverts -> degradation rate and maintenance
  - Surface drainage -> degradation rate and driver safety
  - Construction -> timing/ staging, worker safety, dewatering
  - Unstable slopes -> landslides and debris flows



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

Images courtesy of C. Mohney, ODOT

Data Needs + Requirements

- Real-time and past precipitation estimates are critical for ODOT to assess rainfall thresholds, drainage basin values and landslide susceptibility throughout Oregon
- Landslide susceptibility maps are of particular interest to ODOT
- Precipitation estimates + landslide susceptibility maps are important to produce more effective early traffic warning systems throughout the state

Potential Opportunities:

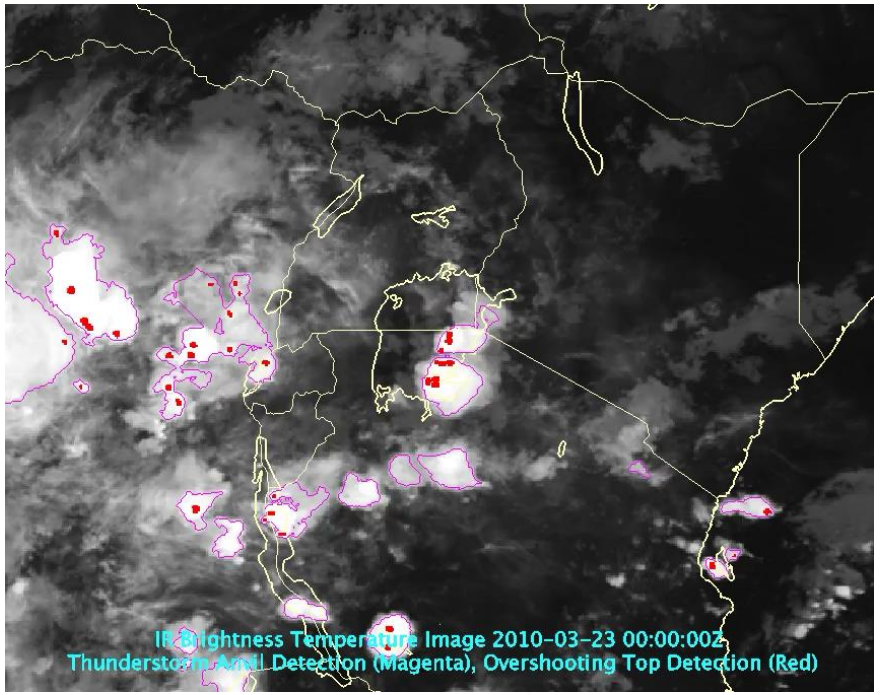
- GPM precipitation data for applications
- Landslide Hazard Assessment for Situational Awareness (LHASA) model

Mapping Climatological Thunderstorm Activity Over Lake Victoria

- *Kris Bedka from NASA LaRC provided an overview of satellite data needs for observing hazardous storms over Lake Victoria for the 2020 GPM-ACCP Transportation Workshop.*

Lake Victoria: A Hotspot For Hazardous Thunderstorm Activity

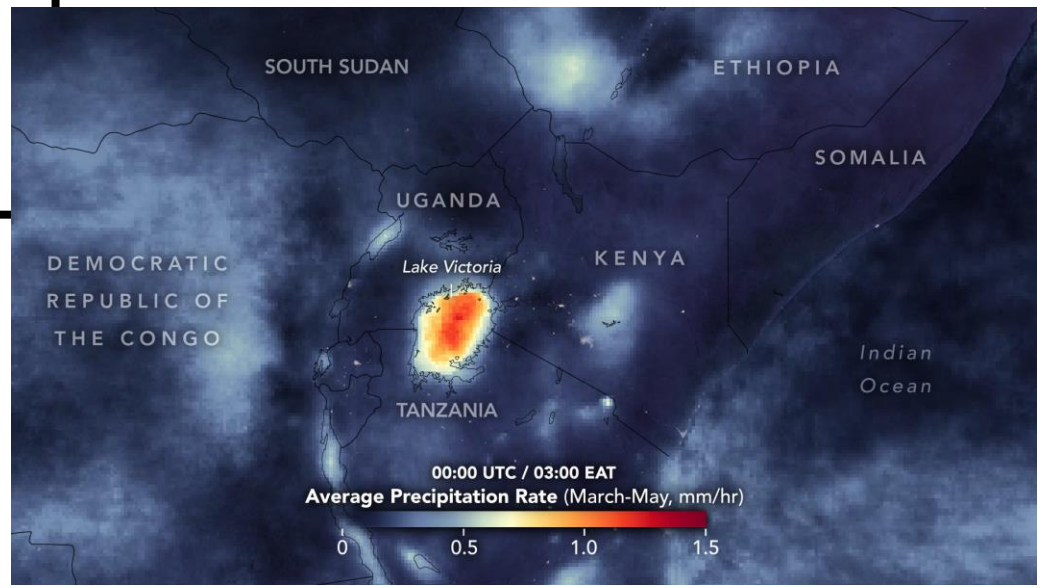
- With a surface area of 26,564 km^2, Lake Victoria is the largest lake in Africa, slightly larger than West Virginia
- The lake directly sustains 30 million people living near its coasts, and its fishing industry is a critical for communities in East Africa
- Lake Victoria in East Africa is a dangerous place for the 200,000 people who fish, often overnight
- The International Red Cross estimates that 3,000-5,000 people per year lose their lives in violent thunderstorms on the lake
- Geostationary infrared data can be used to map intense updraft regions in near real time, and also be compiled to form climatologies to better understand hazardous storm development
- **GPM IMERG data was also used to show night-time storm maximum over Lake Victoria**



Automated Geostationary Infrared Deep Convection (magenta) and Overshooting Top (red) Detections Across a 24-Hour Period Over East Africa

"Having this (IMERG) precipitation data sampled every half hour, we're able to see storms grow and propagate across the lake." "You would never know or understand this complete process unless you had this frequent sampling across such a long data record." – Kris Bedka, NASA LaRC from EO article.

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

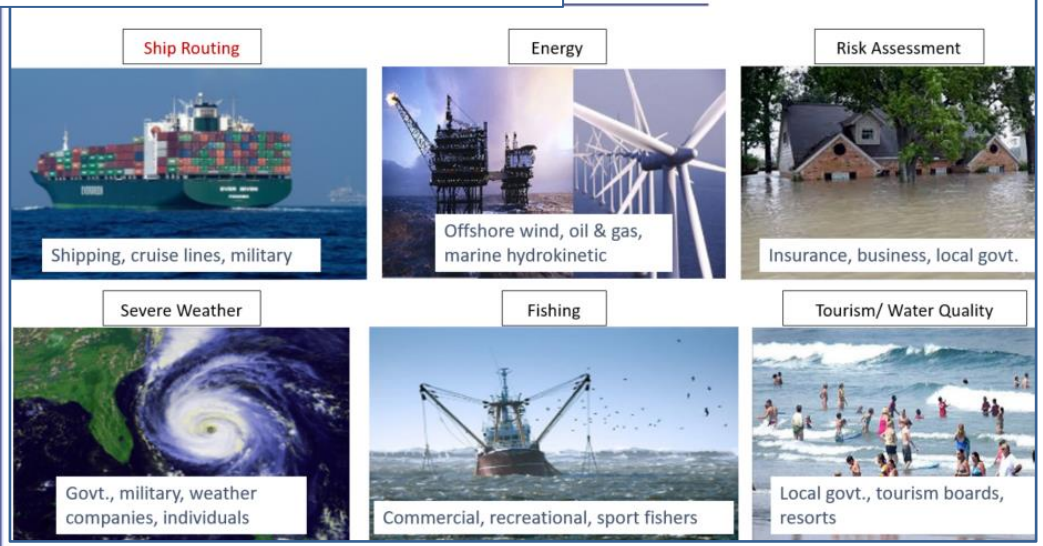


IMERG rainfall patterns around Lake Victoria across a typical 24-hour period during the wet season. It represents the precipitation rate as calculated every half hour and averaged across 18 years (2000-2018). Credit: *J. Stevens, NASA EO*

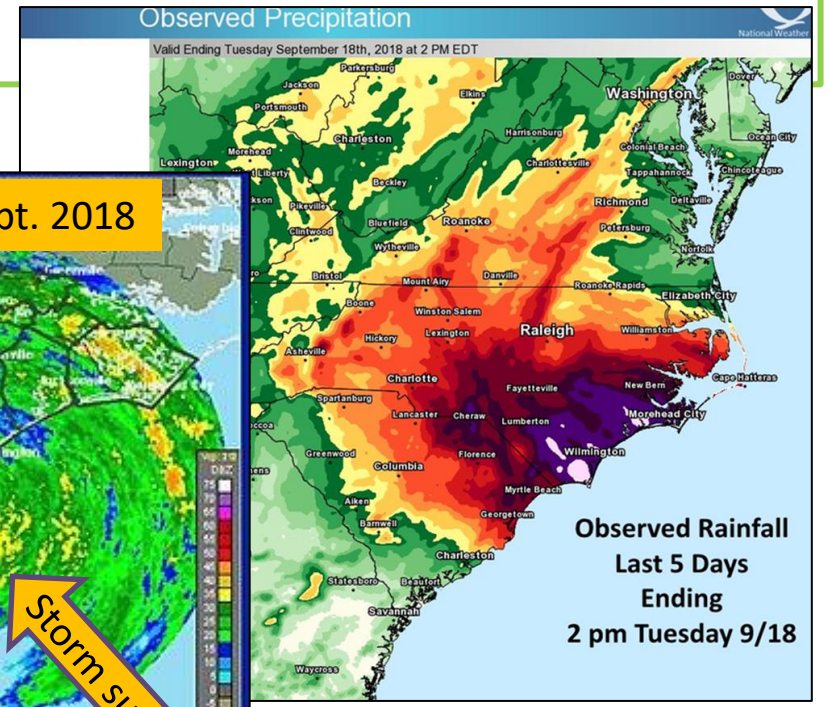
Text and top image courtesy of K. Bedka, NASA LaRC

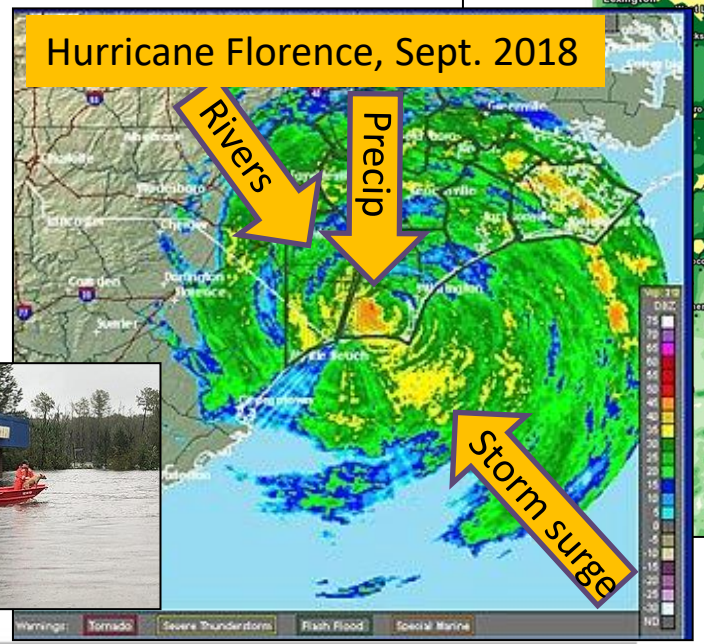
Using GPM Data at Fathom Science

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

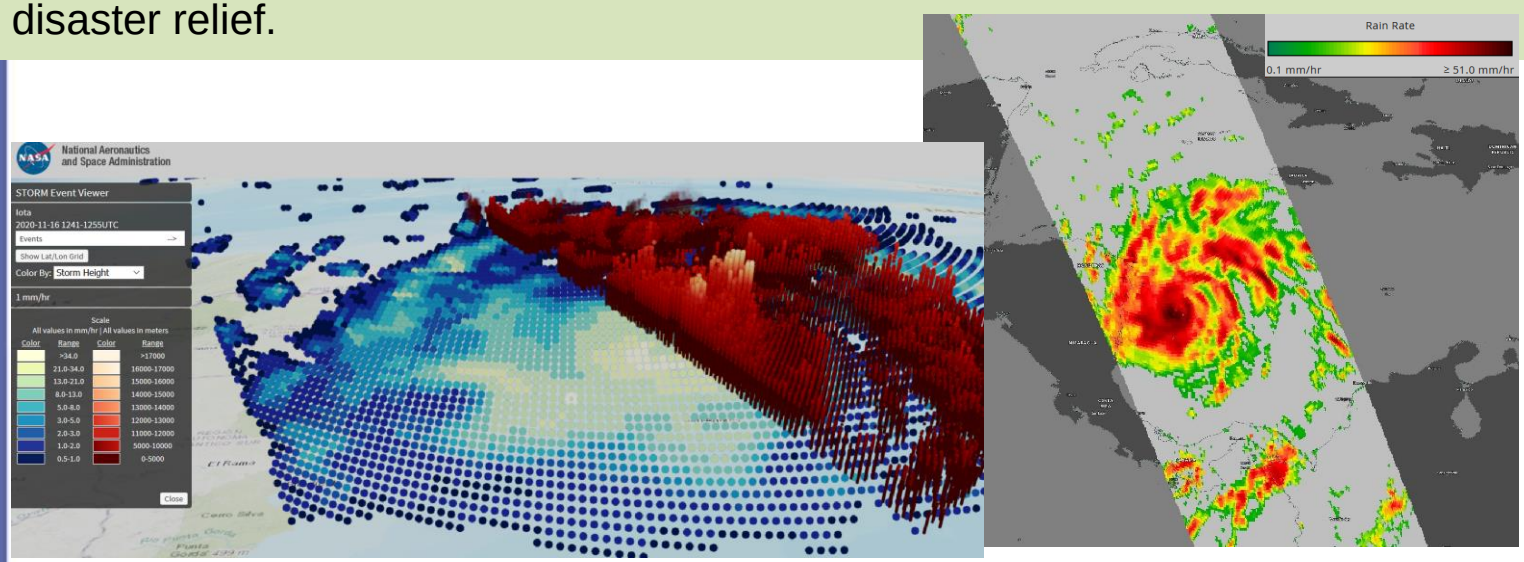
Images courtesy of Fathom Science

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.



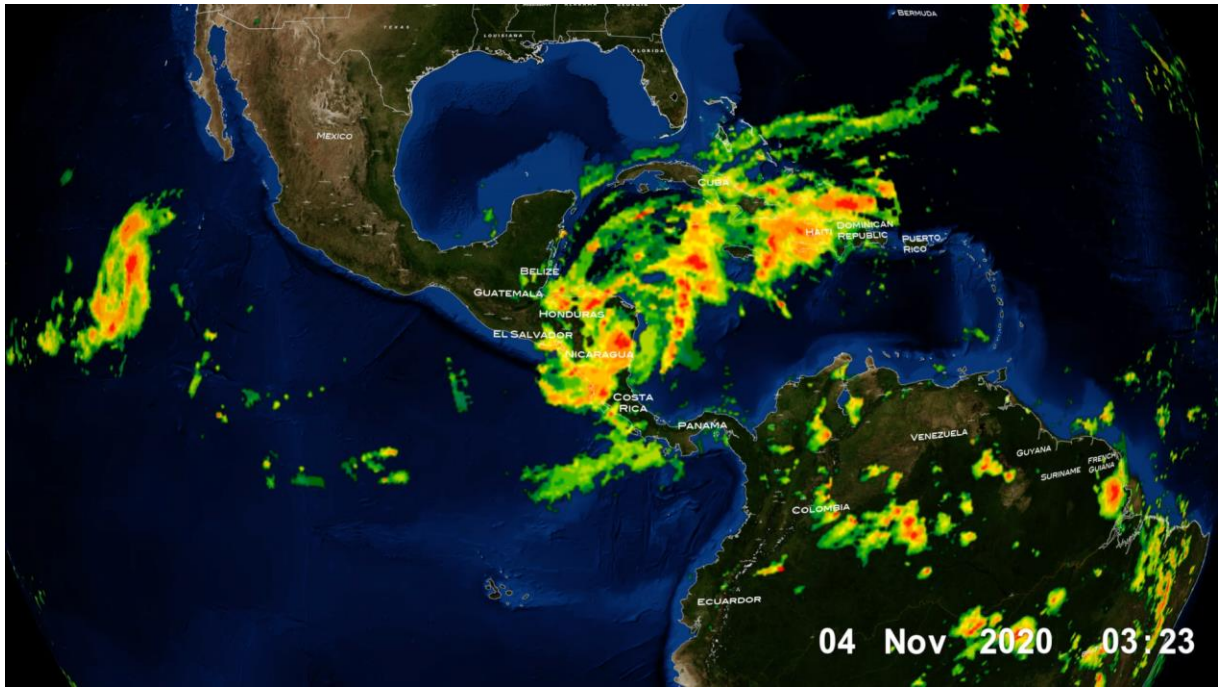
GPM's GMI (right) and DPR (red, left) can be used to view rainfall rates and internal structure of the storm. Credit: Andrea Portier (GSFC/ SSAI), extracted from NASA Worldview (right) and NASA STORM Viewer tool (left).

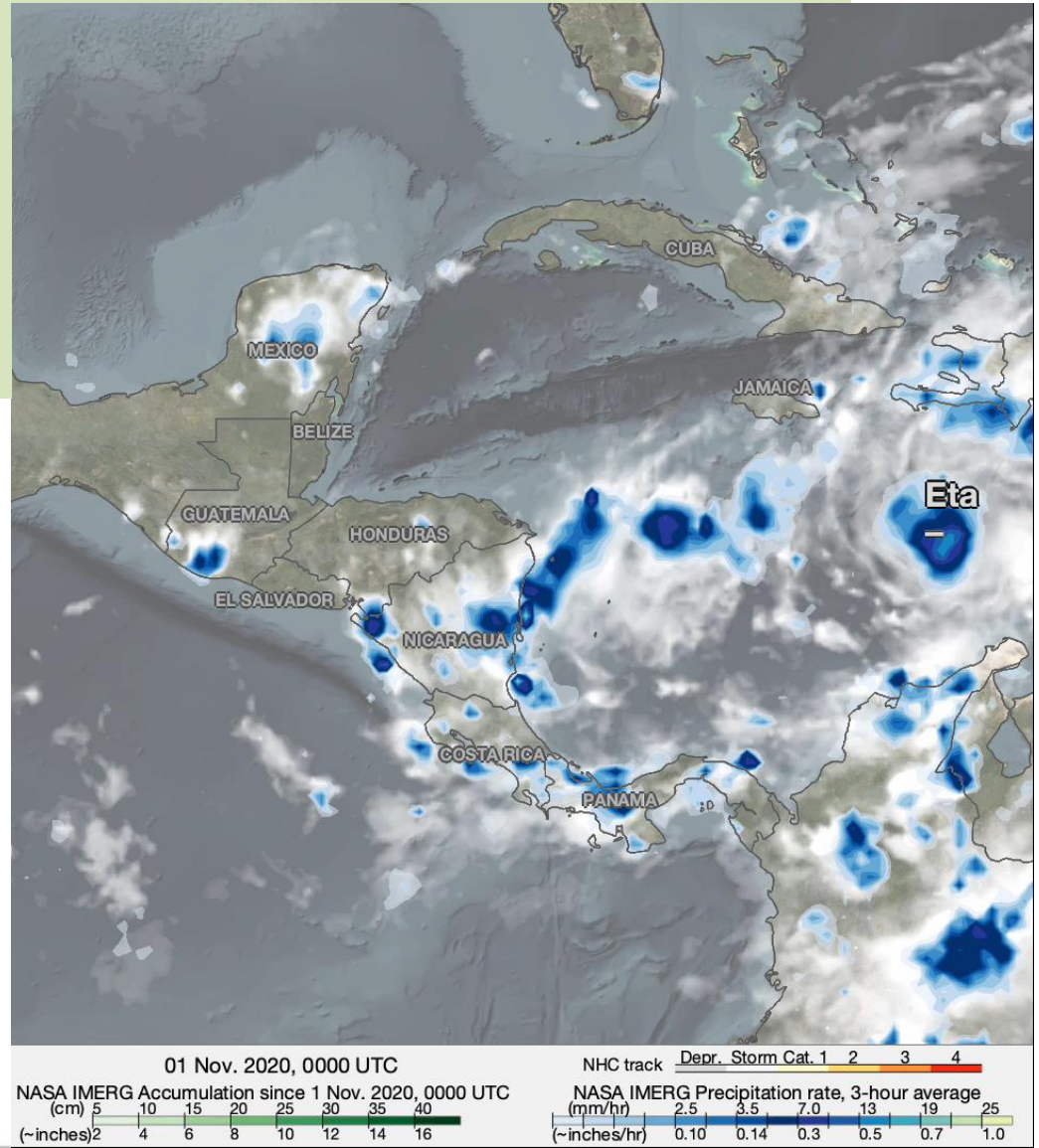
The PDC Twitter account shows their efforts using GPM IMERG to show rainfall accumulation (right) as well as the NASA LHASA (landslide model) that uses GPM as input to communicate risks throughout Central America.

Hurricane Eta: Disaster Communication using GPM

Hurricane Eta, the 28th named storm of the 2020 Atlantic Hurricane Season, made landfall in Nicaragua the afternoon of Tuesday, November 3rd. The storm brought heavy rainfall to Central America over the course of a week, causing devastating floods and landslides.

The GPM mission's instruments, the GMI and DPR, captured rainfall rates and the storm's structure on November 4th just after making landfall (below). GPM's IMERG product was used to show rainfall estimates from Nov 1st – 6th during Eta's development and after it made landfall (right).





GLOBAL PRECIPITATION MEASUREMENT

Hurricane Eta: Disaster Communication using GPM

IMERG was also used to help generate a landslide hazard probability map for November 3rd using the Landslide Hazard Assessment for Situational Awareness (LHASA) model (below) and to estimate the impacts of flooding using the Global Flood Monitoring System (GFMS) (right) from Hurricane Eta. These products can then be used as guidance to support aid response and recovery.

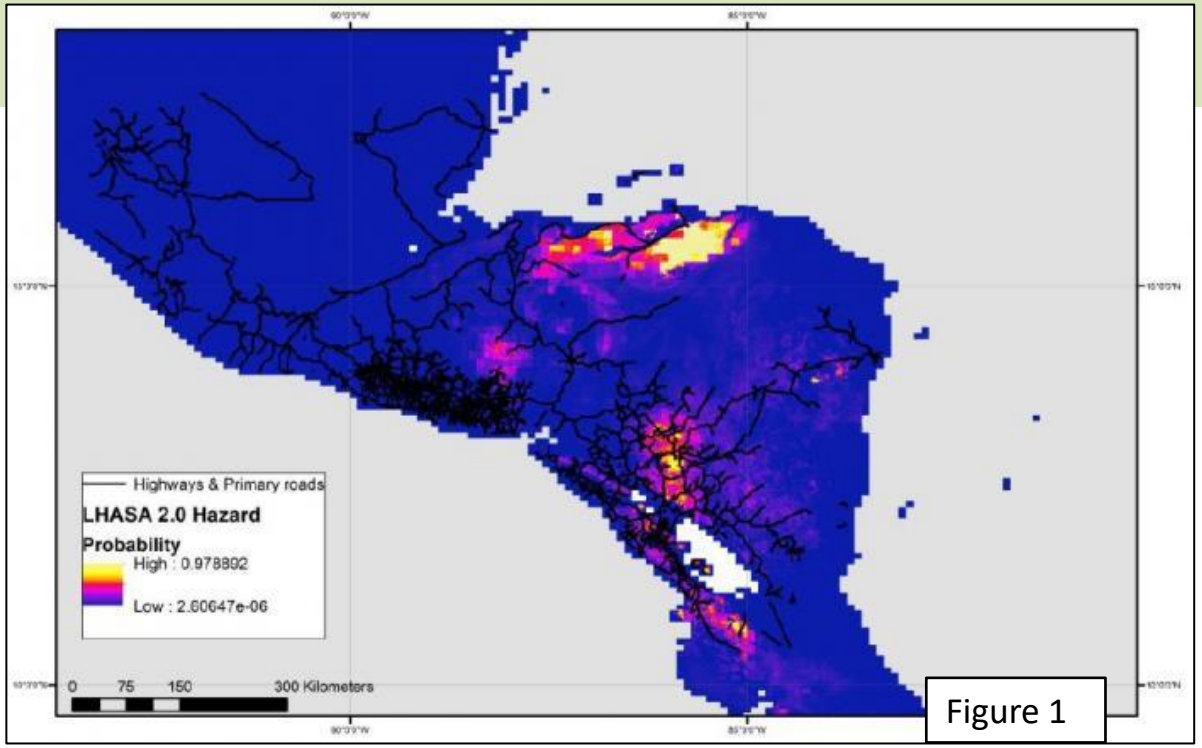


Figure 1

The map of estimated probability of landslide hazards in Central America for November 3, 2020, with warmer colors indicating a higher likelihood of landslides. The location of major highways and roads are also shown, using data from the Global Roads Inventory Project (GRIP). Credits: NASA GSFC Hydrological Sciences Laboratory, GRIP

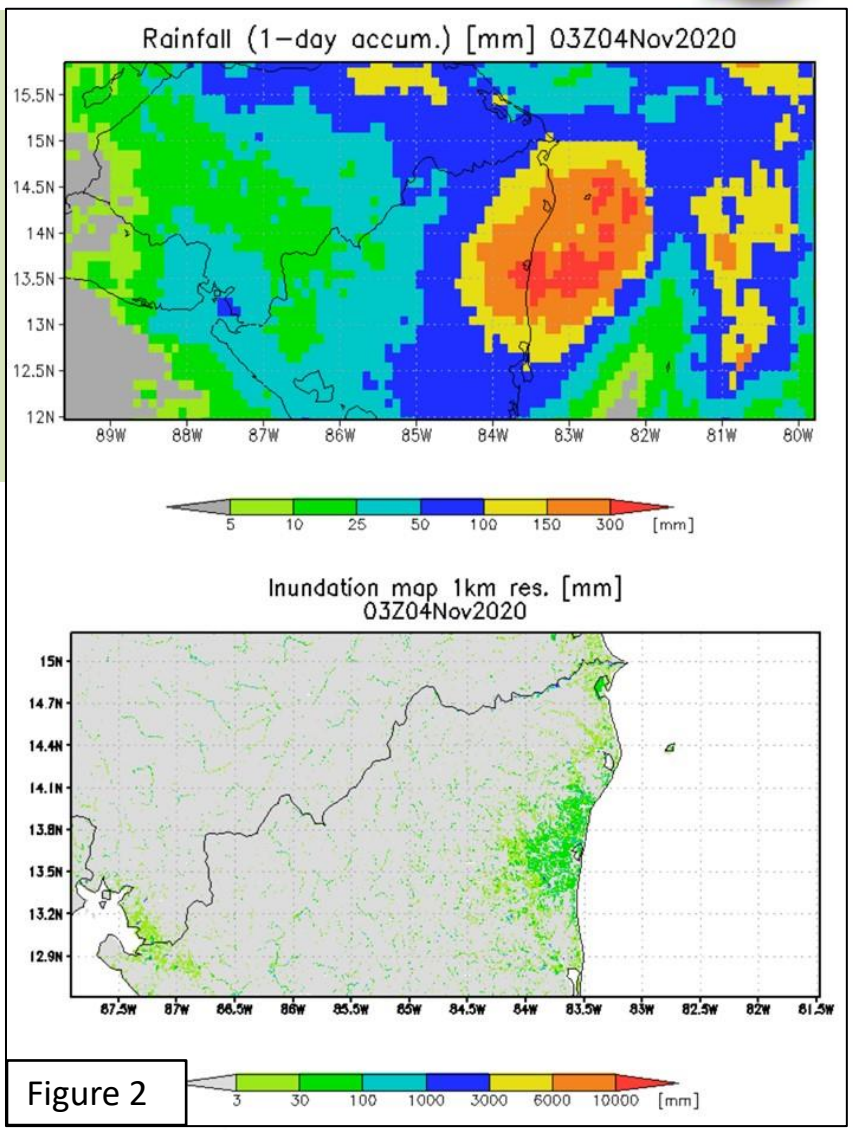


Figure 2

GPM-derived one-day rainfall estimates for northern Nicaragua on November 4 are shown above and flood estimates for the same day are shown below. Credit: NASA, University of Maryland, Dartmouth Flood Observatory.

Hurricane Eta: Disaster Communication using GPM

NASA Articles and Resources for Hurricane Eta Highlight

Visualization 1: The GPM Core Satellite with its two instruments, GMI and DPR, observed a large swath of heavy precipitation extending to the north and east of the hurricane's center, which matched earlier forecasts that called for particularly heavy rainfall across the storm's path. For more information see GPM Eyes Hurricane Eta Over Nicaragua

Visualization 2: IMERG rainfall estimates from Hurricane Eta in near real-time from November 1 - 6, 2020. This animation shows estimated 3-hourly rainfall rates in shades of blue and yellow, and estimated total rainfall accumulation in shades of green, using data from NASA's IMERG algorithm. The NASA data is overlaid with NOAA infrared satellite cloud data, shown in shades of white and gray. The multi-colored line shows Eta's track based on National Hurricane Center advisories, with yellow, orange and red indicating hurricane categories 2, 3 and 4, respectively. Credit: Jason West (NASA GSFC). For more information see Hurricane Eta Drenches Central America

Figure 1*: Estimated probability of landslide hazards in Central America for November 3, 2020, with warmer colors indicating a higher likelihood of landslides using the Landslide Hazard Assessment for Situational Awareness (LHASA) model. The location of major highways and roads are also shown, using data from the Global Roads Inventory Project (GRIP). Credits: NASA GSFC Hydrological Sciences Laboratory, GRIP

Figure 2*: GPM-derived one-day rainfall estimates for northern Nicaragua on November 4 are shown above and flood estimates for the same day are shown below. These are derived from the Global Flood Monitoring System (GFMS). Credit: NASA, University of Maryland, Dartmouth Flood Observatory.

*Please note that LHASA and GFMS are experimental products that may be used as guidance to identify areas of potential flood or landslide risk, but may not indicate the actual presence of floods and landslides. For more information see Hurricane Eta 2020.

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.

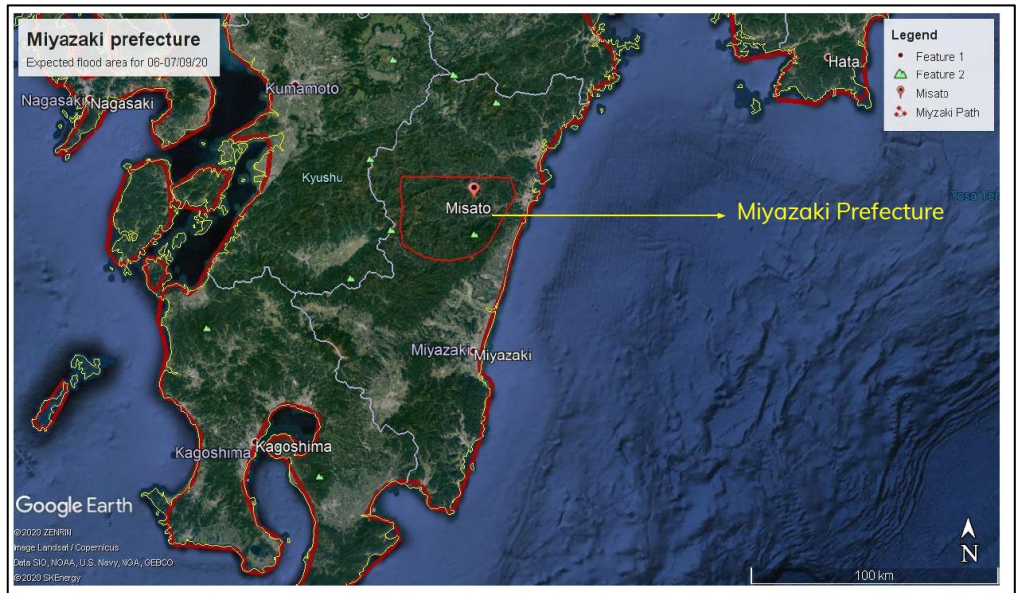


Figure 1: Expected area with very high probability for urban flooding in the Miyazaki prefecture

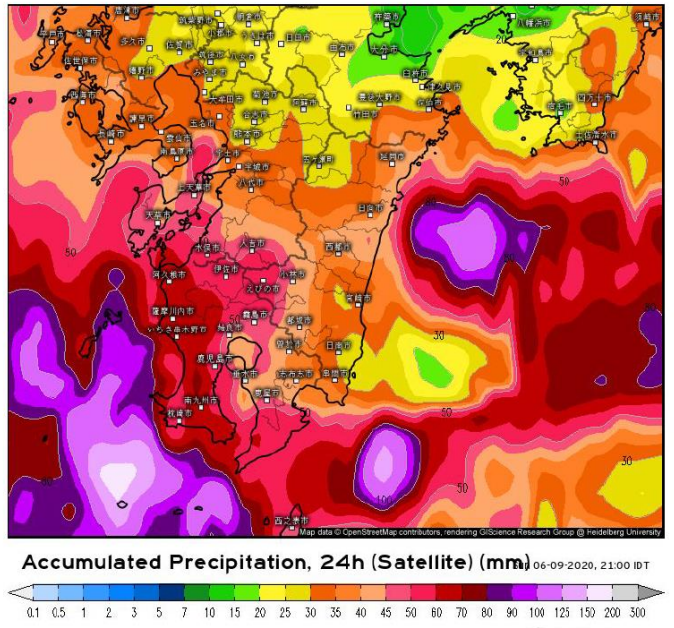


Figure 3: Observed 24h accumulated precipitation for Typhoon Haishen, the Miyazaki Prefecture, Japan

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/.

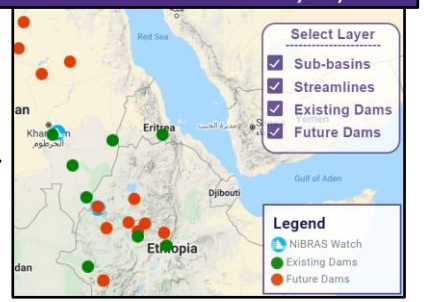
Improving Livelihoods in Challenging Environments Using GPM Data

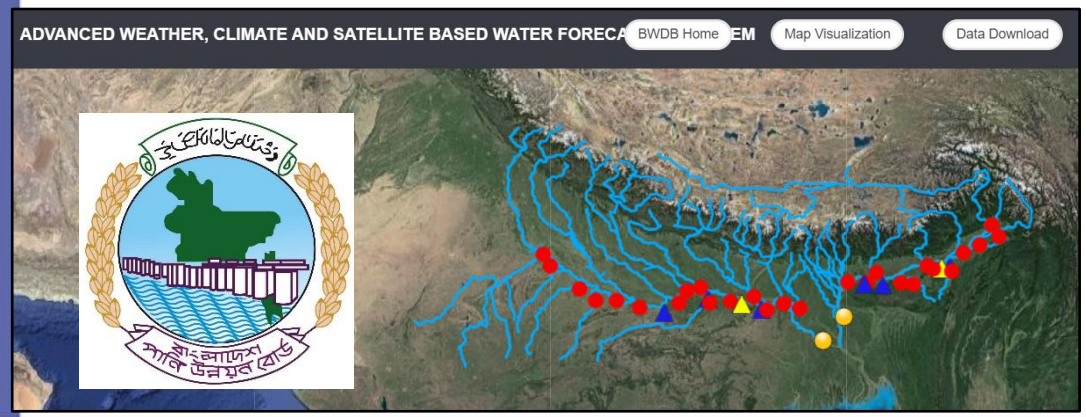
University of Washington's Sustainability, Satellites, Water and Environment (SASWE) research group and collaborators are using GPM IMERG data along with a combination of other NASA data including GRACE, LANDSAT, and MODIS, ground sensor data and IoT in numerous decision support systems built for organizations in SE Asia and Africa to improve water management practices. These organizations can then customize visualizations and easily access information to enable decision-making.

Improving irrigation practices

Updates on surface water fluxes for basins

Real-time monitoring of reservoir operations





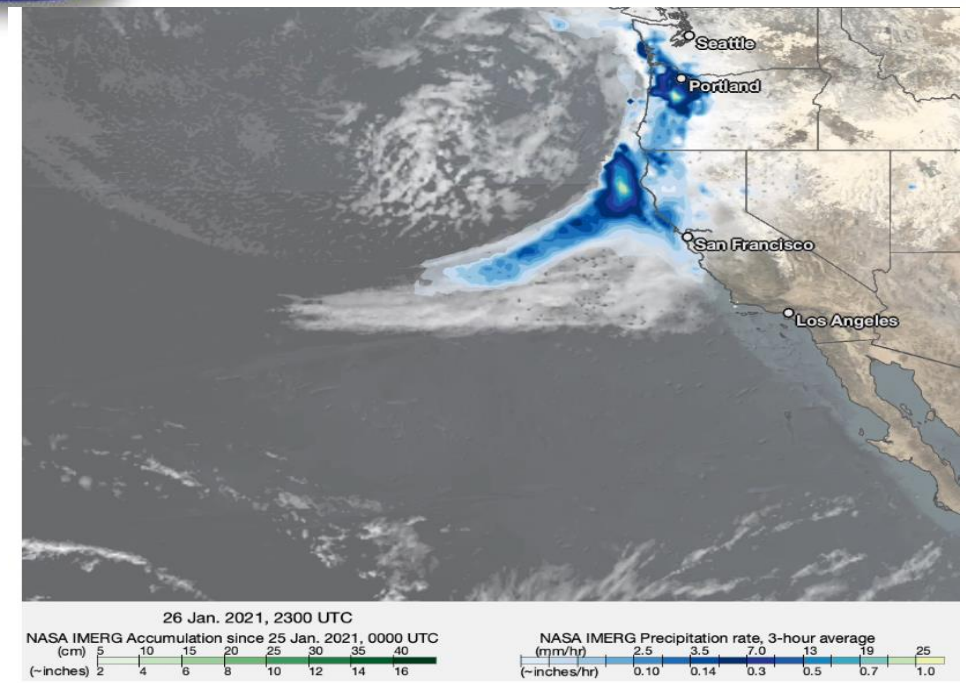
Left: Tool to support activities at the Bangladesh Water Development Board

Effective water resource planning

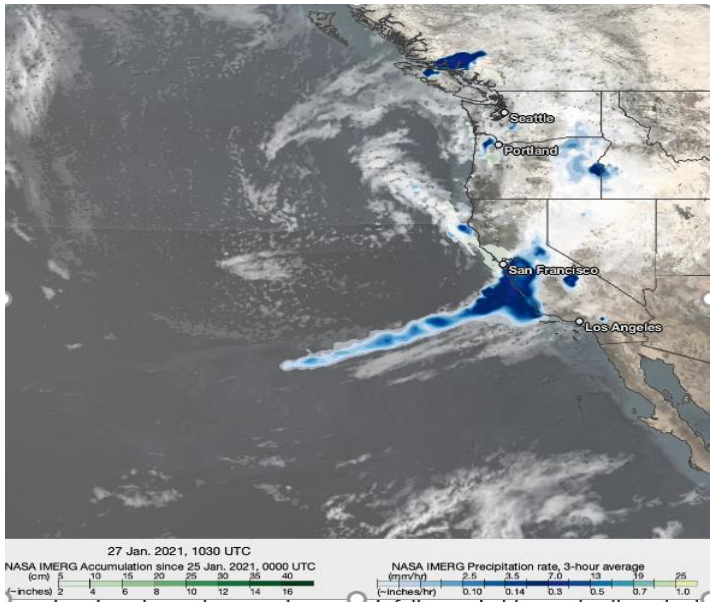
www.saswe.net/models

saswe research group

GPM IMERG Captures Atmospheric River Rainfall



The images above and to the right show estimated rainfall rates in blue from NASA's IMERG algorithm, overlaid on shades of white and gray from NOAA infrared satellite data which shows cloudiness. *Images extracted from NASA Viz developed by Jason West (NASA/ ADNET).*

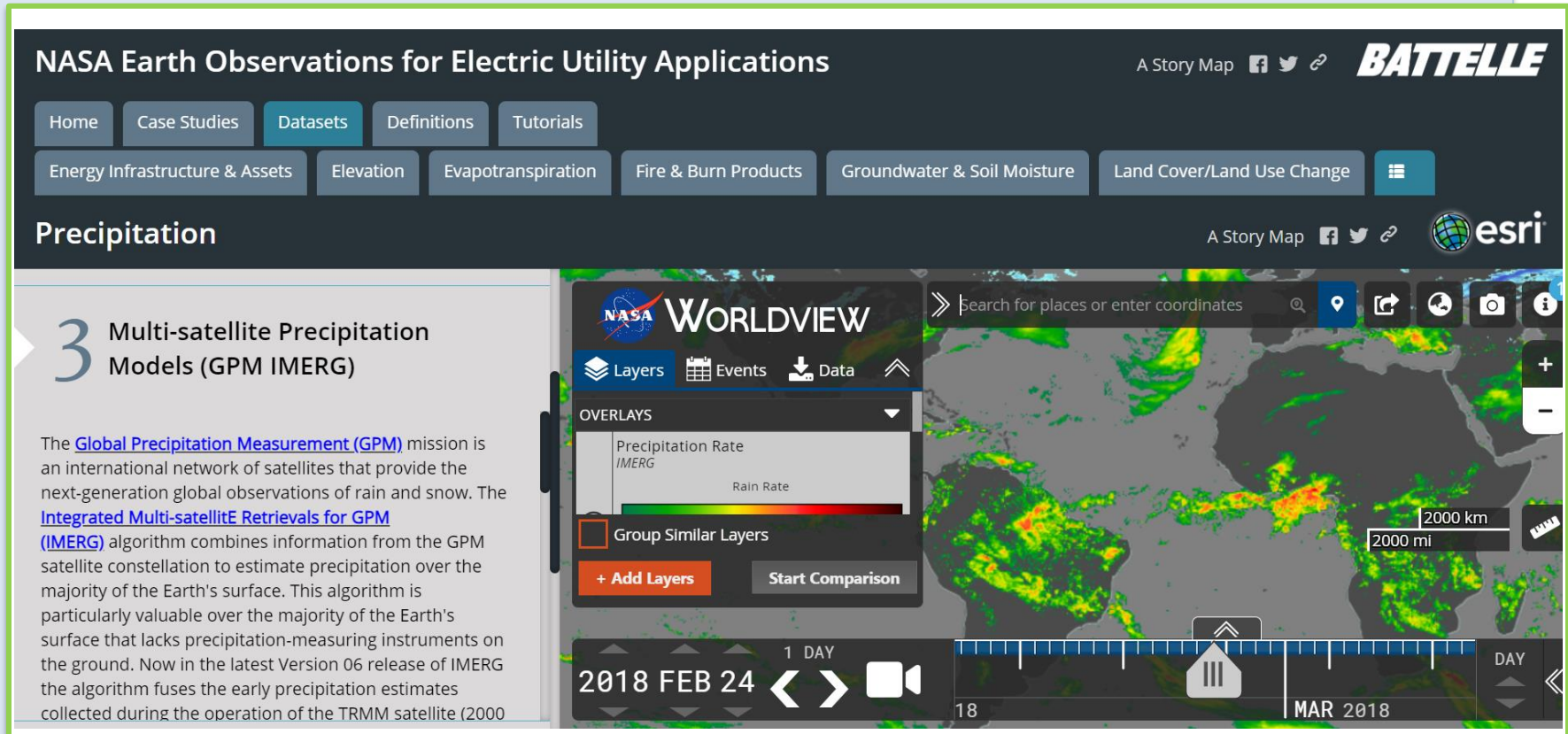


- GPM's IMERG product was used to estimate an Atmospheric River event over the U.S. West Coast from January 25 - 29, 2021.
- IMERG estimated that much of central California received over 2 inches of rainfall during this event, with areas south of San Francisco seeing up to 14 inches at high elevations.

  **National Weather Service observations were broadly consistent with the IMERG estimates
- Atmospheric river events are responsible for a considerable percentage of winter precipitation for the U.S. West Coast, and this event was consistent with that pattern.
- Understanding the amount of precipitation and where it falls can help provide critical information to organizations including disaster response teams to assess flood risks and water resource management to prevent dam failures.
- Check out the full Viz at gpm.nasa.gov!

Supporting Electric Utility Applications with GPM

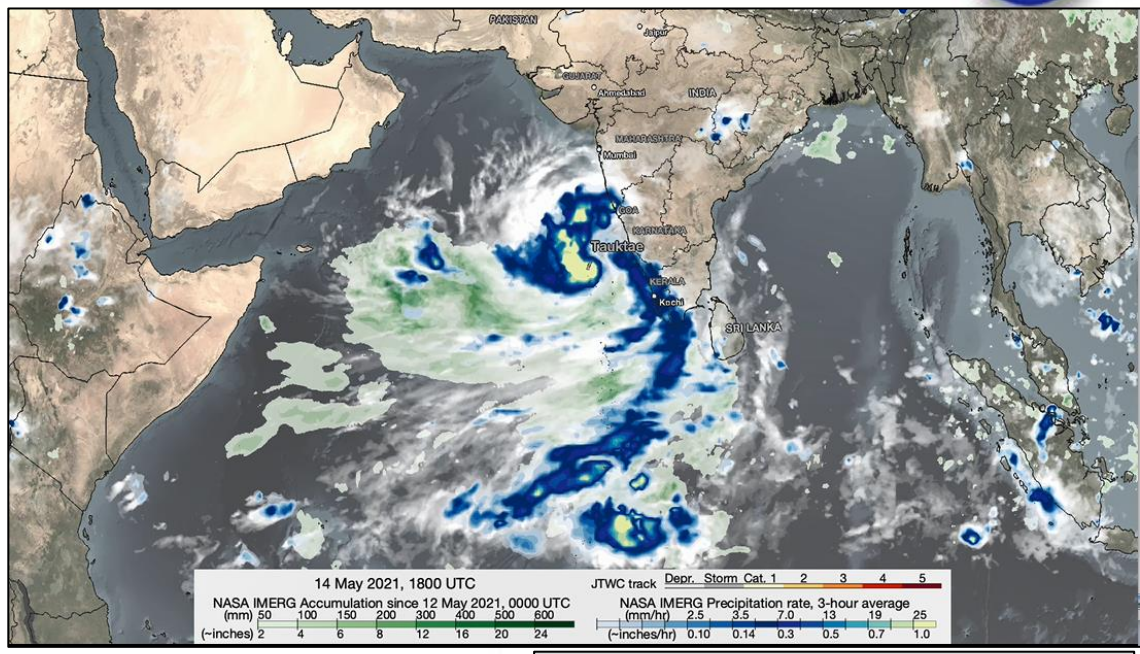
- To make NASA EO data more accessible for electric utility end user needs, Battelle developed a StoryMap to directly support energy applications.
- GPM data, products and tutorials are provided to support these electric utility end users.
- This StoryMap was designed to offer actionable information 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!

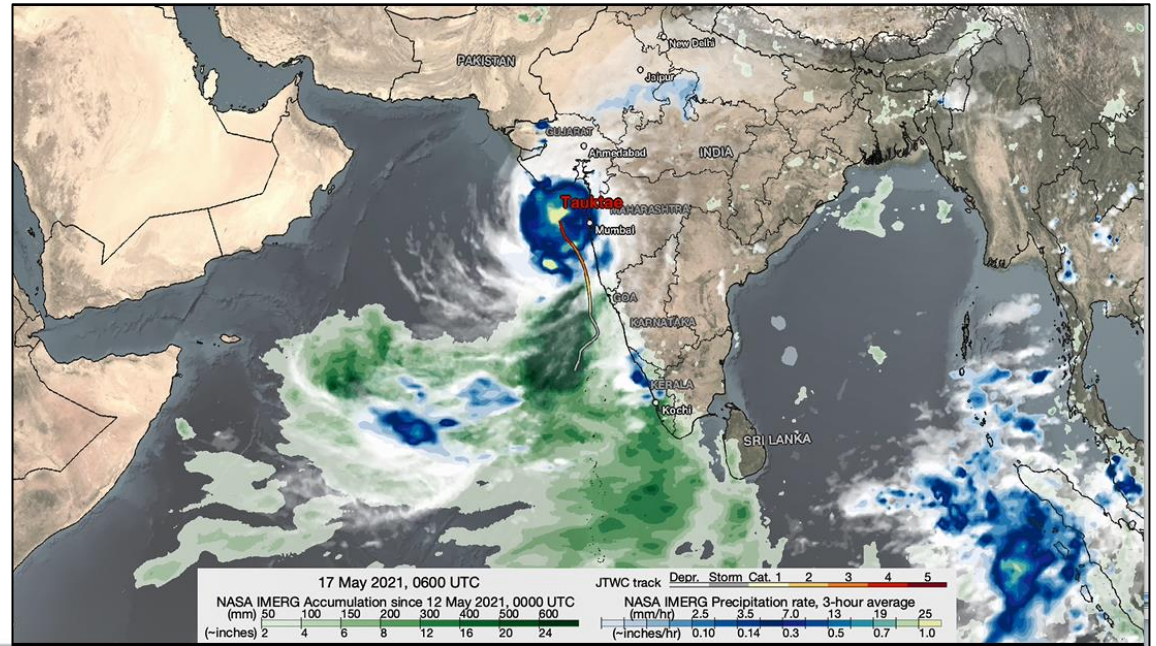


Screenshot of the StoryMap Portal highlighting GPM tools that are available for stakeholders to use for electric utility applications.

Observing Tropical Cyclone Tauktae with GPM

- In mid-May 2021, a Madden-Julian Oscillation event was accompanied by a westerly wind burst just north of the equator, contributing to the formation of a tropical cyclone Tauktae in the Arabian Sea.
- Tauktae made landfall over the northwestern Indian state of Gujarat on May 17 as a Category 3-equivalent cyclone.
- GPM's IMERG product was used to show precipitation rates and accumulations of Tauktae over a 7 day period, capturing the highest precipitation accumulations of >250 mm (10 inches) around Mumbai.
- These estimates were consistent with measurements by the Indian Meteorological Department.





Images: Precipitation rates (blue/yellow) and accumulations (green) at half-hourly intervals from May 12-19, 2021, using IMERG. Underneath the precipitation data, cloud cover shown in white/gray based on geosynchronous satellite infrared observations. On top of the precipitation data, the cyclone's approximate track is displayed based on estimates from the Joint Typhoon Warning Center. Screenshots taken from Tauktae animation, credit: Jason West (NASA GSFC).

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

Statement of the Problem:

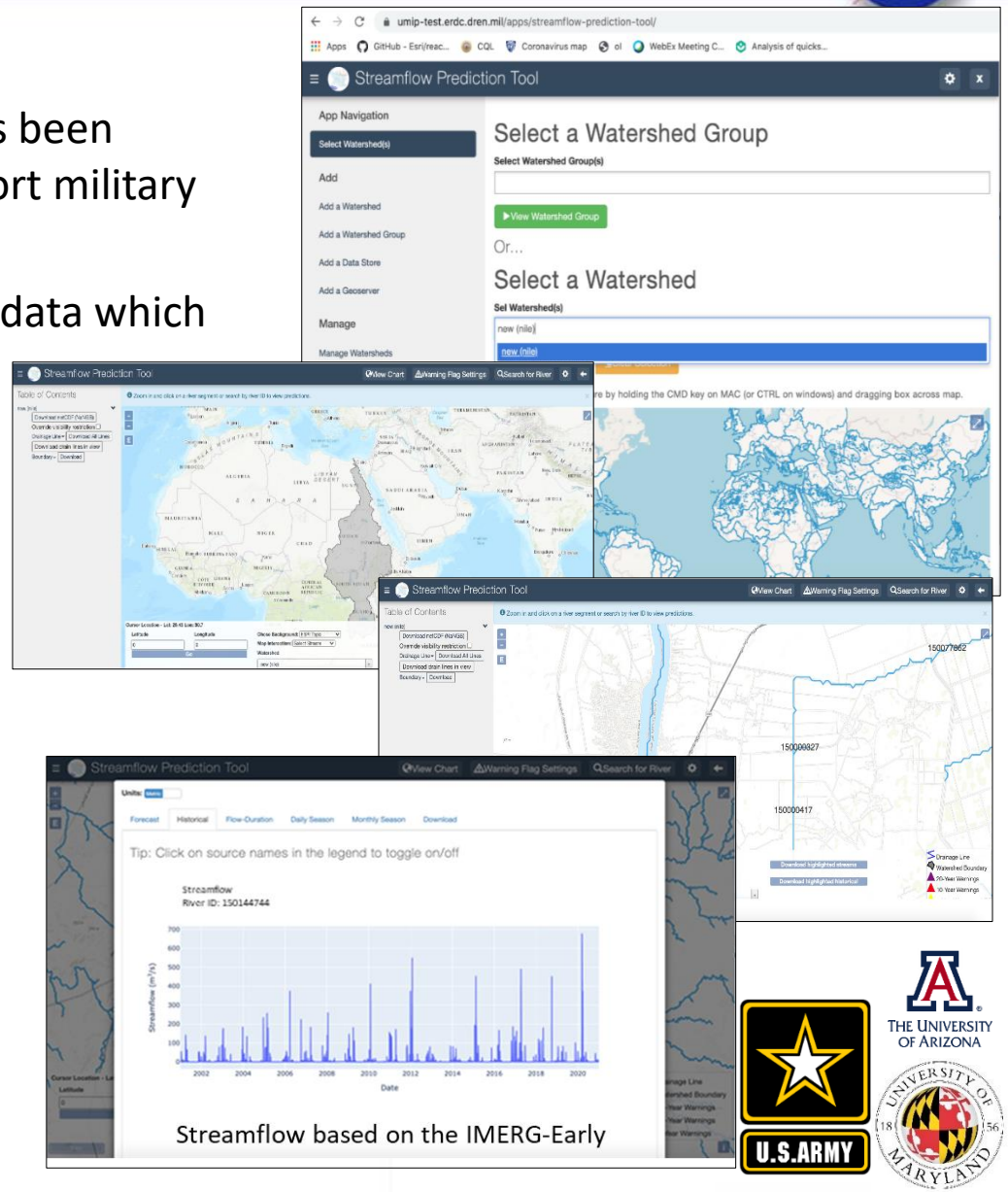
- The U.S. Army Engineer Research and Development Center (ERDC) has been maintaining and developing Streamflow Prediction Tool (SPT) to support military costumers and first responders.
- The SPT framework for flood prediction is lacking NASA observational data which can enhance the SPT capability to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

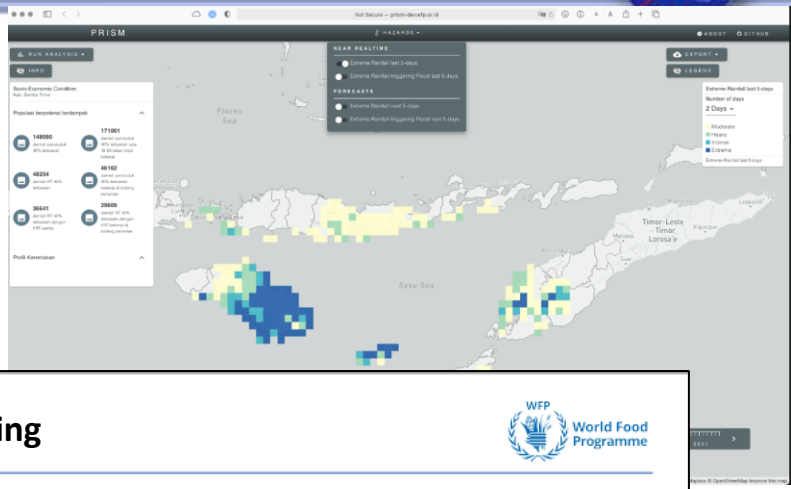


Text and image credit: Ahmad Tavakoly (ERDC/UMD)

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

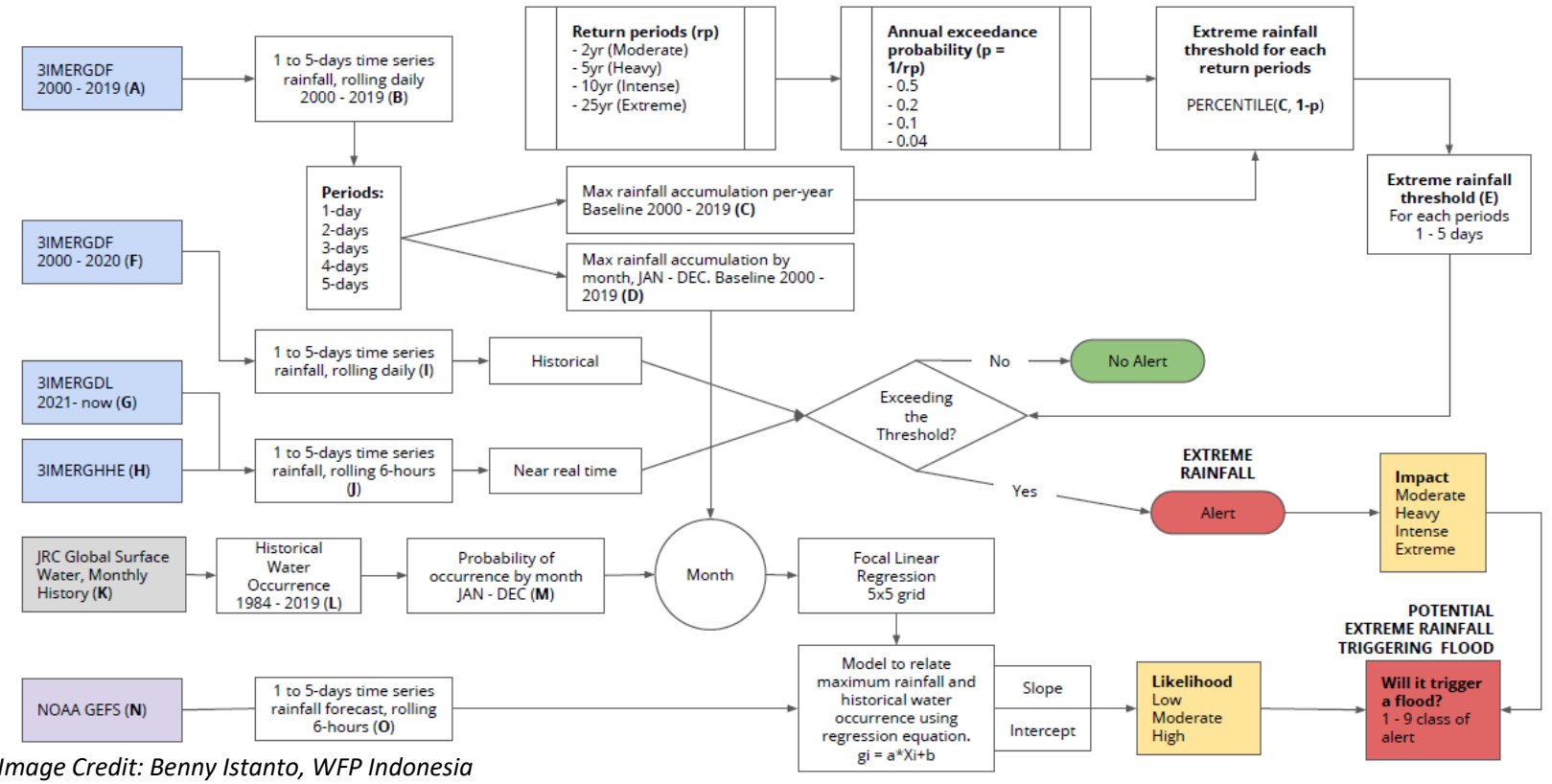
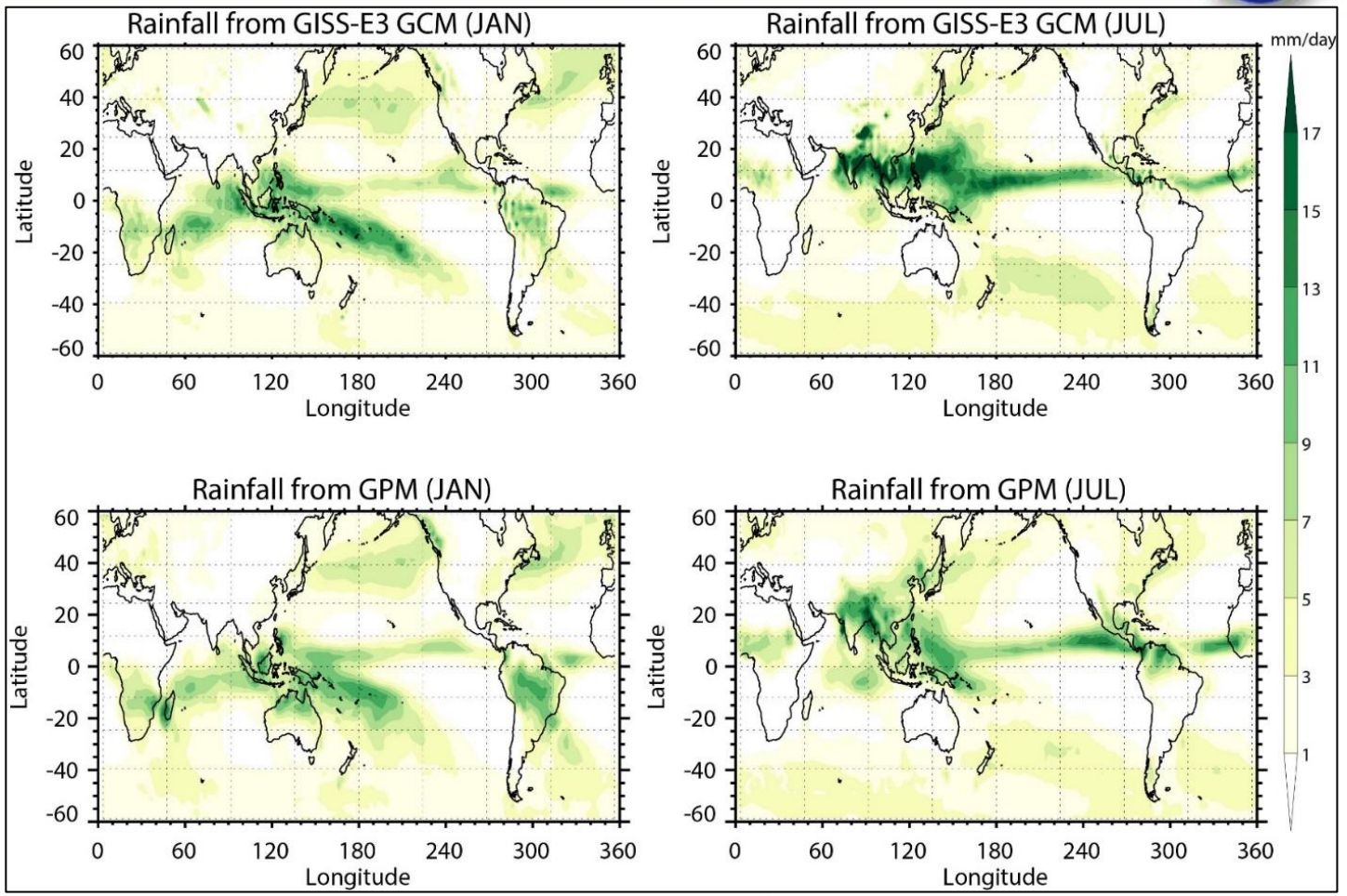


Image Credit: Benny Istanto, WFP Indonesia

Enhancing GISS Climate Models with GPM

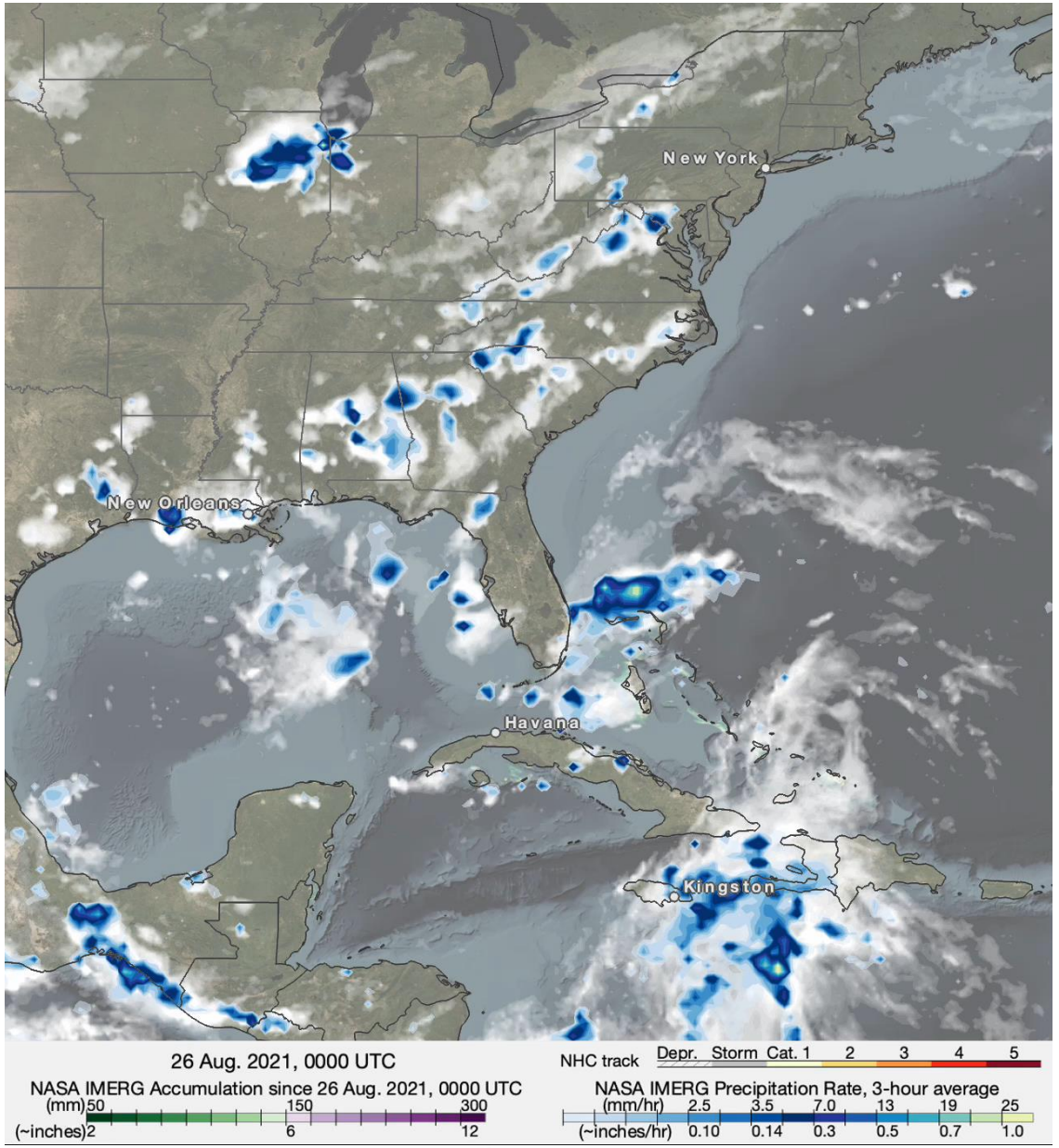
- NASA's Goddard Institute of Space Studies (GISS) integrates precipitation measurements observed by GPM into GISS global climate models.
- GPM data products such as GPM's multi-satellite product, IMERG, and GPM's Convective-Stratiform Heating (CSH) Level 2 product help support modeling activities including improving model parameterization development and for model validation.
- These type of activities are essential to make climate predictions more reliable and support a range of research and applications including understanding human impact on the climate as well as the effects of a changing climate on society and the environment.



Average rainfall patterns from 2014-2020 over winter (January, left) and summer (July, right) using the GISS-E3 climate model (top) and precipitation estimates derived from GPM's multi-satellite product, IMERG (bottom). Climate models such as the GISS-E3 must accurately simulate seasonal cycles observed by GPM in order for their predictions to be more reliable. Using the GPM rainfall magnitudes as benchmarks, new model equations are being worked on to improve this area of rainfall simulation and improve climate projections. Image credit: Greg Elsaesser.

IMERG Adds Up Ida's Rainfall

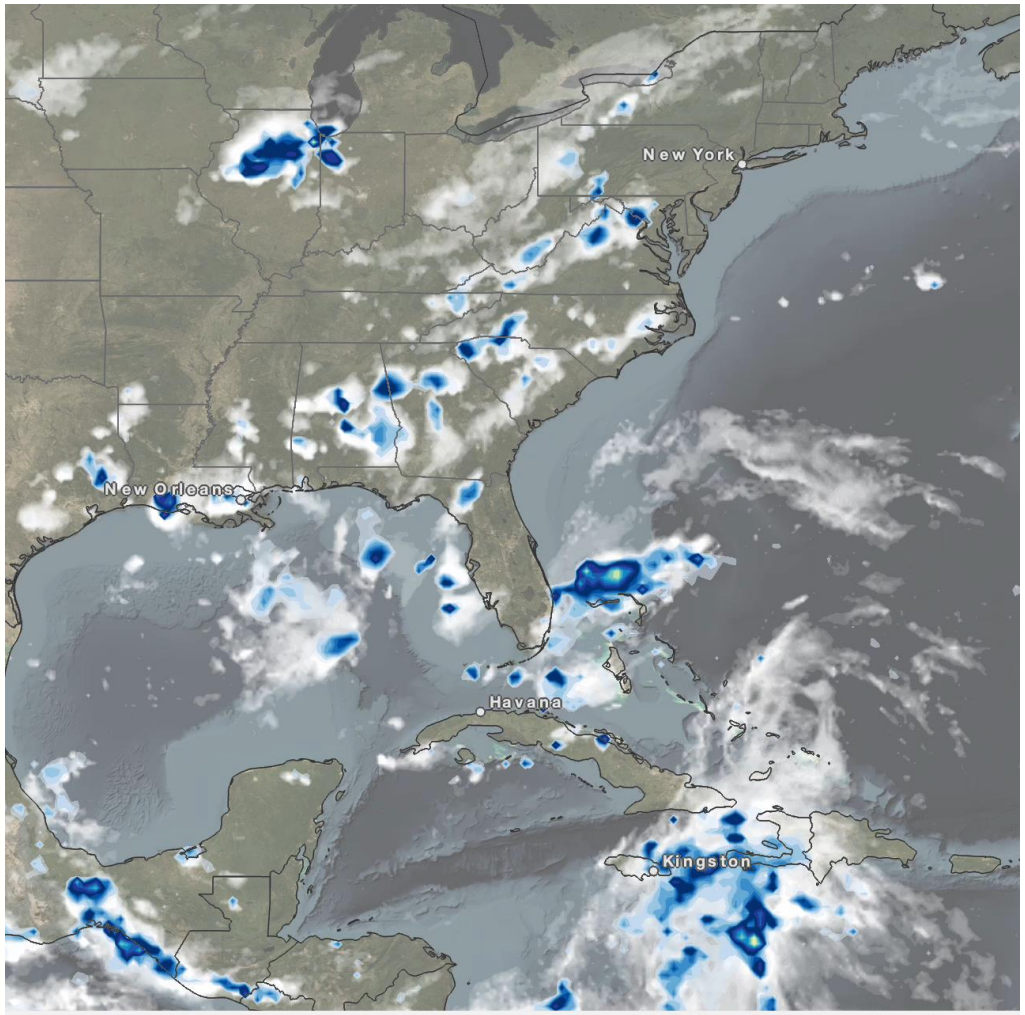
- Hurricane Ida made landfall in Louisiana on August 29, 2021, and made its way north, reaching Virginia mid-day and New York on the evening of September 1st.
- The animation, using real-time data from NASA's IMERG algorithm, shows the precipitation that fell during the entire lifecycle of Ida from before landfall in Louisiana through the impacts on New York City.
- The 7-day total accumulation from Hurricane Ida near New Orleans was 15 to 20 inches, according to ground-radar data. These ground-based observed accumulations are broadly consistent with the satellite-based IMERG estimates.
- *Read the full story on GPM's webpage, HERE.*



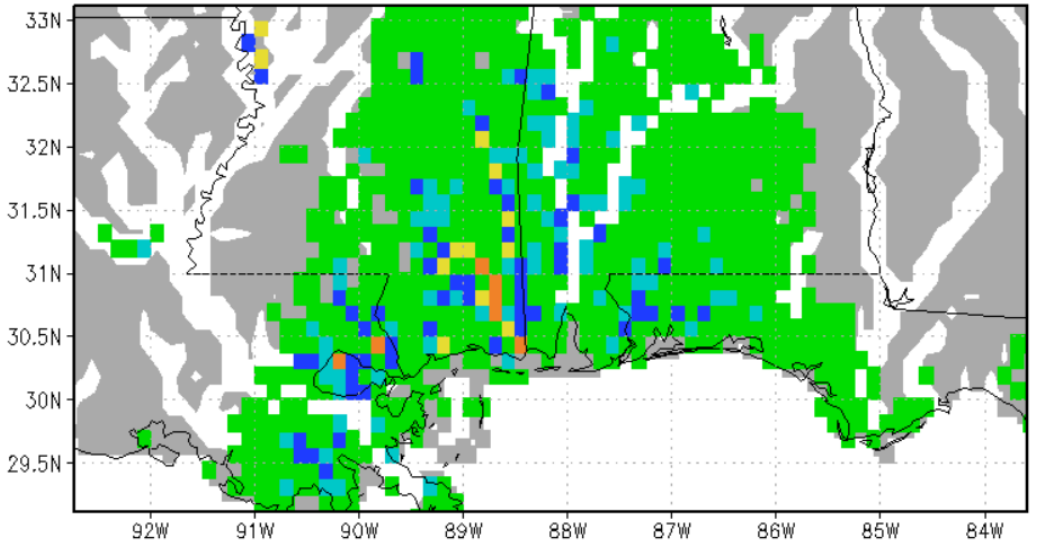
Animation by Jason West (NASA GSFC / PPS)

Flood Susceptibility

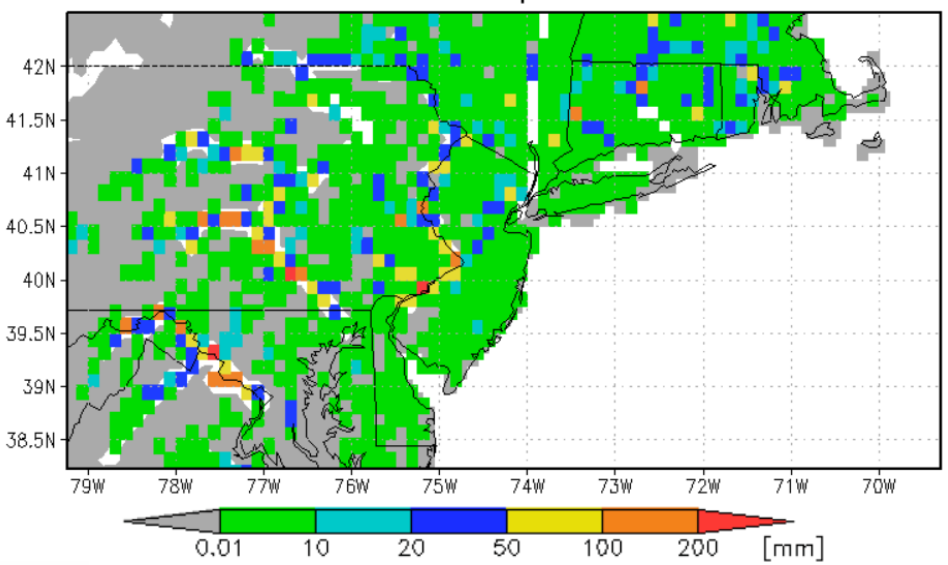
IMERG Accumulations: H. Ida Aug/Sep 2021



Flood Intensity (depth above threshold [mm]) Forecast 31 Aug



Flood Detection/Intensity (depth above threshold [mm])
12Z02Sep2021

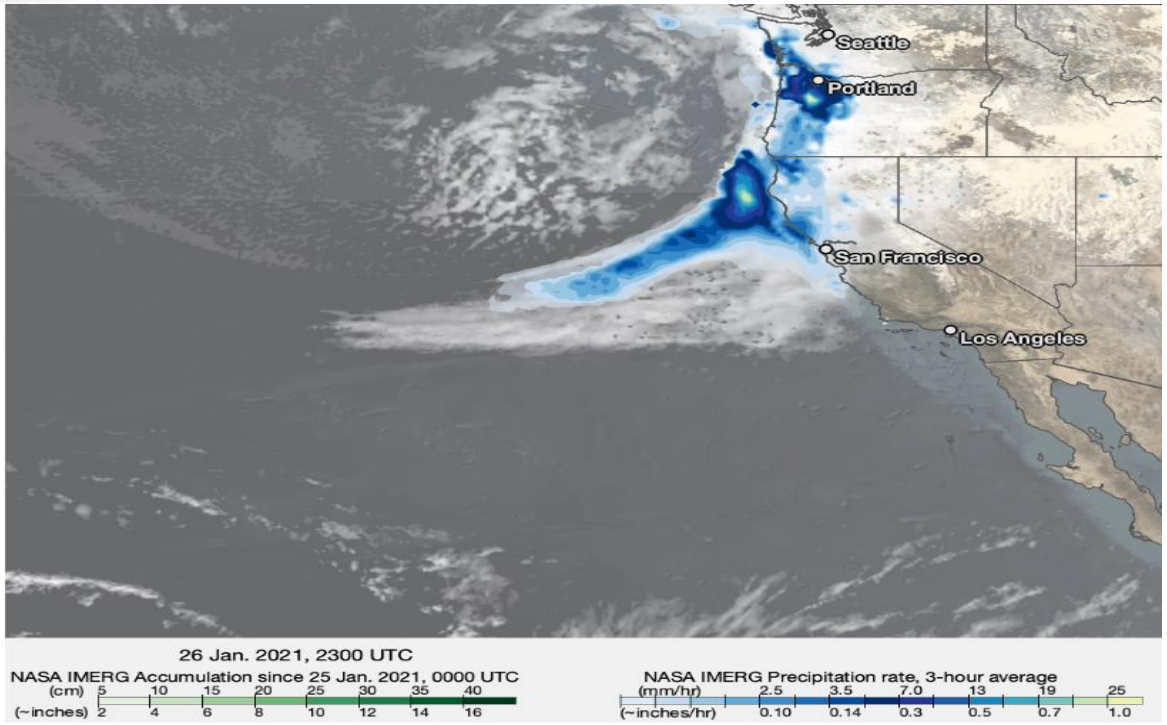


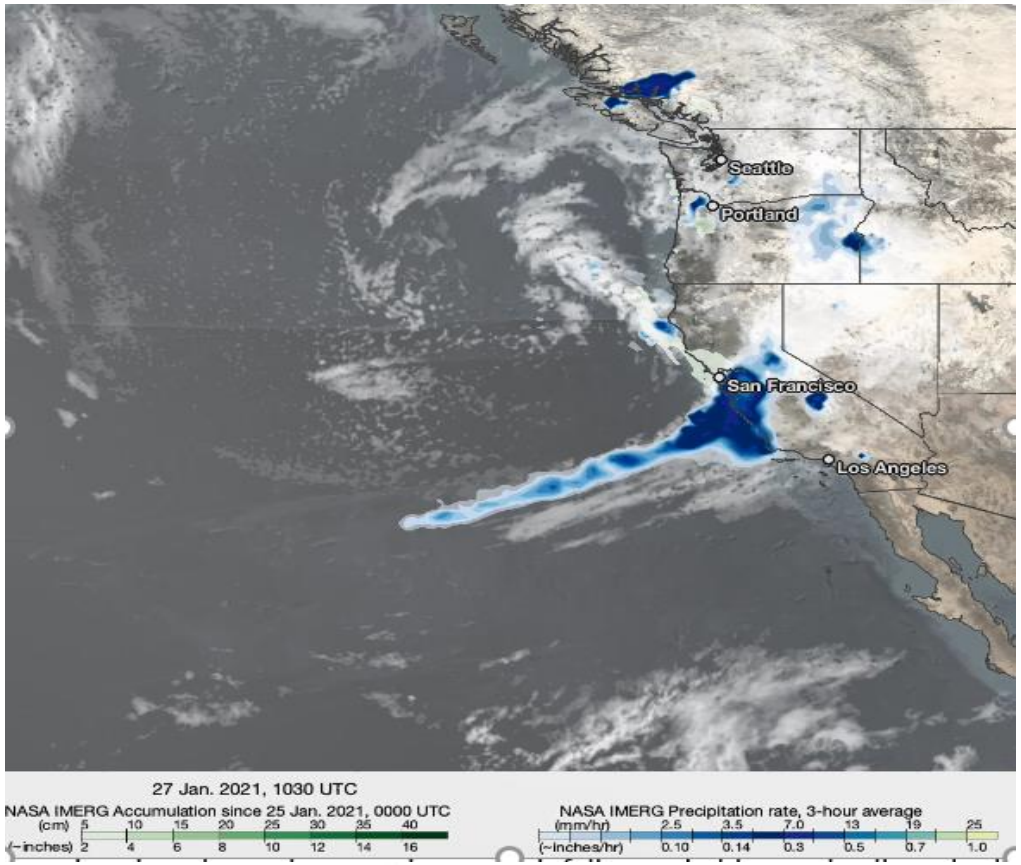
flood.umd.edu
Global Flood Monitoring System

Rainfall Data:
IMERG RT

news.sky.com

GPM IMERG Captures Atmospheric River Rainfall





The images above and to the right show estimated rainfall rates in blue from NASA's IMERG algorithm, overlaid on shades of white and gray from NOAA infrared satellite data which shows cloudiness. *Images extracted from NASA Viz developed by Jason West (NASA/ ADNET).*

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- Understanding the amount of precipitation and where it falls can help provide critical information to organizations including disaster response teams to assess flood risks and water resource management to prevent dam failures.

GLOBAL PRECIPITATION MEASUREMENT

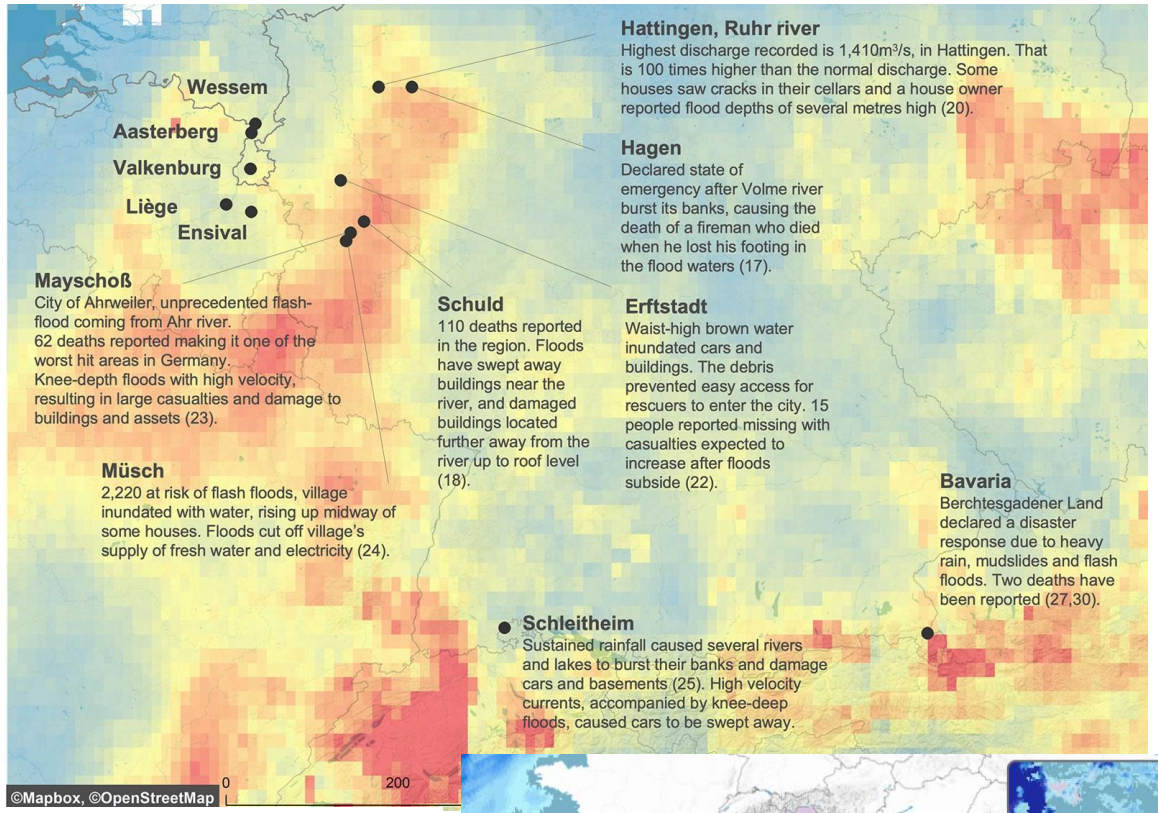
JBA Risk Management Uses IMERG to Raise Awareness of Extreme Rainfall

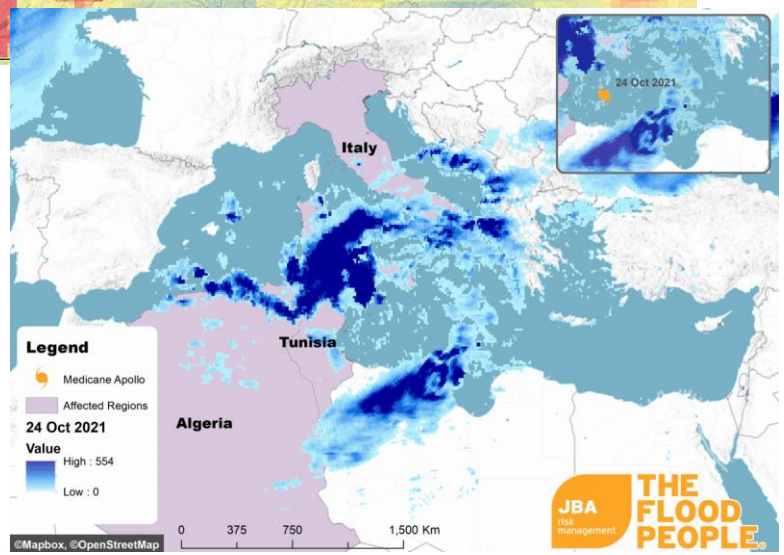
Netherlands
In **Aasterberg**, Limburg, the Meuse River overflowed and the dikes along Juliana Canal were breached. At least 3,000 people were displaced (28). **Valkenburg** was hit as well, with water levels not seen since 1911 and 16,000 residents affected (21). Flood depths reached thigh-level in **Wessem.**

Belgium
Liège was one of the most severely affected areas in Belgium, with at least 23 deaths reported. In some areas, floods reached neck-level (16).

Ensival was placed under red alert as water rose to 1.8m with several houses damaged along the Vesdre River (19).

www.jbarisk.com





Above: *Rainfall accumulation from 11 to 18 July 2021; the highest rainfall is represented by red with a maximum of 210mm over the 7-day period.* ***Right:*** *Video showing daily rainfall (in mm) between 24 October and 2 November 2021 over the Mediterranean along with the estimated tracking of Medicane Apollo.*

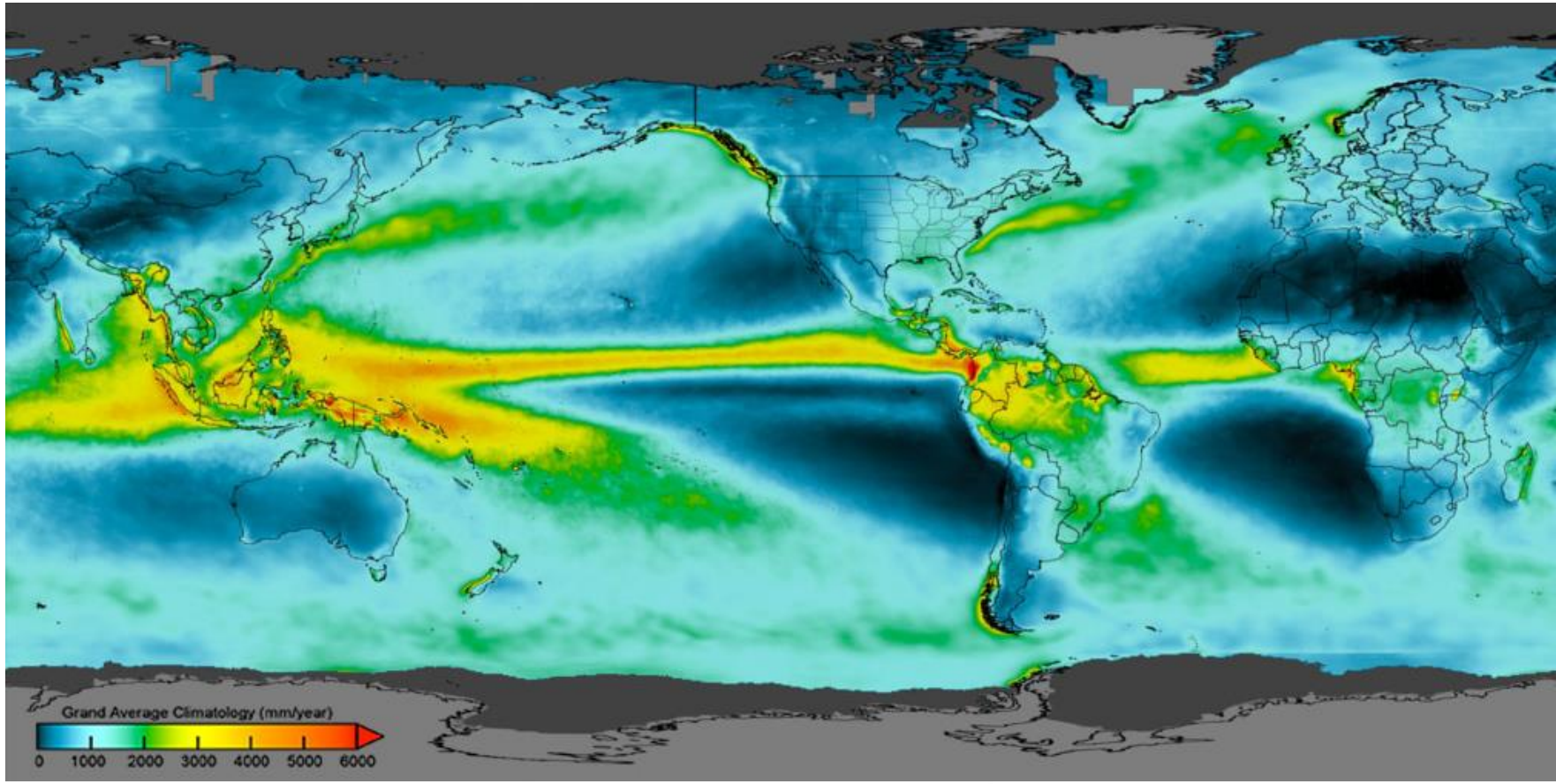
See full articles at *https://www.jbarisk.com/flood-services/event-response/summer-floods-in-europe-2021/ and https://www.jbarisk.com/flood-services/event-response/medicane-apollo/. Credit: JBA Risk Management*

- JBA Risk Management is a flood risk consultancy company that uses IMERG Late to help create flood footprints to quantify and mitigate flood risk throughout the world.
- As part their services, they create flood blogs showing rainfall accumulation to draw attention to and raise awareness of flood events in different regions. Goals of the blog are to
  - identify rainfall patterns during that event and cross-reference with ground data and JBA's flood maps;
  - identify vulnerable locations in the world to flood risk; and
  - show the increasing intensity of rainfall due to climate change
- Their resources help aid decision-making for insurers, reinsurers, governments, NGO's and disaster risk financers.

Precipitation Climatology

- The 20-yr satellite precip record collected by GPM, TRMM and the GPM constellation satellites provides a valuable method to observe long-term trends and patterns in Earth's precipitation over time.

- Helps determine average precipitation that falls around the globe and produce precipitation climatology maps.
- Helps compare these long-term averages with short-term precipitation events to see how much they deviate to produce maps of precip anomalies.
- Helps quantify the severity of extreme precipitation events and droughts.



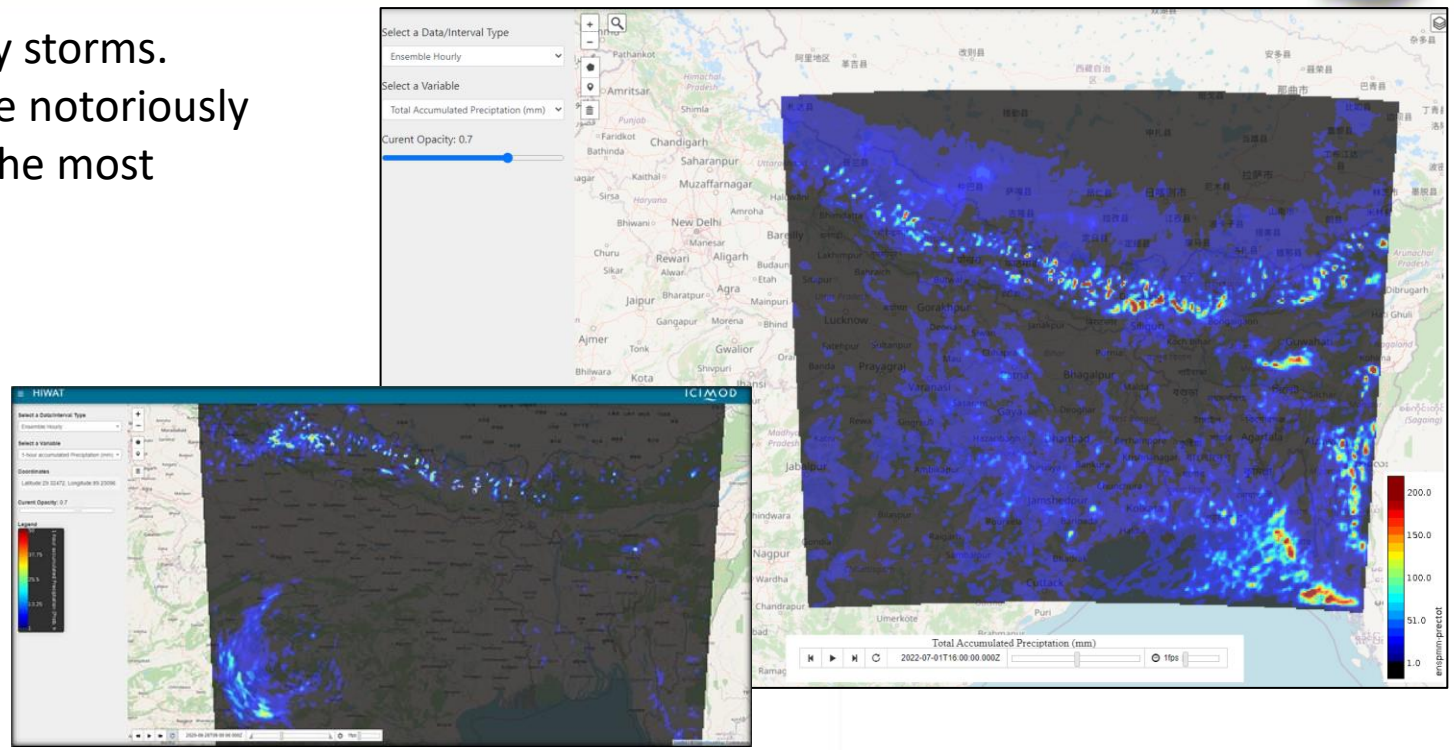
Check out more at https://gpm.nasa.gov/data/imerg/precipitation-climatology

The High-Impact Weather Assessment Toolkit (HIWAT)

Bangladesh has a long history of deadly and costly storms. Because these storms are so localized, they can be notoriously difficult to forecast, especially without access to the most advanced weather prediction technology.

Researchers have created a new tool to boost the country's ability to forecast severe weather. The U.S.-based SERVIR program and the Bangladesh Meteorological Department (BMD) recently launched the **High-Impact Weather Assessment Toolkit (HIWAT)**, a web-based tool that **feeds data from GPM** along with other NASA data with BMD's local observations in order to improve weather forecasts, giving BMD meteorologists a more thorough and detailed pool of data.

These inputs can help produce more reliable forecasts and allow scientists to predict hazards that were previously more difficult to anticipate, like lightning and hail!



Tool description: HIWAT uses a mesoscale numerical weather prediction model and the GPM constellation of satellites to assess high impact convective weather events over the Hindu Kush Himalaya region. The toolkit includes a suite of ensemble model forecasts to constrain the uncertainties and provides a 54-hour probabilistic forecast for improved decision making. HIWAT provides outlooks for lightning strikes, high impact winds, high rainfall rates, hail, and other weather events.

Image credit: High Impact Weather Assessment Toolkit (HIWAT) application

Check out the full article HERE

SERVIR HINDU KUSH HIMALAYA

GLOBAL PRECIPITATION MEASUREMENT

Intermediaries Help Facilitate the Use of GPM Data for Societal Benefit

- Peruvian park rangers and managers of the Junin Natural Reserve (JNR) participated in a 2-week training program taught in Spanish and designed to meet previously identified data needs.
- The training covered the fundamentals of Earth Observations, precipitation estimates from space (focus on IMERG), and land cover and change mapping. Using coding (Earth Engine for interoperability with other parks) and non-coding platforms (NASA GIOVANNI, which garnered enthusiasm), participants analyzed several local case studies.
- New local applications to IMERG were identified during the training by the participants, which had not been listed in the pre-training surveys and interviews. As a result, new pilot projects were designed jointly to address specific park needs.
- e-Andes (funded by CONCYTEC, Peru) is assessing and addressing information gaps for a better characterization and monitoring of Andean ecosystems, using the JNR as a demonstration site. Land cover dynamics, carbon sinks, and water quality are being studied using field and remote sensing data.

Left: Study area.

Below: Screenshot of training session.

Next steps: Using the lessons learned in the current program and work leading to it, the capacity-building program will be expanded to other parks and regions. e-Andes is open to collaboration with other teams.

****E-Andes is one example how intermediaries play an integral role in ushering information and decision-support products toward end users!***

***Project leads**: Vasco Mantas (University of Coimbra) and Claudia Caro (Universidad Nacional Agraria La Molina)*

Proyecto e-Andes

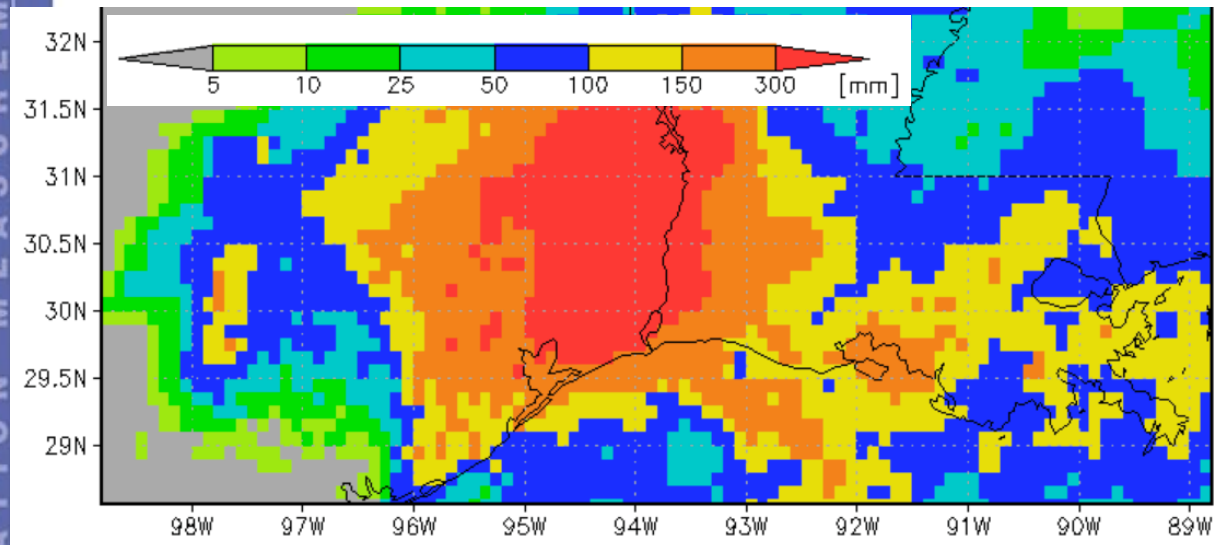
Text and Image Credit: e-Andes

Applications: Hurricane Harvey Flood Susceptibility

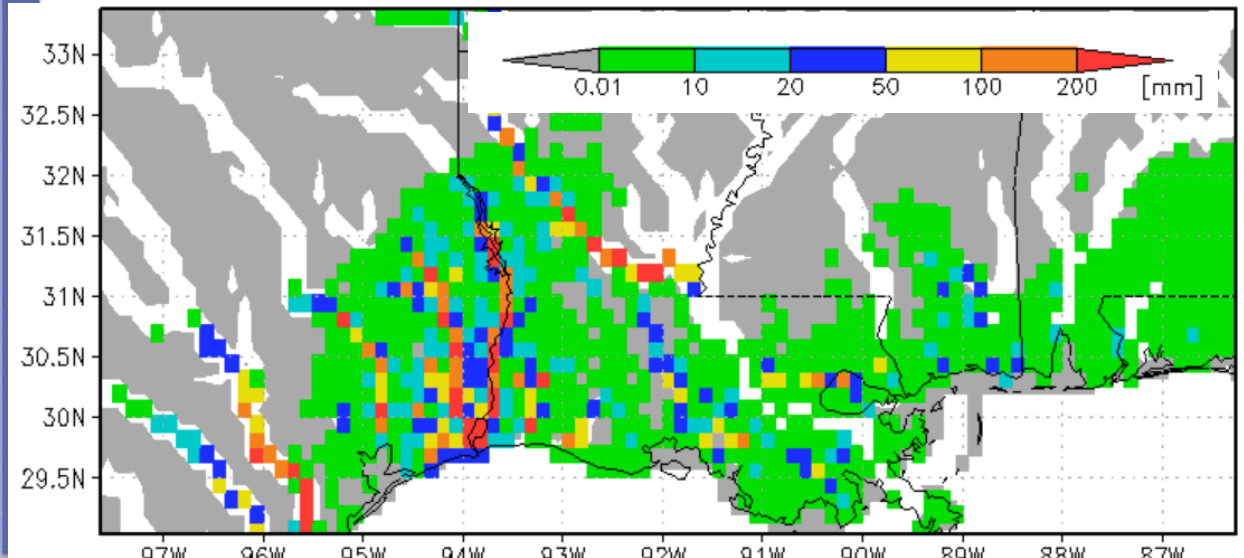
30 August 2017

flood.umd.edu

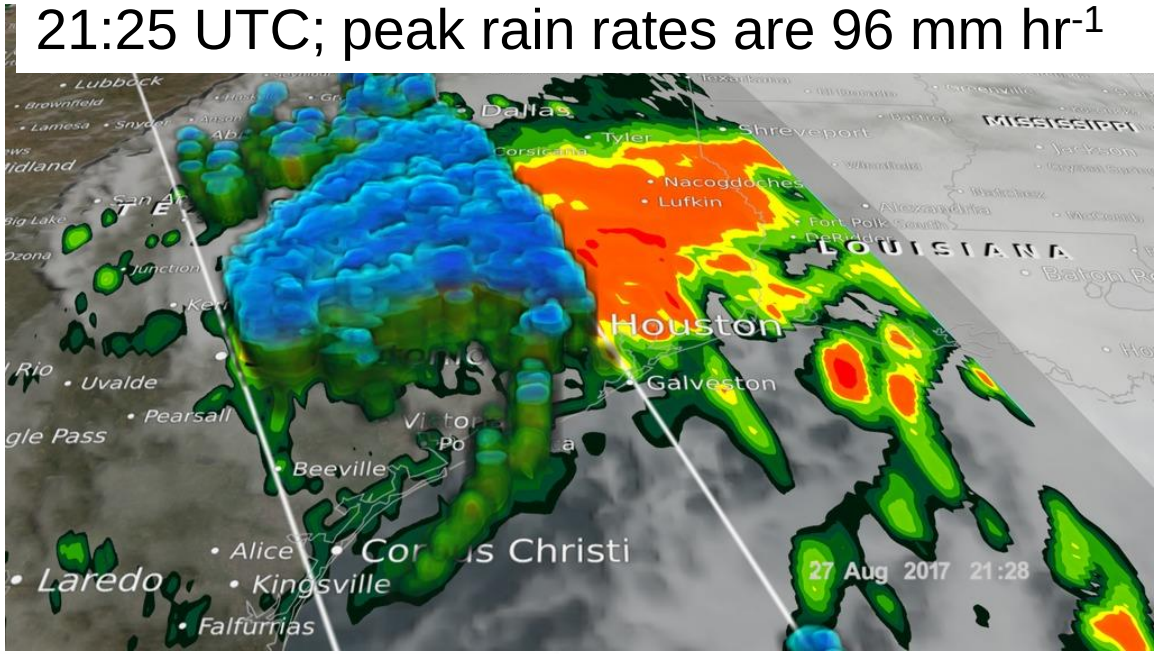
IMERG Rainfall (3-day accum.) 30 Aug 2017



Flood Intensity (depth above threshold [mm]) Forecast 30 Aug



GPM Core Observatory Overpass Aug 27 21:25 UTC; peak rain rates are 96 mm hr^{-1}

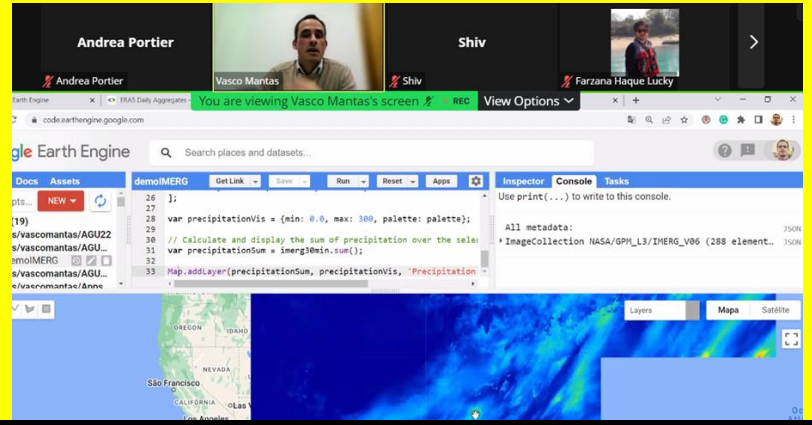


GPM User Engagement at AGU

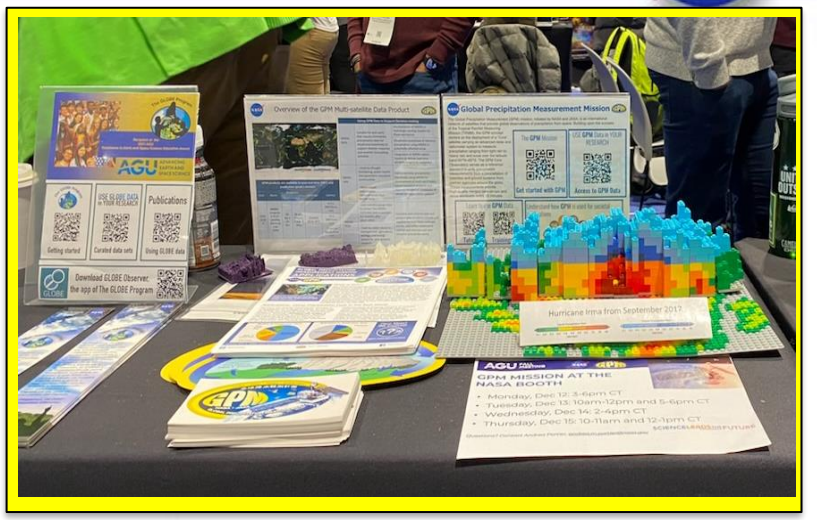
At the 2022 AGU Fall Meeting, the GPM Applications and Outreach Team created several opportunities for meeting participants to learn about the GPM mission and facilitate the uptake and use of GPM data for societal applications.

AGU-GPM Workshop!

- 150 participants
- Workshop catered to novice to intermediate users of remote sensing data to increase awareness of GPM data products and resources.
- Participants were exposed to applications presented by researchers and developers, and created a fully operational data analysis and dissemination web app using Google Earth Engine.



Applying Earth Observation Data for Research and Applications in Sustainable Development



GPM at the AGU NASA Booth!

Meeting participants had a chance to learn about the capabilities of the GPM Core Observatory and learn about ways they can use GPM data for real-world applications.

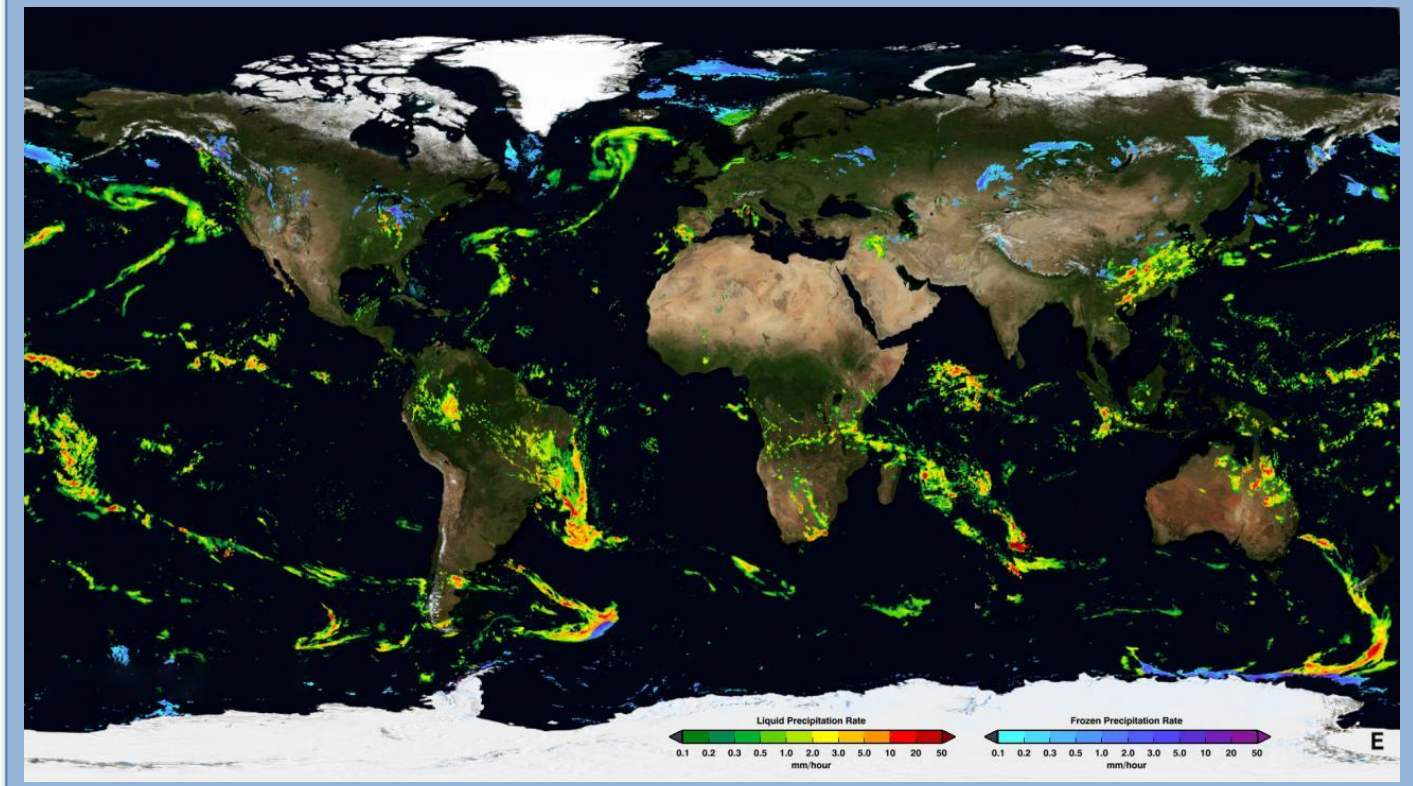
AGU FALL MEETING
SCIENCE LEADS THE FUTURE
CHICAGO, IL & ONLINE EVERYWHERE
12-16 DECEMBER 2022

GPM Applications at the Google Booth!

Andrea Portier (NASA/SSAI) and Vasco Mantas (Uni Coimbra) were invited to present at the Google Booth to showcase the use of IMERG for societal applications and a present a short tutorial on building a “rainfall harvesting” app using Google Earth Engine

U.S. Air Force Officially Integrates GPM IMERG

- U.S. Air Force (USAF) 557th Weather Wing has continuously maintained the U.S. DoD's only operational land data assimilation system since January 1958.
- In this role, they provide routine geospatial intelligence information to decision-makers across the military, agricultural and research sectors.
- A strategic partnership between USAF and NASA GSFC led to the use of the NASA Land Information System (LIS), allowing rapid transition of terrestrial hydrological modeling research into USAF operational weather forecasts and advisories.
- In the latest LIS version, support has been added for **officially integrating GPM IMERG Early product as observations**, and retiring the older SSMIS, GEOPRECIP, and CMORPH products, to support USAF applications.



"The IMERG precipitation data are an invaluable input to global land surface characterization capabilities, as well as input to numerical models," said Maj. Kurtis A. Schubeck, chief of weather prediction and modeling strategy at the Headquarters Air Force Directorate of Weather.

557TH WEATHER WING

Assessing Agricultural Impacts using GPM IMERG

- Monitoring weather's impact on global food and feed production during a growing season is critical to understanding global supply and demand.
- To assess these impacts, Nutrien Ag Solutions uses IMERG precipitation estimates to capture and evaluate extreme precipitation events.
- This information is part of their daily delivery of weather content to the company and their clients where these efforts help prepare for potential disruptions across the supply chain.

"NASA's GPM mission is an integral part of my global weather analysis toolset. Without NASA's global precipitation products, like IMERG, I wouldn't be able to observe weather events in near-real time that are impacting global ag productivity" Eric Snodgrass

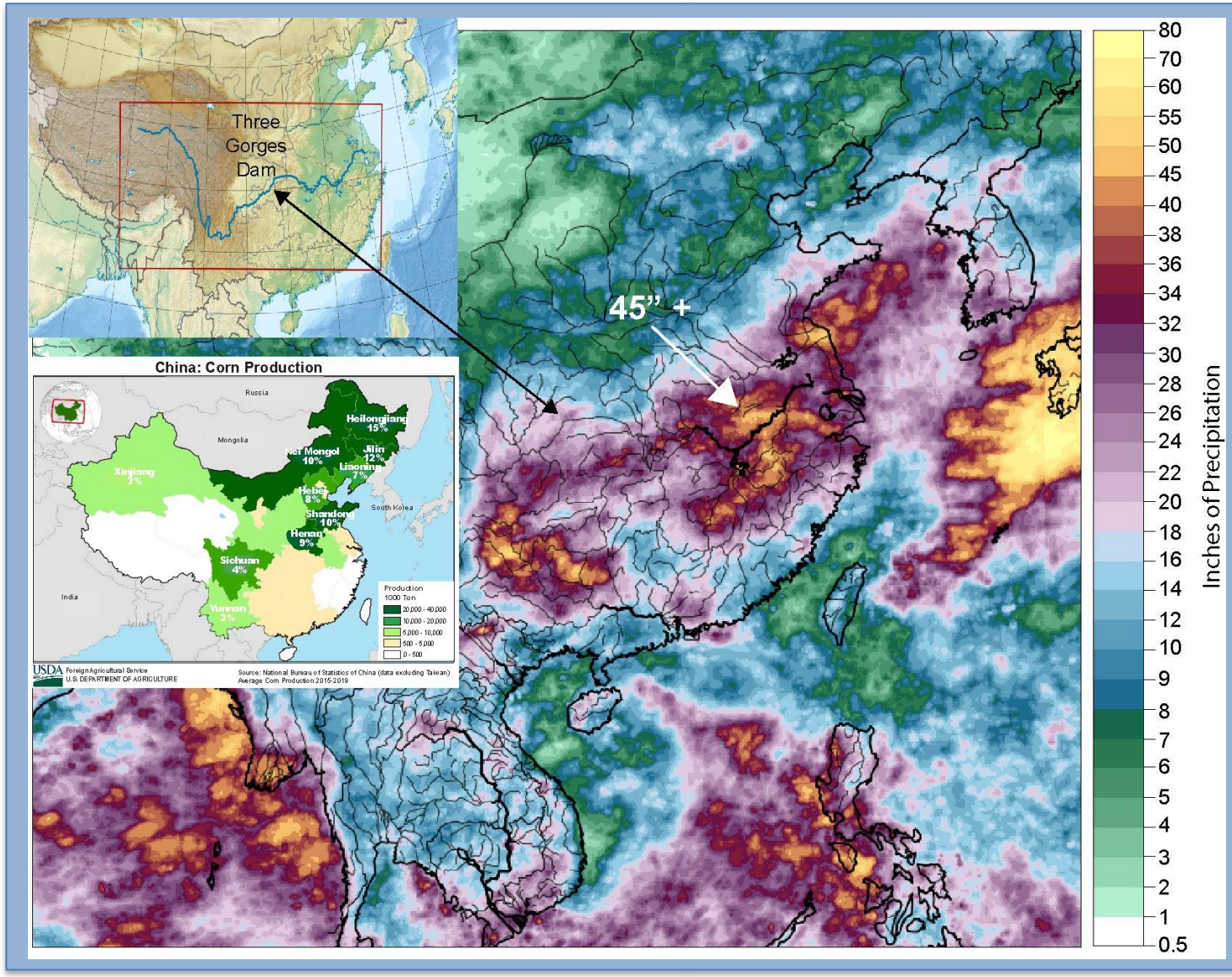


Figure: Total accum. precip using IMERG from 06/01 to 08/03, 2020 over China; (Top inset image) Location of precip event in China; (Btm inset) Corn production in China from 2015- 2019. Credit: Eric Snodgrass, Nutrien Ag Solutions.

Check out the full case study at https://doi.org/10.1016/j.rsase.2022.100853

Using IMERG for Hydropower Production in Africa

- The lack of optimal hydropower reservoir operations cause more frequent power outages and associated economic losses.
- Decision support systems (DSSs) for hydropower operations have the potential to provide critical information on inflow forecasts and optimize reservoir outflow operations.
- Researchers from the University of California of Los Angeles, led by Mekonnen Gebremichael, have developed a DSS that uses IMERG Final to quantify the uncertainty in climate ensemble forecast products and reduce the forecast uncertainty.
- This DSS tool is applied to hydropower systems in Ethiopia (e.g., Gilgel Gibe hydropower dam) to optimize hydropower production.

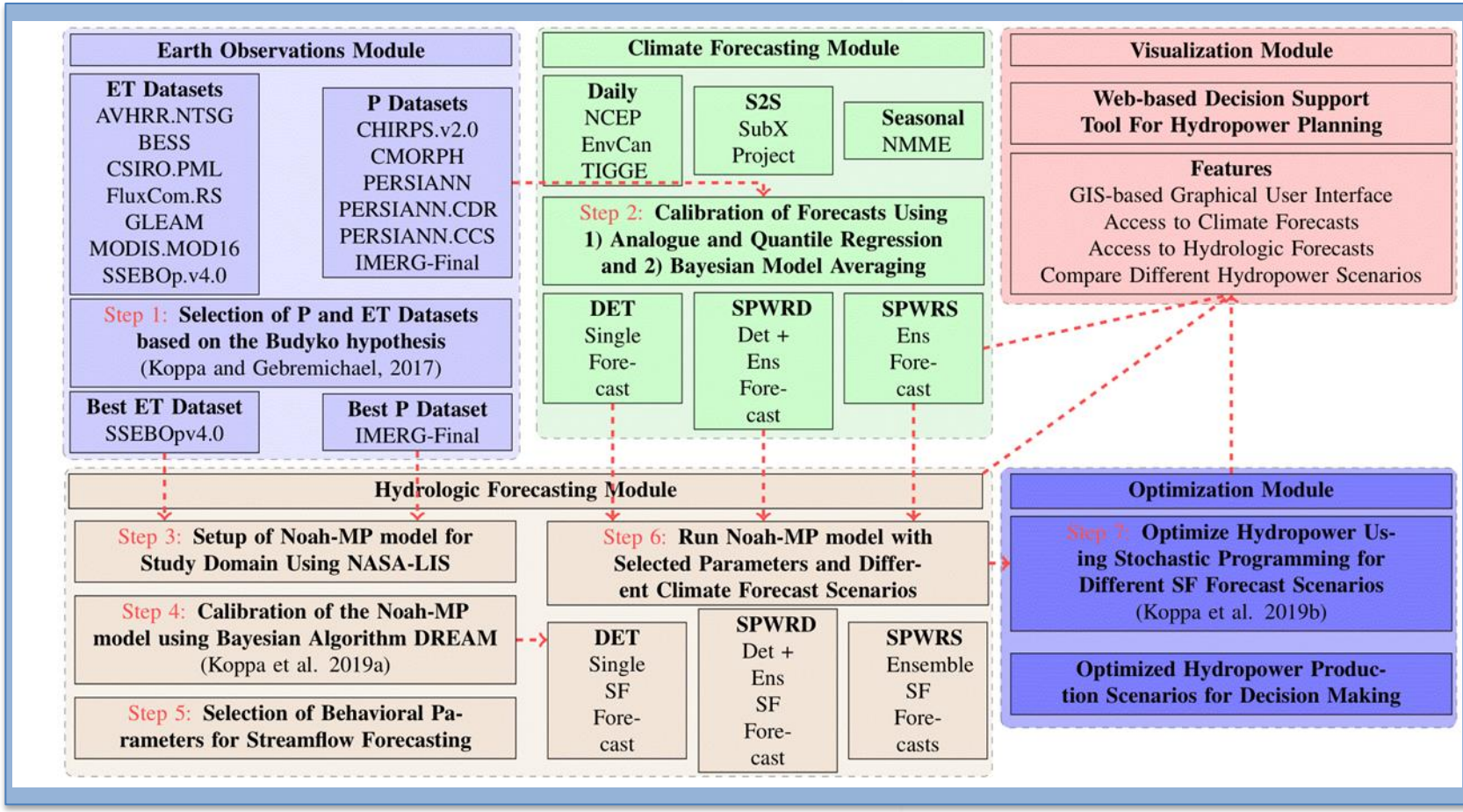


Figure: Block diagram of the hydropower DSS. ET, evapotranspiration; P, precipitation; for a full list of terms see Koppa et al. (2021).

Check out the full case study and results at https://doi.org/10.1016/j.rsase.2022.100853

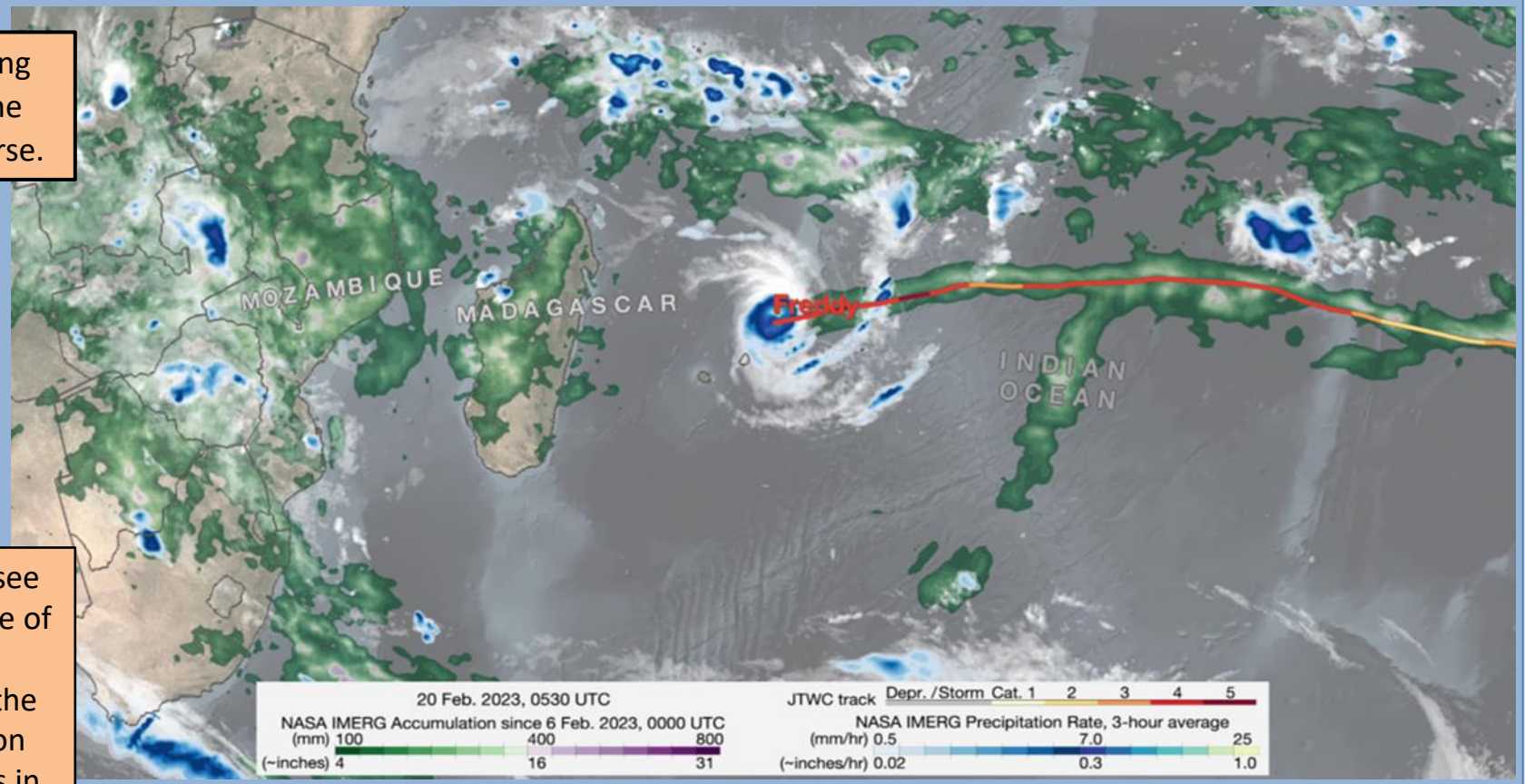
Tracking Cyclone Freddy with IMERG

- TC Freddy lasted over five weeks to become the longest-lived tropical cyclone in recorded history.
- Freddy originated in the Timor Sea in early Feb. 2023 and tracked across the entire Indian Ocean in almost a straight line.
- Freddy caused widespread flooding across parts of Mozambique due to the storm stalling out near the coast after making landfall.

NASA GPM's IMERG is ideal for monitoring and studying tropical cyclones around the world, especially over the open ocean where ground-based observations are sparse.

- Organizations like GDAC, ACAPS or Assessment Capacities Project, and relief organizations used IMERG as their precipitation source to assess TC Freddy and impacts!

Using IMERG, the image (right) and visual developed (see link) show rainfall estimates associated with the passage of Freddy across the Indian Ocean as well as Freddy's corresponding track and intensity. Over the course of the storm's history, IMERG reveals a variety of precipitation features and trends that relate closely to the variations in Freddy's intensity.



Check out the full story and video at https://gpm.nasa.gov/applications/weather/news/tropical-cyclone-freddy-brings-heavy-rain-and-flooding-madagascar-and-Mozambique.

The Integrated Rice Advisory System (IRAS) for Smart Agricultural Water Management

- The 100% stakeholder-owned & co-developed IRAS is here!
- Based on satellite-based tracking of on-farm water use, crop water demand and precipitation from LANDSAT, **GPM** and GFS to advise farmers when irrigation is not necessary.
- Maintained by Bangladesh Department of Agricultural Extension at http://iras.bamis.gov.bd to reach 10 million agricultural users via comprehensive dissemination system.
- During March 2023, IRAS correctly called for reducing irrigation at **97% of** Agricultural districts based on **GPM** data

IRAS helps deliver bi-weekly irrigation and weather advisories for 2187 agricultural districts via mobile, radio, social media, etc. These advisories inform if irrigation can be avoided or reduced!

Anticipated Long-term Impact

- ✓ 30% reduction in irrigation water use
- ✓ ↓ rate of groundwater table decline during Jan-June
- ✓ 116 million USD savings/year in fossil-fuel subsidies
- ✓ 0.3 million tons of CO_2 emission reduction/year

Resources provided by Faisal Hossain (UW CEE); Technology co-developed by Shahzaib Kan (UW CEE); Dr Kamal Khan of Agrometeorological Information System Development Project is the stakeholder agency lead

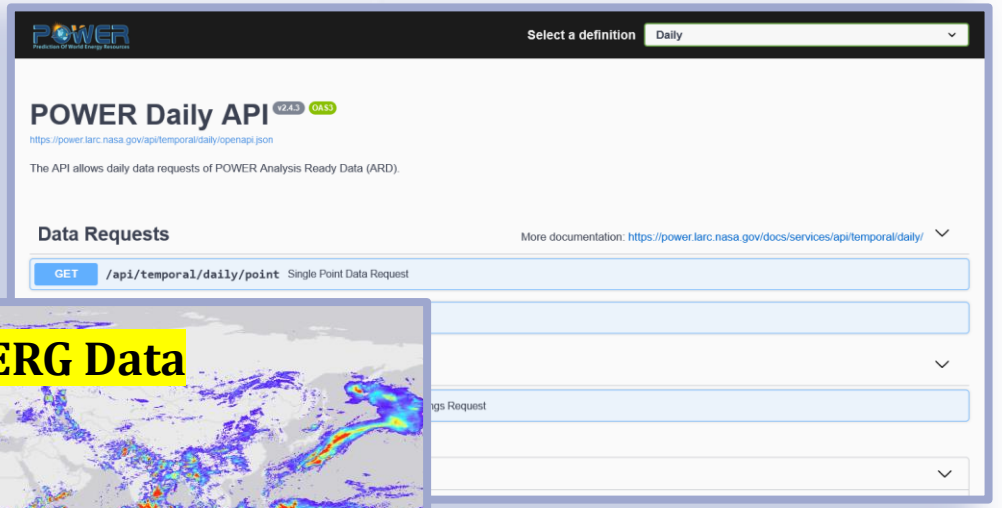
The Prediction Of Worldwide Energy Resources (POWER) Project

The NASA POWER project facilitates the integration of NASA satellite and modeling datasets into decision support tools used by **renewable energy**, **sustainable buildings**, and **agroclimatology** communities. POWER makes **surface solar radiation, meteorology data** and **value-added parameters** easily accessible through a variety of tools and web-based services. Precipitation datasets from IMERG and MERRA-2 are among the meteorological parameters available through POWER.

Precipitation data has a wide range of applicability across POWER's three communities. For example, users within the…

- Renewable Energy Community use historical precipitation datasets to support decisions on planning energy generation, grid management, and resource allocation to meet usage demands. Renewable energy infrastructure siting, design, management, and weather-related risks decisions are supported by precipitation information.
- Sustainable Buildings Community can find out if the structures they manage are likely to frequently receive heavy rains throughout the year and decide to design drainage and stormwater management infrastructure.
- Agroclimatology Community use historical rainfall Information and its seasonal variations help farmers decide crop planting dates, irrigation schedules, crop type selection and crop yield improvements.

Tool description: POWER's API supports Analysis Ready Data (ARD) distribution through a framework of microservices that retrieve, subset, and convert the data into user community specific ARD formats.



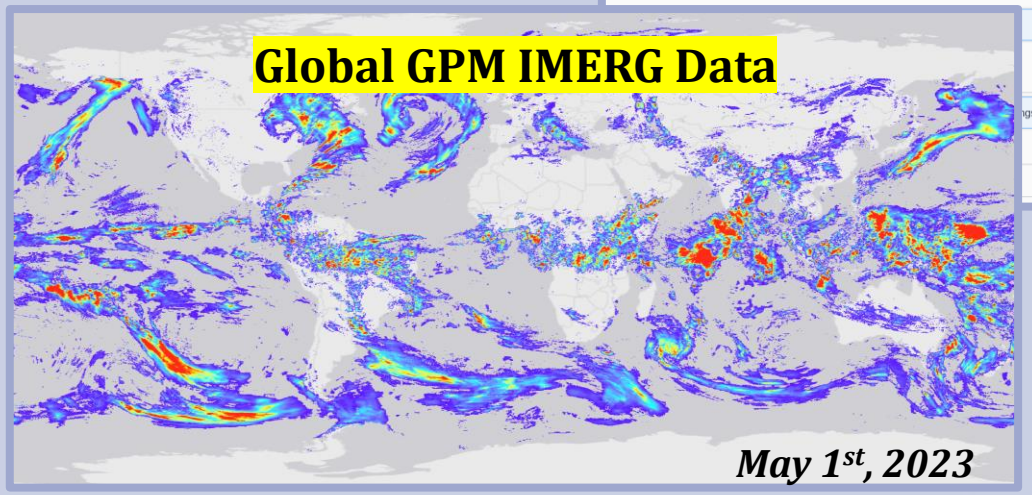


Image description: The image to the left displays IMERG data downloaded from POWER's API as a NetCDF and displayed in the Esri® ArcGIS Pro environment.

The POWER Application Programming Interface (API) allows single point daily time series requests from 2001-1-1 to Near Real Time (NRT). We achieve the NRT by using the IMERG Final Run for the full period of availability and filling the time series with the IMERG Late Run until it is replaced by IMERG Final Run.

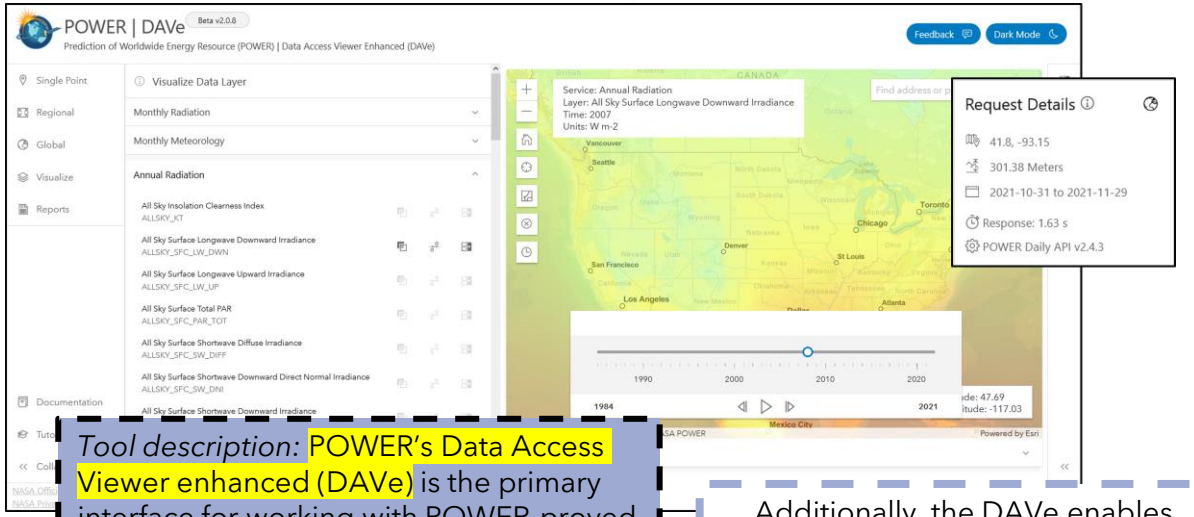
Visit: *https://power.larc.nasa.gov* | ***Contact:*** *larc-power-project@mail.nasa.gov*

The Prediction Of Worldwide Energy Resources (POWER) Project

The POWER Project, a NASA Applied Sciences Project, provides a full suite of application-ready low-latency, high-quality **global** and **long-term surface solar irradiance** and **meteorology data,** along with community-relevant derived variables through a large variety of openly available accessibility options to cater to the needs of our community of users.

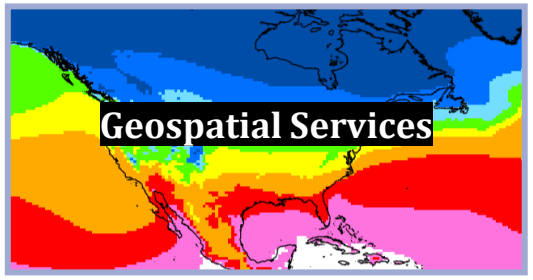
Through the POWER tools and services, users can interactively access and work with Earth Science data related to:

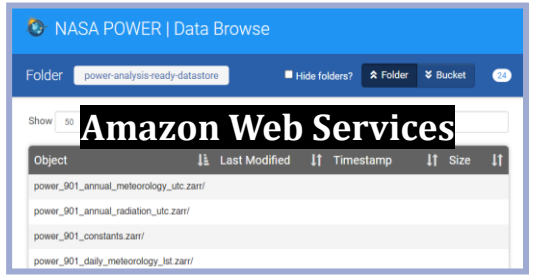
- **Energy fluxes**, including solar irradiance and thermal infrared energy from the CERES Project and the GEWEX Surface Radiation Budget project
- **Meteorology**, particularly surface conditions with some column averaged properties such as water vapor acquired from model data available through NASA's GEOS and MERRA-2
- **Precipitation data** available through GEOS and from NASA's GPM IMERG
- **Derived products** specific to the three POWER focus areas



Tool description: POWER's Data Access Viewer enhanced (DAVe) is the primary interface for working with POWER-proved data. The viewer is a responsive web mapping application that provides easy-to-use visualization tools, data subsetting, charting, and integrated climate reports.

Additionally, the DAVe enables users visually and graphically compare all the parameters within POWER data store to one another.





Tool description: POWER provides Esri® ArcGIS Image and Feature Services that allow users to efficiently interact with the POWER data in Geographic Information System (GIS) applications and related tools. The project also provides access to its entire data catalog (about 8.5TB of data!) via the Amazon Web Services (AWS) Open Data Portal, a sustainable data initiative.

POWER
Prediction Of Worldwide Energy Resources

Visit: https://power.larc.nasa.gov | ***Contact:*** *larc-power-project@mail.nasa.gov*

IMERG Improves Accuracy of Canada's Operational Precipitation Analysis System

- Quantitative precipitation estimates (QPEs) are required to support several societal applications.
- Since June 2021, Environment and Climate Change Canada (ECCC) assimilates IMERG Early into the Canadian precipitation analysis (CaPA) system as a new source of QPE, in addition to the usual radar QPEs and surface stations.
- Observations are combined to short lead-time forecasts using optimal interpolation over the North America domain.

Why is IMERG useful?

- It has the same spatial resolution of CaPA (~10km).
- Helps cover several regions lacking data (especially Northern Canada) and regions above water (Great Lakes region).

Why is this important?

- IMERG helps improve significantly the accuracy of operational CaPA precipitation analyses.
- The precipitation analyses produced by CAPA are useful to many organizations via operational applications related to economic activities and societal needs, such as weather forecasting, flood forecasting, crop management, wildfire prevention, water management and hydroelectric power generation

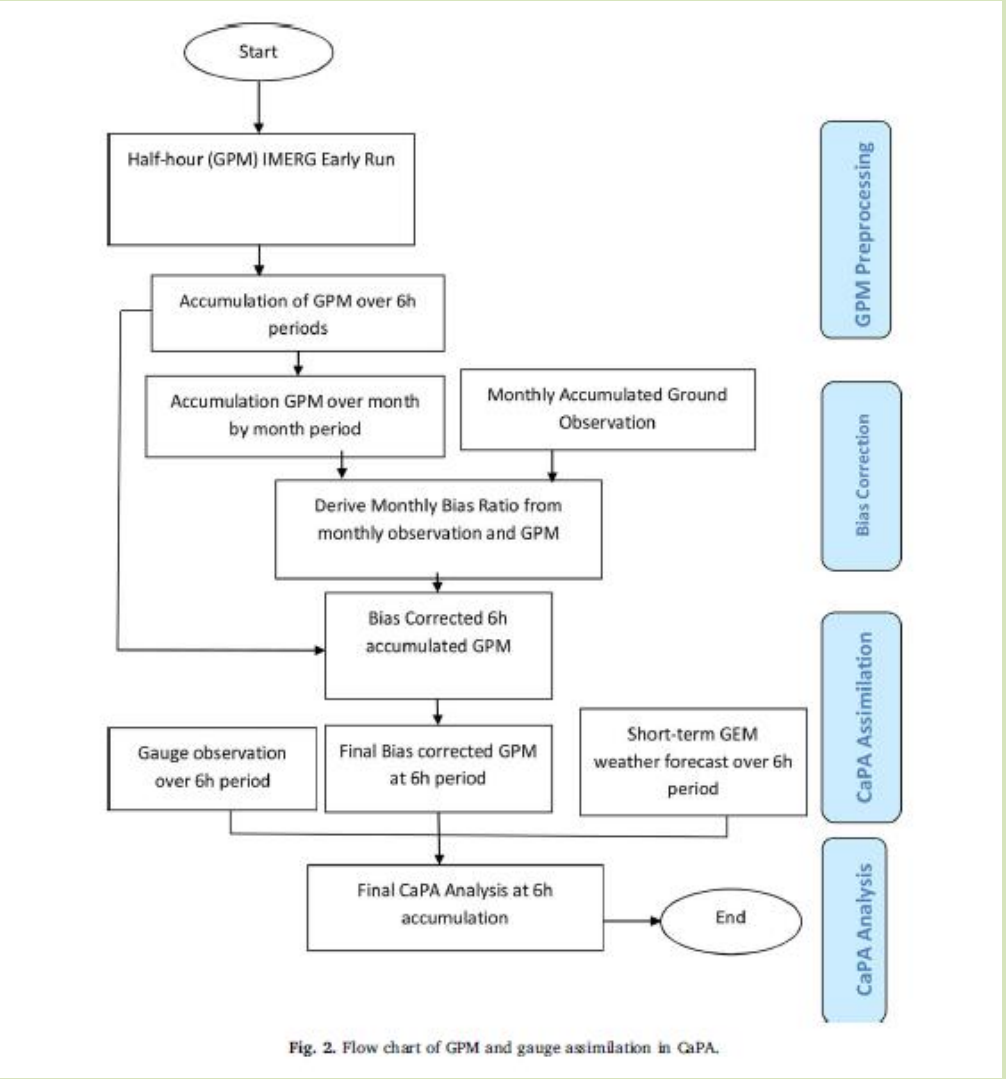


Fig. 2. Flow chart of GPM and gauge assimilation in CaPA.

Flow chart of GPM and gauge assimilation in CaPA.
See full article for more details.

IMERG Precipitation Improves the SMAP Level-4 Soil Moisture Product

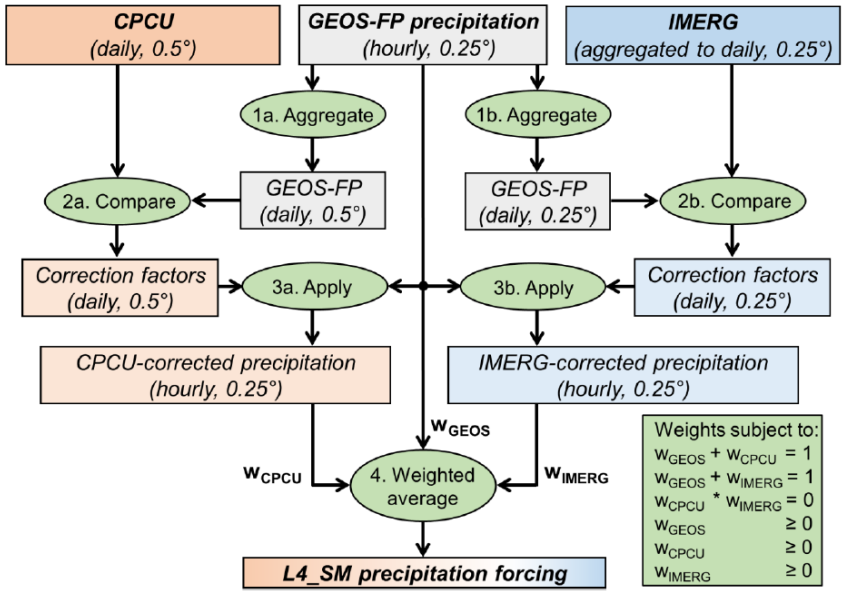
- A team of researchers evaluate the use of IMERG Late and Final in the SMAP Level-4 Soil Moisture (L4_SM) algorithm. This product is already known to support a variety of science research and applications.

Why is this Important?

- The use of GPM's IMERG helps improve temporal variations in the estimated soil moisture product.
- As a result, IMERG helps expand the use of SMAP's soil moisture product in otherwise poorly instrumented regions in South America, Africa, Australia, and East Asia enhancing flood prediction and drought monitoring applications.

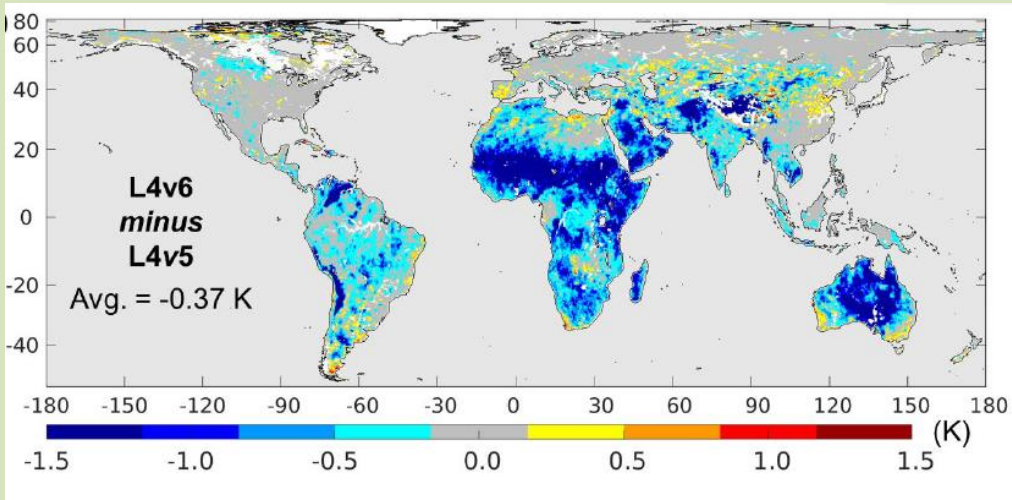
For more information?

- Check out the journal article "IMERG Precipitation Improves the SMAP Level-4 Soil Moisture Product," Journal of Hydrometeorology, https://doi.org/10.1175/JHM-D-23-0063.1.



Schematic of the daily, grid cell-wise precipitation correction algorithm in L4_SM. In L4_SM Version 5, only CPCU observations are used. In L4_SM Version 6, both CPCU and IMERG observations are used.

Difference in time series standard deviation of observations-minus-forecast (O-F) Tb residuals from L4v6 and L4v5. Blue colors indicate improved Tb simulation skill in L4v6 compared to L4v5.

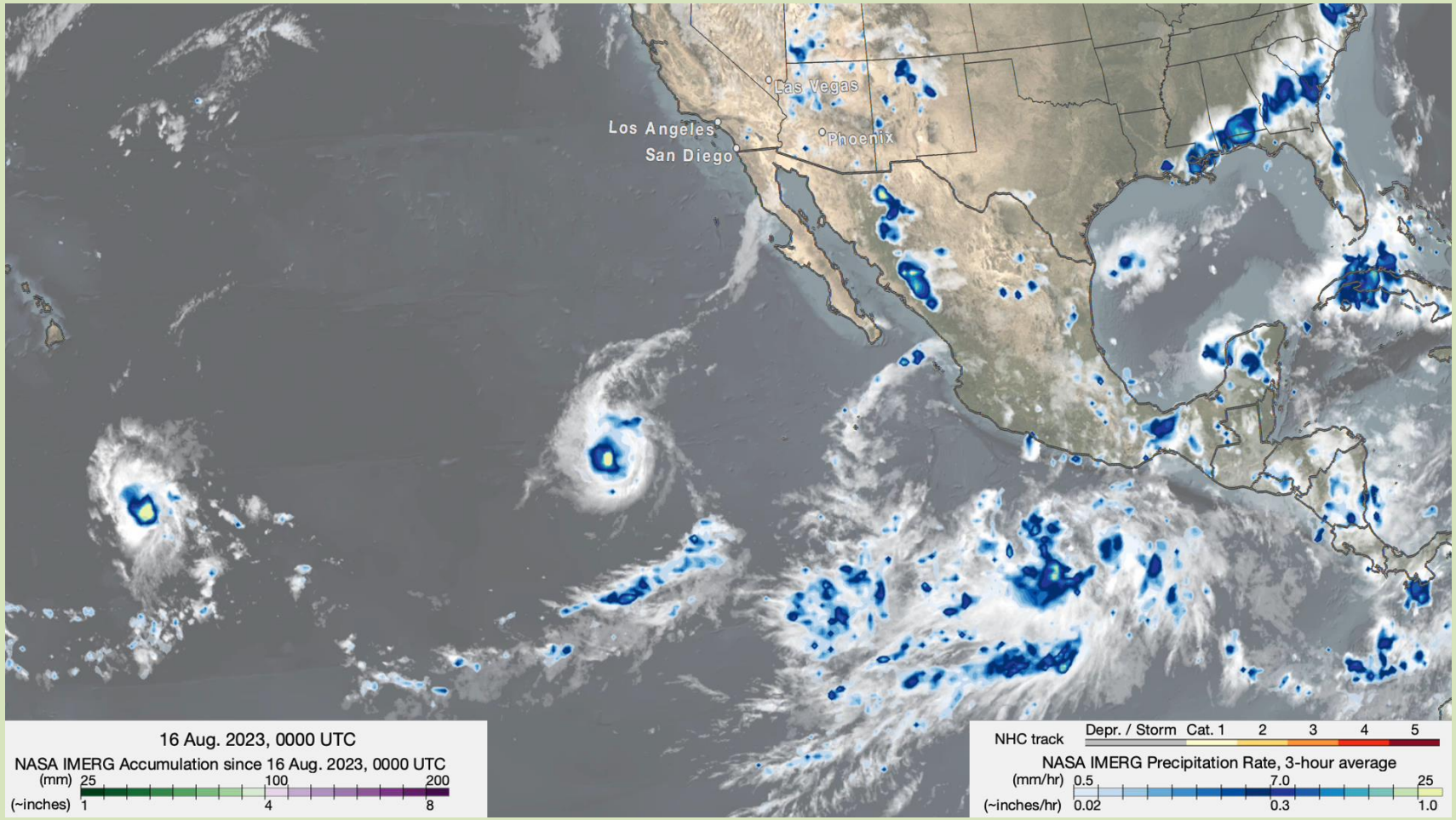


See full article for more details.

IMERG Captures Historic Hurricane Hilary

- Hurricane Hilary is the first tropical storm to hit California since Sept. 24, 1939.
- Hilary's rains have resulted in widespread flooding, landslides, washed out roads and numerous other closures.
- GPM's IMERG product produced surface rainfall estimates associated with the passage of Hilary.

- IMERG shows that the heaviest rains remained offshore and south of Baja, with totals over 8 inches (200 mm) shown in dark purple.
- Over land the heaviest rainfall was along the western coast of mainland Mexico.
- IMERG shows that rainfall amounts along Hilary's path decreased significantly as the storm moved north from the East Pacific up through the Southwest U.S. and into Idaho.

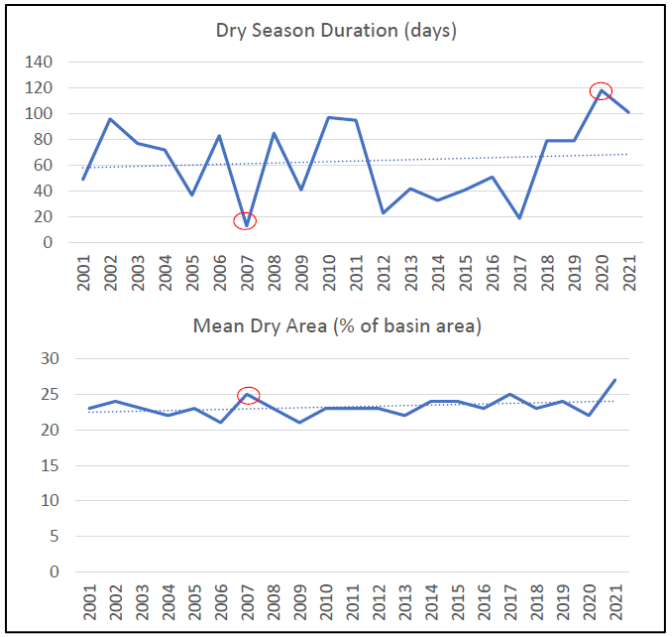


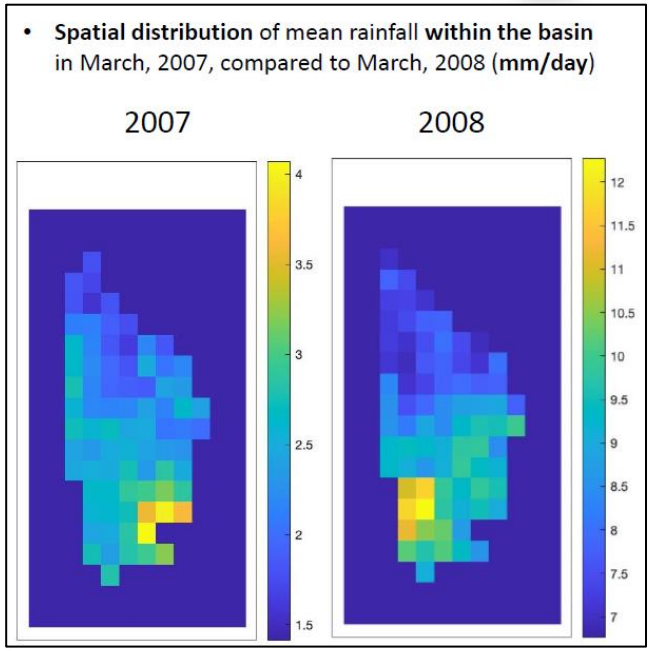
See full article for more details. Credits: Animation by Jason West (NASA GSFC, PPS, KBR)

Characterizing Tropical Droughts Using GPM Data

Overview of Project

- The National Water Agency (ANA) in Brazil explored the use of IMERG Final Daily data for seasonal rainfall characteristics to detect changes in tropical drought patterns in river basins in central region of Brazil.
- Extraction of drought statistics using IMERG included number of wet and dry days per year and duration of dry season per year.
- Detecting changes in dry season patterns can help water management decisions related to irrigation timing at the farm scale, and to water allocation at the river basin scale.
- Dissemination of results are planned to support drought monitoring in Brazilian organizations including ANA and National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN).
- Next steps:
  - Extend analysis to other river basins
  - Input data into hydrological models to derive drought indicators





Extracting drought statistics using IMERG F (left). Spatial distribution of mean rainfall within the basin (right). Credit: Alan Vaz Lopes

2023 Team

PMM Mentor:
Joe Turk
NASA JPL

Mentee:
Alan Vaz Lopes
ANA

Improving Water Resource Management Practices using GPM

Overview of Project

- The Private Institute of Climate Change Research (ICC) in Guatemala works with government institutions and the agro-industrial sector to support disaster risk reduction efforts by understanding potential risks and monitoring them over time.
- To help support this effort, ICC evaluated the use of IMERG in western Guatemala to increase coverage and information to enhance their extreme precipitation analysis efforts.
- ICC then assessed biases between IMERG estimates and data collected from 48 local weather stations in the region.
- ICC now plans to use IMERG as a complementary dataset to station data for hydrological analysis and establish basin base flows that will allow a better understanding of the planning and management of water for their stakeholders.

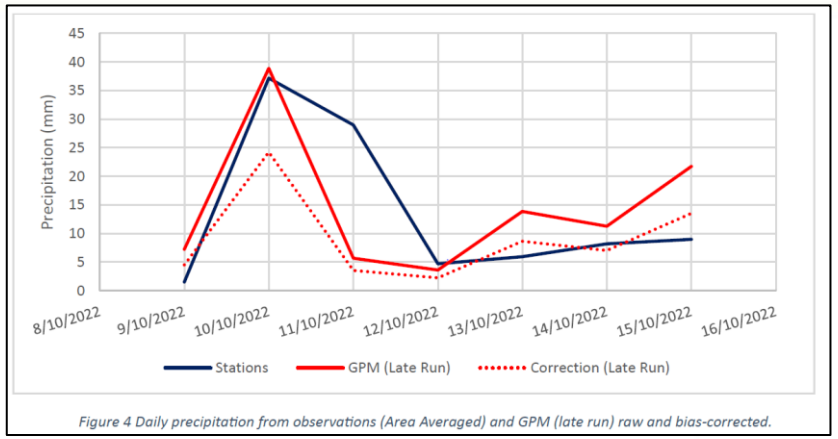


Figure 4 Daily precipitation from observations (Area Averaged) and GPM (late run) raw and bias-corrected.

Screenshots of data and analysis provided by ICC team member, Amy Molina.

Top: Daily precipitation using IMERG Late.

Right: Accumulated precipitation using IMERG Late.

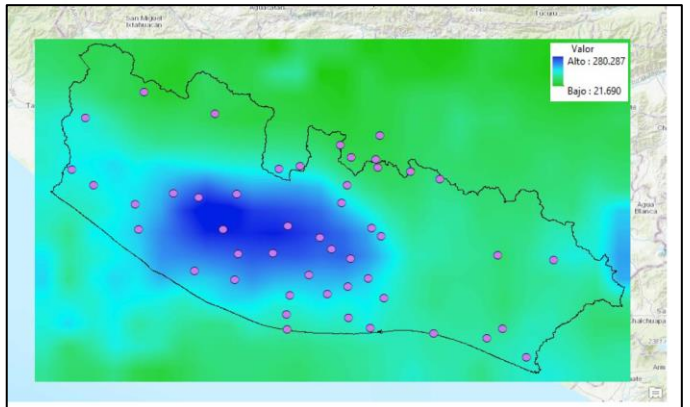


Figure 8 Precipitation accumulated during Hurricane Julia – GPM (Late Run)

2023 Team

Mentee:
Amy Molina
ICC

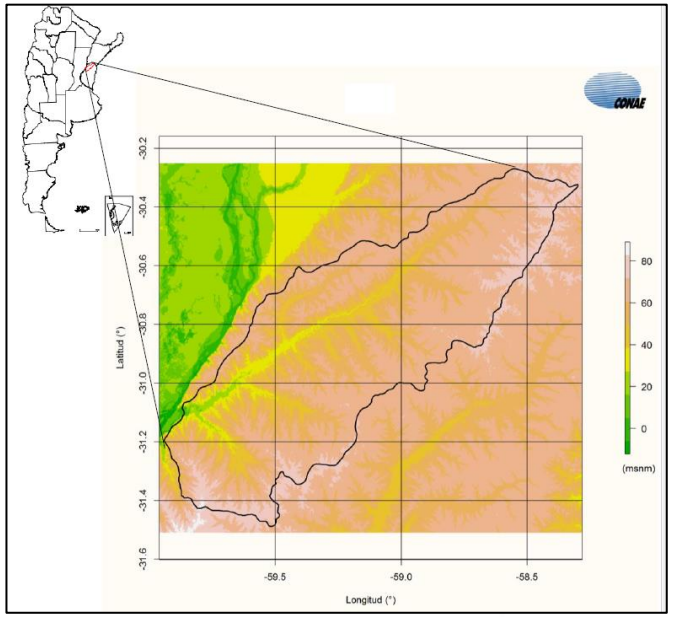
PMM Mentors:

Vasco Mantas, U. of Coimbra
Zhong Liu, NASA/MSU
Mircea Grecu, NASA/ MSU
Andrea Portier, NASA/SSAI

Hydrological Modeling with GPM IMERG

Overview of Project

- The team explored the use of IMERG as input to hydrological models for Argentina's lowland Feliciano Basin and compared results with those obtained with in-situ measurements.
- IMERG was used to:
  - calculate mean precipitation
  - run statistical analysis on detection of intense storms
  - feed into model to obtain streamflow time series
- The team plans to continue the evaluation of the use of IMERG into models to generate more accurate hazard warning systems that cater to lowland catchment areas in Argentina.

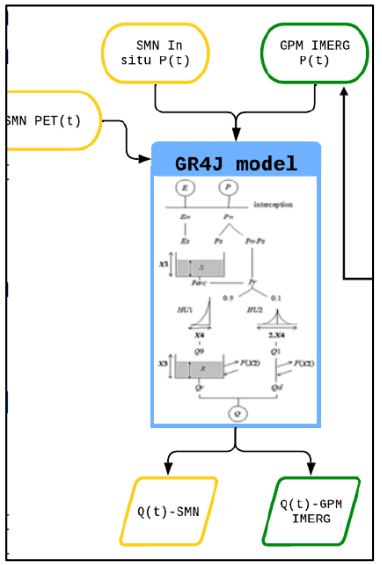


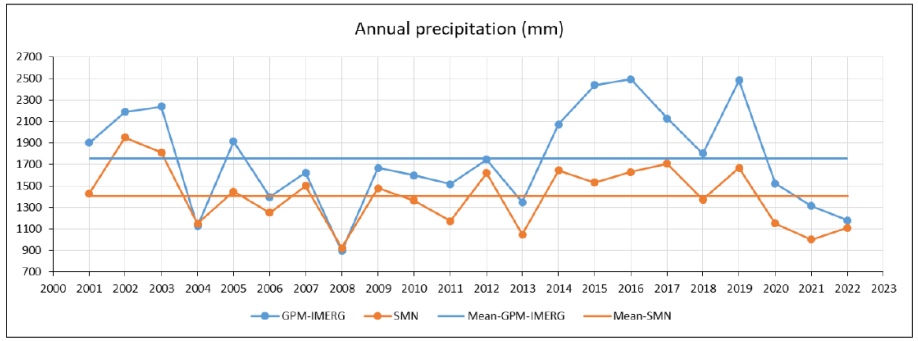
Left: Feliciano Basin in NW Entre Ríos province, Argentina.

Below left: Annual precipitation using IMERG.

Below right: Screenshot of model inputs.

Credit: Ana Mari Pinilla, CONAE





2023 Team

PMM Mentor:
Marcelo Uriburu Quirno
CONAE

Mentee:
Ana Maria Pinilla
CONAE

Investigating Diurnal Cycle of Precipitation in the Amazon Rainforest

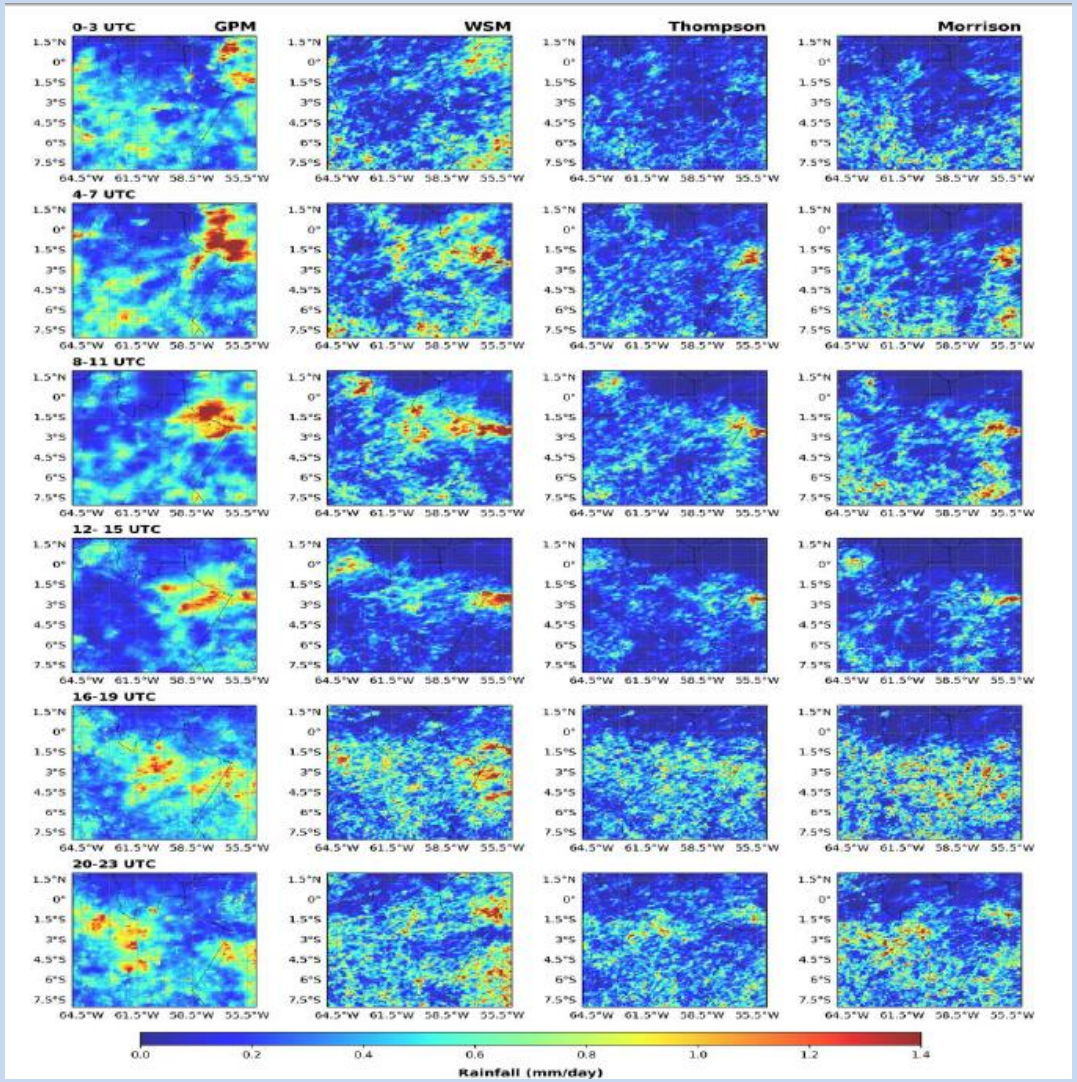
Overview of Project

- The Amazon Rainforest is one of the world's hot spots of convective activity.
- However, models do not produce a realistic representation of precipitation.
- To explore this topic, the team compared three microphysical schemes (WSM6, Thompson, Morrison) of the WRF model against GPM precipitation data near Manaus, Brazil.
- Results indicate that the coarser resolution WRF model inadequately captures GPM precipitation and the WSM schemes exhibit superior performance in compared to other schemes.
- Future Work: Model simulation at a finer spatiotemporal resolution to enhance accuracy and detail.

2023 Team

PMM Mentor:
Mei Han
NASA/MSU

Mentee:
Chetan Gurung
UMBC



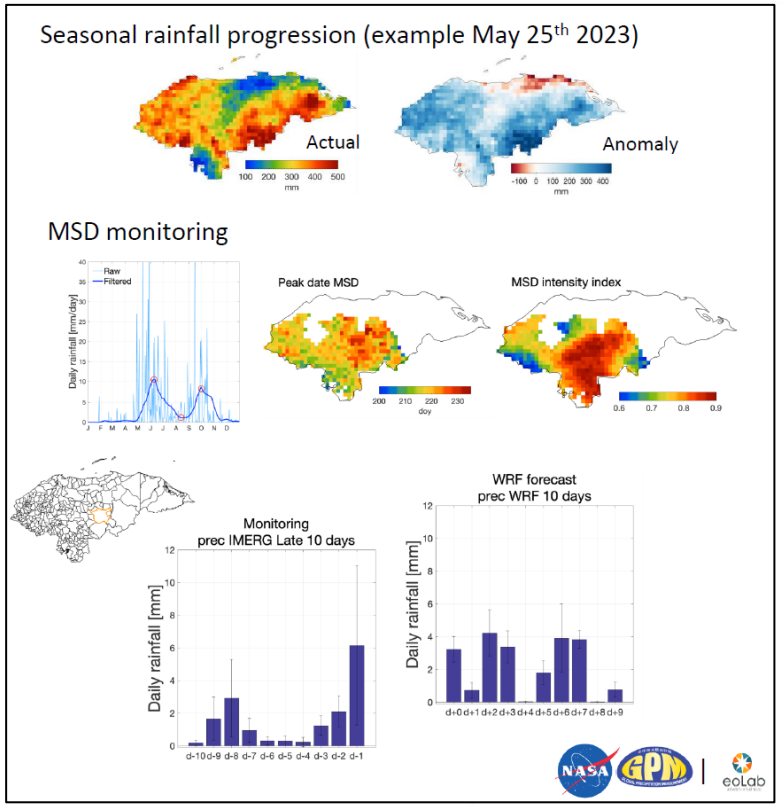
Results from project- Investigating diurnal cycle of precipitation with GPM vs three different microphysical schemes. Credit: Chetan Gurung.

GLOBAL PRECIPITATION MEASUREMENT

Using IMERG in Monitoring Rainfall & Midsummer Drought in Honduras

Overview of Project

- Rainfall variability and the Midsummer Drought (MSD) (*canícula*) shape multiple socio-economical activities in Honduras.
- The International Maize and Wheat Improvement Center (CIMMYT) aim to develop a framework for the use of IMERG Final and Late runs in monitoring rainfall and MSD.
- Integration into national monitoring and forecasting systems of Honduras is underway for the National Weather Service (CENAOS) and for agricultural extension organizations (InfoAgro):
  - Monitoring + weather and seasonal forecasts of rainfall and the MSD
  - Recommendations for specific crops and regions
- Ongoing work includes interactive platform for visualization and data source for agromet bulletins.



Summary of results from project. Credit: Carlo Montes (CIMMYT)

2023 Team

Mentee:
Carlo Montes
CIMMYT

PMM Mentors:

Vasco Mantas, U. of Coimbra
Zhong Liu, NASA/MSU
Mircea Grecu, NASA/ MSU
Andrea Portier, NASA/SSAI

Impact of Climate Change in SW Angola: Discovering Solutions with GPM

Overview of Project

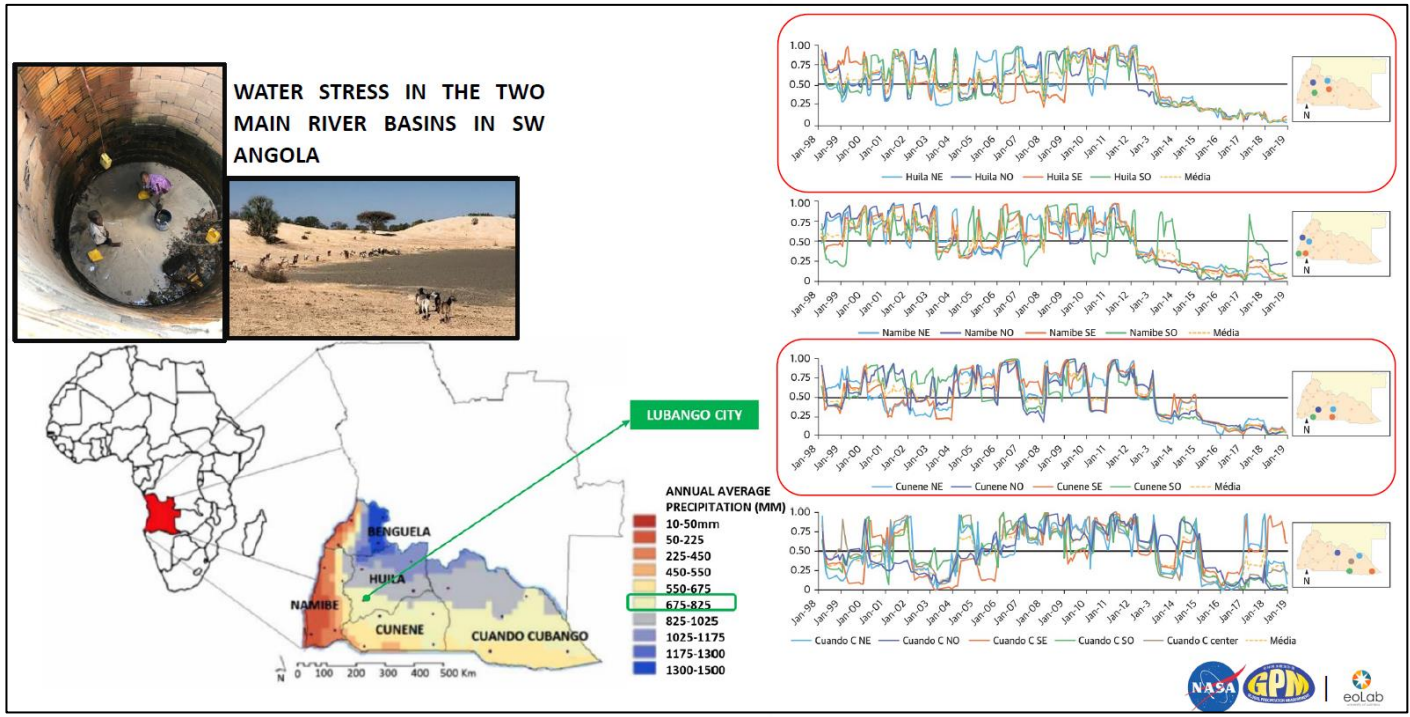
- Creating measures in support of water and food security in Angola is highly needed.
- A precipitation climatology was developed using IMERG to evaluate impacts of climate change within the southwest region of Angola and help advance the analysis for systematic monitoring and enable disaster preparedness in real time.
- This will help integrate an efficient vision of water resources in the Okavango and Cunene watersheds of Angola.
- Next steps: Involvement with stakeholders
  - Ongoing political dialogue and analytical work with multiple governments = essential to advance systematic monitoring
  - Review and strengthen information-action mechanisms for drought preparedness and drought response programs
  - Develop drought and extreme weather preparedness programs for emergency water supply and associated training

2023 Team

Mentee:
Edson Baptista
Huila Provincial Water & Sanitation Company

PMM Mentors:

Vasco Mantas, U. of Coimbra
Zhong Liu, NASA/MSU
Mircea Grecu, NASA/ MSU
Andrea Portier, NASA/SSAI

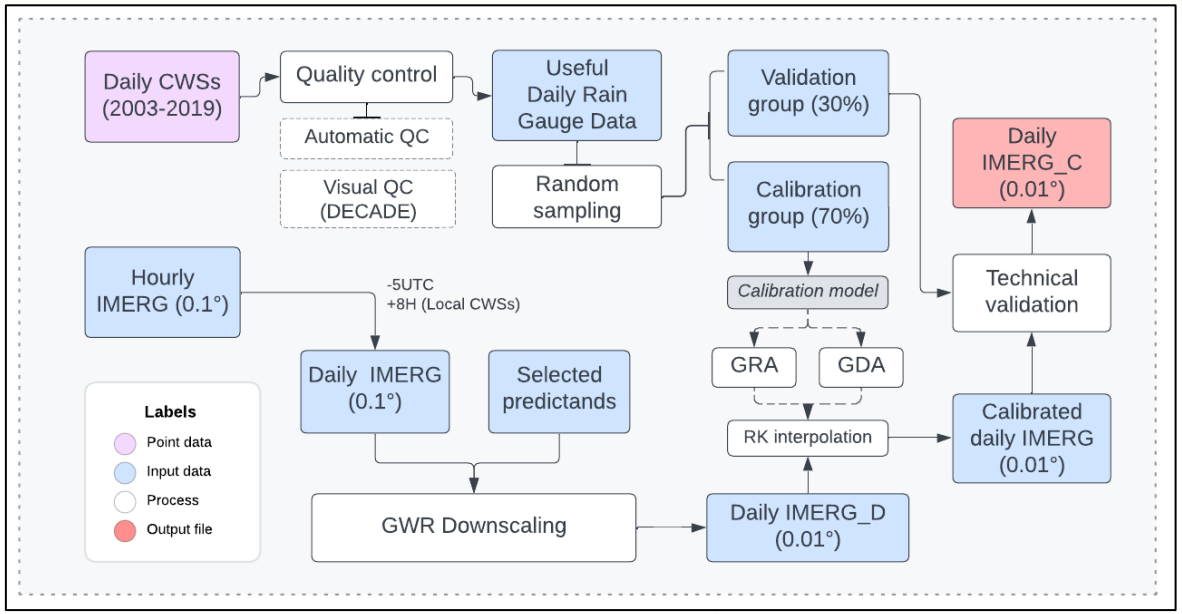


Summary of rainfall data using TRMM and GPM data across SW Angola region and provinces. Credit: Edson Baptista, Huila Provincial Water and Sanitation Company.

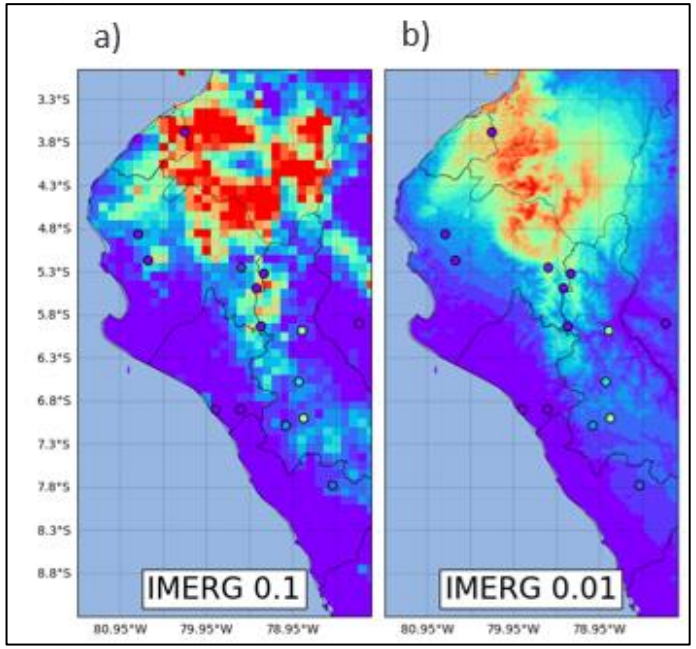
Spatial Downscaling of IMERG Final Over the North Coast of Peru

Overview of Project

- The coarse resolution of precipitation products have insufficient precision for direct use in finer scale hydrological and meteorological applications.
- To address this issue, the team explored a spatial downscaling approach based on the relationship between precipitation and multigeospatial factors.
- A geographically weighted regression (GWR) method was used to reduce the spatial scale of IMERG Final from 0.1° to 0.01 ° on the north coast of Peru, focusing on the summer season.
- By improving spatial resolution in precipitation estimation, it is expected to improve monitoring of extreme weather events, optimize water resource management, and support informed decision-making regarding food security, hydrological and meteorological forecasting, and early disaster prevention alerts in the region.



Top: Flowchart of the applied methodology. Right: Spatial distribution of original IMERG and downscaled for March 01, 2017. Credit: G. Bastidas



2023 Team

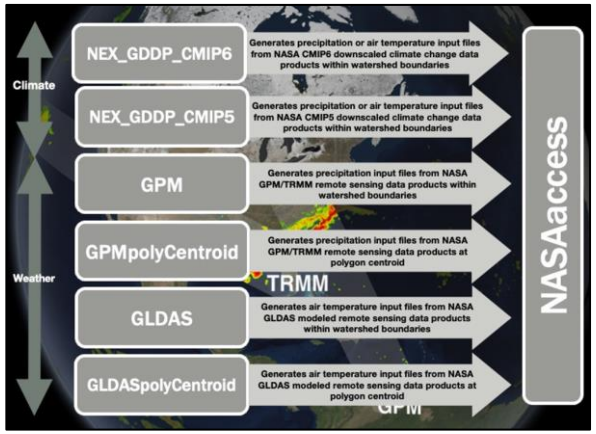
PMM Mentor:
Chuntao Liu
TAMU

Mentee:
Gianella Botetano Bastidas
National Agrarian University

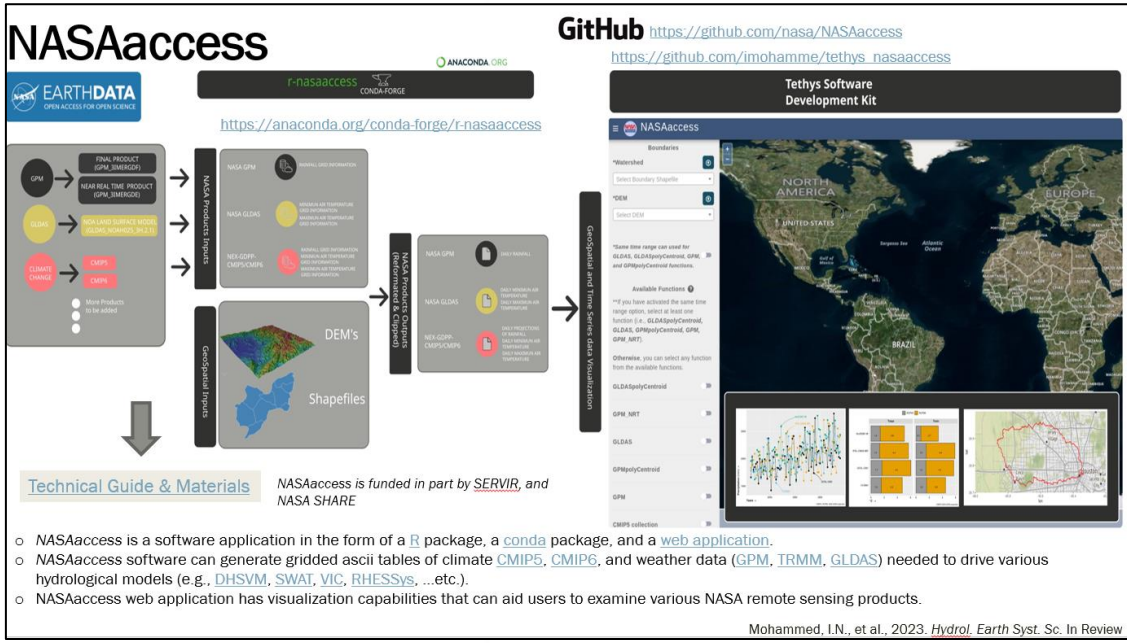
Exploring GPM Data via the NASAaccess Tool

Overview of Project

- NASAaccess is an open-source platform for accessing and presenting quantitative remote sensing Earth observation, and climate data products in an interactive format.
- The tool allows users with easy access and retrieval capabilities to weather and climate data for any watershed.
- Taking advantage of the platform, the team did a preliminary analysis of precipitation using GPM over oceans.
- The goal of the research is to analyze different regimes of precipitation through different analyses and focus on extreme events in particular.



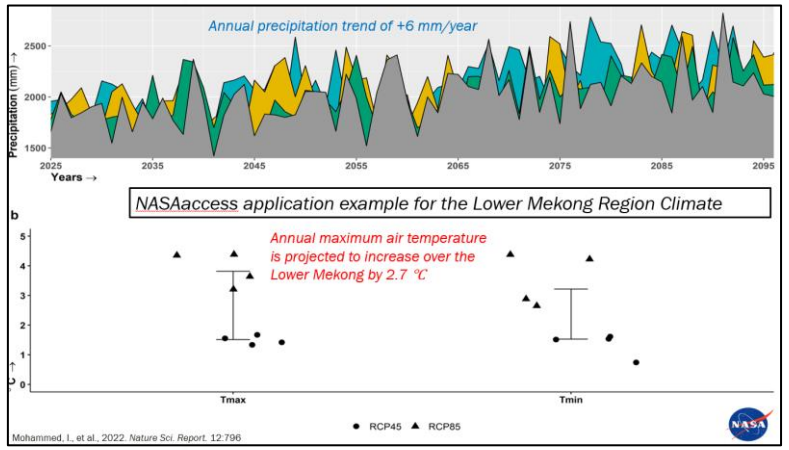
Top: Datasets included in the NASAaccess tool. Right: NASAaccess is a software application in the form of a R package, a conda package, and a web application. Bottom: NASAaccess application example for the Lower Mekong Region Climate.



2023 Team

PMM Mentor:
Ibrahim Mohammed
NASA/SSAI

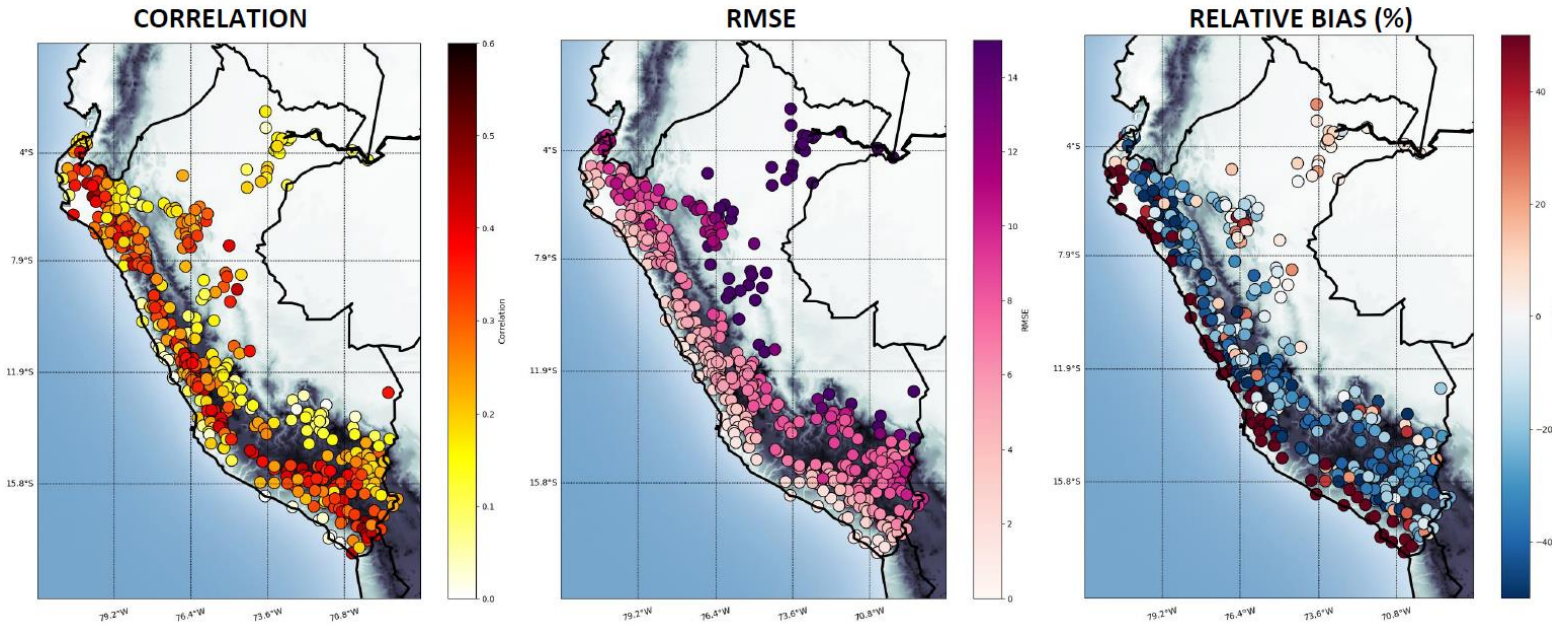
Mentee:
Giorgio Dalmasso
University of Pavia



Evaluation of IMERG Products for Daily Precipitation Analysis Over Peru

Overview of Project

- The spatial coverage of rain gauge stations in Peru are insufficient for adequate monitoring and forecasting of extreme rainfall events.
- The National Service of Meteorology and Hydrology of Peru (SENAMHI) analyzed the performance of IMERG products to represent daily rainfall in Peru using the following statistical metrics:
  - Correlation; RMSE; Relative Bias (%)



Summary of results assessing performance of IMERG with different statistical metrics. Credit: Gustavo De La Cruz (SENAMHI).

- Results show that biases in IMERG daily products may be corrected by statistical techniques.
- Ongoing work includes applying bias correction methodologies for the IMERG-E product (example machine learning) and develop an operational bias correction system for daily rainfall monitoring purposes.
- These data will serve as input for forecasting with the goal of reducing human and economic losses that occur during extreme events such as El Niño.

2023 Team

Mentee:
Gustavo De la Cruz
SENAMHI

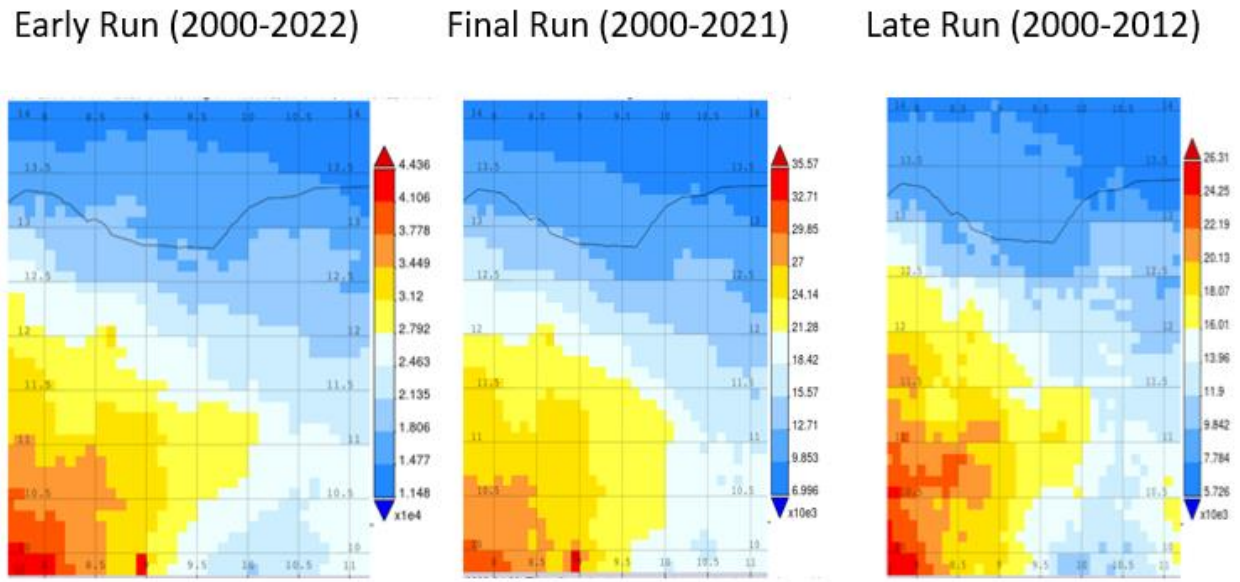
PMM Mentors:
Vasco Mantas, U. of Coimbra
Zhong Liu, NASA/MSU
Mircea Grecu, NASA/ MSU
Andrea Portier, NASA/SSAI

Assessing Impact of Climate Change in Northern Nigeria

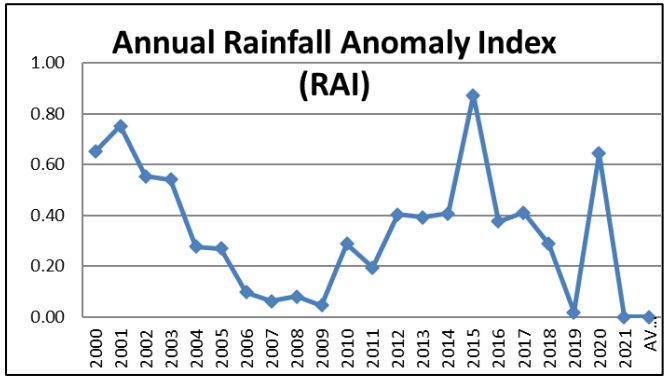
GLOBAL PRECIPITATION MEASUREMENT

Overview of Project

- Increasing climate variability in Nigeria is causing more intense and untimely rainfall.
- Working with mentors, a representative from the Economic Community of West African States (ECOWAS) in Nigeria explored various ways to access and download publicly available precipitation data.
- Using IMERG 20+ year record, ECOWAS analyzed the frequency and intensity of precipitation in northern Nigeria to develop a new algorithm for flood monitoring and forecasting.
- Future efforts include working with governmental bodies to develop flood vulnerability maps and operational tools in areas that are most vulnerable to flooding.



Mapping precipitation using IMERG. The red area is an indicator of precipitation extremes. Credit: Idris Baba (ECOWAS).



Using IMERG, the annual RAI was used to analyze the frequency and intensity of dry and rainy years. Credit: Idris Baba (ECOWAS).

2023 Team

Mentee:
Idris Baba
ECOWAS

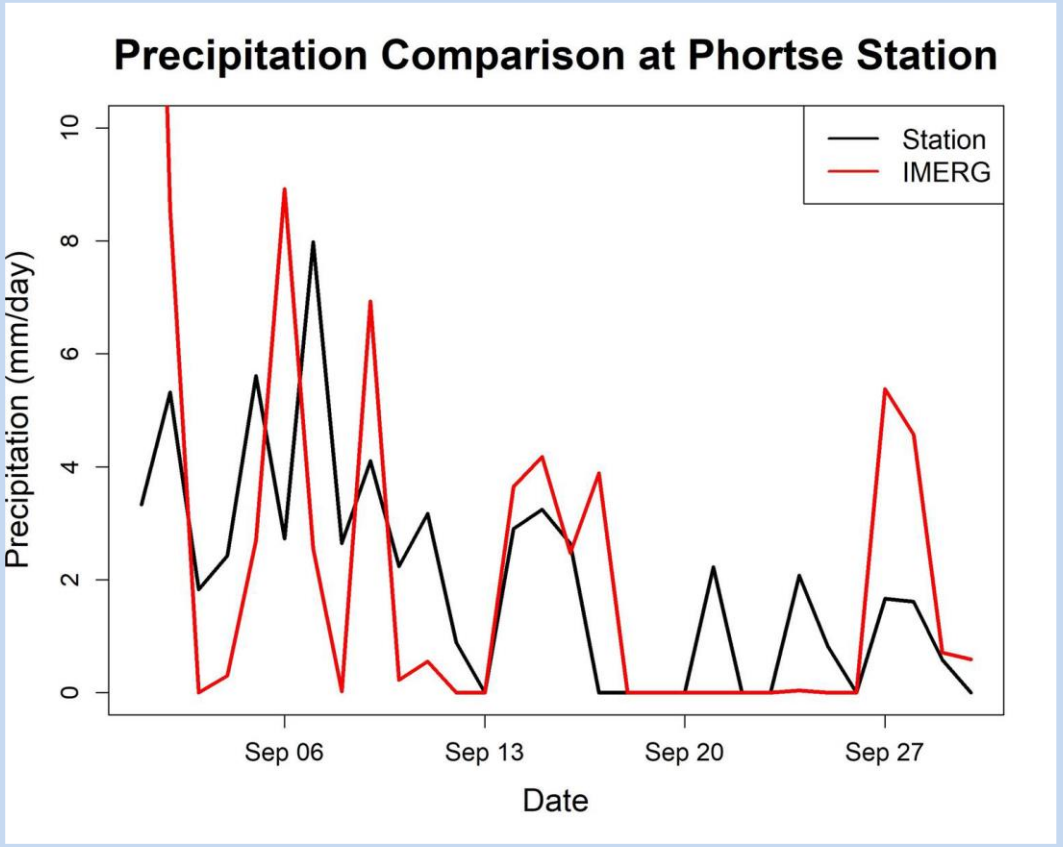
PMM Mentors:

Vasco Mantas, U. of Coimbra
Zhong Liu, NASA/MSU
Mircea Grecu, NASA/ MSU
Andrea Portier, NASA/SSAI

Evaluation of IMERG Over Nepal's High Himalayan Region

Overview of Project

- Observing rainfall over remote regions of steep topography and at high altitude remains a challenge.
- Working with mentors, a representative from Nepal's Department of Hydrology and Meteorology (DHM) assessed IMERG's ability to measure rainfall in the Solukhumbu region of Nepal by comparing IMERG daily rain rates to the rain gauge observations.
- Project objectives include understanding of new data and data access as well as improving rainfall estimates and information over Nepal where ground information is limited.
- These efforts can be beneficial to local communities, including Sherpas as well as tourists and mountain climbers.
- Future efforts include exploring DPR data to calculate phase changes and improve detection of severe weather.



Assessment of IMERG in the Solukumbu region, Nepal. IMERG slightly overestimates higher rain rate events but misses some weaker events. Results consistent with Khadka et al 2022. Credit: K. Ghimire (DHM).

2023 Team

Mentee:
Kaman Ghimire
Nepal DHM

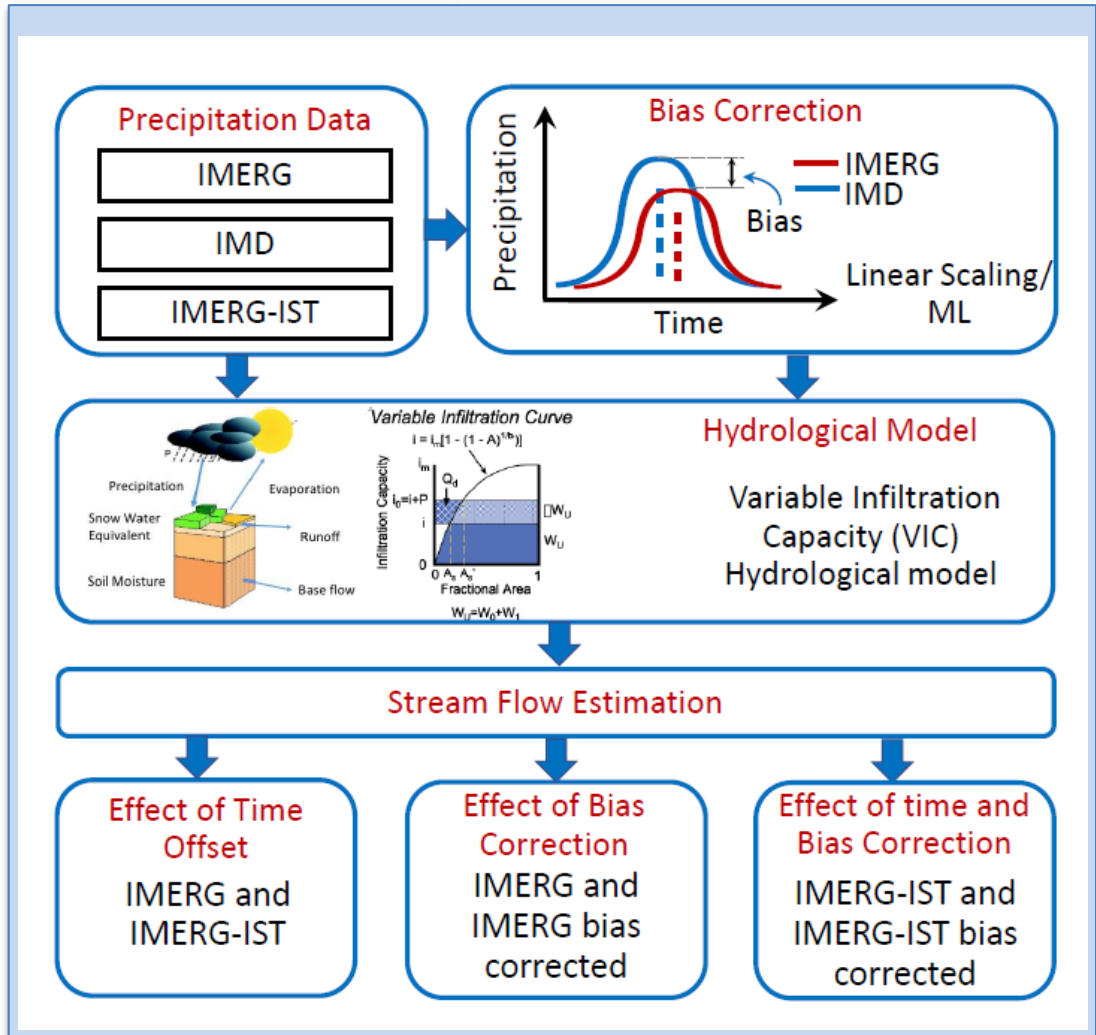
PMM Mentor:
Courtney Schumacher
TAMU College Station

PMM Mentor:
Aaron Funk
TAMU-College Station

Comparing the Performance of IMERG: Implications for Streamflow Simulation

Overview of Project

- The team compared the variation of IMERG HH vs daily to investigate its adequacy on streamflow simulation and quantify the effect of the bias correction in the Western Ghats through machine learning.
- Ongoing work:
  - Compare output of hydrological model with gauged streamflow at daily scale.
  - Test machine learning approach for bias correction.
  - Assess changes in streamflow due to effect of time offset and bias in precipitation estimates.
- The participant plans to continue this effort to use IMERG as input for hydrological modeling research to support water resource management and climate analysis activities.



Methodology of project. Credit: K. Sadwani

2023 Team

PMM Mentor:
Jackson Tan
NASA/UMBC

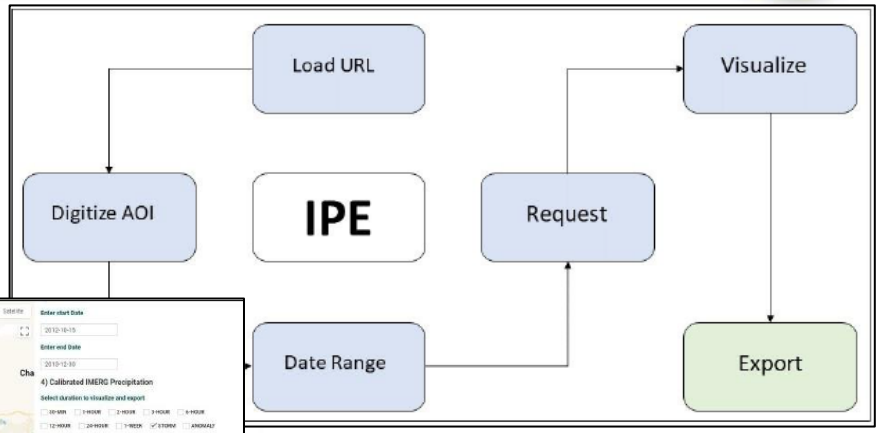
Mentee:
Kashish Sadhwani
Indian Institute of Technology Bombay

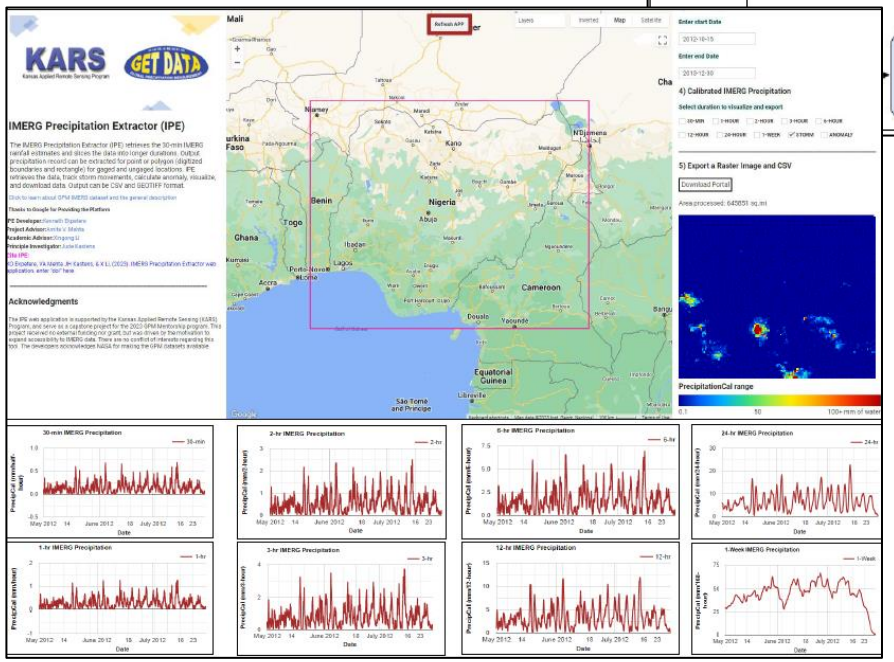
IMERG Precipitation Extractor Tool

Overview of Project

- Users face issues with accessing and processing IMERG data for local analysis and for calculating monthly anomalies.
- To address this issue, the team developed the IMERG Precipitation Extractor (IPE)
  - A tool for rapid extraction, visualization, and downloads of IMERG precipitation data throughout the globe.
- The tools allows users to
  - Extract IMERG time series estimates (short and long intervals)
  - Calculate monthly deviations from annual estimates using IMERG
  - Track storms to see direction of movements and intensities
- This can be especially useful for stakeholders that would like to enhance their data extraction capabilities and model impacts of extreme events.

Btm. left: Method and interface. Right: IPE outputs. Credit: K. Ekpetere.





https://cartoviews.users.earthengine.app/view/ipe

Check out the full results via the Project PPT!

2023 Team

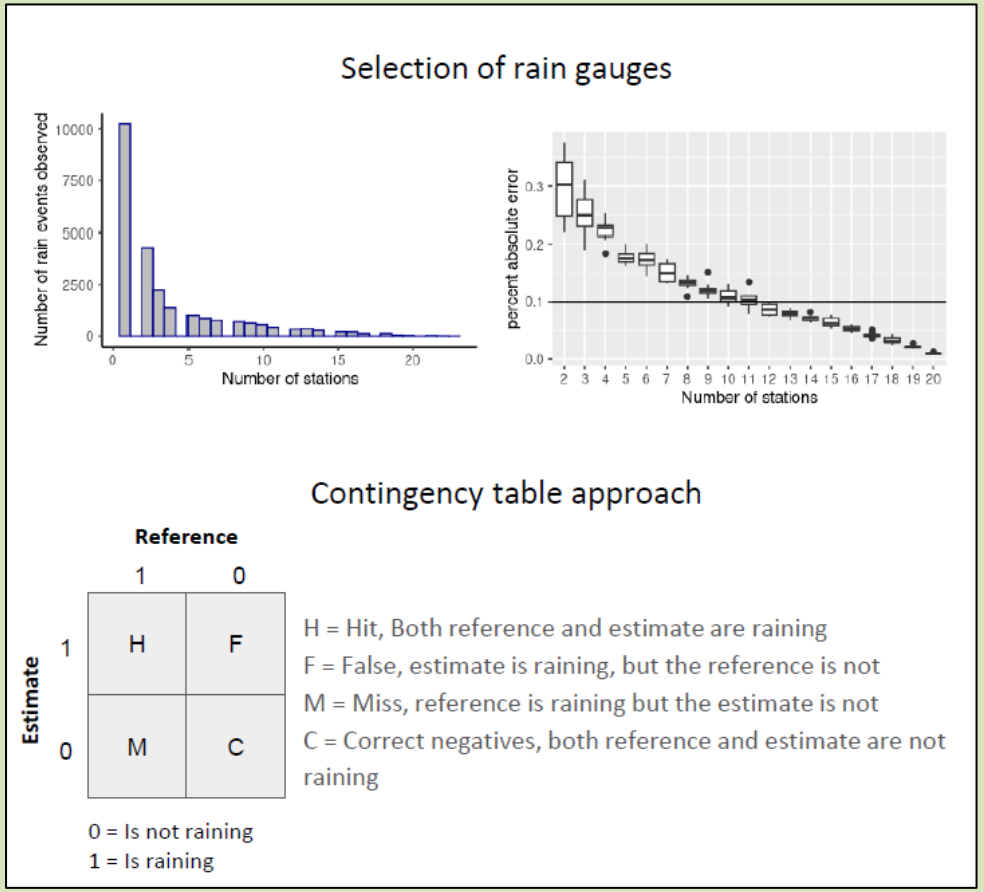
PMM Mentor:
Amita Mehta
NASA/UMBC

Mentee:
Kenneth Ekpetere
University of Kansas

Ground Validation of Hourly IMERG in Brazil

Overview of Project

- The team assessed the performance and reliability of IMERG Late and Final estimates in capturing rainfall events over urban areas in the São Paulo Metropolitan Region (SPMR) using a novel selection of rain gauges managed by CEMADEN.
- IMERG L and F were validated considering contingency table statistics and correlation metrics.
- The project helped form a framework for analyzing CEMADEN database for hourly precipitation and enhance the monitoring networks for flood risk assessment.
- Next steps:
  - Publish findings
  - Expand the study to different scales
  - Test the method to other urban areas
  - Compare rain gauges with estimates from different sensos
  - Test the new Version 7 when released



Top: Screenshot of results and applied methodology. Credit: M. Benso.

2023 Team

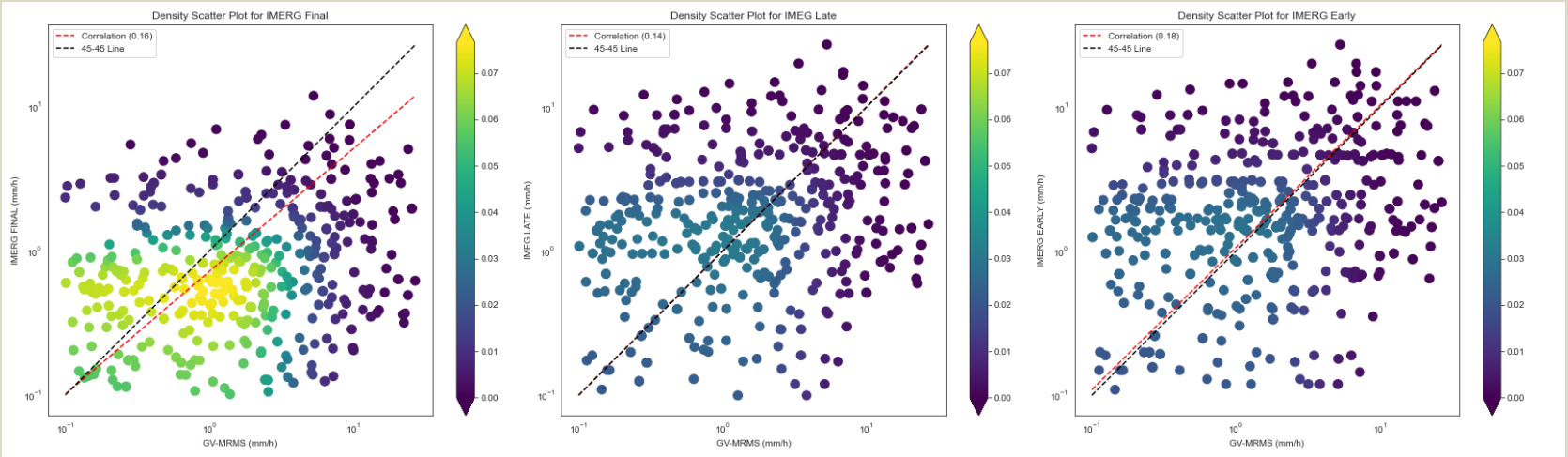
PMM Mentor:
Ali Tokay
NASA/UMBC

Mentee:
Marcos Roberto Benso
University of São Paulo

Analysis of a Flash Flood Event using GPM Data

Overview of Project

- Satellite data products suffer from errors, especially when estimating extreme precipitation.
- This stresses need to validate satellite-based data with ground observation and understand the source of errors.
- The team analyzed one notable flood event that occurred in Death Valley National Park, California on October 18, 2015.
- Project goals:
  - Evaluate IMERG products against GV-MRMS ground data
  - Select IMERG products that could be useful for flash flood events
  - Convey results that can be beneficial to scientific community, national meteorological services, and flood early warning systems.
- Next steps:
  - Conduct work in a wider area with a longer dataset.



Scatter density plot for (L to R) Final, Late and Early against GV-MRMS data . The participant noted that precipitation activities in IMERG-E are observed, particularly in the 0.75 quantile. This quantile closely matches the GV-MRMS. Credit: M. Akin

2023 Team

Mentee:
Melek Akin
Istanbul Technical University

PMM Mentor:
Yagmur Derin
Uni. Of Oklahoma

PMM Mentor:
Pierre Kirstetter
Uni. Of Oklahoma

El Niño and La Niña Events: Comparison of Monthly Precipitation in Peru

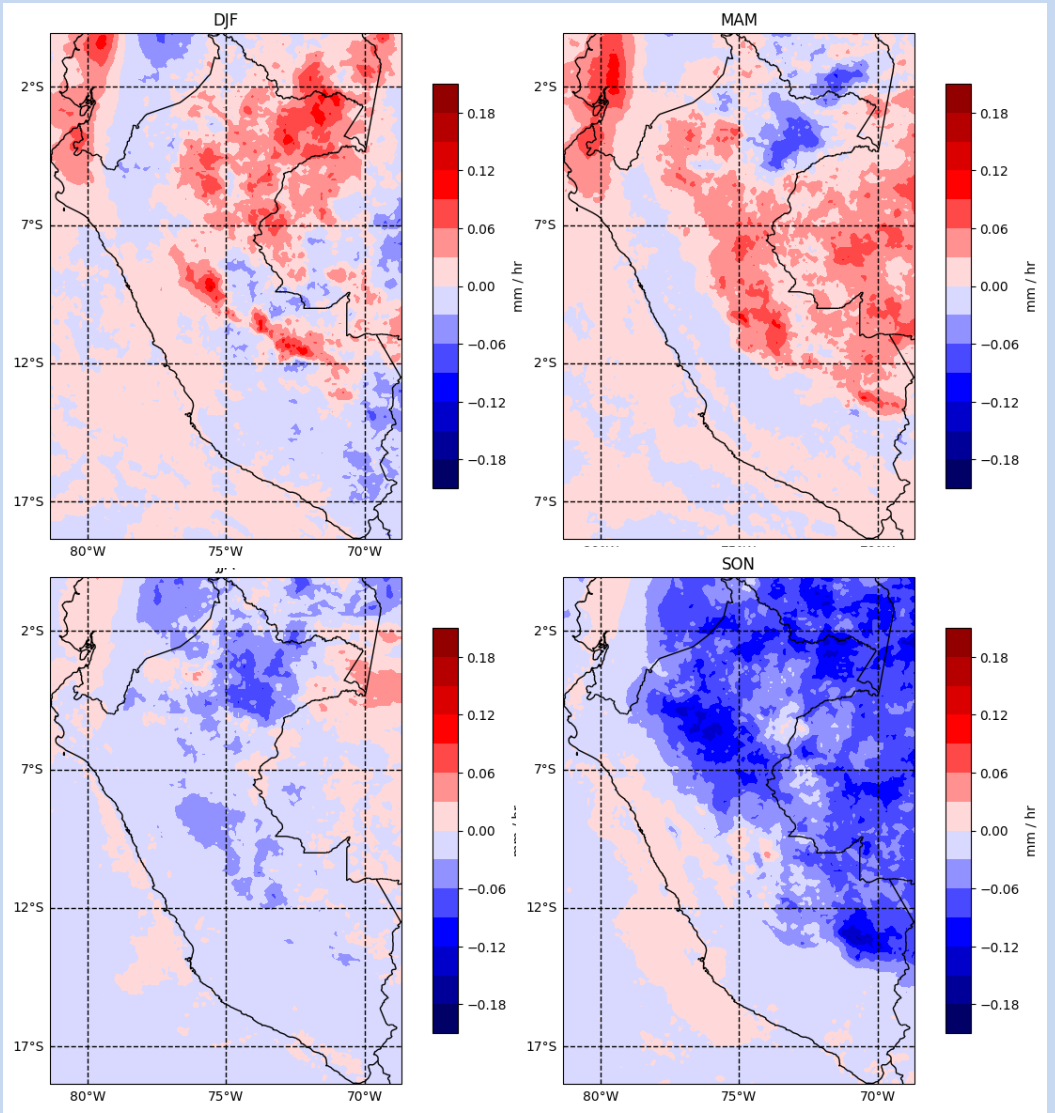
Overview of Project

- Peru is a country directly affected by coastal El Niño and La Niña, causing extreme precipitation and flooding events.
- Working with a mentor, a representative from the Ministry of the Environment of Peru (MINAM) used IMERG monthly data to gain a better understanding of the probability of occurrence and magnitude of precipitation in Peru in the periods of coastal El Niño (and La Niña) during the period 2000-2021.
- Understanding more about these events can help the government to mitigate the effects of El Niño and La Niña in Peru.

2023 Team

PMM Mentor:
Andrey Savtchenko
NASA/GES DISC

Mentee:
Rogelio Campos
MINAM



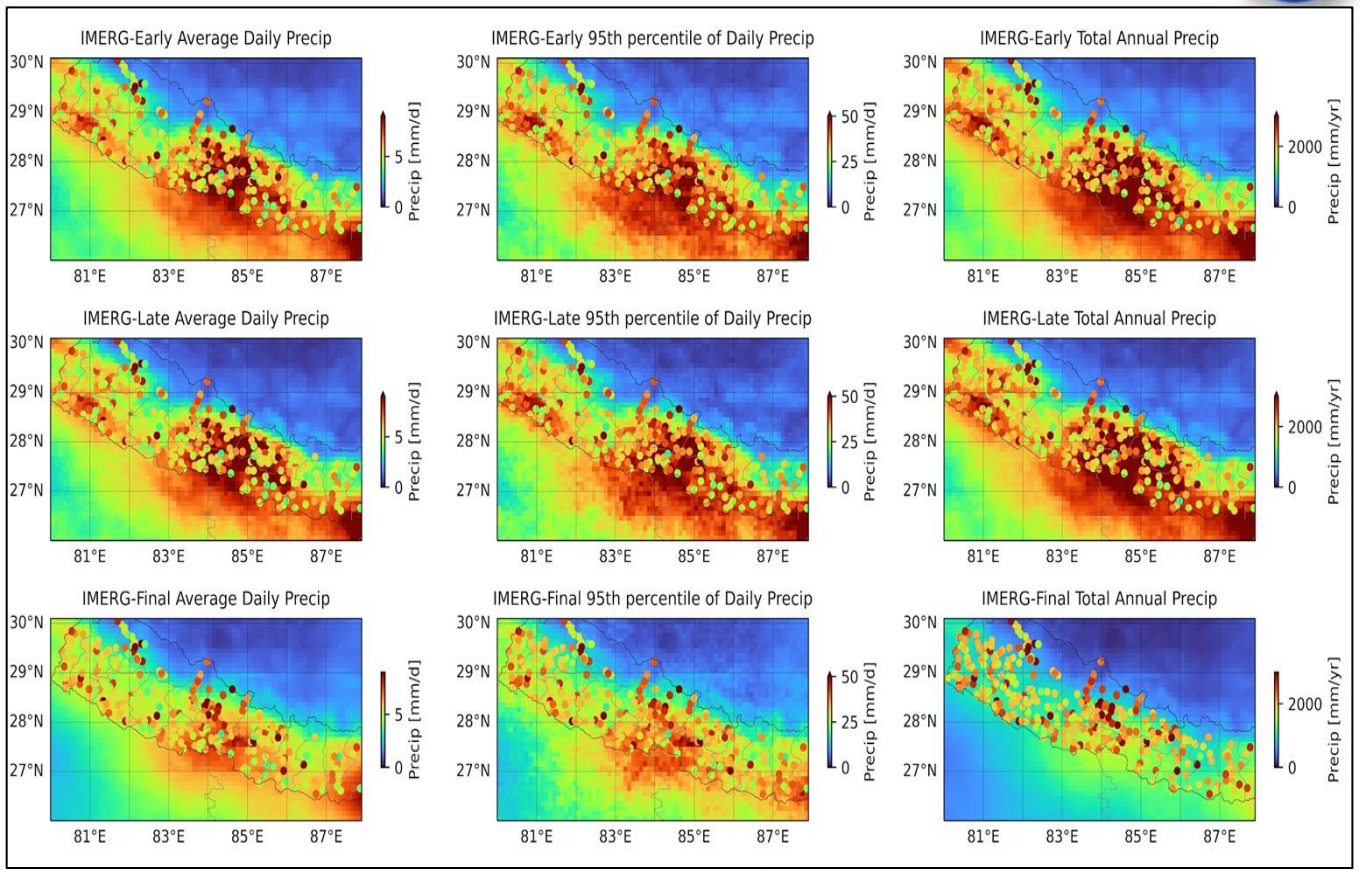
Results from project- Subtraction of El Niño and La Niña average monthly precipitation for 2000-2021 (mm/hr), by season. Credit: R. Campos.

GLOBAL PRECIPITATION MEASUREMENT

Investigating the Application of IMERG in Ungauged Regions in Nepal

Overview of Project

- Gauge data is limited in mountainous regions of Nepal, creating a need for satellite precipitation data.
- Working with mentors, a representative from Nepal's Department of Hydrology and Meteorology (DHM) evaluated IMERG Early, Late, and Final products to understand which product is most suitable for precipitation estimates in high elevation, ungauged regions of Nepal.
- Previous research projects compare a single version of IMERG to gauge data in Nepal, but they do not compare accuracy of multiple IMERG products.
- The goal of these efforts are to determine whether IMERG can fulfill the region's need for precipitation data and help improve weather forecasts.
- Results will help DHM:
    1) Understand climatology and current precipitation in ungauged regions.
    2) Increase trust that the best product is being used.



Precipitation statistics (average daily precip, 95th percentile of precip, and average annual precip) for IMERG E, L, F (top to bottom). Note the high spatial variability among gauge stations that IMERG is unable to capture. Credit: R. Lamichhane.

2023 Team

Mentee:
Rojan Lamichhane
Nepal DHM

PMM Mentor:
Ankita Pradhan
University of Wisconsin-Madison

PMM Mentor:
Sam Hartke
NCAR

Evaluation of IMERG for Drought Classification

Overview of Project

- Argentina's economy is mainly based on the export of raw materials such as meat, corn and soybeans.
- This stresses the need for both local and national governments and producers to classify the magnitude of drought.
- The team explored the suitability of IMERG throughout the Pampas region of Argentina to classify drought conditions through the computation of the Standardized Precipitation Index (SPI).
  - This will help support local and national government initiatives for early drought warning systems.
- Results indicate that as IMERG database grows, thus reducing the sampling error, the reliability of the IMERG based drought classification will increase.

CLASSIFIED AS DROUGHT BY GPM-IMERG	CLASSIFIED AS DROUGHT BY IN-SITU DATA: YES	NO	TOTAL
YES	16	12	28
NO	13	132	145
TOTAL	29	144	173

POD (Probability of Detection) = 55.2%

FAR (False Alarm Ratio) = 42.9%

Using IMERG daily for the 2000 to 2020 years a gamma probability distribution function was fitted against monthly accumulated precipitation for six locations where in situ data is available in the most fertile region of Argentina. Above show results for detecting drought. Credit: S. Villar.

2023 Team

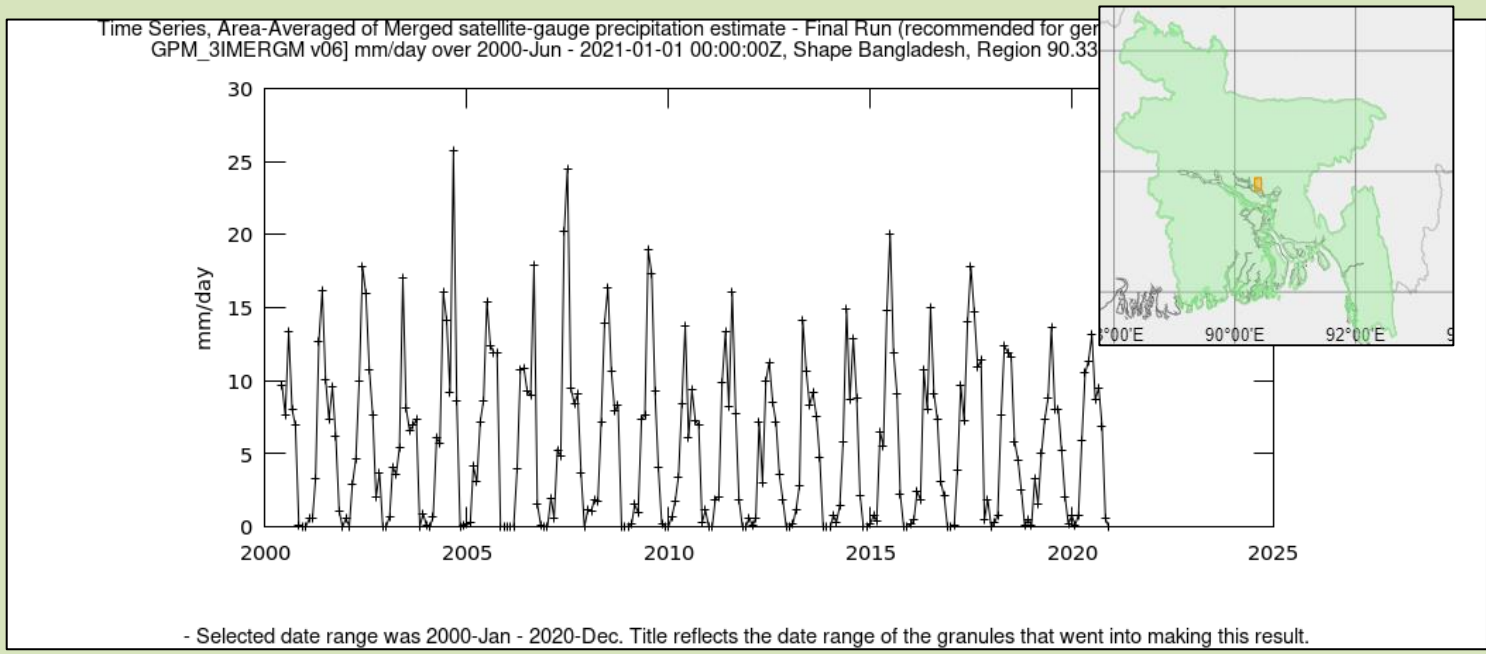
PMM Mentor:
Marcelo Uriburu Quirno
CONAE

Mentee:
Santiago Villar
U. Of Buenos Aires

Understanding Data Access Tools to Assess Urban Flooding Events

Overview of Project

- To examine scenarios of urban flooding caused by climate factors in Dhaka, India, the participant explored the use of IMERG to gain a deeper understanding of long-term precipitation patterns and potential impacts on the local ecosystem and human activities.
- The participant was introduced with data access tools across the GPM webpage and GES DISC sites, including Giovanni.
- Next Steps:
  - Analyze extreme events using IMERG
  - Calculate event frequency and duration
  - Explore temporal patterns through time series plots
  - Assess interannual variability
  - Detect trends using statistical methods
- Results will be able to demonstrate an urgent need to plan and manage development in a way that preserves and enhances hydrological connectivity.



Monthly Average Precipitation calculation from 2000 to 2020 using IMERG in Dhaka. Map highlights designated area of interest. Credit: Zahrun Zannut (Bangladesh University)

2023 Team

Mentee:
Zahrun Zannut
Bangladesh University

PMM Mentors:

Vasco Mantas, U. of Coimbra
Zhong Liu, NASA/MSU
Mircea Grecu, NASA/ MSU
Andrea Portier, NASA/SSAI

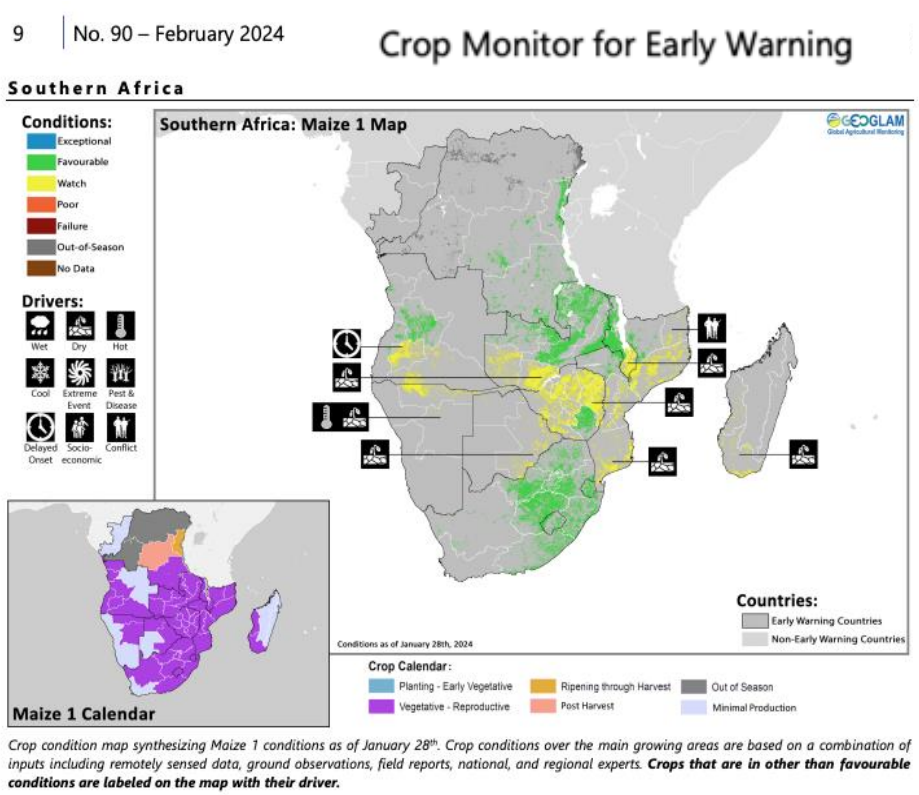
GPM/IMERG for Food and Water Security Applications

Earth Action Solutions for impact

feedback

Earth Science & Applications incubation

Earth Observations & Infrastructure



Crop condition map synthesizing Maize 1 conditions as of January 28th. Crop conditions over the main growing areas are based on a combination of inputs including remotely sensed data, ground observations, field reports, national, and regional experts. ***Crops that are in other than favourable conditions are labeled on the map with their driver.***

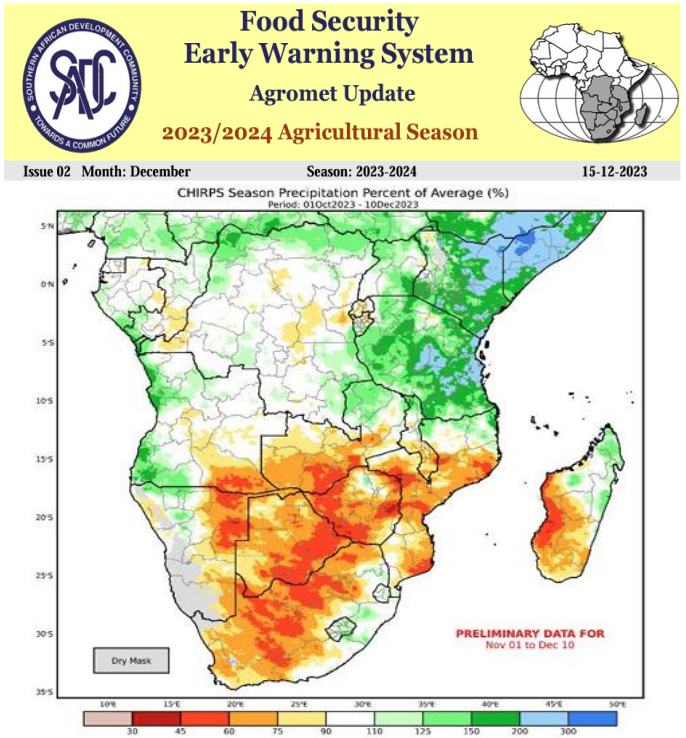


Figure 1. Cumulative rainfall during the October 1-December 10, 2023, period shown as a percent of the 40-year average. Source: UCSB CHC

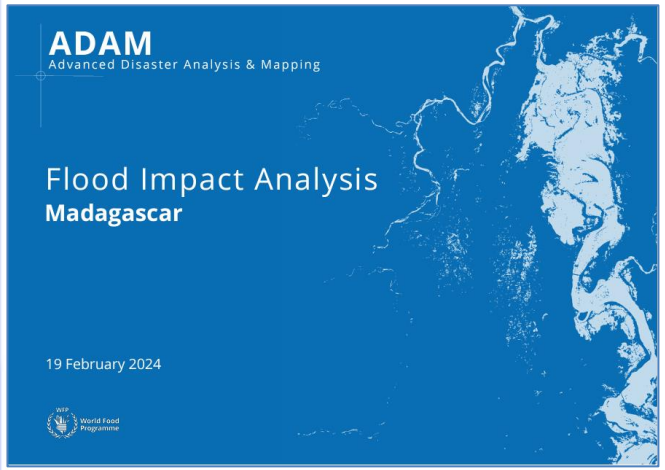
CHIRPS is input to Agricultural and Food Security Early Warning products used for humanitarian response.

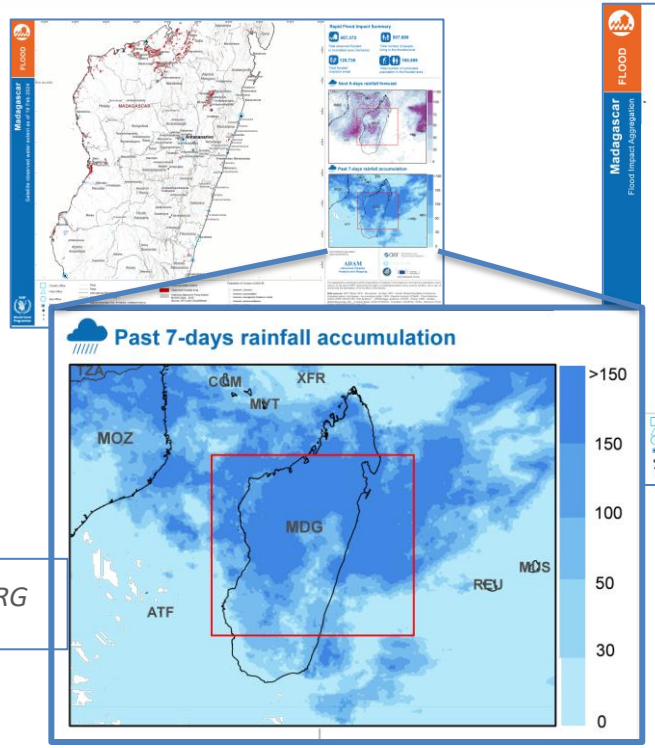
CHIRPS is widely used with 7K+ IP addresses in 3-months alone!

IMERG is input to CHIRPS and CHIMES precipitation, and the FEWS NET Land Data Assimilation System hydrology products, developed for agricultural monitoring in data sparse regions.

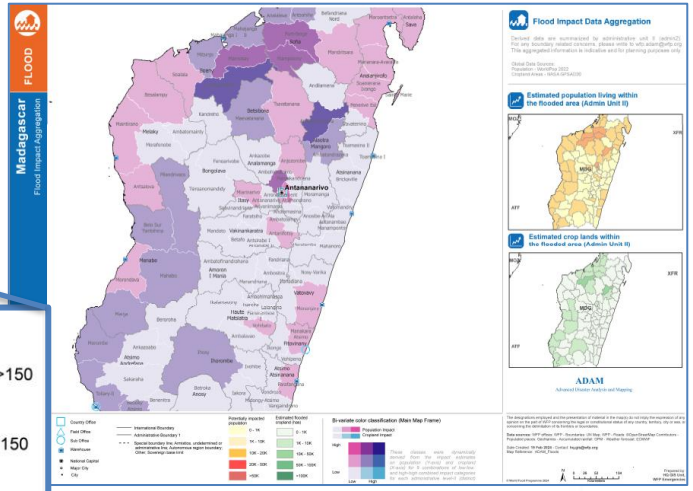
TRMM, GPM, GOES-IR, AOS; GPROF, GPI, IMERG; NASA LIS, NCCS, PPS, GES DISC

GPM IMERG Supports Flood Impact Analysis for Disaster Response Applications





GPM IMERG



Learn more at: https://arcg.is/1H1KKr

ADAM Floods is fully operational both for early warning and response. ADAM Floods is designed to be the very first analysis to become available for humanitarian organization and governments to assist in initial planning.

ADAM Floods Impact Analysis Report → 72 hours after flooding → Automated reports and analysis based on satellite observations

Earth Action

Earth Observations & Infrastructure

- World Food Programme's Advanced Disaster Analysis and Mapping (ADAM) is an operational system for collecting, analyzing and mapping geospatial and socio-economic information following sudden onset humanitarian emergencies.
- **IMERG, 7-day accumulation estimates,** is used by ADAM Floods part of their Flood Impact Analysis reports to communicate the magnitude of a flooding event to enable rapid humanitarian response.

GLOBAL PRECIPITATION MEASUREMENT

GPM IMERG Enables FloodMapp's Forecast Product

FloodMapp is a technology company that specializes in rapid real-time flood forecasting and flood inundation mapping to provide greater warning time and situational awareness.

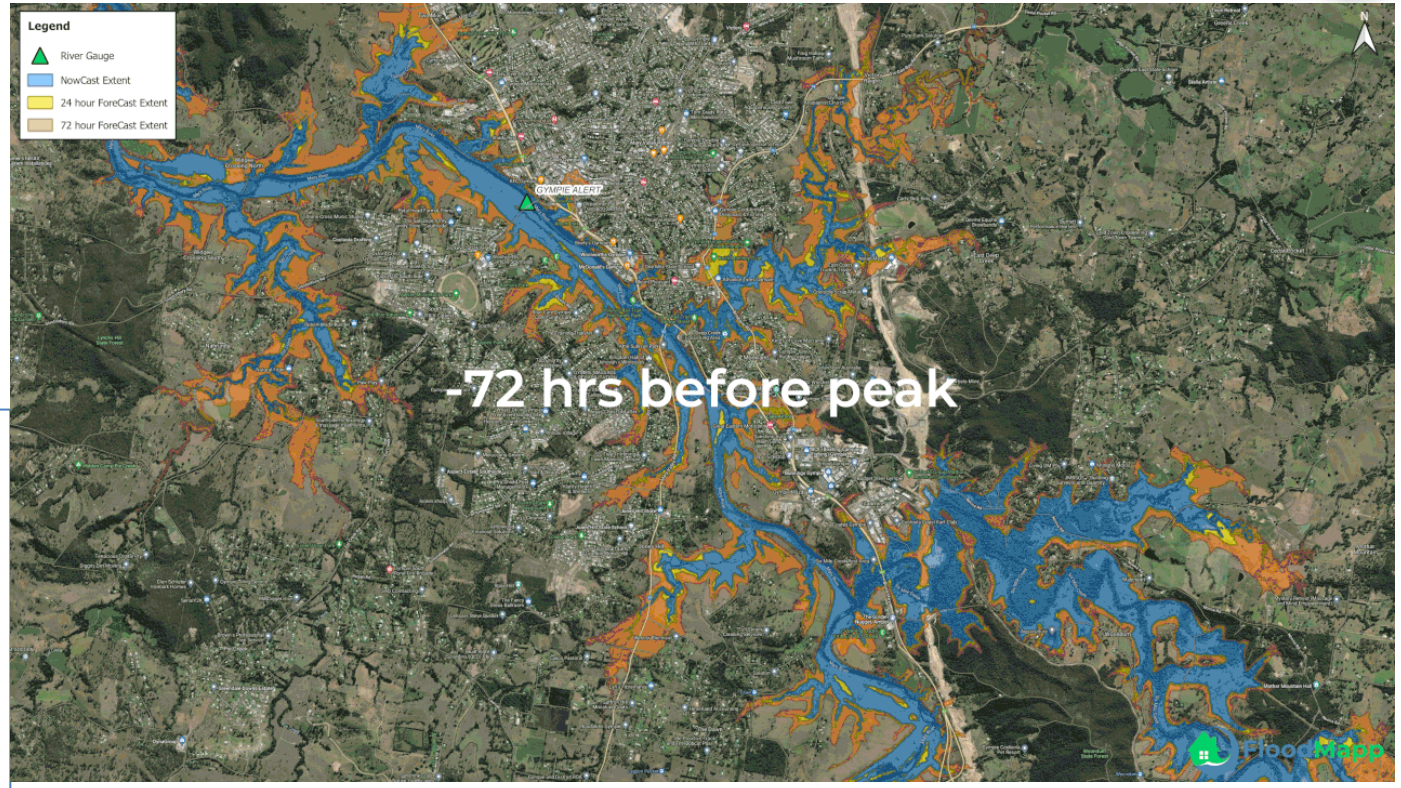


Figure: *FloodMapp ForeCast product (which is enabled by IMERG precipitation data) alongside the NowCast (real-time flood extents) and PostCast (historic extents) layers.*

*** ForeCast is currently available across the contiguous US and all of Australia.*

GPM Infrastructure

- IMERG Early, Late and Final products used for operational use and validation.
- Used as input into FloodMapp's hydrology model to produce water levels.

Application Solutions

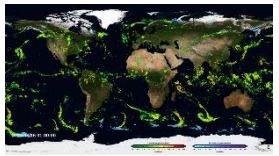
- Results help derive boundary conditions required to calculate flood extent within **FloodMapp ForeCast product** over short time horizons **(from 6 hours up 72 hours).**

Public Soceital Benefits

- Forecasts utilized by government, private sector, and emergency managers to prevent loss of live, assess damage/ risks, and coordinate evacuations from expected flood impact zones.

GLOBAL PRECIPITATION MEASUREMENT

Argentina's Space Agency Leverages NASA GPM Data for Hydrological Ops



GPM IMERG Late Daily accumulative rainfall

Helps compute

Gridded, daily Antecedent Precipitation Index (API)

as proxy for soil moisture

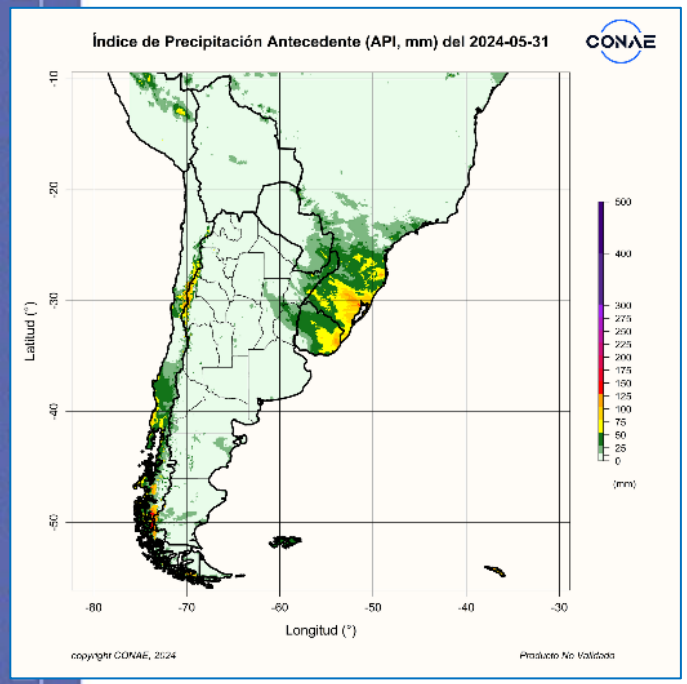
Creates derived products

Land Hydrological Status product

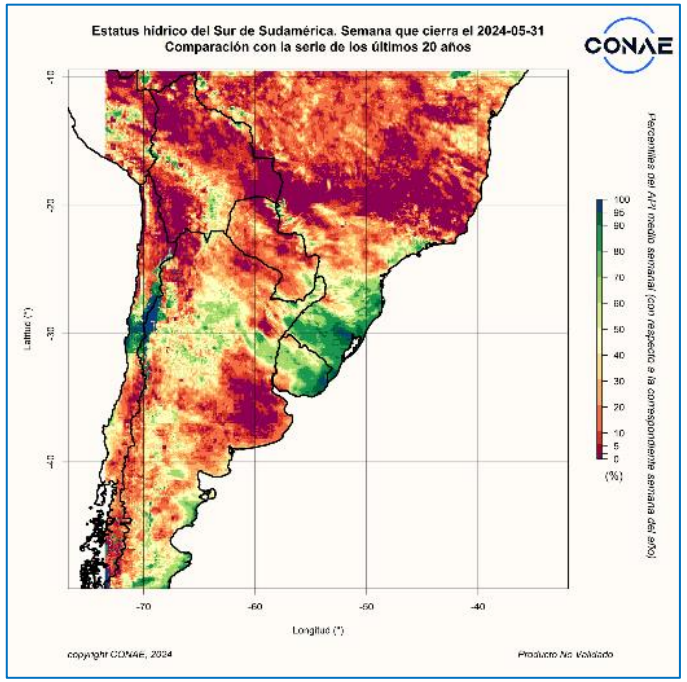
Dynamic Curve Number product

Hydrological information to support agricultural and water resource sectors

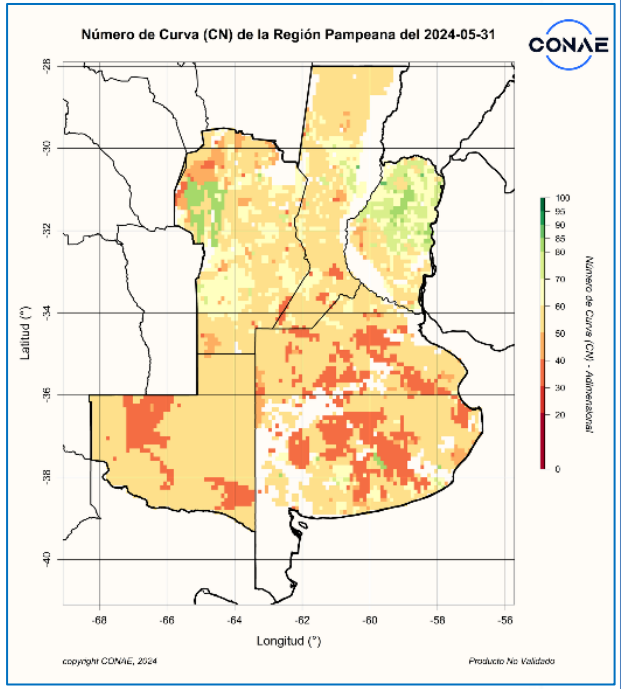
GPM Infrastructure — **Application Solutions** — **Public Societal Benefits**



Daily API



Hydrological status (Percentiles of weekly API)



Dynamic Curve Number

Comisión Nacional de Actividades Espaciales (CONAE) data products, supported by GPM IMERG, are made available to the public through CONAE's freely accessible, geo-portal.

****The agricultural community makes up the largest number of users. The geographical coverage includes almost all of southern South America.***

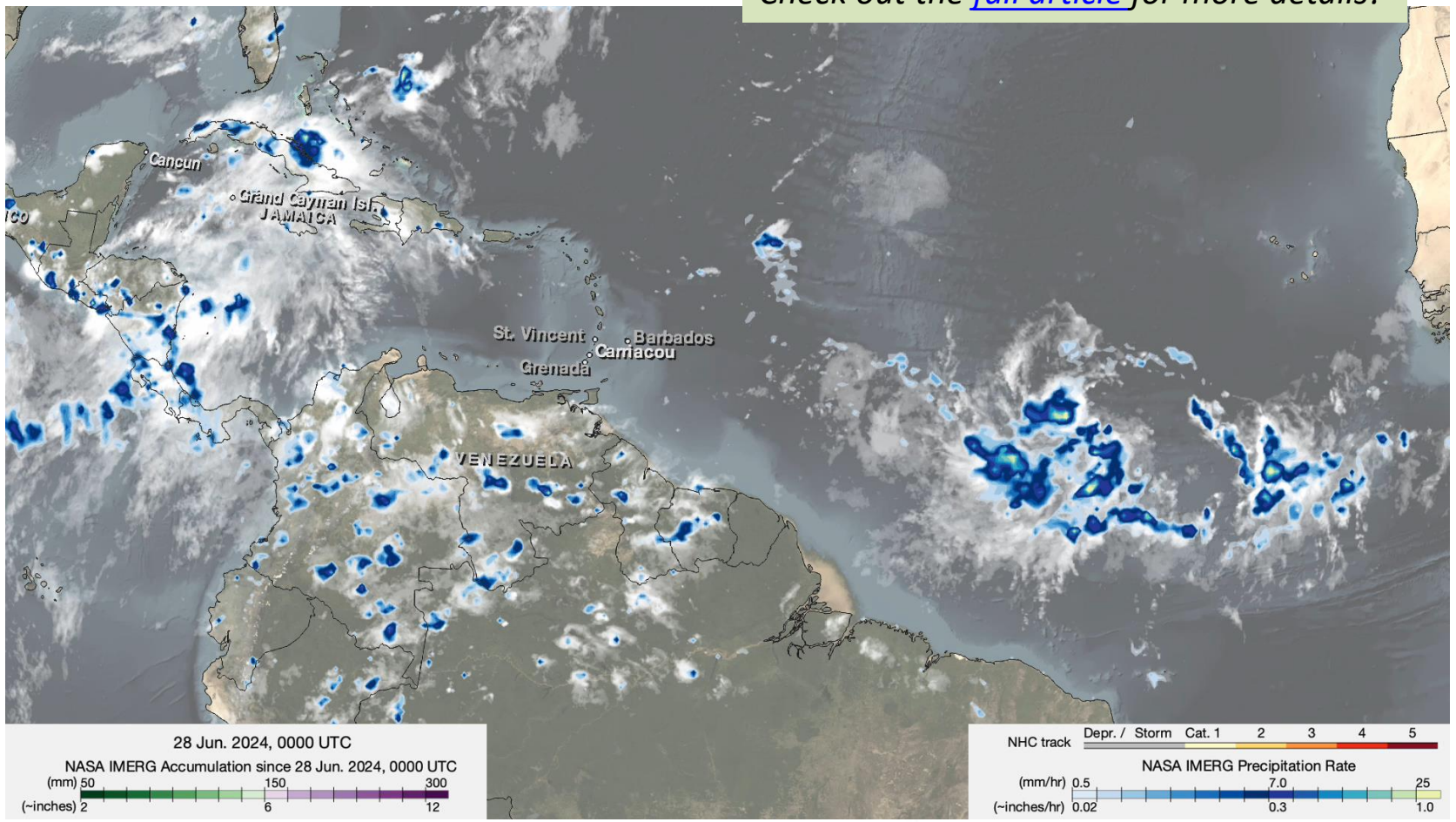
GPM Captures First Major 2024 Atlantic Hurricane

Hurricane Beryl becomes earliest Category 5 storm and strongest and easternmost forming June hurricane on record in the Atlantic

Check out the full article for more details!

How GPM Helps:

- GPM's IMERG product captured the full evolution of the storm from the African Easterly Wave to its development into a Cat 5 storm.
- Beryl made landfall over the Windward Islands, Yucatan, and Texas.
- IMERG shows that the heaviest total rainfall amounts along Beryl's path are over the western Atlantic and eastern Caribbean when Beryl was a major hurricane.
- Beryl caused widespread flooding and building, roof, tree, and electrical damage



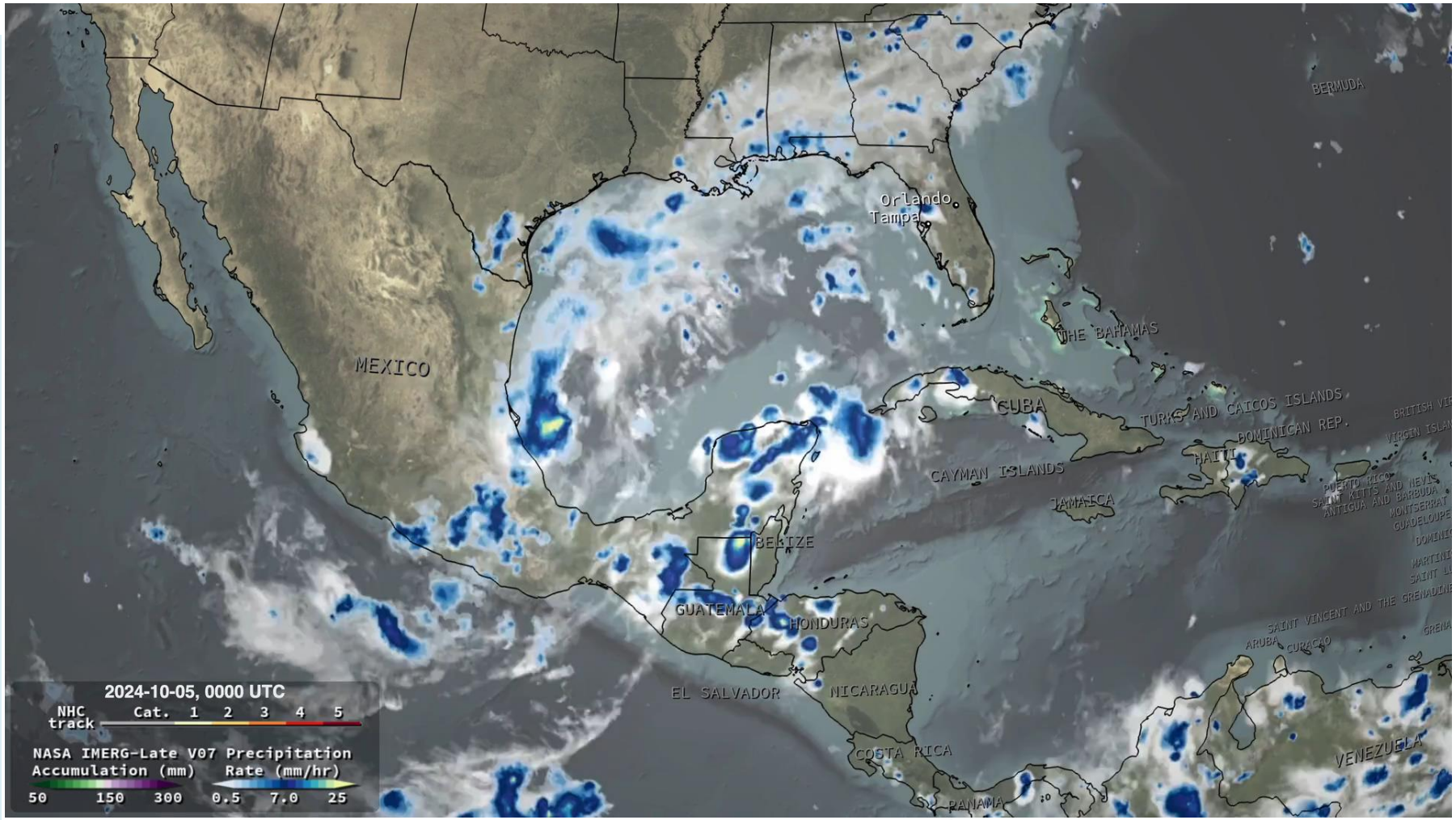
This animation shows surface rainfall estimates from NASA's IMERG precipitation product associated with Beryl from its formation in the central Atlantic, across the Caribbean and Yucatan, and over the western Gulf of Mexico and into Texas.

Credits: Animation by Jason West (NASA GSFC, PPS, KBR)

Tracking the Extremely Powerful Hurricane Milton and Rainfall Amounts

- GPM'S IMERG product helped capture the evolution of precipitation along Milton's track from development through landfall from Oct 5-10, 2024.
- **What did IMERG uncover**:
  - Identified a predecessor-like rain event to Milton delivering heavy rainfall (>6in.) across central and southern Florida from Oct 5-9.
  - As Milton passed over Florida, accumulations north of the Tampa-Orlando corridor would exceed 10in. in some locations (dark purple colors).

**The NWS estimated similar totals from rain gauges in the area, with some isolated gauges reporting totals >12 in.*



The animation shows IMERG precipitation rates (blue/yellow) and accumulations (green/purple) from Oct. 5-10, 2024. Cloudiness shown in white/gray using infrared geosynchronous satellite data. The animation pauses at Oct 9, 0000 UTC (Oct. 8, 8:00pm ET) to show that accumulations over southern Florida from this rain event had already exceeded 6 inches in some areas (light purple colors) - totals which were confirmed by NOAA ground radar observations. *Animation by Jason West (NASA GSFC, PPS, KBR)*

Check out the IMERG article for more details!

Hurricane Helene Makes Landfall in the Florida Big Bend

Hurricane Helene made landfall on Florida's northwest coast late September 26th , 2024 as a Category 4 hurricane.

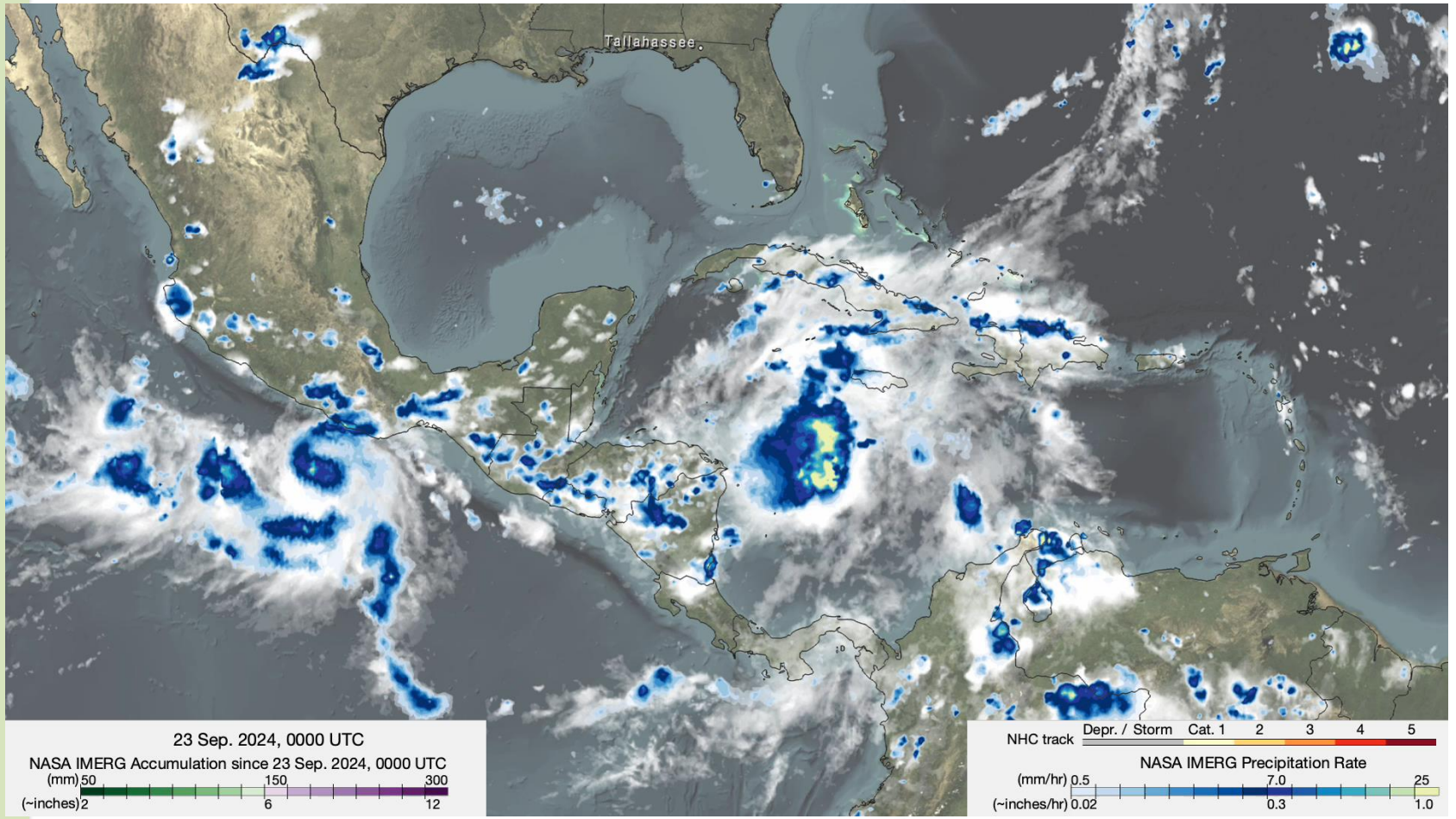
Check out the full article for more details!

How GPM Helps:

- GPM's IMERG product helps capture the evolution of the storm, from its development in the far NW Caribbean to making landfall in NW Florida.
- IMERG provides surface rainfall estimates associated with Helene, showing heavy rains (6 to 12 inches) over the NW Caribbean and Florida panhandle as well as over northern Georgia and the southern Appalachians.

Remnants from Helene will continue to pose a flooding threat over the next few days.

**Locally higher amounts on the order of 16 inches or more have been reported over parts of the Florida panhandle and southern Appalachians.*



This animation shows surface rainfall estimates from NASA's IMERG precipitation product associated with Helene from its formation in the NW Caribbean, traveling north in the Gulf of Mexico, and making landfall in Florida.

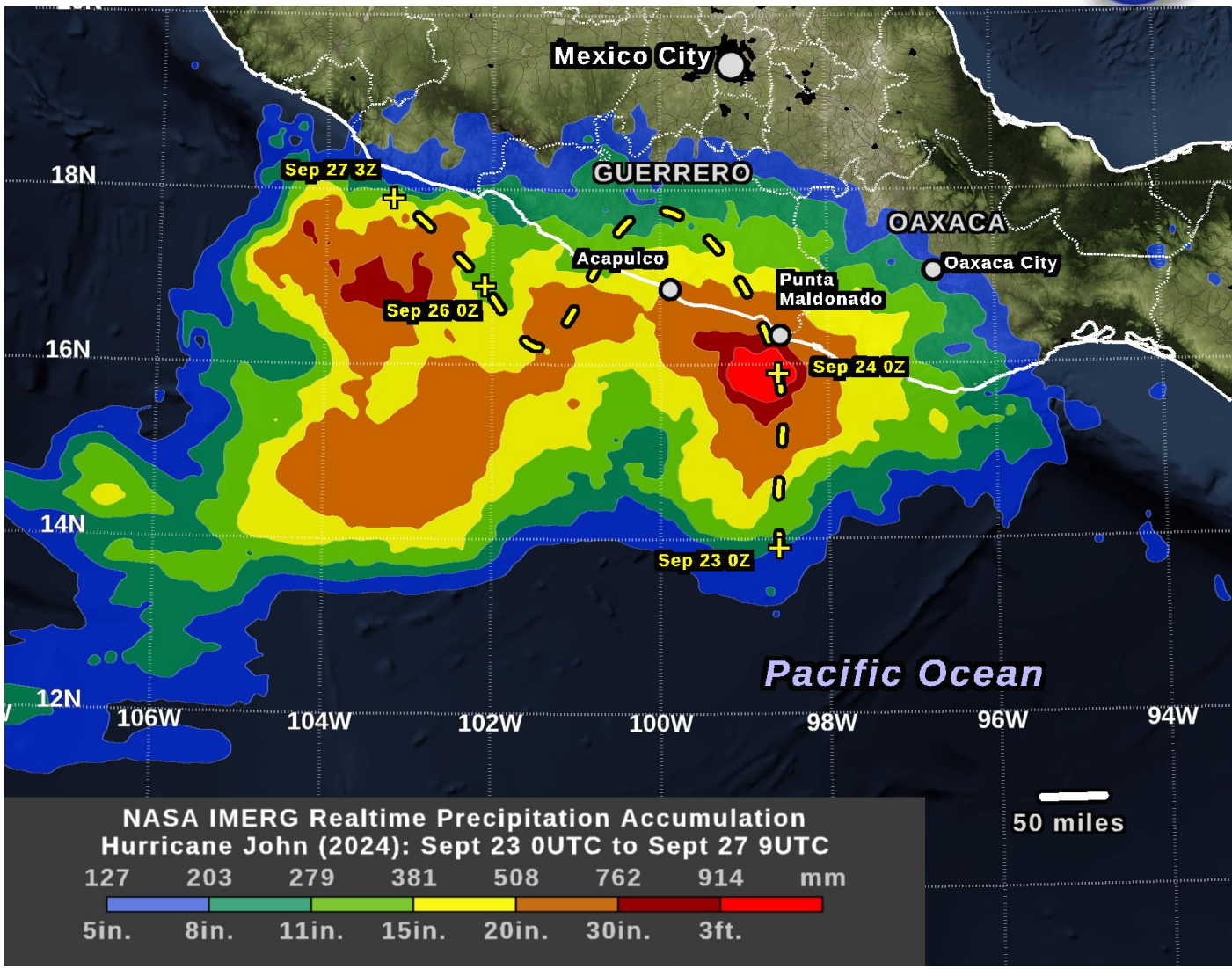
Credits: Animation by Jason West (NASA GSFC, PPS, KBR)

GLOBAL PRECIPITATION MEASUREMENT

GPM's IMERG reveals information about Hurricane John

How GPM Helps:

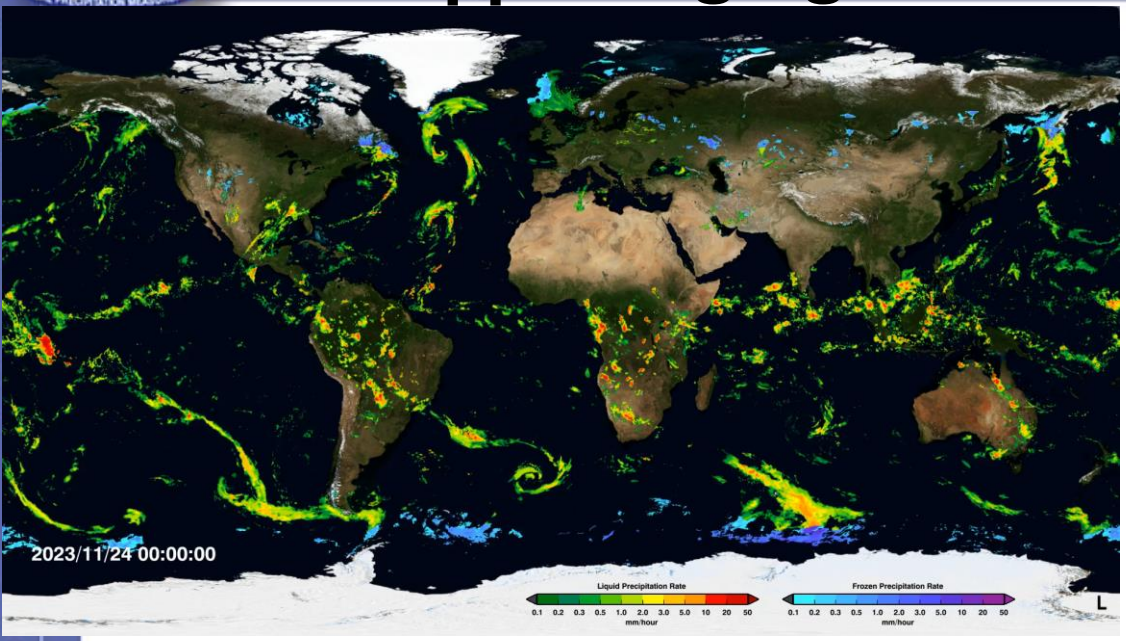
- Late Sept. 23, 2024, an unusual hurricane struck southern Mexico, dumping 20 inches of rainfall along the coast according to estimates from NASA's IMERG precipitation product.
- In the rural area of SW Mexico where Hurricane John struck, IMERG was particularly valuable for understanding the storm as it unfolded due the limited rain gauge network that provides public data in real-time.
- IMERG estimates indicate from 5 (blue) to 36 inches (bright red) of rainfall fell during a four-and-a-half-day period.



Surface rainfall estimates from NASA's IMERG precipitation product associated with John. Image by Owen Kelley (NASA PPS and GMU).

Check out the Hurricane John full article for more details!

Supporting Agriculture with GPM's Multi-satellite Product



IMERG:

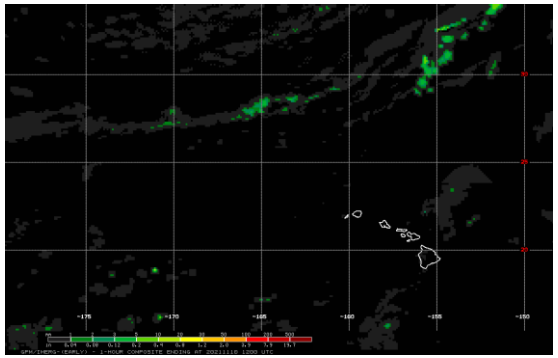
- Surface precipitation, globally at 0.1°
- Every half-hour beginning in June 2000
- IMERG has three runs
- V07 enhancements**

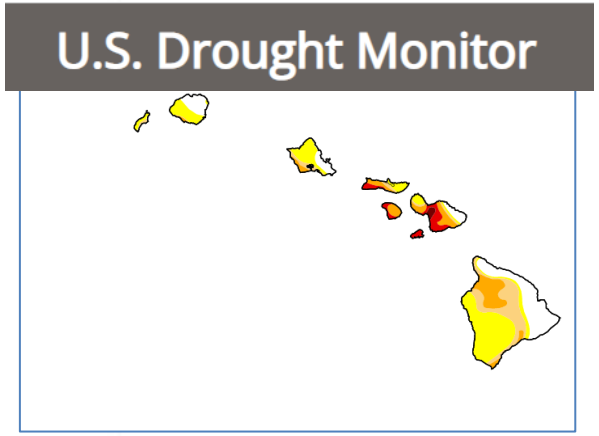
Near-real-time data is important for application and operational users.

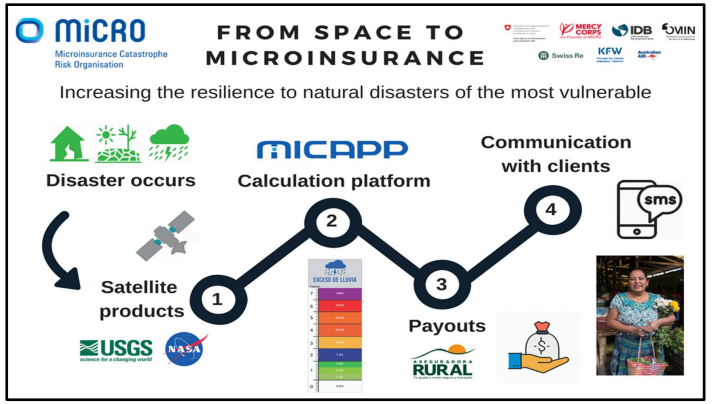
More accurate data available later for research.

Use Cases: User Engagement

Hawaii US Drought Monitor Report: using IMERG accumulations

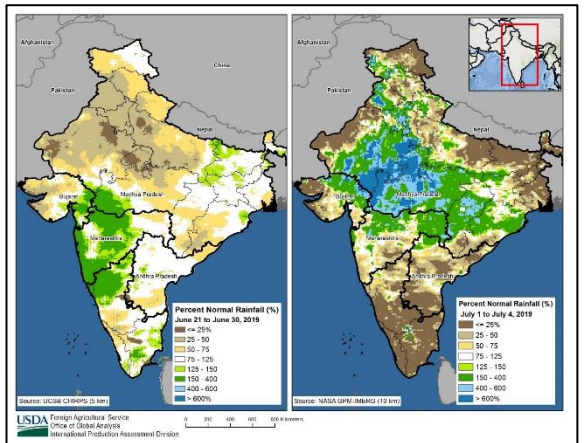






Insurance/ MiCRO:
Define extreme precipitation thresholds using IMERG (Early, Late, Final) for index-based insurance products and trigger policy payouts

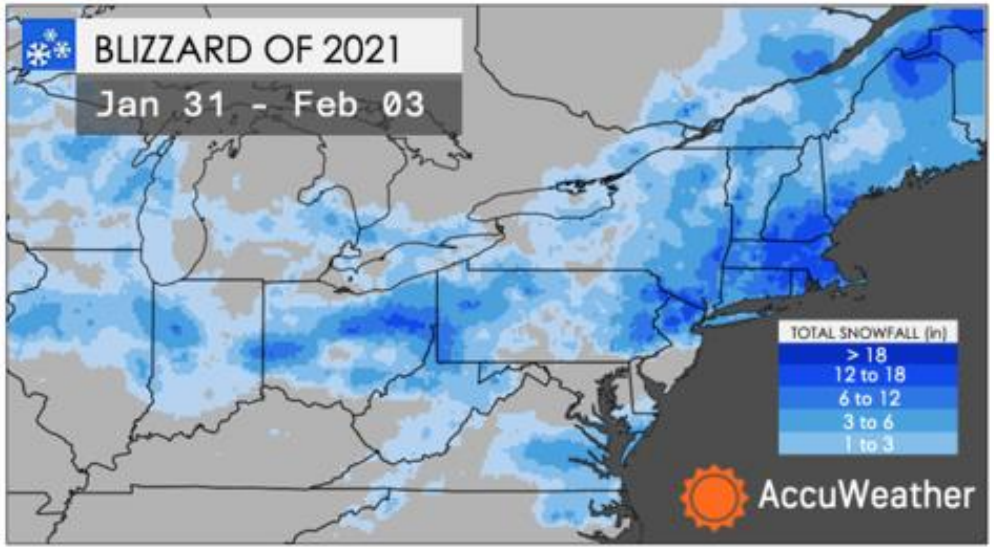
USDA FAS:
Integration of IMERG (Early, Late) for validation to estimate growing season onset, crop productivity and other variables.



GPM IMERG Supports the AccuWeather Data Suite

The AccuWeather Data Suite is a global collection of weather data, providing a set of past, current, and forecast weather data to support data-driven weather decisions by businesses and organizations

Figure: *AccuWeather historical data is used to study extreme events like the January-February 2021 blizzard in Northeast U.S. AccuWeather's historical data showed the total snow being up to 2 ft during January 31- February 3, 2021.*



"We prioritize utilizing sources that offer long-term and consistent monitoring, low latency, and high spatial resolution to minimize gap information, and ensure access to the most current information which is critical for our users to optimize businesses operations."

-AccuWeather

GPM Infrastructure

- GPM IMERG Late and Final products are integrated within AccuWeather's reanalysis model to create the most reliable weather historical data.

Application Solutions

- The historical data includes over 100 parameters at both hourly and daily time-scales, covering more than 30 years of global data. This includes parameters such as **total precipitation, type of precipitation, precipitation intensity, total snow, snow liquid ratio, and RealFeel® Temperature**.

Public Soceital Benefits

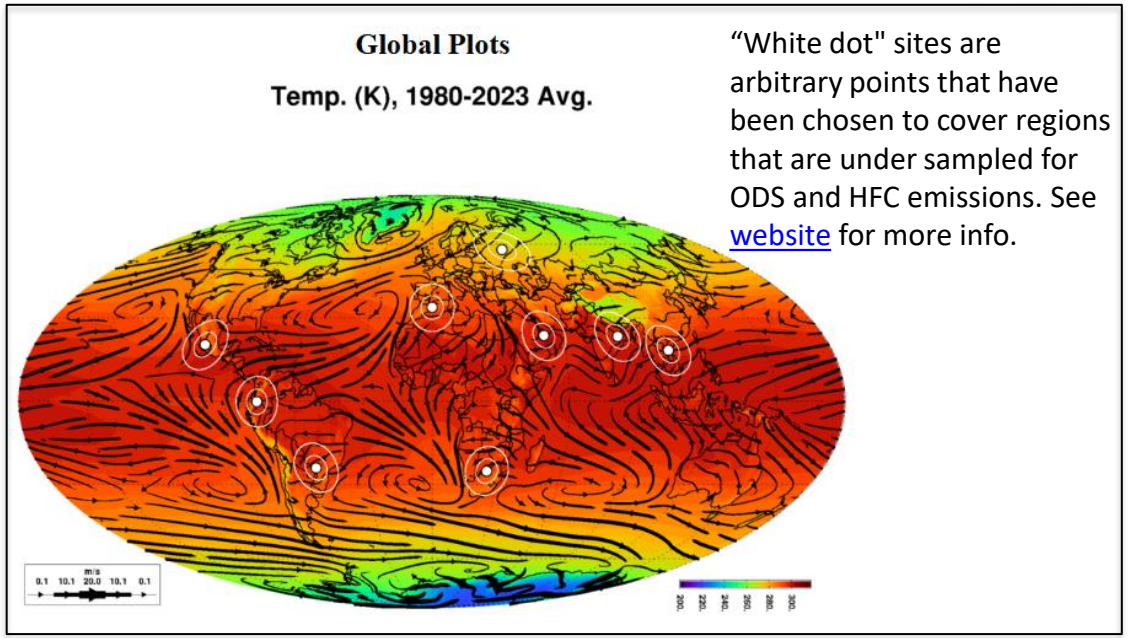
- By leveraging the AccuWeather Data Suite, companies and organizations can optimize their business operations by ensuring employee safety, protecting assets, increasing revenue, reducing expenses, and minimizing business disruptions.

GLOBAL PRECIPITATION MEASUREMENT

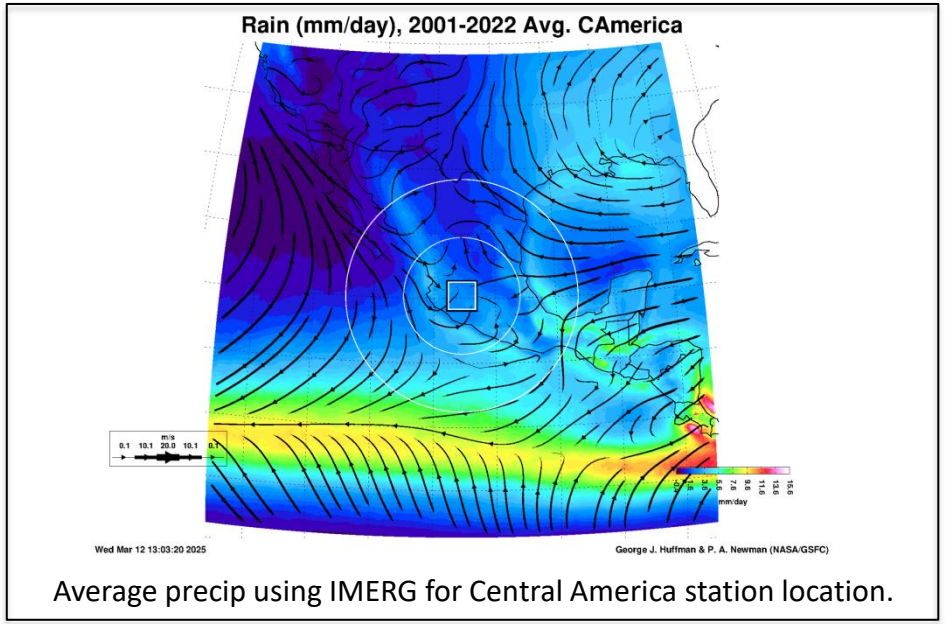
Supporting the Montreal Protocol: Using IMERG to Identify Ground Station Locations

Overview

- **Montreal Protocol:** an international agreement that controls the production and consumption of ozone-depleting substances (ODS) and fluorinated climate gases such as hydrofluorocarbons (HFCs).
- A combination of ground-based and satellite measurements helps monitor ODS, but **ground-based station observations provide information that ensures compliance with the Protocol on regional scales.**
- **There is a need to Identify ground station locations that are suitable to monitor unsampled areas of ODS and HFC emissions to ensure compliance with production and consumption controls**



"White dot" sites are arbitrary points that have been chosen to cover regions that are under sampled for ODS and HFC emissions. See website for more info.



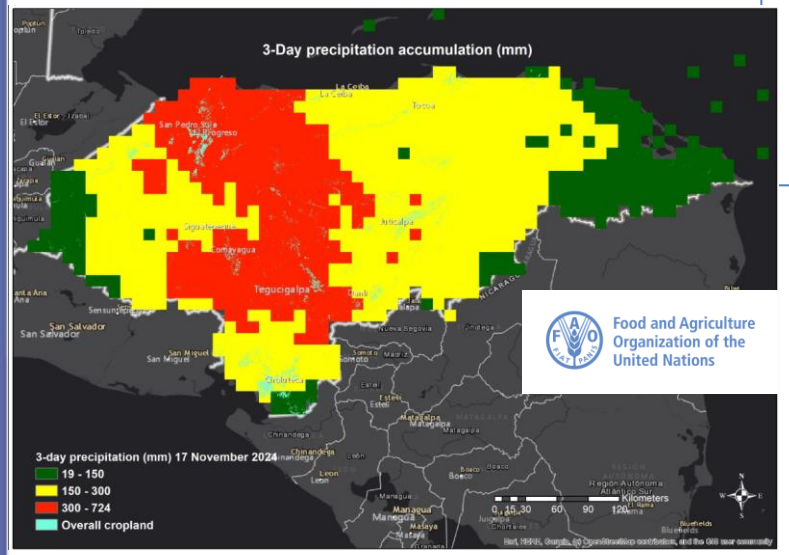
Average precip using IMERG for Central America station location.

NASA Support and Infrastructure

- **GPM IMERG V07B Final Run** along with other NASA datasets are used to make broad climatological assessments **to identify best locations to install ground stations.**
- Led within Goddard's Atmospheric Chemistry and Dynamics Laboratory, **a website was developed to help evaluate and position new station locations**.
- **Researchers use the website to analyze regional data and** propose strategic ground stations **for diplomatic meetings in support of Montreal Protocol agreement.**

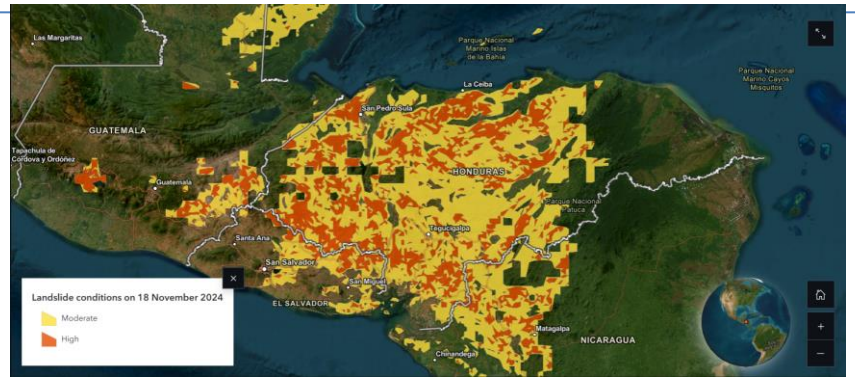
UN Food and Agriculture Organization (FAO) using GPM-based Data and Tools

FAO's mission is to reduce poverty and end hunger and malnutrition worldwide.

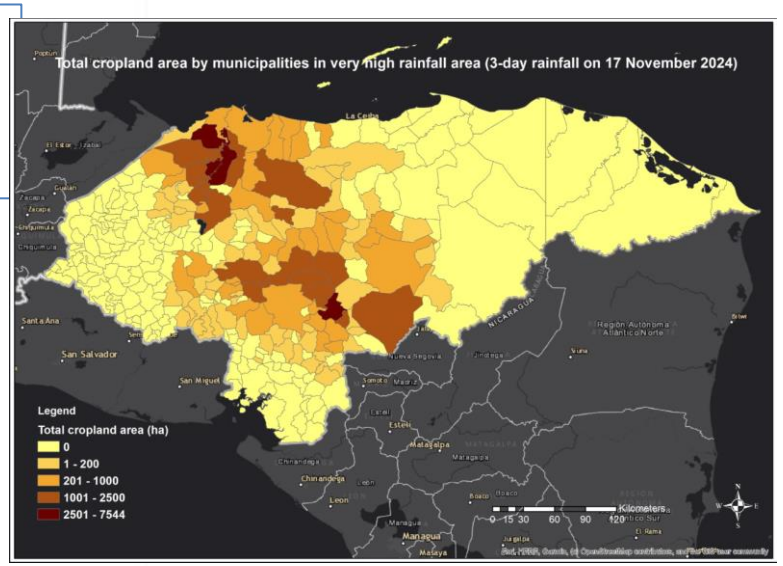


IMERG 3-day accumulated rainfall data 17 Nov 2024. The threshold was set at 100 mm per day and anything over this threshold was considered intense rainfall.

Tropical Cyclone SARA-24, Honduras 2024:
Assessing impact of Sara on agriculture and livelihoods across Honduras



The NASA landslide nowcast (18 Nov 2024). High risk of landslides (red areas) indicated across Honduras.



Total cropland area by municipality in the intensive rainfall area on 17 Nov 2024. Total cropland area impacted by extreme rainfall area was 72 543 ha.

GPM Infrastructure

GPM IMERG Late Run (1-day and 3-day precip. accumulation) and the NASA Global Landslide Nowcast tool are used within FAO's disaster impact assessment process, which aims to analyze impacts of extreme rainfall events on agricultural production and livelihoods.

Application Solutions

The analysis helps FAO determine: (1) areas in need of assistance and (2) better prioritize the locations and targeting of household data collection.

Public Societal Benefits

This then informs decision-making by providing an understanding of the hazard and an estimate of damage and losses to the agricultural sector. Results may be utilized by external organizations too.

GPM IMERG Supports Google's Flood Forecasting Initiative

GPM Infrastructure

- GPM IMERG Early V07 is one of several inputs to Google's LSTM ML global hydrologic model.
- Use of IMERG for both training the model and real time inference based on live feed.

Application Solutions

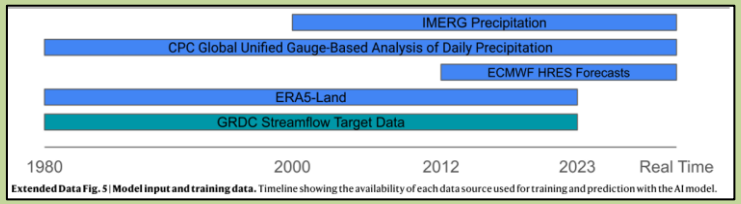
Google uses IMERG in two settings: (1) hourly to generate hourly forecasts and (2) daily to generate daily forecasts with a 7 day lead-time.

Application Availibility

The Google flood forecasting initiative provides flood forecasting alerts through different channels: Google Search, Android Notifications, Google Maps and Flood Hub.

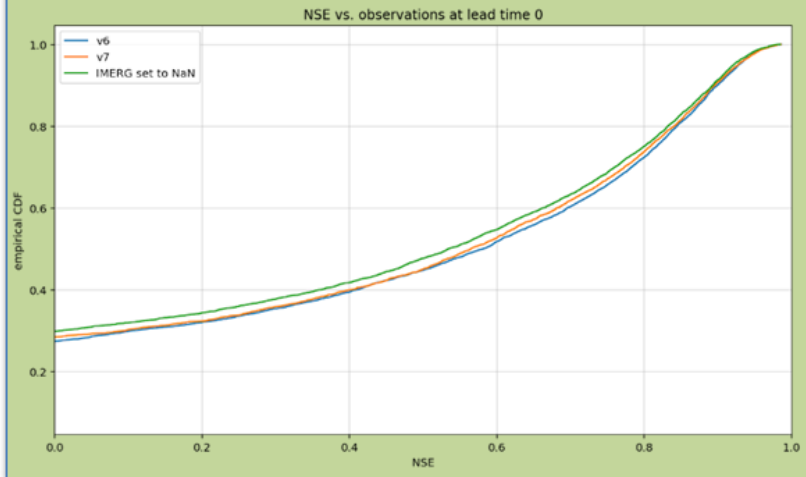
Public Soceital Benefits

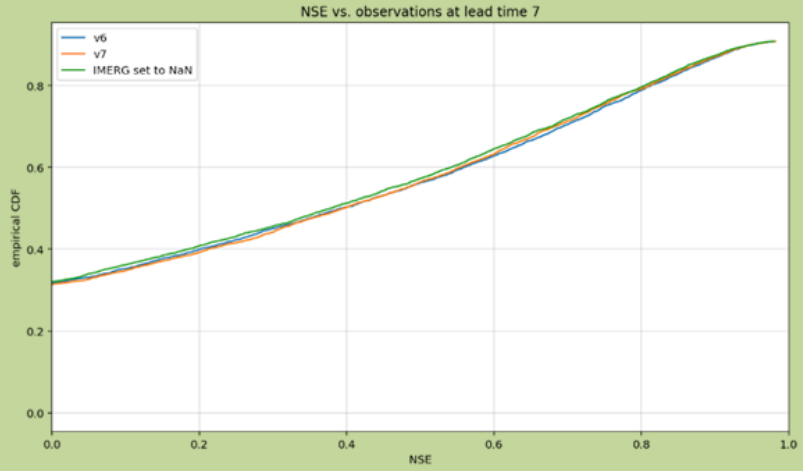
It is intended for the use of governments, NGOs, researchers and individuals directly affected by floods.



Extended Data Fig. 5 | Model input and training data. Timeline showing the availability of each data source used for training and prediction with the AI model.

Figures: (Left) *Model input and training data used and taken from literature.* ***(Btm left)*** *Empirical CDF (lower to the right is better) of the model on a large set of gauges with IMERG V06 and V07 and without any. Goal is to demonstrate that without IMERG, metrics are worse. Note: There is no direct and fair comparison between V07 and V06, the runs in the graph were trained with V06 but evaluated on both (V06 and V07), that's the reason V06 is better than V07.* ***(Btm right)*** *Screenshot of FloodHub from blogpost.*

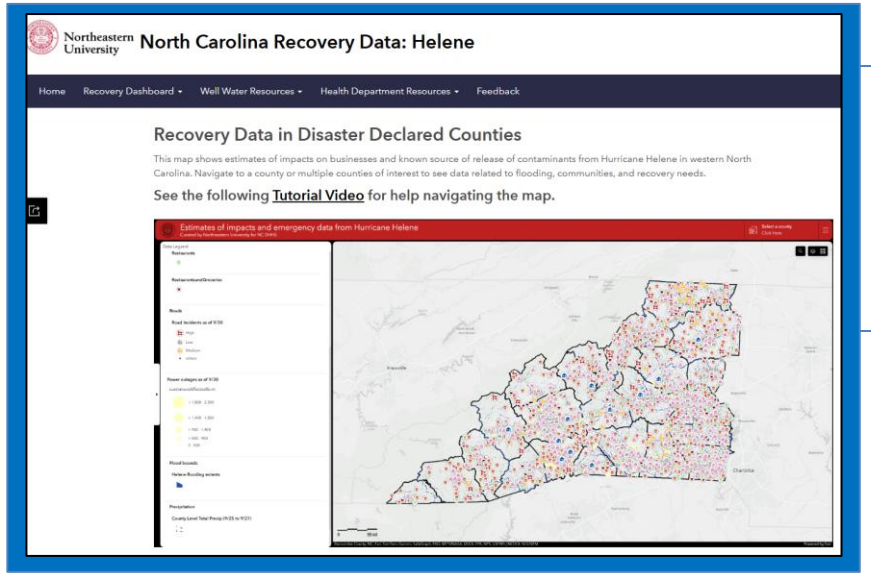




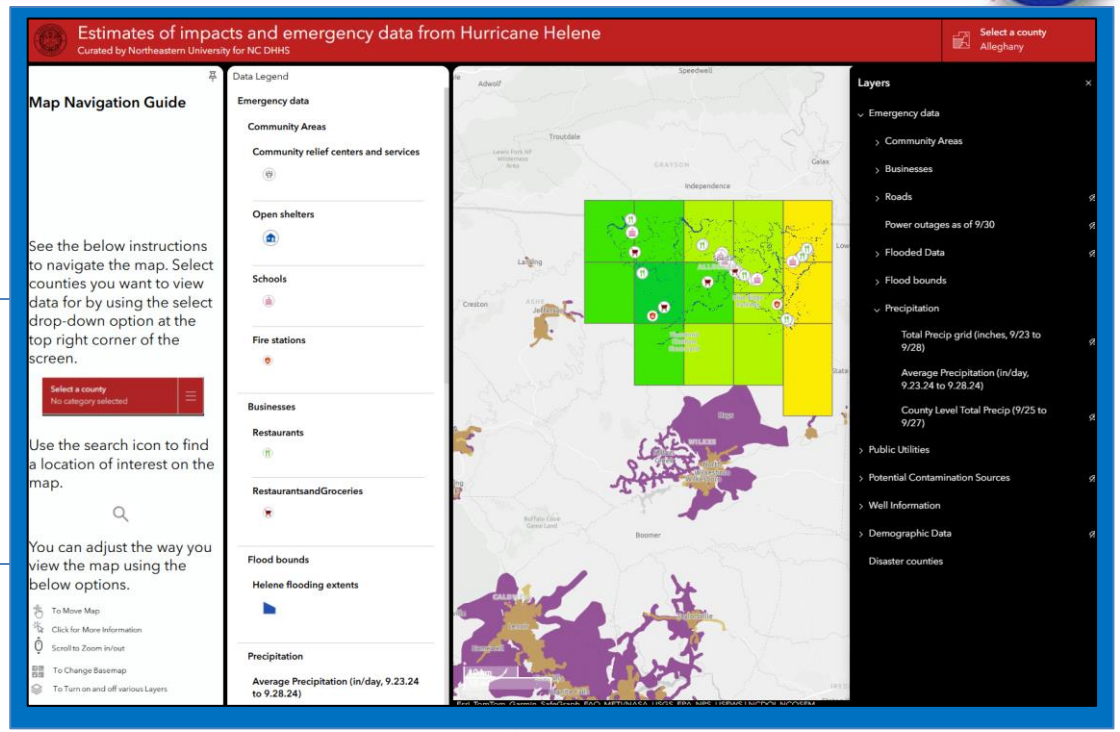
Flood Hub coverage in Nigeria during September 2023

Aiding Hurricane Helene Recovery Efforts

An open access data and recovery resource database to aid in the aftermath of September 2024's Hurricane Helene.



Hurricane Helene (September 2024): ***A publicly available ArcGIS online database*** *at the county level*



Dashboard screenshot showing average precipitation (in/ day) using IMERG (greens-yellows) overlaid with power outages, road conditions, community areas, businesses, and wells impacted by Helene's flooding.

Earth Action

North Carolina health departments use the dashboard to support private well recovery efforts through disinfection strategies, well damage assessments tools, and well water testing strategies.

Earth Observations & Infrastructure

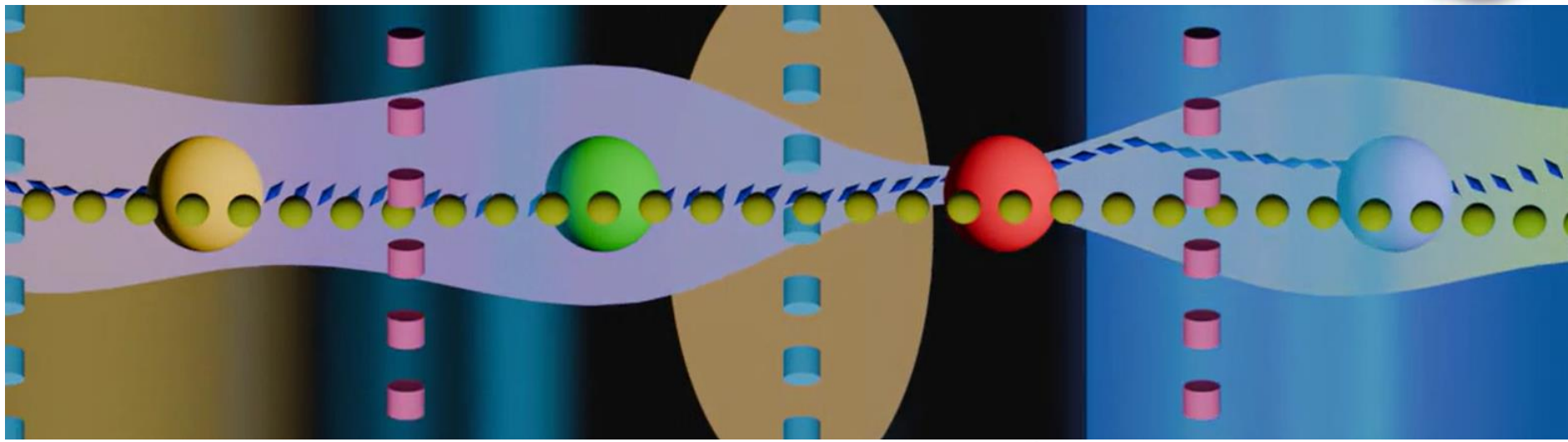
North Carolina Recovery Data: Helene Dashboard, developed by Northeastern University's Well Water Lab, is a publicly available ArcGIS online platform to communicate well water information along with Hurricane Helene's flooding impacts on businesses and community areas at the county level in western North Carolina.

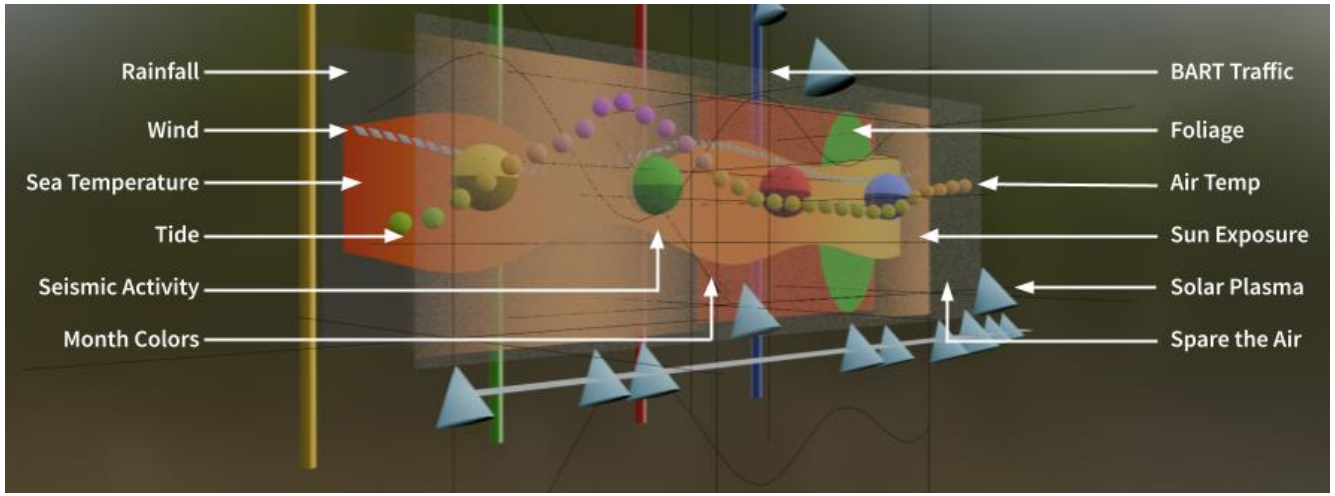
IMERG, daily accumulation estimates, along with flooding extent and socio-economic data are used to estimate the number of private wells contaminated within Hurricane Helene's flooding areas.

GLOBAL PRECIPITATION MEASUREMENT

GPM's IMERG Data Used to Communicate Science through Art

"The lifeblood of Synchronicity is data—collected, refined, and shared openly by government-funded science programs. These datasets make the Bay Area's hidden rhythms accessible, relatable, and memorable" -Niemeyer





- **Greg Niemeyer** (data artist and professor at U.C. Berkeley) created the data animation "Synchronicity", which was displayed on the crown of the Salesforce Tower, San Francisco, CA, daily throughout December 2024.
- It uses multiple NASA and other data sets, including **GPM's IMERG**, to create an abstracted, coordinated view of natural and human activity in the San Francisco area from the summer solstice of 2023 through 2024.

See https://www.gregniemeyer.com/synchronicity for further information and a posting of the animation

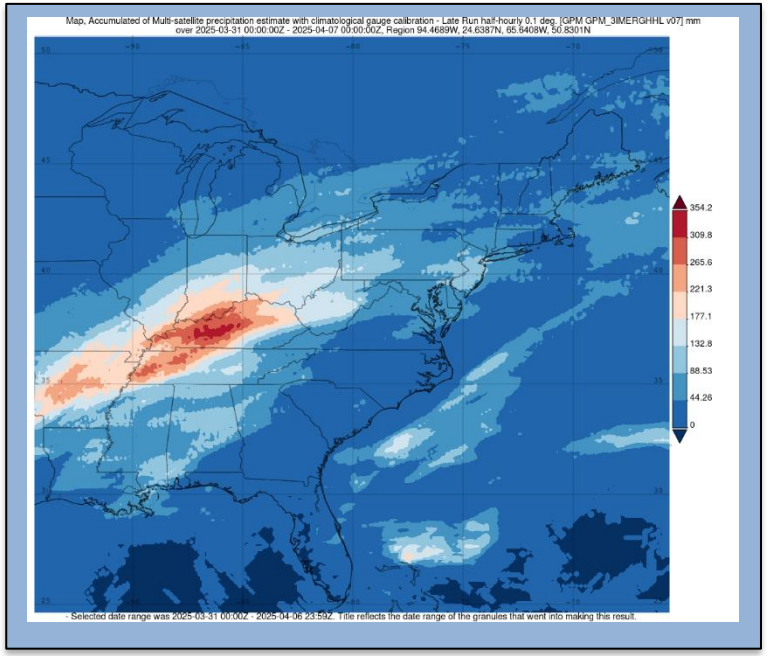
GPM IMERG Supports Google's Flood Hub

The Problem:

Floods are the most common and deadliest of natural disasters putting communities at risk.

"We have been using IMERG since the early days of the project and it, beyond doubt, improves our forecasts."

–Google



Total precipitation (mm) using IMERG from March 31 to April 6, 2025.

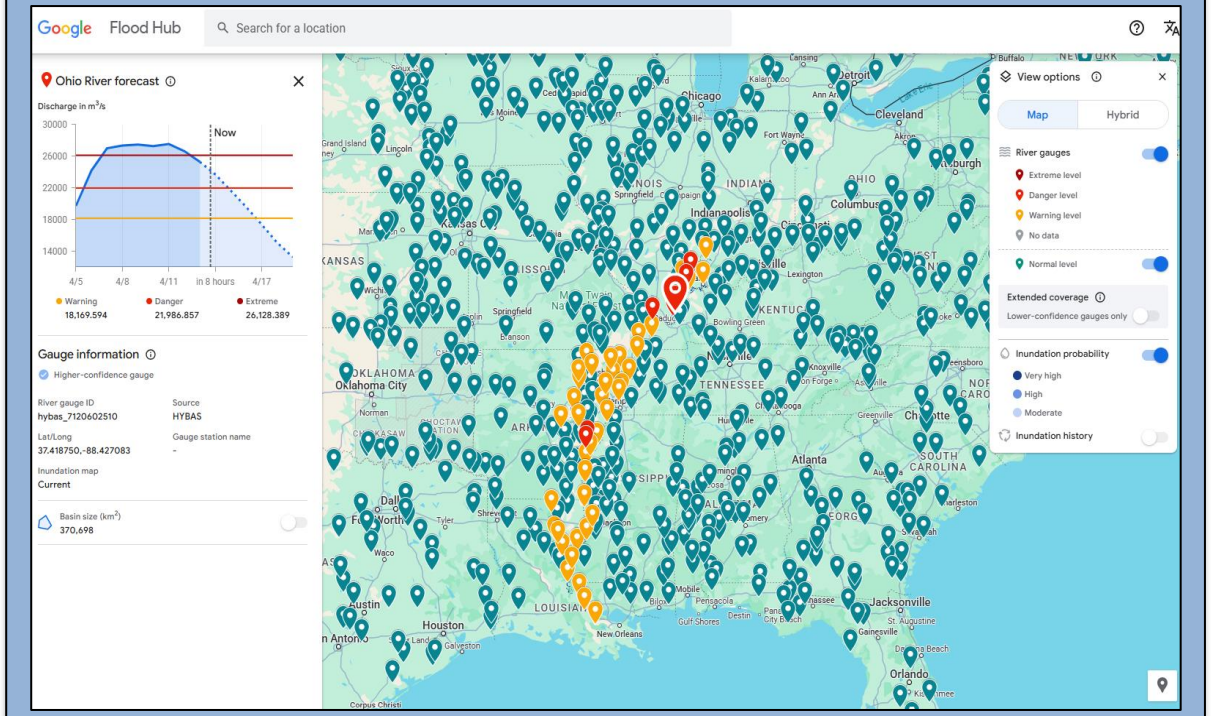
The Solution:

Google Flood Hub provides publicly available flood information via hourly and daily flood forecasts to the public using a user-friendly platform.

NASA GPM's IMERG Early product is a key input to Google's ML hydrologic model for flood estimation to support the Flood Hub app. **IMERG's low latency and fine time/space resolution meets Google's data needs!**

The Impact:

Global flood information is used by governments, NGOs, researchers and individuals. Google also collaborates with local humanitarian organizations to accelerate their ongoing anticipatory actions supporting local communities.



FloodHub flood predictions for Ohio River, USA (April 2025).

Evaluating the Diurnal Cycle within Singapore's Climate Model using GPM IMERG

The Third National Climate Change Study for Singapore was released early 2024 to meet challenges in the changing climate.

https://www.mss-int.sg/v3-climate-projections/learn-about-v3/v3-explained

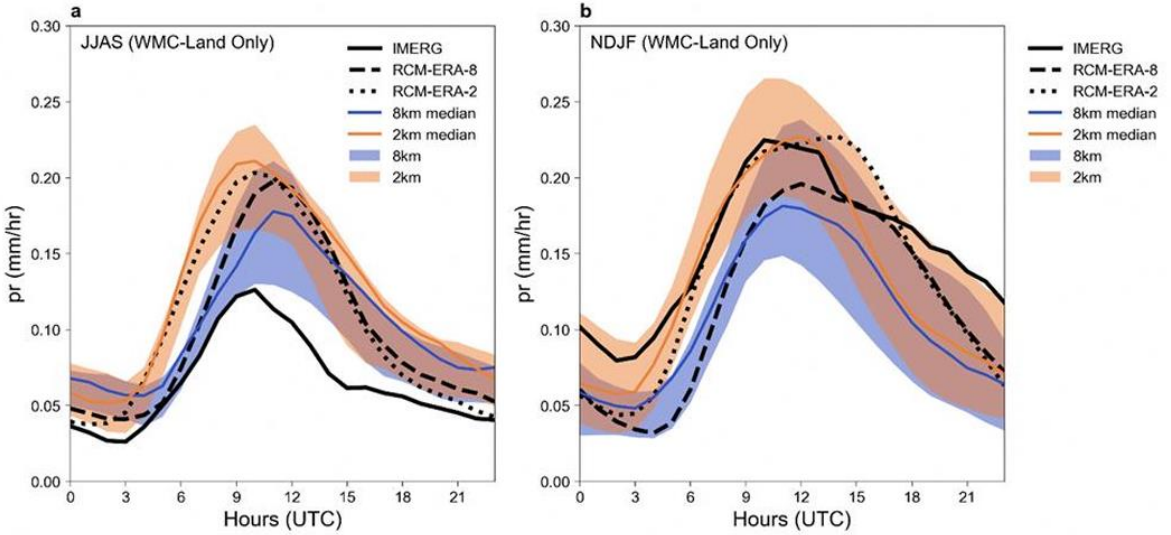


Figure 7.7: Diurnal cycle of Precipitation area averaged over WMC domain for JJAS and NDJF. a) Ensemble median and spread for SINGV-2km and SINGV-8km compared to IMERG-obs (JJAS), b) Ensemble median and spread for SINGV-2km and SINGV-8km compared to IMERG-obs (NDJF). Units in mm/hr. Note that Singapore is 8 hours ahead of UTC. The precipitation peak is around the late afternoon of Singapore local time.

Reference: https://www.mss-int.sg/docs/default-source/v3_reports/v3_science_report/v3_science_report_chapter_7.pdf

GPM Infrastructure & Application Solutions

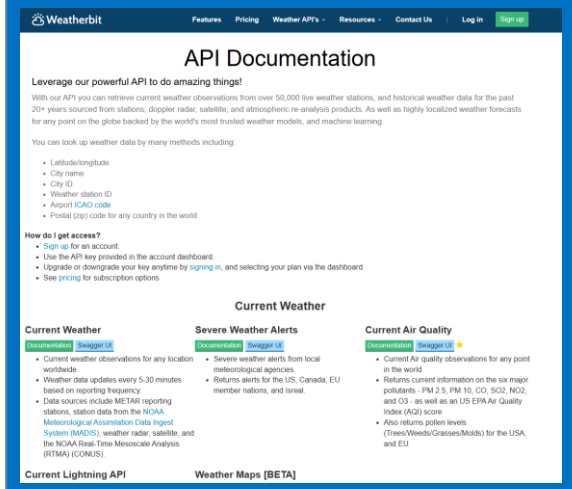
- To further advance the understanding of tropical climate variability and change for Singapore and SE Asia region, Singapore Met Service's Centre for Climate Research Singapore (CCRS) developed the V3 downscaled climate model product.
- Due to its "exceptional temporal resolution", **GPM's IMERG Hourly product was used** in the V3 study report **as a reference for evaluating diurnal precipitation** against the downscaled 8 km and 2 km simulations.

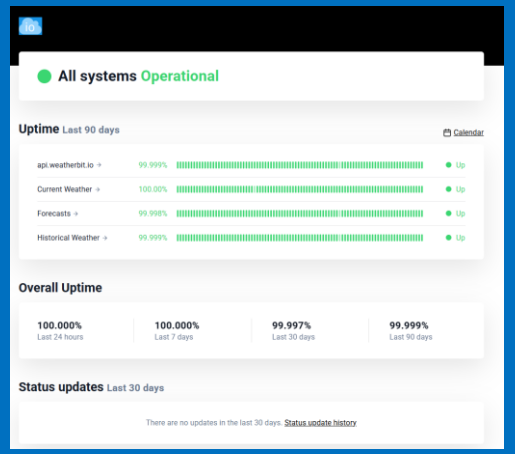
Public Societal Benefits

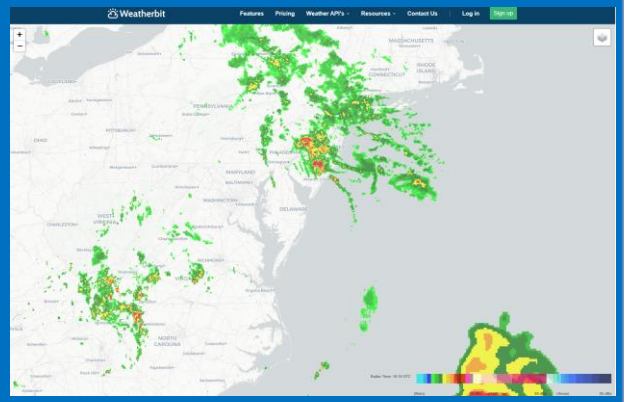
- The V3 climate projections will provide a scientific basis for Singapore's approach to adapting to and planning against climate change in key applications including water resources, flood management, human health and energy, biodiversity and food security, and sea level research.

Use of GPM IMERG at Weatherbit.io

Weatherbit.io: A weather data platform offering APIs that provide real-time, historical, and forecast weather information for locations worldwide.







Screenshots from Weatherbit.io highlighting their API documentation, API Status, and Weather Map pages.

"IMERG dataset is critical to our ability to present accurate precipitation data to our users. Its spatial coverage, resolution, and temporal continuity provides a unique advantage over more sparse products such as radar or rain gauge data."
- Colin Craig (Weatherbit.io)

Stakeholder Infrastructure & Earth Observations

Weatherbit leverages **IMERG Late and Final products for:**

- **Validation/quality control of precipitation data from ground radars, reanalysis products, and gauge data**.
- **Precipitation measurement proxies in areas where there is minimal radar coverage** (open water, mountainous areas, and remote regions - such as Central Africa/South America).

Weatherbit uses IMERG, GLDAS, ERA5 and other sources to build their Historical Weather and Current Weather API tools.

Endusers

Customers that rely on accurate precipitation data and use Weatherbit's API tools include Agro-monitoring (farm monitoring), construction, and insurance industries.

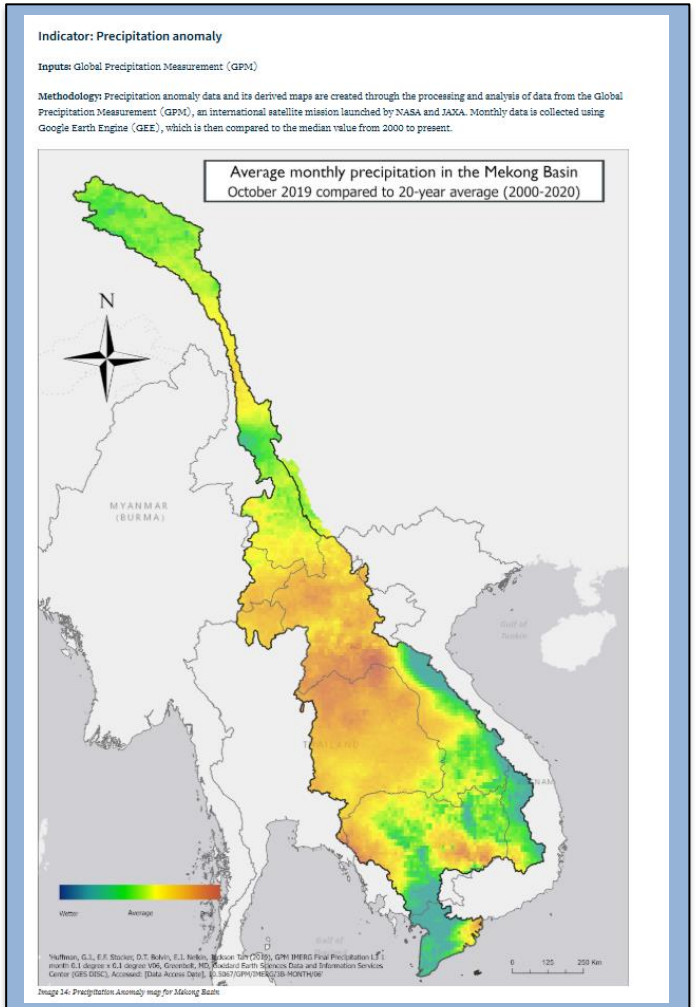
GLOBAL PRECIPITATION MEASUREMENT

Use of GPM IMERG within the Mekong Dam Monitor Platform

The Problem: The Mekong River, spanning six countries (China, Myanmar, Laos, Thailand, Cambodia, and Vietnam) is vital for the livelihoods over 60 million people. However, the development of dams has disrupted the river's natural flow, altering flooding areas and changing water levels that impact fisheries, agriculture and water resources.

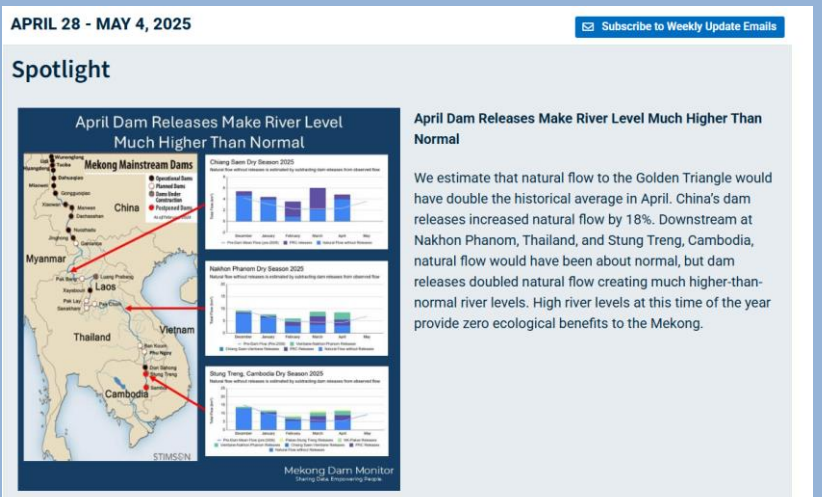
The Solution: The Mekong Dam Monitor, an online platform, for near-real time monitoring of dams and environmental impacts using open-source data and freely available inputs to derive 15 indicators for Mekong Basin.

One indicator is precipitation anomaly. This data and its derived maps are created through **the processing and analysis of GPM IMERG. Monthly data is collected using GEE,** which is then compared to the median value from 2000 to present.



Screenshots of (above) precipitation anomaly data using GPM IMERG taken from Mekong Dam Monitor Methods and Processes page: Mekong Mainstream Dam Monitor, and (right) "Spotlight" page providing weekly updates.

The Impact: Better data improves the understanding of contributing factors to changes in river flow and allows decisionmakers and stakeholders across the Mekong to establish a common baseline, enabling a more effective response to new developments and challenges, and of mitigation efforts towards current and future dam impacts.



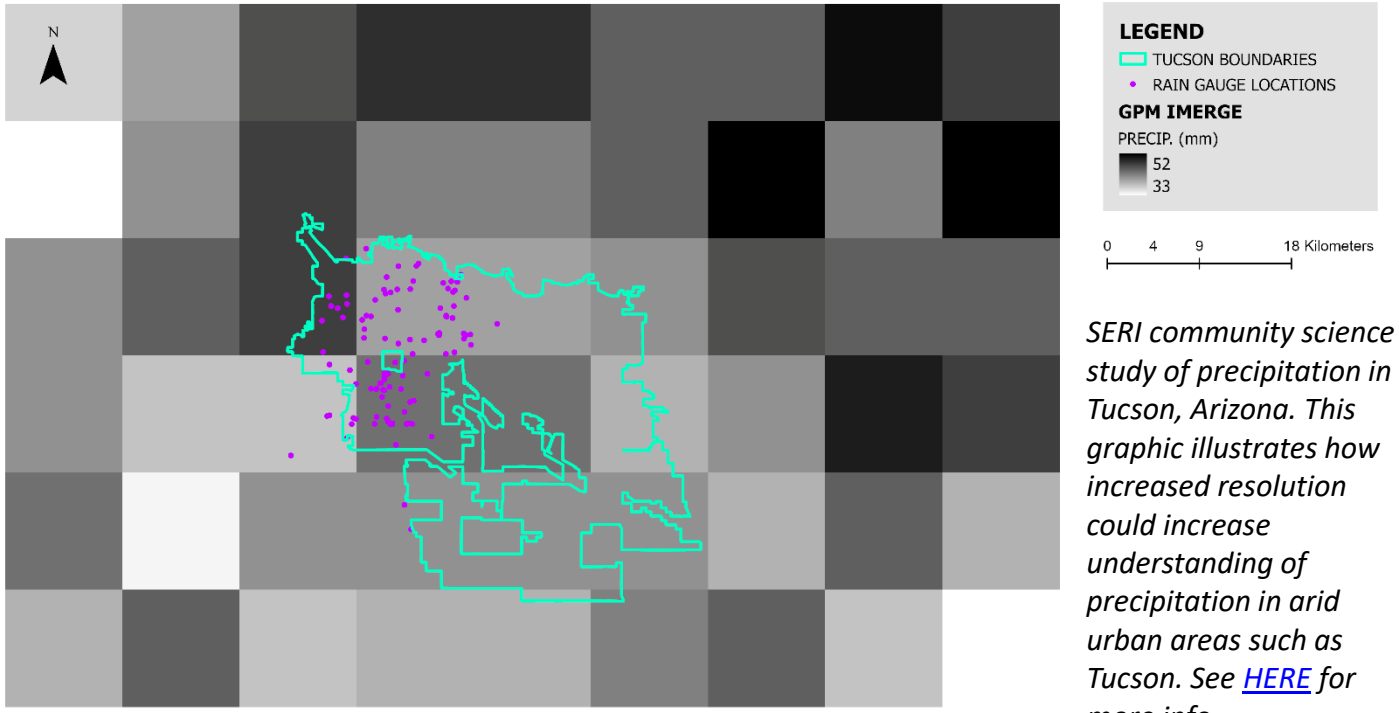
A collaborative partnership formed by the Stimson Center's Southeast Asia Program and Eyes on Earth, Inc.

Use of GPM IMERG at Sonora Environmental Research Institute

Sonora Environmental Research Institute (SERI): a nonprofit based in Tucson, Arizona focuses on enhancing communities' ability to protect the environment and human health by implementing science and engineering solutions with local leaders.

> ***"A significant percentage of rain in arid regions such as Tucson is convective, which varies significantly in both space and time. Higher resolution GPM data will provide valuable information to arid cities working to expand their green space."***
>
> - ***Theresa Foley, Climate Science Specialist, SERI***

DECEMBER 2023 GPM IMERGE DATA IN TUCSON, ARIZONA



SERI community science study of precipitation in Tucson, Arizona. This graphic illustrates how increased resolution could increase understanding of precipitation in arid urban areas such as Tucson. See HERE for more info.

Stakeholder Infrastructure & Earth Observations

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Soceital Benefit

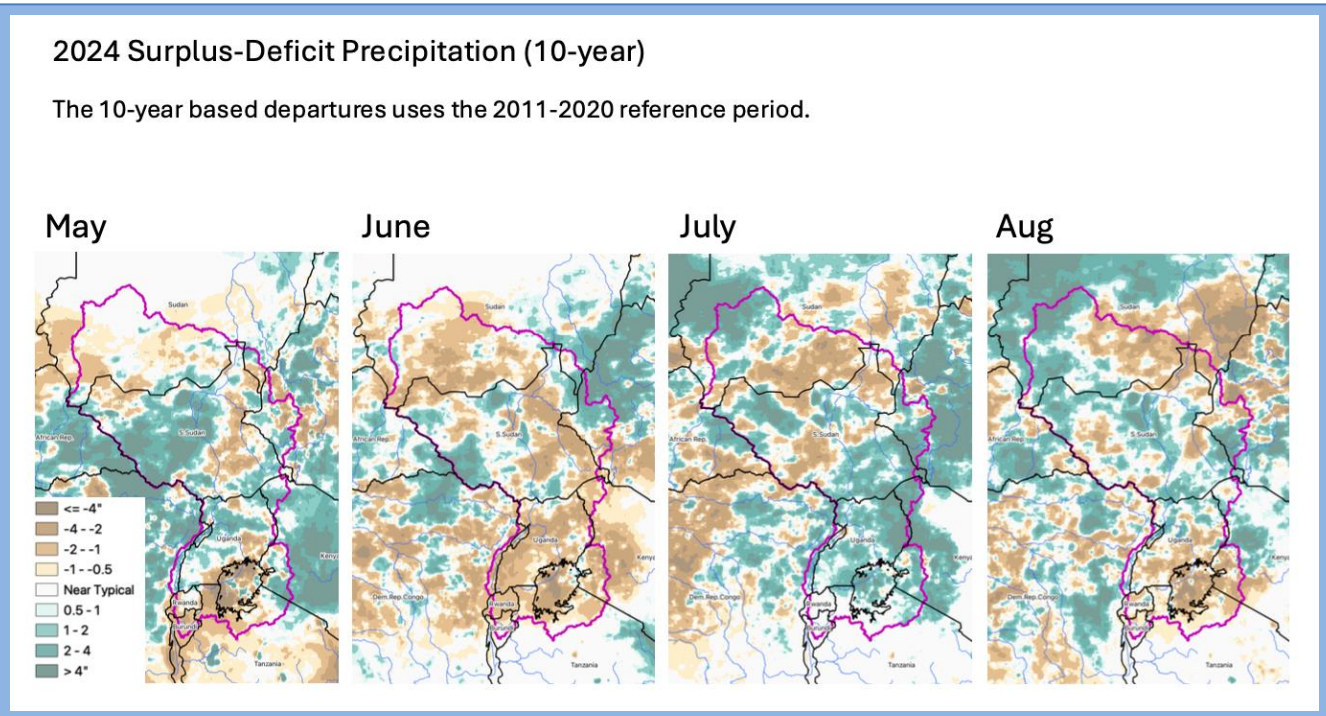
SERI leverages the GPM IMERG Final (and GeoTIFF) datasets to compare IMERG precipitation data against in-situ rain gauge data, US Census demographic data, and lidar greenness data.

These **datasets help evaluate relationships between precipitation, green space, and poverty in the greater Tucson area** and identify Tucson neighborhoods that are prone to higher temperatures and drought.

Results indicate the need for more green space in low-income areas. SERI works with local communities through grant initiatives to install rainwater harvesting systems and plant trees across these neighborhoods to help them become cooler and greener.

Use of GPM IMERG at Adiabat: A Weather Intelligence Company

Adiabat **provides organizations with contextual weather intelligence across the globe for informed decision making.**



Precipitation surplus/ deficit maps of Sudan in 2024 given to the geospatial intelligence community for understanding water levels of the White Nile River. Credit: Ashley Ballard (Adiabat).

"We use IMERG in general for it's resolution (temporal and spatial) and global coverage since our projects cover countries all over the world."
- Ashley Ballard (Adiabat)

Stakeholder Infrastructure & Earth Observations

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Endusers

Adiabat leverages **IMERG Early, Late and Final products to:**

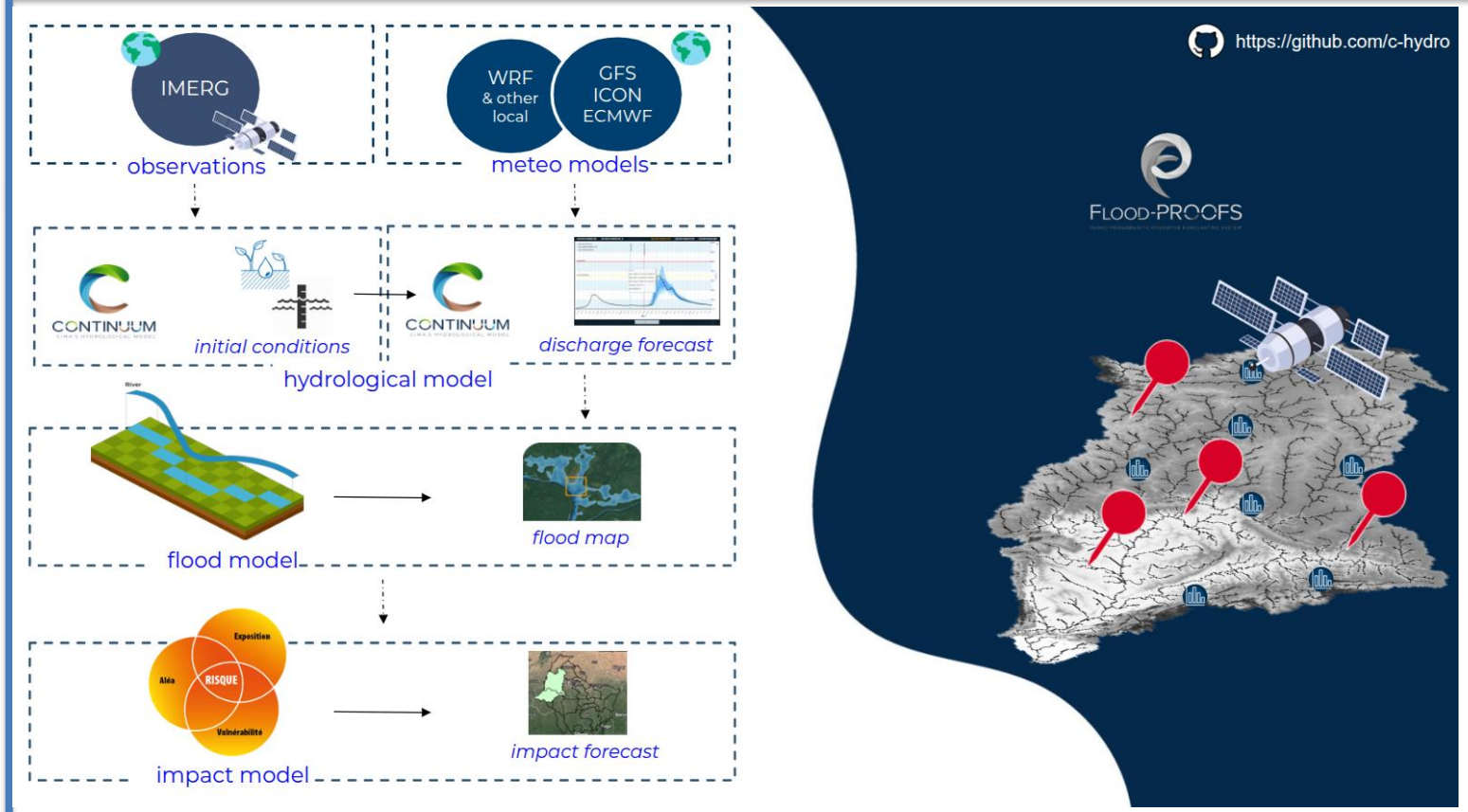
- **calculate short-term and long-term statistics including surplus deficits, percent of normal, and total precipitation;**
- **assess rainfall return intervals and develop intensity duration and frequency curves; and**
- **uses IMERG in areas where in-situ station observations are lacking.**

Customers use Adiabat's actionable precipitation data for various needs including **road safety, emergency management (flooding) and agricultural monitoring**, with beneficiaries coming from **supply chain companies, insurance agencies/underwriters, real estate investors, U.S. farmers, NGOs, and Department of Defense / Intelligence community.**

GLOBAL PRECIPITATION MEASUREMENT

FloodPROOFS: An Operational Impact-based Flood Early Warning Tool

TOOL: FloodPROOFS (Flood PRObabilistic Operative Forecasting System) is a system designed by CIMA Research Foundation to support decision makers during the operational phases of flood forecasting and monitoring.



Schematic of FloodPROOFS. Credit: A. Libertino (CIMA)

"We (CIMA) have operational chains based on IMERG in several countries: Volta river basin (Burkina Faso, Cote d'Ivoire, Ghana, Mali, Togo, Benin), Mozambique, Lebanon, Laos, Cambodia and others are under implementation."
- Andrea Libertino (CIMA)

INFRASTRUCTURE:

FloodPROOFS leverages **IMERG Early, Late and Final products to use** within the hydrological model continuum for flood monitoring and forecasting in two ways:

- **IMERG Early and Late set up the initial hydrological states of the model and initialize several forecast run.**
- **IMERG Final is used for calibration and identification of model thresholds.** The estimated threshold are used to estimate impacts, raise warnings and, consequently, foresee early actions.

FloodPROOFS has a 5-days forecast horizon, allowing stakeholders to issue advisories to local and regional communities.

ENDUSERS

FloodPROOFS end users include national civil protection and meteo/hydrological agencies in several countries, with a particular focus where satellite rainfall is the only way to feed hydrological models.

GLOBAL PRECIPITATION MEASUREMENT

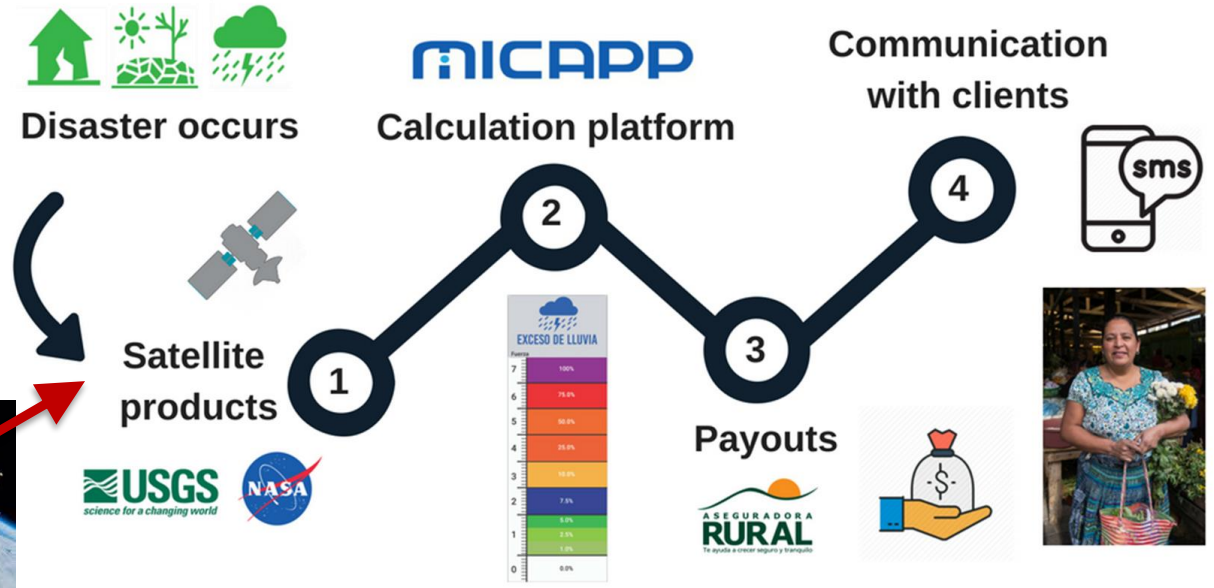
Building Climate Resilience with Satellite Data

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



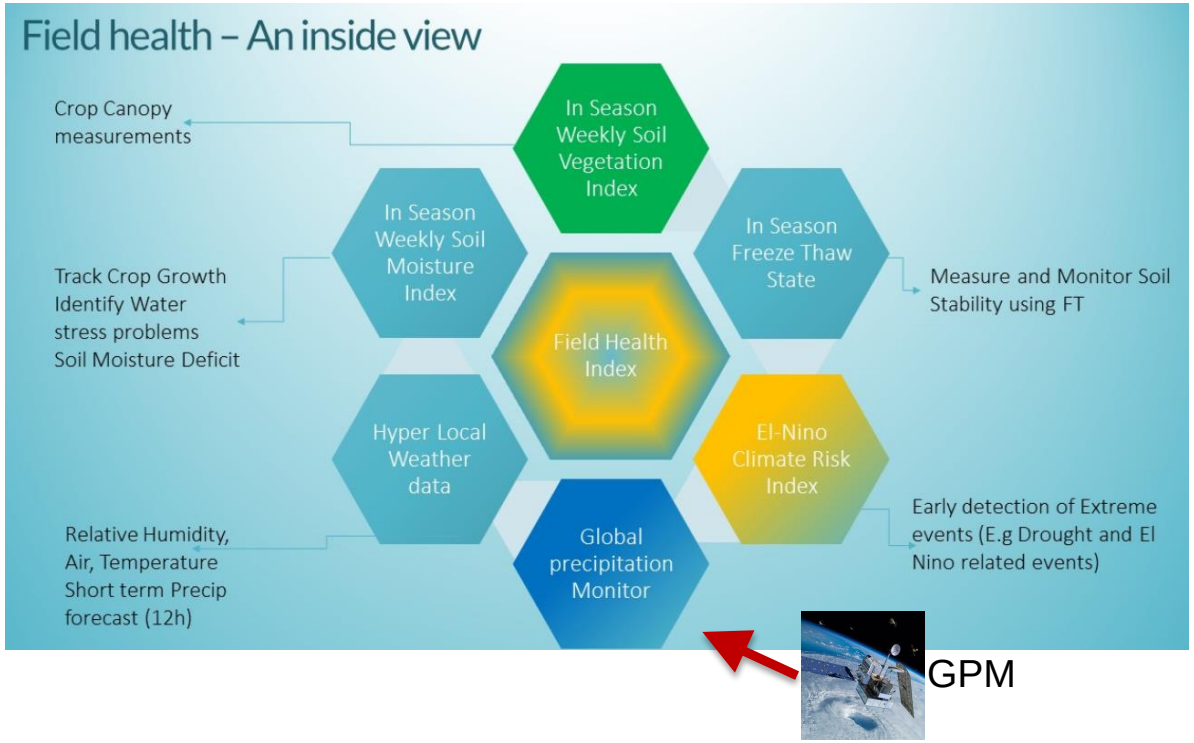
MiCRO's flow chart depicting how they determine the amount of a payment to insured clients when a disaster strikes: NASA satellite data (1) is used to design payout triggers (2). When disasters occurs and depending on its severity, payment is determined (3) and clients are informed via text (4).

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

GLOBAL PRECIPITATION MEASUREMENT

Global Precipitation Monitoring with GPM

To protect thousands of farmers from financial disaster and to combat food insecurity, Agvesto, a climate technology company, uses climate and weather data, and earth observations (including GPM precipitation data) to monitor and manage risks in agriculture. Agvesto works with companies ranging from reinsurance brokers, government agencies, and small and large commercial companies throughout the world who rely on Agvesto's insight into field health and risks to a given farmland or area. As a result, GPM precipitation data plays a major role in Agvesto's decision-making.



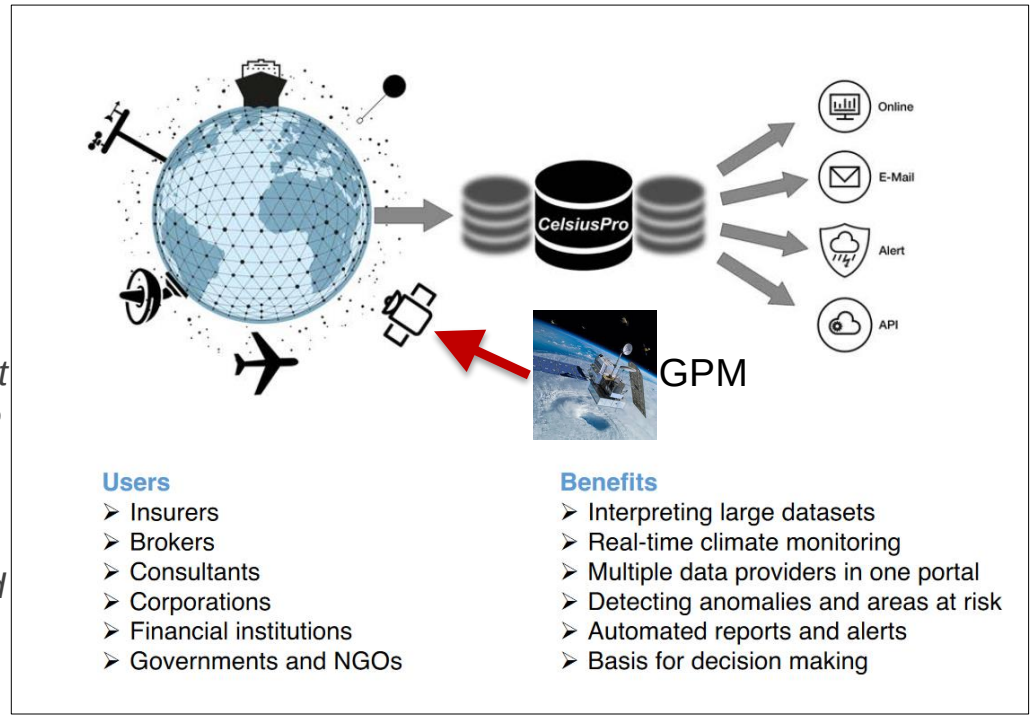
Agvesto's infographic in determining field (site) health using climate and weather data, and earth observations. Credit: Agvesto, https://angel.co/agvesto/jobs.

In April 2016, Argentina and Uruguay received upwards of 300mm above monthly average which led to flooding. To help assess the total crop damage and potential crop yield, Agvesto worked with the Argentine government to provide field health and risk insights using GPM precipitation and SMAP soil moisture data. Credit: Agvesto.

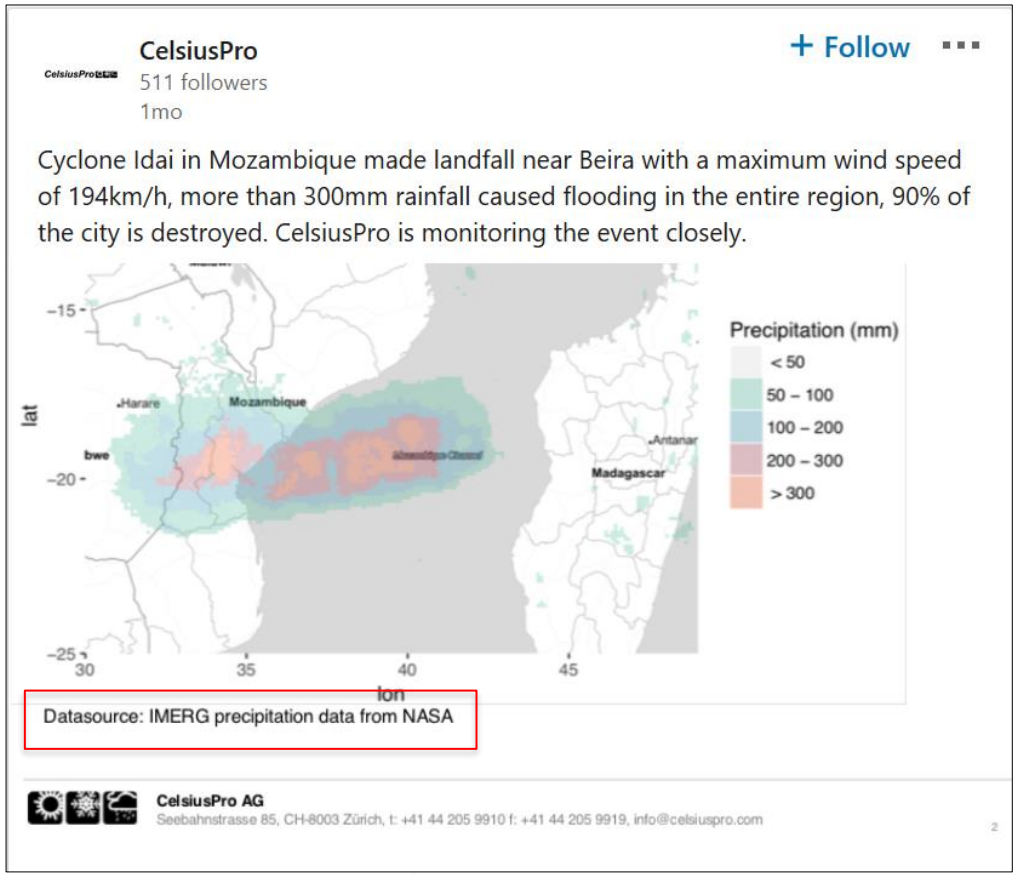
GPM Supports CelsiusPro Products

CelsiusPro, a Swiss insurance technology company, provides global insurance digitalization solutions for insurers throughout the world with a focus on weather, agriculture and parametric disaster products. Their parametric insurance solutions are based on data provided by third-party agencies such as official weather stations or satellites such as the GPM CO. Specifically, CelsiusPro (1) uses GPM precipitation data (TMPA and IMERG) to develop rainfall index products for their clients and (2) provides an online data platform, Environmental Monitoring System (EMS) 2.0, that allows their clients to access and visualize a range of environmental data including IMERG to mange their risks and opportunities.

CelsiusPro's flow chart depicting how EMS 2.0 allows analysts, risk managers and claims officers to access, analyze, visualize and download climate, vegetation from different providers on one single platform. Automated reports can be customized to visually summarize the data and provide a global risk overview.



Credit (text and image): https://www.celsiuspro.com/solutions/

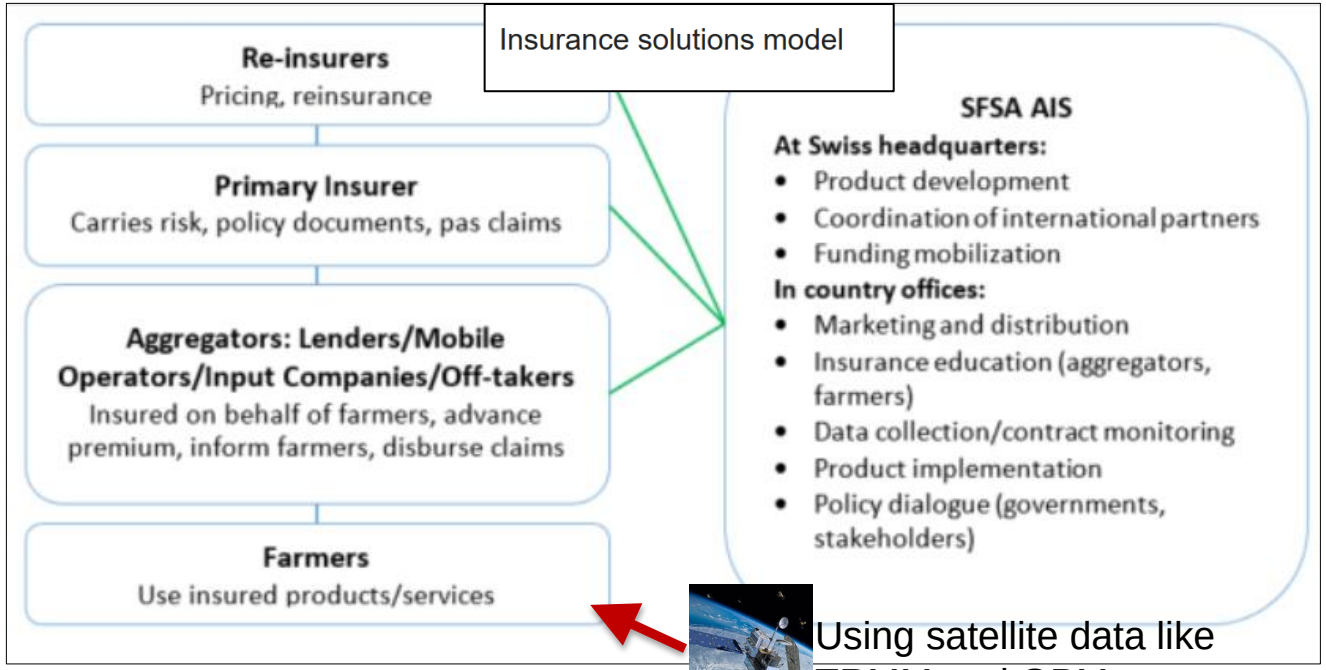


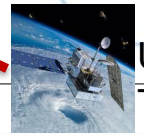
On LinkedIn, CelsiusPro posted the accumulated rainfall that was observed from Tropical Storm Idai using IMERG data. This post is one of many that CelsiusPro uses to communicate how they use environmental data to assess disasters. Image credits: CelciusPro via LinkedIn post.

CelsiusPro

Using Satellite Data to Improve Index Insurance

Syngenta, a global agricultural company, is currently conducting pilot projects in two African countries, Sudan and Morocco, in which TRMM3B42_Daily is used for designing and developing weather index insurance products for small holder farmers. They are using this dataset along side other datasets (i.e. CHIRPS 5 km, CHIRPS 25 km, TAMSAT, ARC2, RFE, NDVI and EVI) to best reflect the weather risk as experienced in a particular region.





Using satellite data like TRMM and GPM

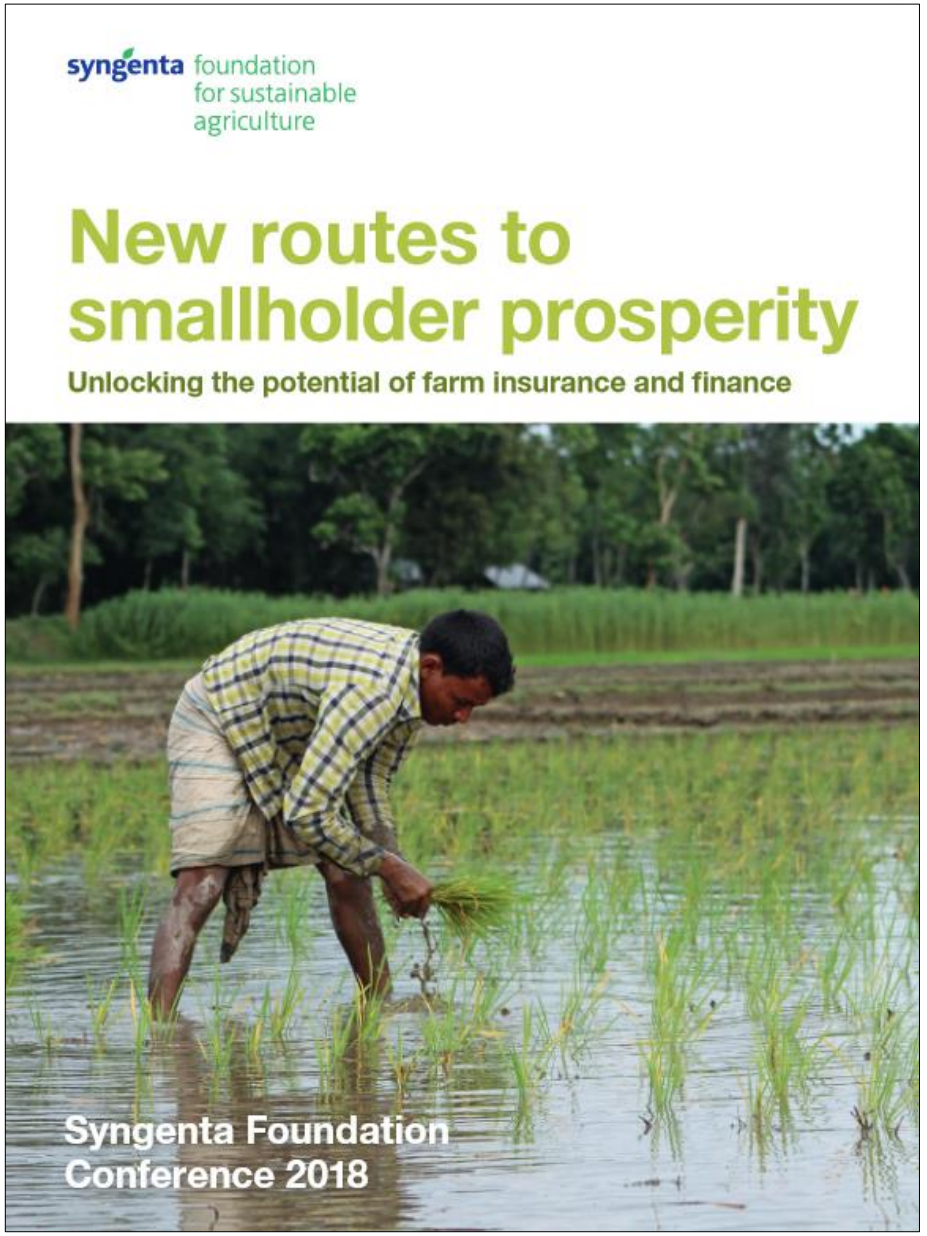
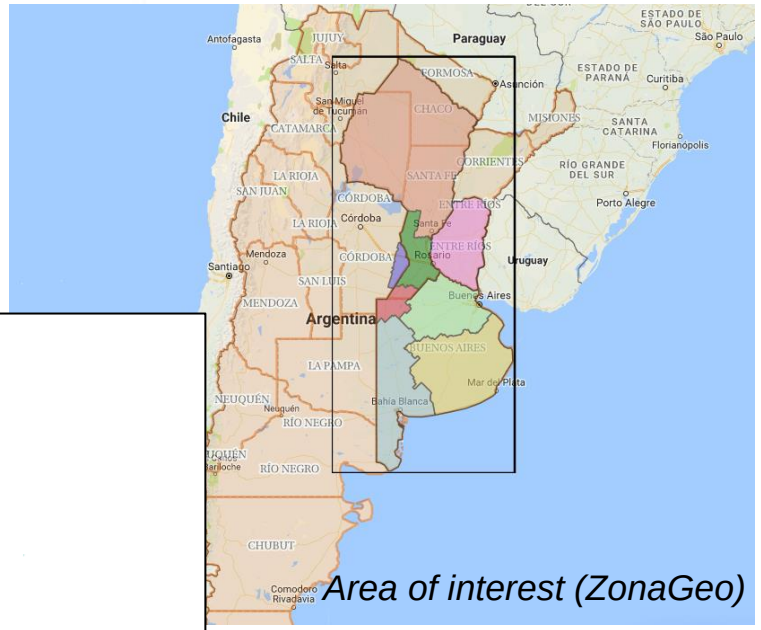


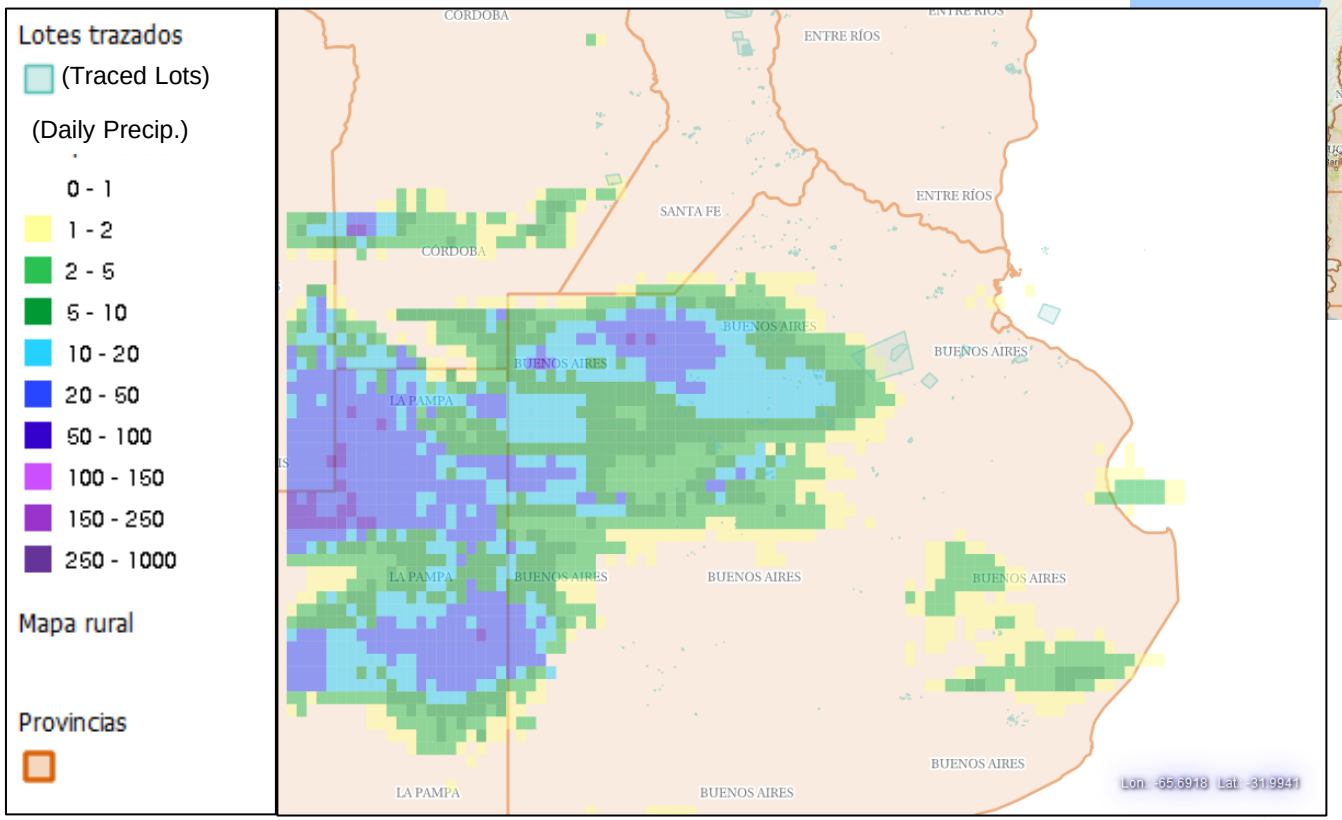
Image Credit: www.syngentafoundation.org

Precipitation Data Supports Agroinsurance in Argentina

ZonaGeo, a geospatial technology company, is using NASA's GPM precipitation data to evaluate accumulated daily rainfall in northeast Argentina as a value added product for clients interested in agroinsurance from the company, Paraná Seguros. Paraná Seguros uses ZonaGeo's data products and incorporates it into their online platform that allows customers to get a quote, contract and manage insurance from electronic devices. Over 200 clients are insured by Paraná Seguros, and as a result use GPM products developed by ZonaGeo.



Area of interest (ZonaGeo)



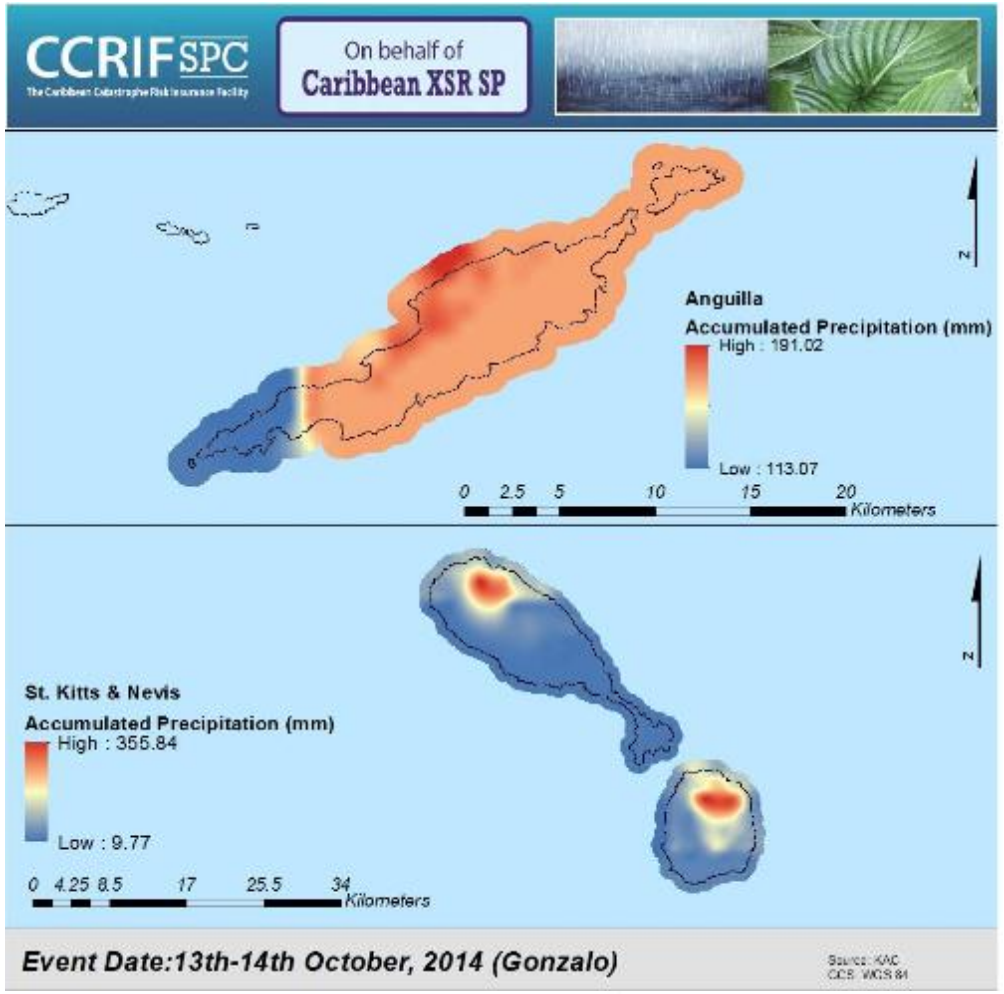
NASA precipitation used to provide agroinsurance quotes in NE Argentina. Black rectangle (right) denotes area that GPM data is used for insurance quotes (far right). Daily precipitation (in mm) for January 26, 2018 (each cell 10Km x 10Km) for NW Buenos Aires, NE La Pampa, and southern Cordoba provinces (right). Green cells represent final insurance clients' assured land.

ZonaGeo

NASA Precipitation Data used by the re/insurance industry to assess for Extreme Rainfall impacts

Reinsurance company Swiss Re is using NASA's Tropical Rainfall Measuring Mission (TRMM) coupled to a portfolio of country-wide exposure to estimate potential loss from heavy rainfall events. This program supports the Caribbean Catastrophe Risk Insurance Facility. In 2014, the program paid out four times (twice to Anguilla, once to St. Kitts and Nevis and once to Barbados). Report from CCRIF showing rainfall accumulation for Tropical Cyclone Gonzalo, 2014 (right).

SwissRe's newest microinsurance program, launched in Guatemala in 2016, uses TRMM data coupled to a loan portfolio to determine micro-loan recipients affected by heavy rainfall. The hope is for this program to be replicated in other parts of Central America.

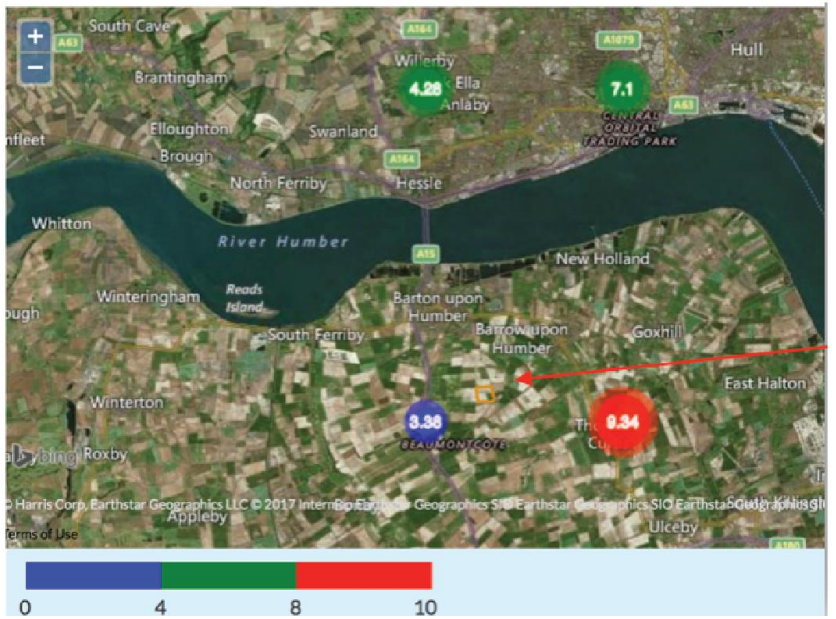


"We are relying on the TRMM, any of its successors (GPM) and other satellite-based rainfall to make initial pitches and explain parametric excess rainfall products conceptually throughout the world… the availability of satellite rainfall allows us to easily develop a conceptual overview for almost any client"

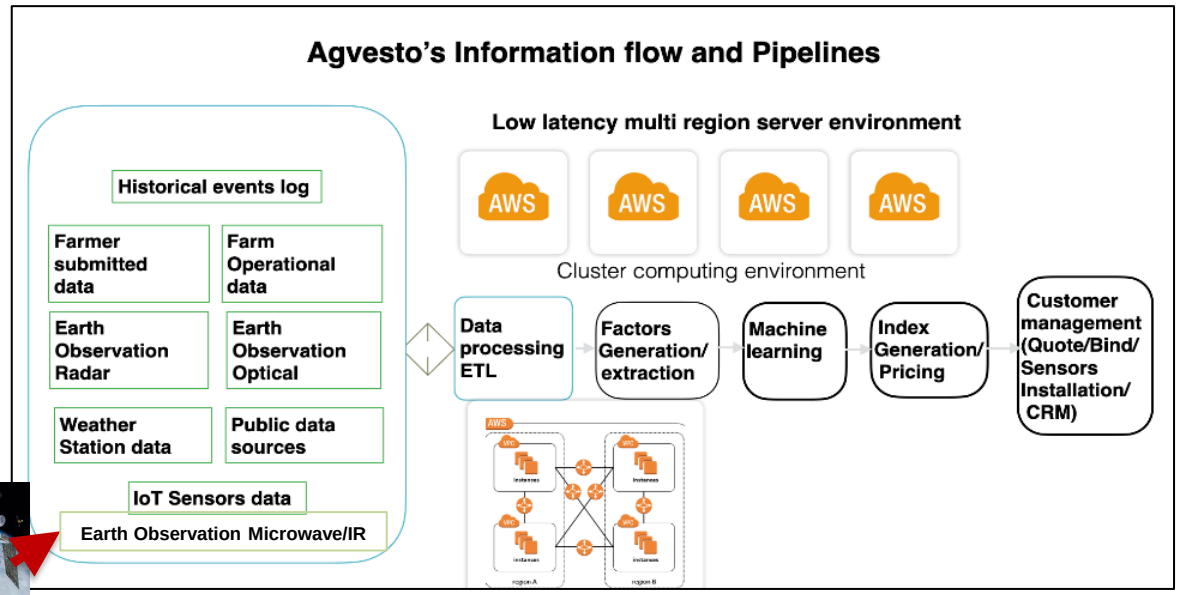
- Megan Linkin, Swiss Re

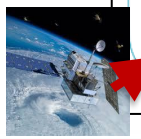
Parametric insurance for agricultural communities using GPM

- Agvesto, a UK-based Agritech business, routinely uses GPM (IMERGv06) to extract historical and real-time precipitation profiles to determine an objective index, develop insurance products and process claims.
- Agvesto has delivered coverage to farmers in the US and UK, and is working to launch similar programs in the emerging markets such as India, Africa and Latin America.



Precipitation data from GPM used to analyze an excess precipitation event and process a claim at a farm in Eastern England. Credit: Agvesto.





The use of EOS data for parametric insurance is very useful in areas where impacts occur from a disaster or extreme event, and where it is hard to send loss adjustors in straightaway due to threats such as floods.

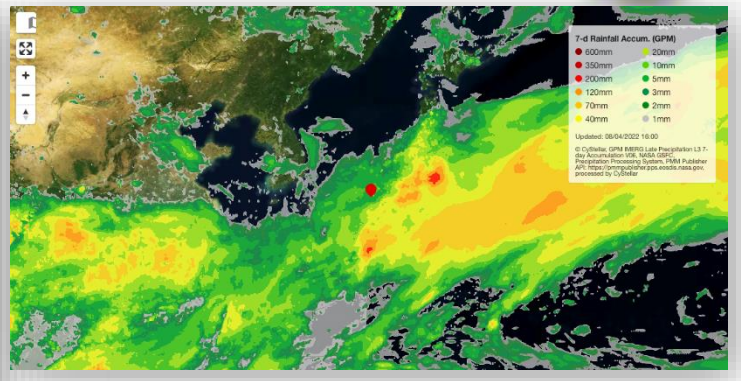
https://agvesto.com/home

AGVESTO

Delivering Geospatial Risk Intelligence to the Insurance Industry

CyStellar is a downstream space technology company that uses GPM data within its cloud-based risk management platform to deliver real-time cumulative risk insights and assessments to insurance companies.

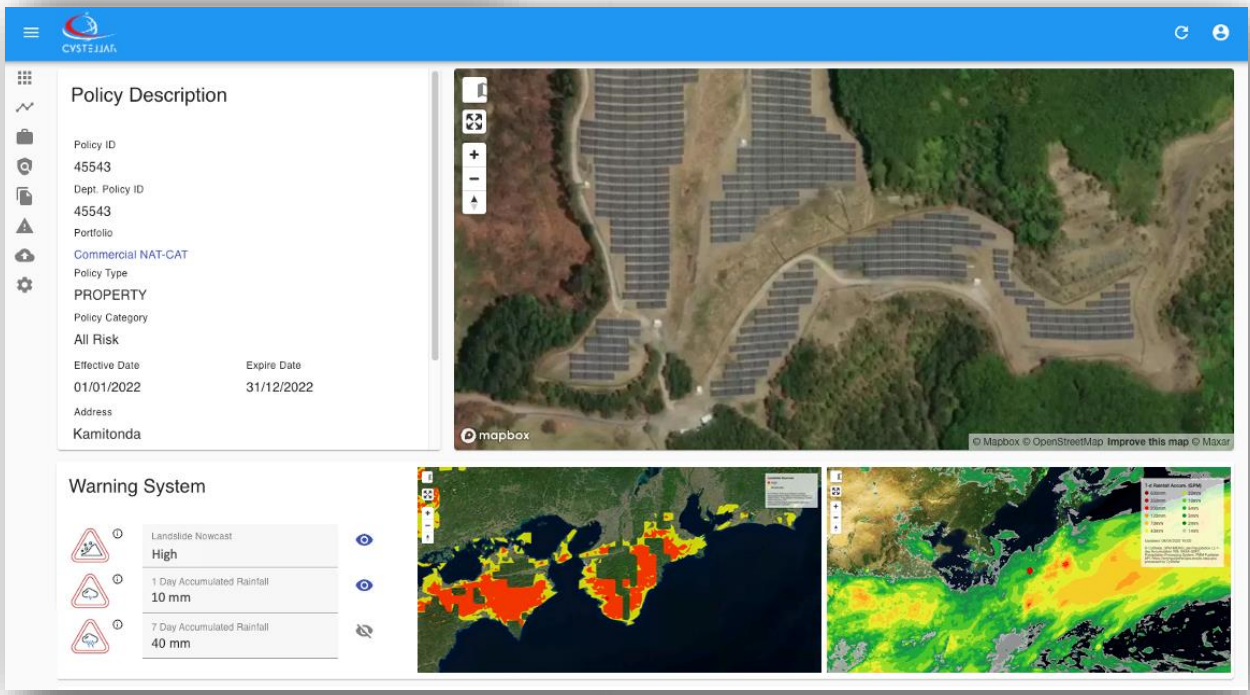
Case Study: A large insurer in Japan introduced a specialized line of insurance covering solar farms.



GPM data (above) processed and visualized by CyStellar on its cloud-based risk management platform (below).

Motivation for data: The insurer has experienced large losses within their solar farm insurance product due to unforeseen adverse weather conditions (e.g., landslides). Most solar farms are in remote locations with limited accessibility, increasing the underwriting and claim assessment costs. The insurer sought a solution to help them better evaluate landslide risk at the locations of solar farms to help tackle these challenges.

Use of GPM: Using CyStellar's geospatial risk management platform and NASA (e.g., GPM IMERG and Landslide nowcast) data, the insurer is now able to assess landslide and heavy rainfall threats of various levels to solar farms across Japan. They are also able to accurately predict losses before they occur.



Credit: CyStellar Ltd

GLOBAL PRECIPITATION MEASUREMENT

Delivering Geospatial Risk Intelligence to the Insurance Industry

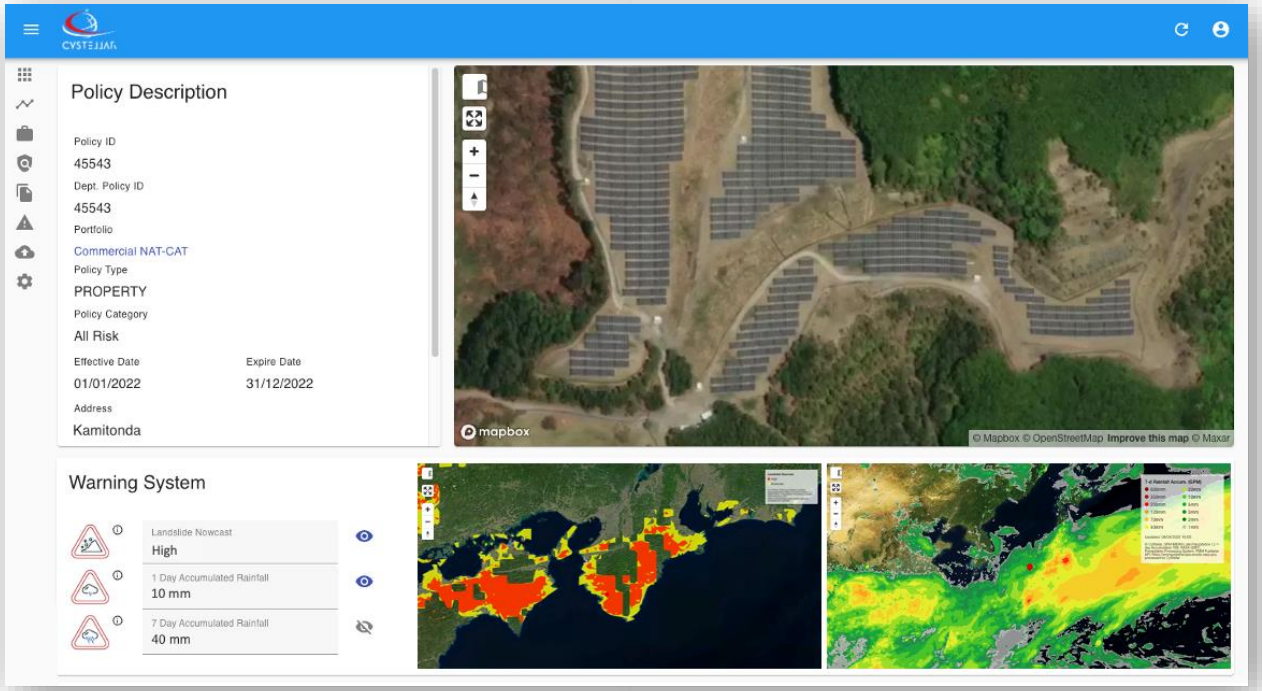
Full slide description: CyStellar is a downstream space technology company that uses GPM data to deliver real-time cumulative risk insights and assessments to insurance companies. One such company, a large insurer in Japan, introduced several years ago a specialised line of insurance covering solar farms. This offering has become increasingly popular as Japan invests in solar energy and reduces its reliance on nuclear and fossil fuel energy sources.

However, the insurer has been experiencing large losses within their solar farm insurance product due to unforeseen adverse weather conditions, primarily from landslides. Furthermore, most of the solar farms the company insurers are in remote locations with limited accessibility, increasing the underwriting and claim assessment costs. The insurer sought a solution to help them better evaluate landslide risk at the locations of their insured solar farms to help tackle the challenges it faced.

Using CyStellar's geospatial risk management platform and NASA (e.g., GPM IMERG and Landslide nowcast) data, the insurer is now able to assess the landslide and heavy rainfall threats of various levels to solar farms all over Japan. Crucially, they are also able to accurately predict losses before they occur.

In addition to the GPM data pulled in to provide landslide and heavy rainfall hazard analyses, CyStellar provides cumulative risk assessments for any location on Earth by generating a digital twin of insured assets. The platform integrates data from radar and optical satellite data providers, IoT weather sensors, as well as social, economic and political data sources, and is processed using techniques such as interferometry SAR, computer vision and machine learning, to deliver underwriting, portfolio optimization, and automated claim assessment services to the insurance sector.

Credit: CyStellar Ltd



GPM data from NASA, processed and visualized by CyStellar on its cloud-based risk management platform, provides vital insights to insurers to identify in near real-time high-risk areas at threat to natural hazards, allowing them to take early mitigative action to reduce losses.

GLOBAL PRECIPITATION MEASUREMENT