National Aeronautics and Space Administration

Global Precipitation Measurement

Core Observatory

Acknowledgments

Global Precipitation Measurement Mission
www.nasa.gov/gpm

Precipitation Measurement Missions
pmm.nasa.gov

Japan Aerospace Exploration Agency
www.jaxa.jp/projects/sat/gpm/index_e.html

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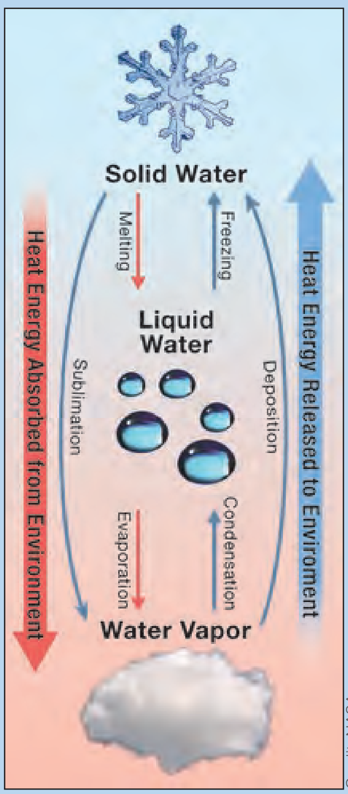
Precipitation Measurement Science

For thousands of years, civilizations have tried to manage the intricate balance between having too much or too little water. Nearly every living organism on Earth has been or will be affected by drought, heavy rains or flooding. Precipitation measurements help scientists gain a better understanding of the distribution of water around the globe. Photo credits: Marty Bahamonde/FEMA, Darin Leach/USDA, Jocelyn Augustino/FEMA, Matt and Kim Rudge

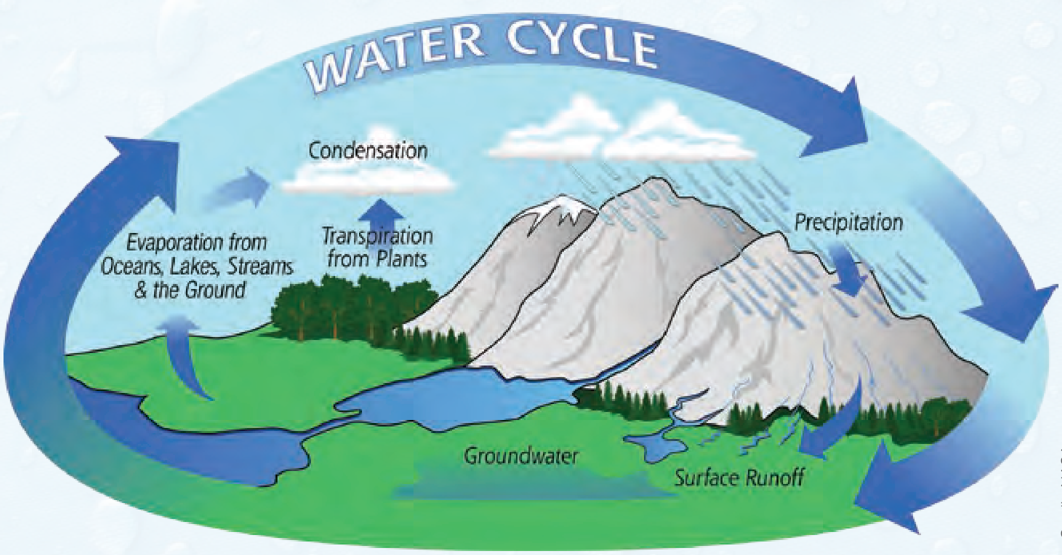


Credit: NASA

This graphic shows how heat is absorbed or released during the six phase changes of water—freezing, condensation, melting, evaporation, sublimation and deposition. By measuring the profile of precipitation as it falls through the atmosphere, scientists can create global maps of latent heat estimates.

Water—the main reason for life on Earth—continuously circulates through one of Earth's most powerful systems: the water cycle. Water flows endlessly between the oceans, atmosphere and land. Precipitation in the form of rain, snow, sleet or hail, for example, is a vital component of the water cycle and affects everyone on Earth.

While the effects of precipitation are felt at local scales, understanding the role of Earth's water cycle and how it interacts with



Credit: NASA

The water cycle describes how water evaporates from Earth's surfaces, rises into the atmosphere, cools and condenses to form clouds, and falls again to the surface as precipitation. About 75 percent of the energy (or heat) in the global atmosphere is transferred through the evaporation of water from the surface, primarily from the oceans. The movement of water by precipitation, infiltration, transpiration, runoff and subsurface flow redistributes water around the globe.

other Earth systems requires a global view. The distribution of water throughout the atmosphere and how it moves, changing between its solid, liquid and gaseous forms, is a powerful vehicle for redistributing Earth's energy and influences the behavior of the planet's weather, climate and other environmental systems.

Energy, in the form of *latent heat*, is absorbed or released when water undergoes a phase change. For example, when water vapor in the atmosphere condenses into clouds latent heat is released—warming the atmosphere. Conversely, when liquid water in the atmosphere evaporates, such as when rainfall moves through a layer of dry air, latent heat is absorbed—cooling the atmosphere. Latent heat drives atmospheric circulation and plays a major role in cloud formation and storm development.

In turn, these clouds and storms produce precipitation over land and oceans, influencing our lives on a daily basis. From drizzle or snow on a morning commute, to flash floods caused by thunderstorms, precipitation enters local watersheds and contributes to the water supply, where fresh water is needed for drinking, agriculture, industry and the environment.

To study the fundamental relationships and effects of precipitation, scientists study moisture and precipitation in the atmosphere. Water, in all its forms, is difficult to measure consistently around the globe. Rain, snow and other precipitation types, such as hail and sleet, vary greatly over land and oceans. Obtaining reliable ground-based measurements of precipitation, from rain gauges for example, often presents a challenge due to large gaps between monitoring instruments on land, and even larger gaps over oceans.

Satellite observations from space, however, cover broad areas and provide more frequent measurements that offer insights into when, where and how much it rains or snows worldwide. Earth-observing satellites carry numerous instruments designed to observe specific atmospheric characteristics such as water droplets and ice particles. These observations are detailed enough to allow scientists to distinguish between rain, snow and other precipitation types, as well as observe the structure, intensity and dynamics of storms. These data are also fed into the weather forecast models that meteorologists use to issue weather warnings.

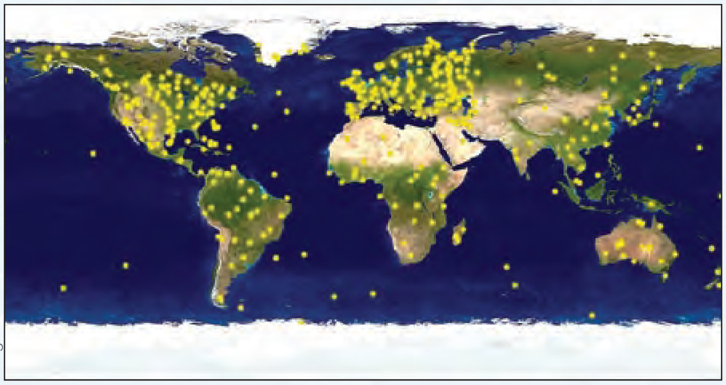
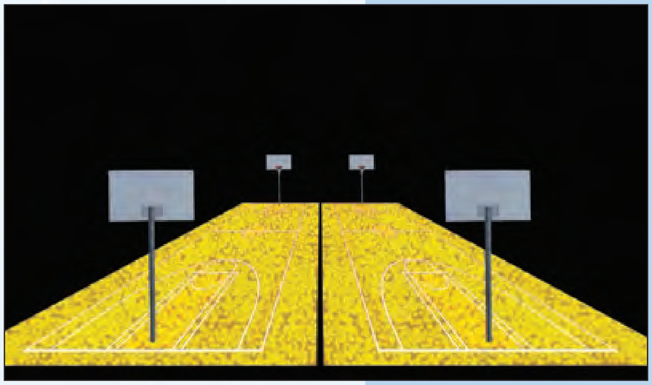


Image credits: NASA



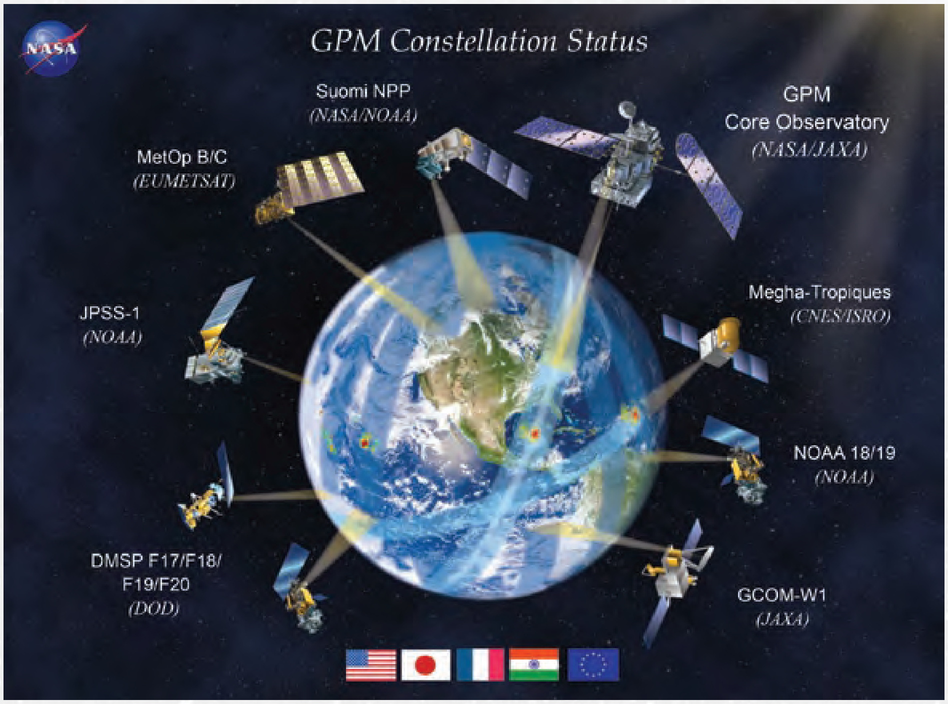
These images illustrate the number and distribution of rain gauges around the globe. If all of the rain gauges in the world [left image] were gathered in one place [right image], they would cover an area the size of approximately two basketball courts. Satellite observations from space, however, can provide global coverage.

Global Precipitation Measurement Mission


Credit: NASA

The GPM Core spacecraft

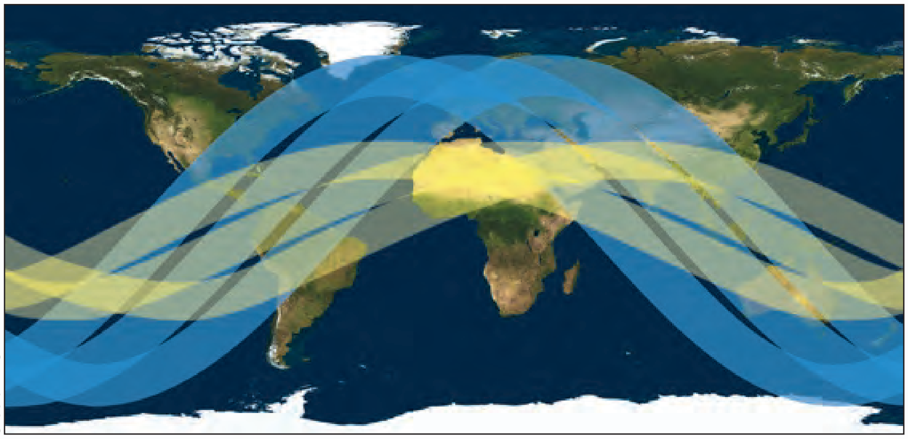
[Right] The GPM mission, initiated by NASA and JAXA, comprises a consortium of U.S. and international space agencies, including the Centre National d'Études Spatiales (CNES); U.S. Department of Defense, Defense Meteorological Satellite Program (DMSP); European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT); Indian Space Research Organisation (ISRO); and the U.S. National Oceanic and Atmospheric Administration (NOAA). The satellites pictured here are expected to form the GPM satellite constellation.



Credit: NASA

The Global Precipitation Measurement (GPM) mission is an international partnership co-led by NASA and the Japan Aerospace Exploration Agency (JAXA). The mission centers on the deployment of the GPM Core Observatory and consists of a network, or *constellation*, of additional satellites that together will provide next-generation global observations of precipitation from space. The GPM Core Observatory will carry an advanced radar/radiometer system and serve as a reference standard to unify precipitation measurements from all satellites that fly within the constellation.

[Right] This graphic compares the area covered by three TRMM orbits [yellow] versus three orbits of the GPM Core Observatory [blue].


Credit: NASA

The GPM mission concept builds on the success of the Tropical Rainfall Measuring Mission (TRMM), a joint NASA and JAXA satellite launched in 1997 that measures precipitation over tropical and subtropical regions, from approximately 35° north latitude (e.g., the Mediterranean Sea) to 35° south latitude (e.g., the southern tip of South Africa).

Measurements from the GPM Core Observatory, however, will provide even greater coverage—between approximately 65° north latitude (e.g., the Arctic Circle) and 65° south latitude (e.g., the Antarctic Circle). These measurements, combined with those from other satellites in the constellation, will provide global precipitation observations approximately every three hours. This integrated approach and unified dataset will help advance scientists' understanding of Earth's water and energy cycle.

The GPM constellation will provide measurements on the:

- intensity and variability of precipitation;
- three-dimensional structure of cloud and storm systems;
- microphysics of the ice and liquid particles within clouds; and
- amount of water falling to Earth's surface.

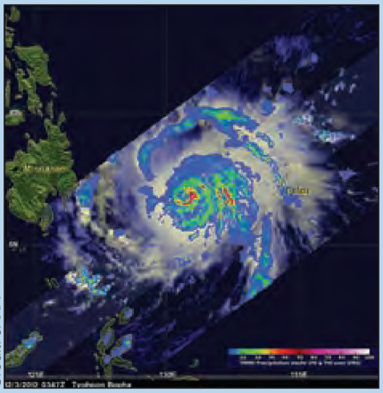
Observations from the GPM constellation, combined with land-surface data, will improve:

- weather forecast models;
- climate models;
- integrated hydrologic models of watersheds; and
- forecasts of hurricanes, landslides, floods and droughts.

Above all, global observations from GPM mission satellites will continue and expand the data records that began with previous precipitation missions, such as TRMM, and improve precipitation estimates around the globe. The mission will help scientists understand how local, regional and global precipitation patterns change over time.

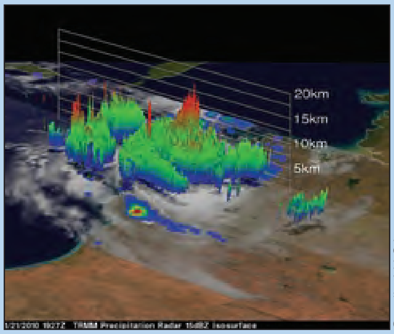
Successes from TRMM

The TRMM satellite was primarily designed to measure heavy-to-moderate rainfall over tropical and subtropical regions. Measurements from TRMM have advanced our understanding of mean annual tropical rainfall, particularly over oceans, and returned many innovative analyses, including the first three-dimensional images of storm intensity and structure from space. TRMM has also provided frequent and detailed observations of precipitation for more than 15 years.



Credit: JAXA

The image at left shows rainfall measurements over the Pacific Ocean just west of the Philippines from Typhoon Bopha as acquired by the TRMM Microwave Imager (TMI) and Precipitation Radar (PR) instruments on December 12, 2012. The images are overlaid on a visible/infrared image from TRMM's Visible and InfraRed Scanners (VIRS) that shows the storm's clouds. This analysis shows that Bopha had a well-defined eye with very heavy rain falling at a rate of over 80 millimeters per hour (~3.1 inches per hour). Ground-based radars are almost universally located on land and cannot make these types of measurements over oceans.



Credit: NASA

The three-dimensional image at right, made from PR data, shows Tropical Cyclone Magda off the coast of Australia on January 21, 2010. Red shades indicate taller, more intense thunderstorms near Magda's eyewall.

GPM Core Observatory

Photo credit: NASA

The GPM mission concept centers on the GPM Core Observatory, pictured here. The drum-shaped instrument and disc [center] is the GMI. The large blocky instrument [bottom of the spacecraft] is the DPR. The gold antenna is the High Gain Antenna for communications. The observatory was built and tested at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

The GPM Core Observatory improves upon the capabilities of its predecessor, the TRMM satellite, with advanced precipitation instruments and expanded coverage of Earth's surface. The GPM Core will carry two instruments: the *GPM Microwave Imager* (GMI) and *Dual-frequency Precipitation Radar* (DPR). These instruments will collect improved observations that will allow scientists to better "see" inside clouds. The GMI has the capability to measure the amount, size, intensity and type of precipitation, from heavy-to-moderate rain to light rain and snowfall. The DPR will return three-dimensional profiles and intensities of liquid and solid precipitation. These data will reveal the internal structure of storms within and below clouds.

The GPM Core Observatory will be able to observe storms forming in the tropical oceans and track these storms as they move poleward into middle and high latitudes. With the advanced observations from the GMI and DPR, scientists will be able to study the internal structure of these storms throughout their life cycles, and view how they change over time. This capability will help scientists understand why some storms change in

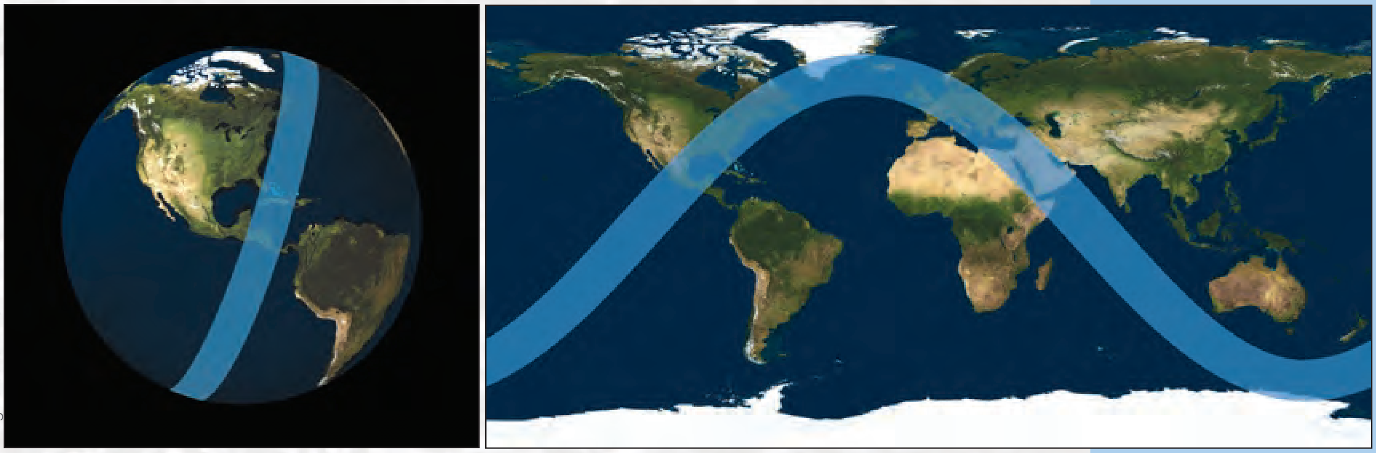


Image credits: NASA

These images show how data from one GPM Core Observatory overpass [left] translate onto a flat map [right]. Data from multiple satellite overpasses can be stitched together to create maps of precipitation from 65° north to 65° south latitude.

intensity as they transition from the tropics to the mid-latitudes.

Together, the GMI and DPR will provide a database of measurements against which other partner satellites' microwave observations can be meaningfully compared and combined to make uniform global precipitation datasets. Measurements from the GMI will also serve as a reference standard for cross-calibration of other satellites in the GPM constellation. For example, when overlapping measurements of the same Earth scene are made, measurements from GMI will be used to calibrate precipitation estimates from GPM constellation sensors within a consistent framework.

GPM Core Observatory Characteristics	
Altitude: 407 kilometers (253 miles)	Orbit duration: 93 minutes
Inclination: 65°	Orbits per day: about 16
Speed: 7 kilometers per second (~4.3 miles per second)	Design life: 3 years
Orbit: circular, non-sun-synchronous	Fuel life: 5 years

Photo credit: JAXA

The GPM Core Observatory will launch from the Tanegashima Space Center in Tanegashima, Japan aboard a JAXA H-IIA rocket in early 2014.

Photo credit: NASA

In addition to measuring heavy-to-moderate rainfall, the GPM Core Observatory will measure light rain and detect falling snow. Light rain and snowfall account for a significant fraction of precipitation, especially in middle and high latitudes.

GMI

GPM Microwave Imager

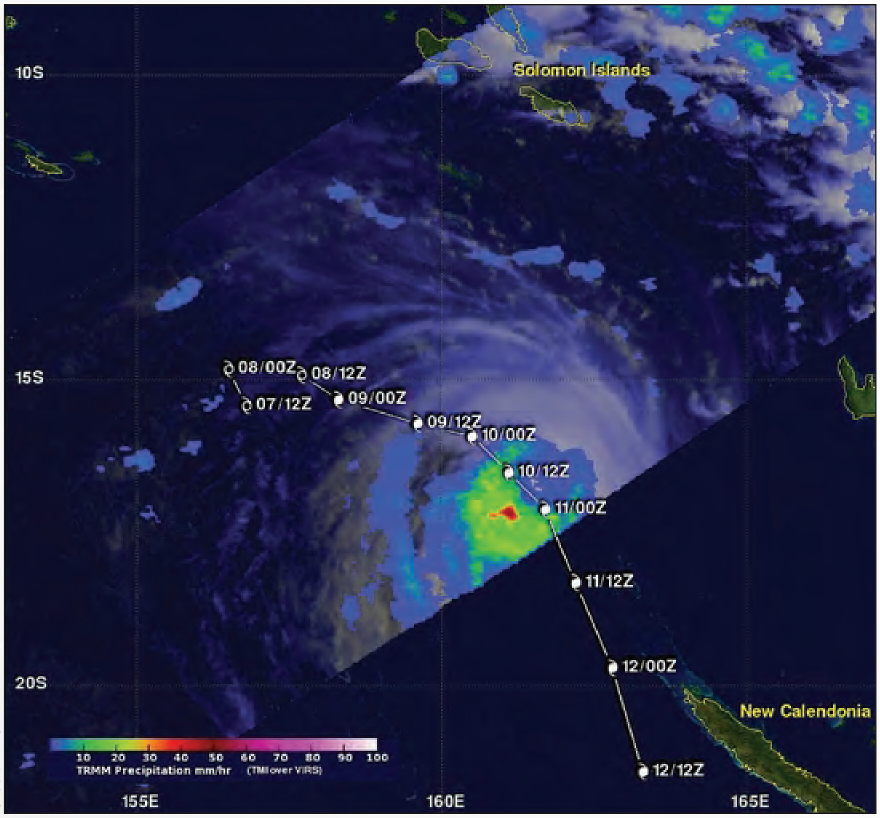
Photo credit: Dzz/morgueFile.com

The GPM Microwave Imager (GMI)—built by Ball Aerospace & Technology Corp. in Boulder, Colo., under contract to NASA's Goddard Space Flight Center—is a multi-channel microwave radiometer designed to sense the total precipitation within all cloud layers, including light rain and snowfall. It does this by measuring the intensity of microwave energy that is constantly emitted by all parts of the Earth system, including rain and snow. Microwaves are part of the electromagnetic spectrum—the range of traveling waves of energy that include gamma and x-rays, ultraviolet light, microwaves and long radio waves. Human eyes can see a narrow band of this spectrum, called visible light. Using satellite sensors such as microwave radiometers, however, scientists can "see" additional wavelengths.

Specifically, GMI uses 13 channels to measure the intensity of microwave radiation emitted

Photo credit: Ball Aerospace and Technologies Corp.

Technicians inside the cleanroom wear protective suits, nicknamed "bunny suits," to prevent dirt, dust, and other contaminants from coming in contact with GMI's instrument parts.



Credit: NASA

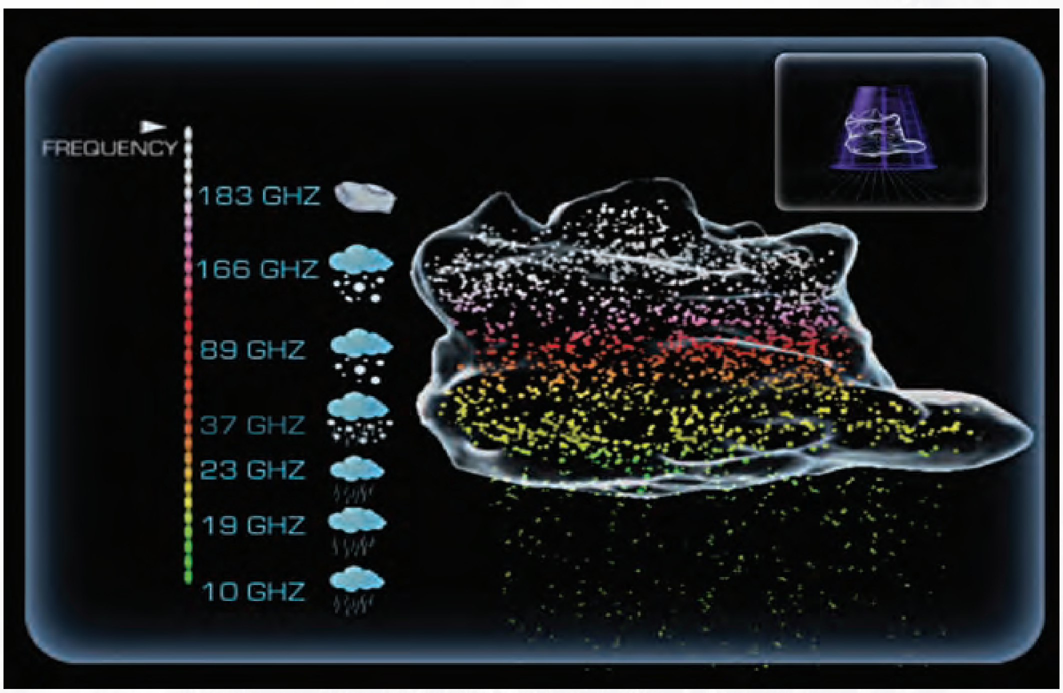
Tropical Cyclone Sandra formed in the Coral Sea south of the Solomon Islands on March 7, 2013. The TRMM satellite passed above Sandra on March 10, 2013. A rainfall analysis using data from the TRMM Microwave Imager (TMI) shows that Sandra contained a large area of rainfall with precipitation falling at a rate of over 50 millimeters per hour (~2 inches per hour) in an area south of Sandra's center of circulation. The GMI onboard the GPM Core will extend measurement capabilities beyond those achieved by the TMI and continue the record of microwave precipitation measurements.

	Channels	Frequency Range	Swath
TMI (TRMM)	9	10 – 85.5 GHz	758.5 km (471 mi)
GMI (GPM)	13	10 – 183 GHz	885 km (550 mi)

This table shows a comparison of the TRMM Microwave Imager to the GPM Microwave Imager.

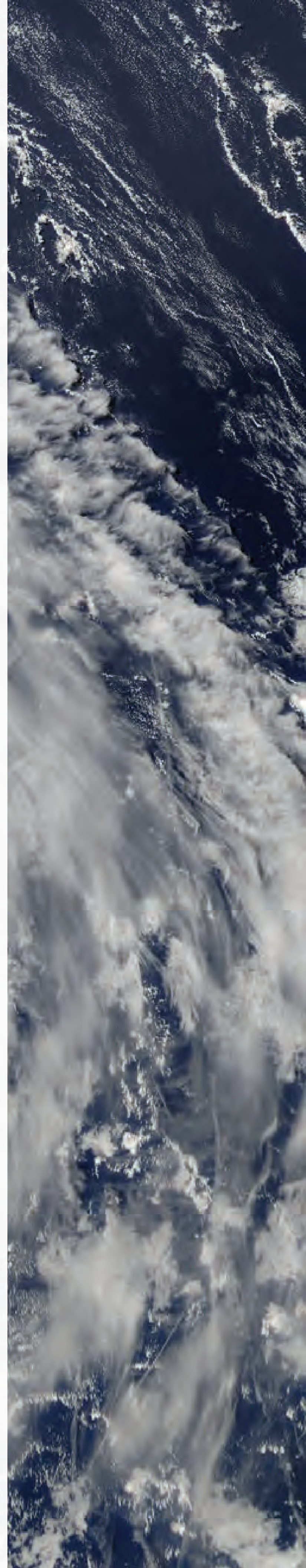
from Earth's surface and atmosphere. The lower frequency channels (10 to 89 gigahertz, similar to those of the microwave imager onboard the TRMM satellite) detect heavy-to-moderate rainfall. GMI's advancements include four additional high-frequency channels (166 to 183 gigahertz) that will measure moderate-to-light precipitation.

Each object, such as rain, snow and Earth's surfaces, emits or scatters energy differently based on the object's temperature and physical properties. Scientists use their knowledge and the contrast between the signals received by the different channels to distinguish between rain and snow and to calculate precipitation rates and quantify precipitation intensity.



Credit: NASA

The GMI will sense the total precipitation within all cloud layers, including snow and ice, with its new high-frequency channels (166 to 183 gigahertz).



DPR

Dual-frequency Precipitation Radar

Photo credit: Gracey Stinson

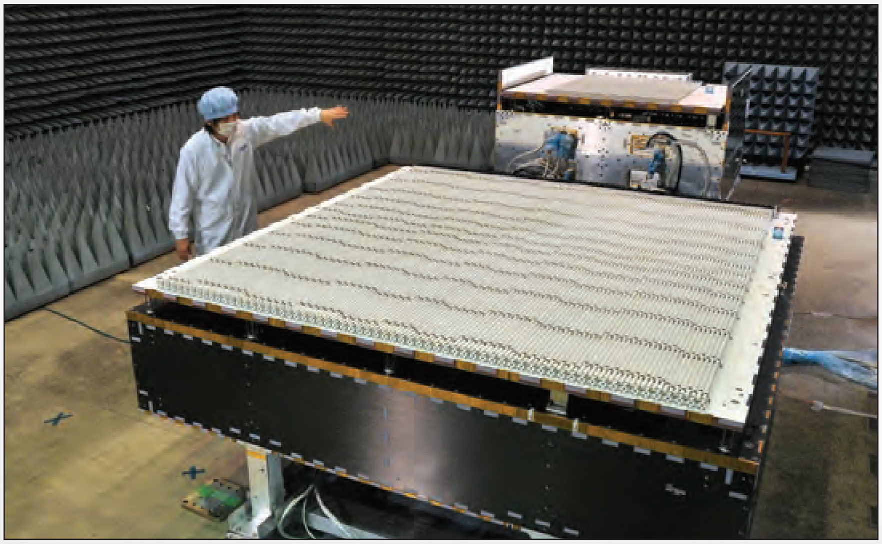


Photo credit: NASA/JAXA

Above, a JAXA technician stands next to the DPR. The Ku-band radar [foreground] measures 2.4 x 2.4 x 0.6 meters (~7.9 x 7.9 x 2 feet), while the Ka-band radar [background] measures 1.44 x 1.44 x 0.7 meters (~4.7 x 4.7 x 2.3 feet).

Ground-based weather radars emerged during World War II and have since been used to measure precipitation, mostly over land. The first spaceborne precipitation radar, however, did not launch until November 1997 onboard the TRMM satellite. The Precipitation Radar (PR) instrument onboard TRMM provides three-dimensional maps of tropical and subtropical rainfall over land and oceans, revolutionizing how scientists see storms.

The GPM Core Observatory will carry the next-generation spaceborne precipitation radar—

The Ka-band frequency radar pictured here will measure frozen precipitation and light rain—an advancement over TRMM's Precipitation Radar.

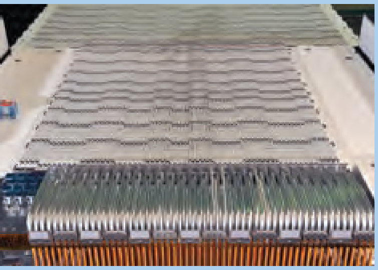
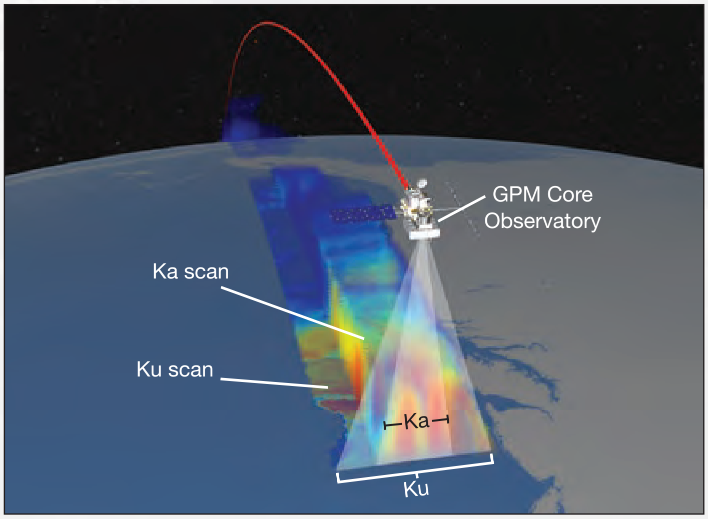
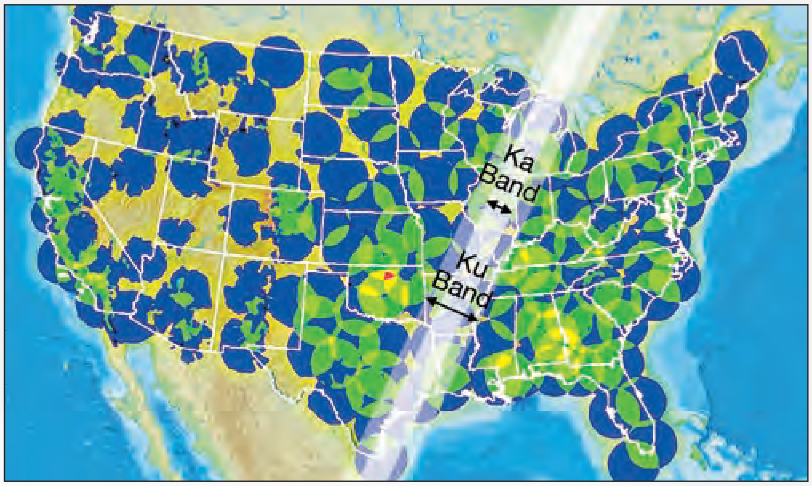


Photo credit: NASA/JAXA



Credit: NASA

This illustration shows the scanning capabilities of the DPR onboard the GPM Core satellite, which will provide data to show the three-dimensional structure of storms. Red, orange and yellow shades indicate heavy-to-moderate rainfall while green and blue shades indicate light rainfall. The scan of the Ka-band frequency is nested within the wider scan of the Ku-band frequency.



Credit: NASA

This map shows continuous DPR coverage over one orbit compared to spotty ground-based radar coverage across the United States. While ground-based radars cover large areas of land, the DPR will provide widespread radar coverage over land and oceans.

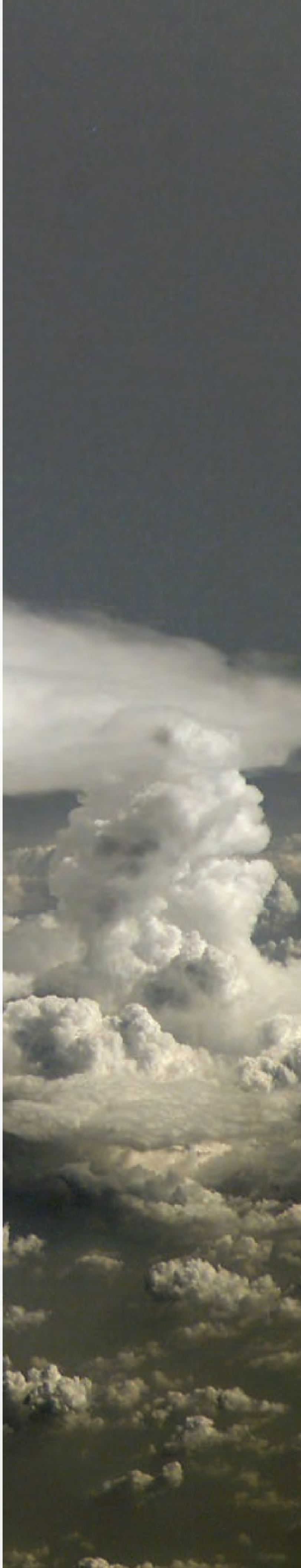
the Dual-frequency Precipitation Radar (DPR). The DPR will make detailed three-dimensional measurements of precipitation structures and rates, and with the Core's expanded coverage, will do so across much more of Earth's surface. NEC Toshiba Space Systems, Ltd. built the DPR, which was designed by JAXA and the National Institute of Information and Communications Technology in Japan.

One of the major advancements of the DPR is the second radar frequency. In addition to the DPR's Ku-band radar that will measure moderate-to-heavy rain at 13.6 gigahertz (similar to the PR), its Ka-band radar will measure frozen precipitation and light rain at 35.5 gigahertz. Simultaneous measurements from the overlapping swaths of Ka/Ku-band data will provide new information on particle *drop size distributions*—i.e., how many raindrops of different sizes are in the cloud layers and how they are spread throughout the storm system.

Improved observations of precipitation size, shape and distribution will offer scientists insight into the microphysical processes of precipitation and help to distinguish between regions of rain and snow. They will also provide bulk precipitation properties such as precipitation intensity, water fluxes and amount of water content. Information on the distribution and size of precipitation particles, together with microwave radiometer measurements made by the GMI, will improve the accuracy of rain and snowfall estimates.

Photo credit: NASA

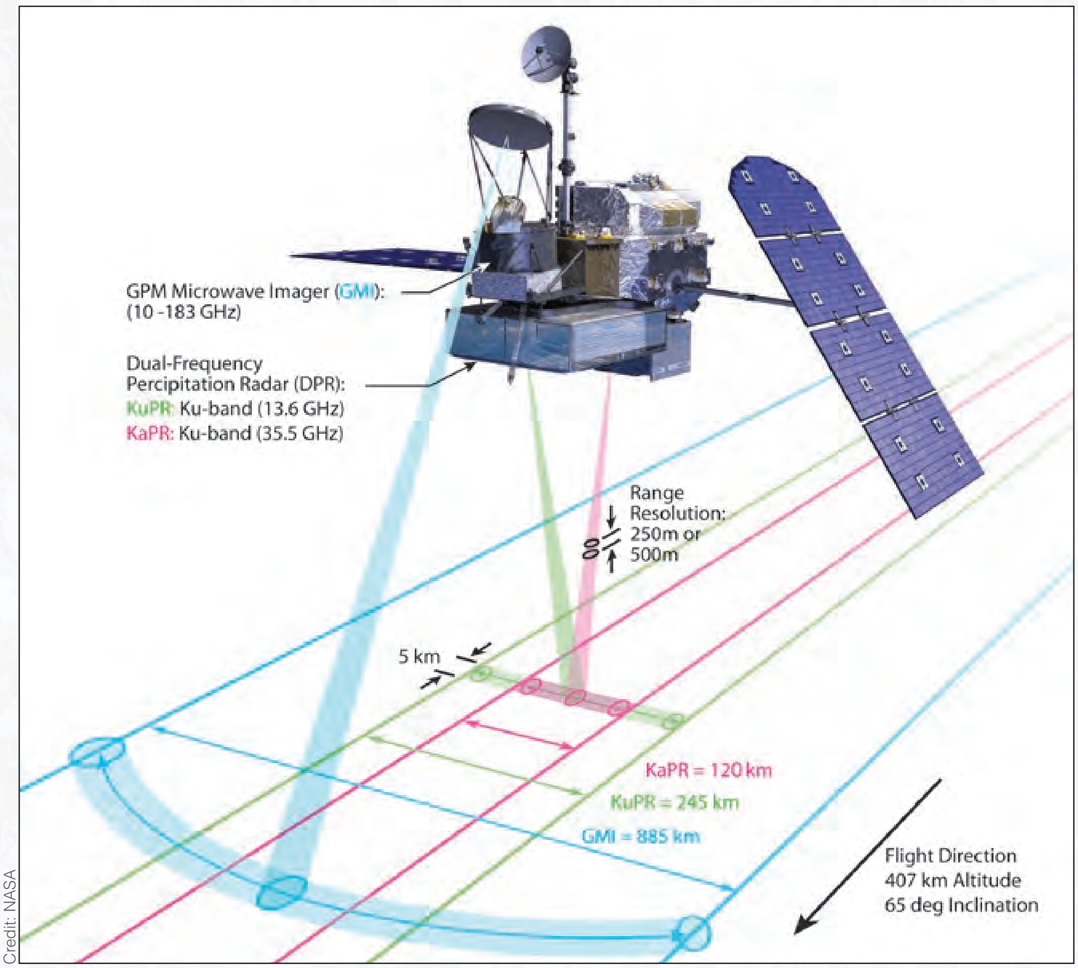
On March 30, 2012, JAXA officials handed off the DPR instrument to NASA. In May 2012, NASA successfully integrated the DPR onto the GPM Core Observatory.



Spacecraft Design

The GPM Core Observatory, developed and tested at NASA's Goddard Space Flight Center, will supply power, orbit and attitude control, communications and data storage for GMI and DPR. The spacecraft consists of the structural/mechanical subsystem, solar array drive and deployment subsystem, power subsystem, attitude and thermal control subsystems, propulsion and guidance, navigation and control subsystems, high gain antenna and radio frequency communications subsystems, and command and data handling subsystem.

Two deployable solar arrays will charge the spacecraft's battery and power the observatory components through the power supply electronics. A solid-state data recorder will provide data storage aboard the spacecraft, and the S-band high gain antenna will

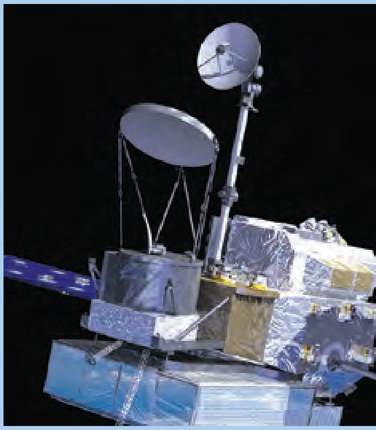


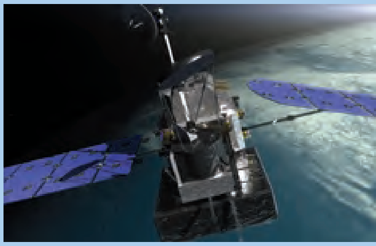
Credit: NASA

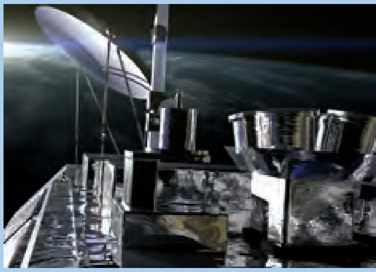
This image shows the GMI and DPR instruments aboard the GPM Core Observatory and their respective *swaths*—the area of Earth's surface observed by the instrument.

transmit GMI and DPR data either in real time or played back from the data recorder.

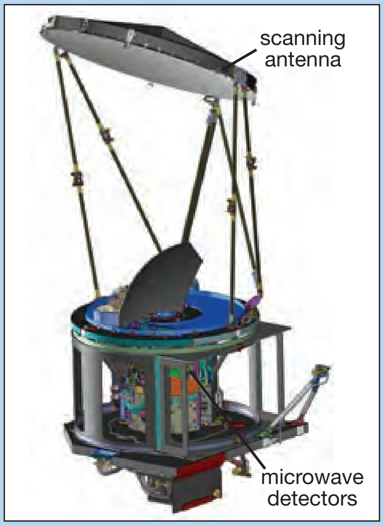
As the GPM Core Observatory orbits 407 kilometers (253 miles) above Earth's surface, the GMI and DPR instruments will constantly scan coordinated areas of the surface below—called *swaths*. The GMI will scan an 885-kilometer-wide swath (550-mile-wide swath), while the DPR's Ku- and Ka-band frequency radars will take overlapping scans in the center of the GMI swath. Specifically, the Ka-band radar will scan across a region of 120 kilometers (~75 miles), nested within the wider scan of the Ku-band radar of 245 kilometers (~152 miles). Measurements within the overlapped swaths are important for improving precipitation retrievals of data and, in particular, the radiometer-based retrievals.







How the Instruments Work



Credit: NASA

GPM Microwave Imager

The GMI is a conical-scanning radiometer. It consists of two main parts: the detectors that measure microwave energy and the scanning antenna that collects the microwaves from the scene and reflects them to the detectors. The scanning antenna spins 32 rotations per minute to collect microwave data along the circular track it traces on the ground. When the antenna faces the arc away from the satellite, it collects data from the scene along the ground path as the satellite moves along. When the antenna faces towards the spacecraft, it does calibration checks to ensure that its measurements are accurate. The GMI's 1.2-meter-diameter antenna will provide significantly improved spatial resolution over the TRMM Microwave Imager.

Dual-frequency Precipitation Radar

The DPR employs two cross-track scanning precipitation radars—a Ku- and Ka-band frequency radar. Both radars will have a spatial resolution of 5 kilometers (~3 miles) and emit 4100 to 4400 pulses per second, with 250-meter (~820-feet) pulse lengths. In the time that it takes the Ku-band frequency radar to measure its wider swath with 250-meter pulse lengths, the Ka-band frequency radar will measure its swath with both 250- and 500-meter (~1640-feet) pulse lengths. This will allow the Ka-band radar to collect measurements that require high sensitivity, crucial for observing smaller water droplets and ice particles. Each radar will return its own data that scientists can analyze separately or together. For example, distinguishing rain from snow is expected to be accomplished by using differences in how the Ku- and Ka-band radar pulses change intensity when they encounter different precipitation types.

Photo credit: NASA

Ground System and Data

The TDRSS ground terminal at White Sands in Las Cruces, New Mexico

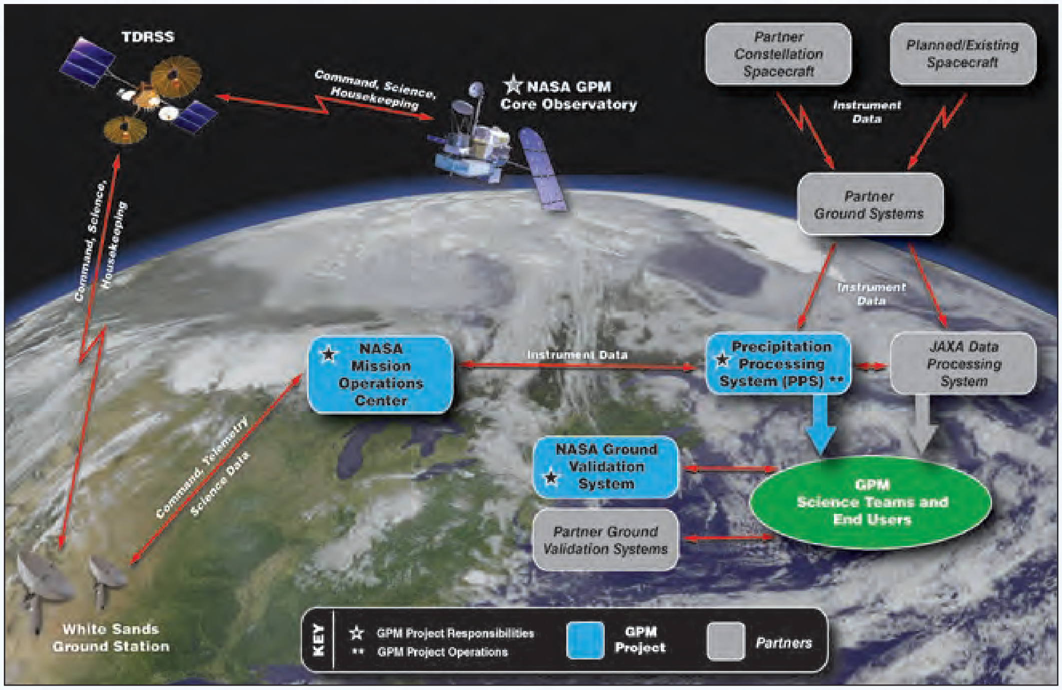
Photo credits: NASA

A second TDRSS ground terminal, also at White Sands

The GPM mission ground system includes all the assets needed to command and operate the GPM Core Observatory in orbit, as well as manage and distribute data received from the Core and other satellites in the constellation.

To communicate with the GPM Core Observatory, the Mission Operations Center, or MOC, at NASA's Goddard Space Flight Center sends software commands through the ground station in White Sands, N.M., to NASA's geosynchronous Tracking and Data Relay Satellite System (TDRSS). This system of three active satellites is used by NASA to communicate to and from other satellite platforms—in this case, the GPM Core Observatory. In return, the GPM Core Observatory transmits spacecraft and instrument telemetry, which report on the satellite's location and proper functioning, as well as science data from the instruments to TDRSS. Once data are transmitted to TDRSS, it sends the information to the White Sands ground station. From White Sands the data go to the MOC, which passes the science data to Goddard's Precipitation Processing System (PPS).

Data from the GPM Core Observatory's GMI instrument are returned continuously through the TDRSS Multiple Access link, while data from the DPR are returned once an orbit—approximately every 90 minutes—through the TDRSS Scheduled Access link.



Credit: NASA

This graphic shows how data travel from the GPM Core Observatory and the constellation satellites to the NASA Precipitation Processing System at NASA's Goddard Space Flight Center.

The partner agencies that control the other satellites in the GPM constellation send their respective satellite data to the PPS via their own data facilities.

The PPS processes all the data returned by GPM constellation satellites, with the exception of data from the DPR. DPR data are sent to JAXA's Mission Operations Systems for initial processing and returned to the PPS as a basic radar product for further processing and integration into global precipitation data products. GPM precipitation datasets will be freely available for download from the PPS website at *pps.gsfc.nasa.gov*.

Ground Validation

To develop methods for data processing and to evaluate how well GPM mission instruments will observe precipitation from space, GPM scientists have designed a series of field campaigns that compare data from ground-based instruments and radars to measurements made by satellites and aircraft instruments that simulate satellite observations. Known as ground validation, the measurements of storms and precipitation events around the world allow scientists to focus on developing methods for measuring different types of precipitation and integrating those datasets into models used for hydrology, weather and flood forecasting, and other applications.

Photo credit: NASA

This view of Barrie, Ontario is taken from the NASA DC-8 research plane during the GPM Cold-season Precipitation Experiment in 2012. The DC-8 carried instruments that simulated measurements that the GPM Core Observatory will make from orbit.

Photo credit: Iowa Flood Center

This field of rain gauges was deployed in eastern Iowa in 2013 for the Iowa Flood Studies. While the rain gauges captured rain on the ground, NASA radars scanned the precipitation as it formed and fell from the clouds above.

Thus far, five field campaigns have taken place: two near Toronto, Canada to measure snowfall (2006–2007 and 2012), one over the Gulf of Finland to measure light rain over high latitudes (2010), one across Oklahoma to measure convective storms over land (2011), and one in Iowa to evaluate Midwest storms and flood forecast applications (2013).

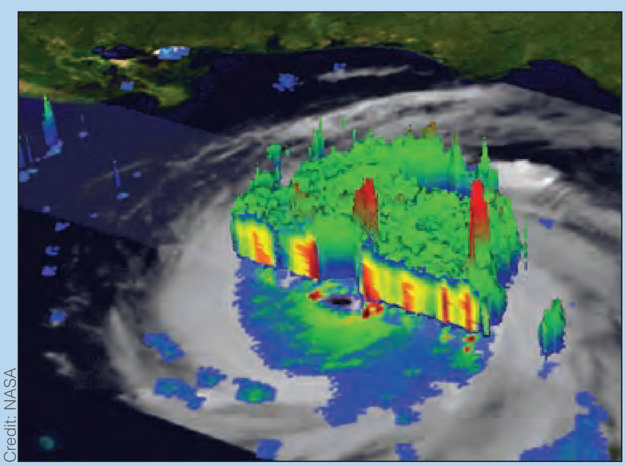
GPM Mission Applications

A Global Understanding for a Better Future

Credits (left to right): NASA, Orange County Archives, Kevin Conners/morgueFile.com, David Fine/FEMA, Beachgranny/morgueFile.com

Water is fundamental to life on Earth. Knowing where and how much precipitation falls globally is vital to understanding how weather and climate impact our environment, including the effects on agriculture, fresh water availability and natural disasters. The

Extended Capabilities in Monitoring and Predicting Hurricanes



Credit: NASA

Satellites allow us to observe changes in the precipitation structure over the life cycle of a storm, especially over oceans and regions where ground-based data are sparse. In particular, TRMM has provided insights into the dynamics of a storm, such as how the eye of a hurricane stays stable as the storm moves across Earth's surface, and how tropical cyclone intensification can be estimated through the presence of hot tower structures. In this image, hot towers (red spikes) present in Hurricane Katrina were observed as the storm was intensifying. The GPM mission will extend coverage and improve scientists' ability to evaluate how storms change in intensity over time. These observations will improve hurricane tracking and forecasts, which can help decision makers save lives.

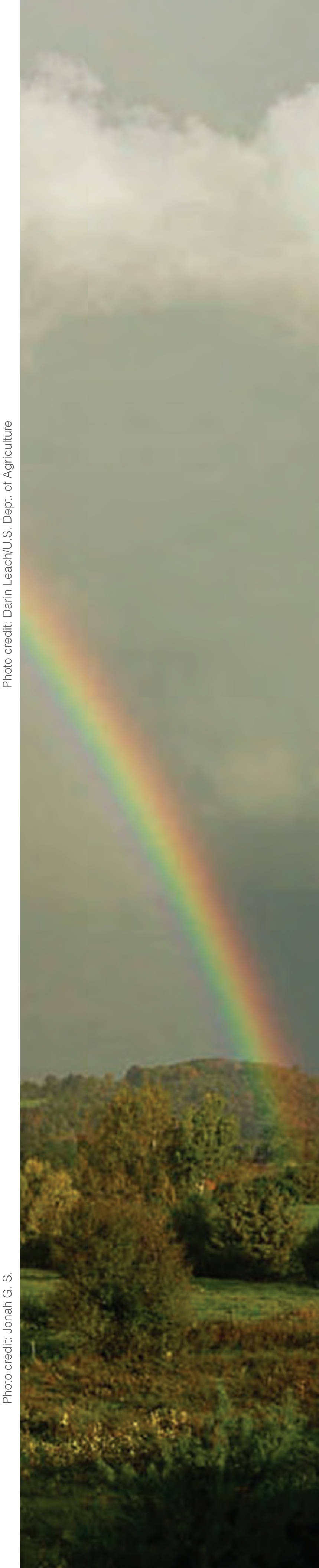


Photo credit: Ben Grader

Enhanced Prediction Skills for Weather and Climate: To predict future changes in weather and climate, scientists use sophisticated computer models. These models rely on available global data to describe the conditions that exist today to project how conditions may change in the future. By providing measurements of precipitation microphysics, GPM advances Earth system analysis and modeling.

Improved Forecasting Capabilities for Floods, Droughts and Landslides: Too much or too little rain can have huge impacts on people around the world. According to the Intergovernmental Panel on Climate Change (IPCC, 2011), an increase in the average global temperature is very likely to lead to changes in precipitation and atmospheric moisture, including shifts towards more extreme precipitation during storms. Data from GPM satellites will help improve forecasting capabilities for natural hazards such as floods, drought and landslides.

Photo credit: Darin Leach/U.S. Dept. of Agriculture

use of advanced spaceborne instruments to measure global precipitation every three hours can reveal new information for a diverse range of applications across agencies, research institutions and the global community.

Among the applications of GPM mission data are improvements to our understanding and forecasting of tropical cyclones, extreme weather, floods, landslides, land surface models, the spread of water-borne diseases, agriculture, freshwater availability and climate change. Data from the GPM Core Observatory, combined with data from other satellites within the constellation, will lead to advances in precipitation measurement science that will subsequently benefit society for years to come.

Photo credit: Kevin Connors/morgueFile.com

Better Agricultural Crop Forecasting: The agricultural community needs to know the timing and amount of precipitation to forecast crop yields and warn of freshwater shortages that might affect irrigation and production. Satellite data from the GPM mission will provide global precipitation estimates over land that can be incorporated into forecast models.

Monitoring Freshwater Resources: Water resource managers rely on accurate precipitation measurements to monitor freshwater resources necessary for human activities including public consumption, irrigation, sanitation, mining, livestock and powering industries. Global observations of precipitation from the GPM constellation of satellites will allow scientist to better understand and predict changes in freshwater supply.

Photo credit: Jonah G. S.

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