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Global Precipitation Measurement Mission

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Raindrop Tales: GPM Meets Mizu-Chan

SUPPLEMENTAL INFORMATION

Description:

When is it going to rain? How much will it rain? We ask these questions every day to know if we need to wear rain boots or bring an umbrella. We also ask these questions to help us make decisions about bigger issues concerning safety, transportation and our jobs. But have you wondered how scientists measure rain and snow? In this story, you will learn how these measurements are made worldwide with satellites and why they are important. Follow along as a satellite, GPM, begins to observe the world of precipitation and meets some new friends along the way.

Inside front cover:

Acknowledgements:

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gpm.nasa.gov, www.nasa.gov/gpm

Precipitation Education

gpm.nasa.gov/education

Supplemental Resources for this Comic Book

gpm.nasa.gov/education/comics

Artist: Aja Moore

Original GPM and Mizu-chan Character Artists: Yuki Kiriga, Sabrynne Buchholz

Script: Kristen Weaver, Ellen Gray

Supplemental Design & Editing: Jacob Reed

Editors/Advisors: Dalia Kirschbaum, Dorian Janney, Kasha Patel

NOTE: IN THE STORY, THE SATELLITES HAVE CHARACTERS TO REPRESENT THEM. HOWEVER, THE REAL SATELLITES ARE REMOTELY OPERATED AND DO NOT HAVE PEOPLE ABOARD.



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Global Precipitation Measurement Mission

Glossary

Word	Definition
Antenna	A device used to transmit signals. GPM uses its antenna to send data and get instructions from the ground.
Calibrate	To measure and adjust readings in comparison to a set standard. The GPM Core Observatory is the calibration standard for the other satellites in the constellation to be able to combine all the data together.
Constellation	In this case, the group of international satellites that combine their data to get global view of precipitation
Drought	Long periods of low precipitation.
Evaporation	The process by which water molecules in liquid water are heated and escape into the air as water vapor.
Flooding	The submerging or covering of land under water.
Frequency	The number of cycles (up and down) per second of a wave of electromagnetic energy as it moves. GPM measures thirteen different frequencies, each sensitive to different types of precipitation.
GPS – Global Positional System	A satellite network used to provide information about the position and velocity of an object.
Hurricane	A tropical storm that has winds of 119 kilometers (74 miles) per hour or higher; the scientific term is “tropical cyclone”.
Instrument	A tool used to make specific measurements to answer a scientific question
Landslide	The sliding down of a mass of earth or rock from a mountain, cliff or other slope.
Microwave imager	A GPM science instrument designed to sense the total precipitation within all cloud layers, including light rain, heavy rain and snowfall.
Monsoon	A seasonally reversing wind pattern that brings heavy rains during certain times of the year.
Orbit	The path followed by an object revolving around another object.
Precipitation	Any product of the condensation of atmospheric water vapor that falls quickly out of a cloud. The main forms of precipitation include drizzle, rain, sleet, snow, graupel and hail.
Precipitation radar	A GPM science instrument that provides detailed three-dimensional measurements of particles of rain and snow, including information about their size, shape and location in the cloud layers
Relay satellite network	The Tracking and Data Relay Satellite System (TDRSS) is a group of communications satellites and ground stations used by NASA for space communications.
Satellite	Anything that orbits or circles something else. Human-made satellites are artificial machines that are put in space in order to collect information or for communication
Solar panel	A panel that absorbs the sun's rays to create electricity. In the case of GPM, this energy powers the scientific instruments.
Star trackers	Devices that measure the positions of stars and use a catalog of star locations to help the satellite know where it is in space
Swath	The area of Earth observed by a satellite as it revolves around the planet

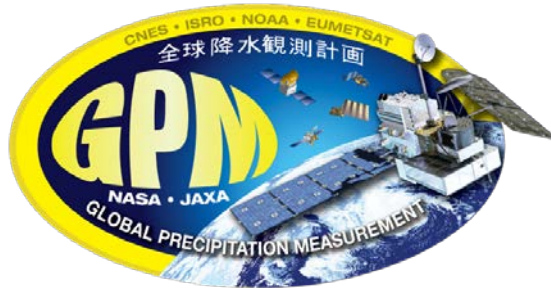
Global Precipitation Measurement Mission

Measuring Rain: On the Ground and From Space

When is it going to rain? How much will it rain? We want to know about precipitation to plan day-to-day events, but also to help us make decisions about bigger issues related to safety, transportation and our jobs. Precipitation also significantly affects our food and water supply. Therefore, it is important to accurately measure rain and snowfall.

There are many ways to measure precipitation. Rain gauges collect and measure rainfall in a location over a period of time. However, rain gauges only measure rain in one specific spot. Radars can be set up on land and cover more area. From Earth, radar sends out a signal to the sky and measures how much of the signal is scattered by rain or snow. However, radars are only available in certain locations and do not measure rain over most of the oceans.

For a truly global picture of precipitation—over land, oceans and in all parts of the world-- we use satellites in the sky.



The Global Precipitation Measurement mission (GPM) is an international network of satellites that are all looking down on Earth and measuring precipitation from space. The GPM concept centers on the deployment of the GPM Core Observatory, a satellite that helps measure precipitation all over the world every three hours. Not only will this data give us a better picture of global precipitation, it will help advance our understanding of Earth's water and energy cycle and improve forecasting of extreme events like floods, droughts, landslides and hurricanes.

Below left: A simple rain gauge. Credit: CoCoRaHS

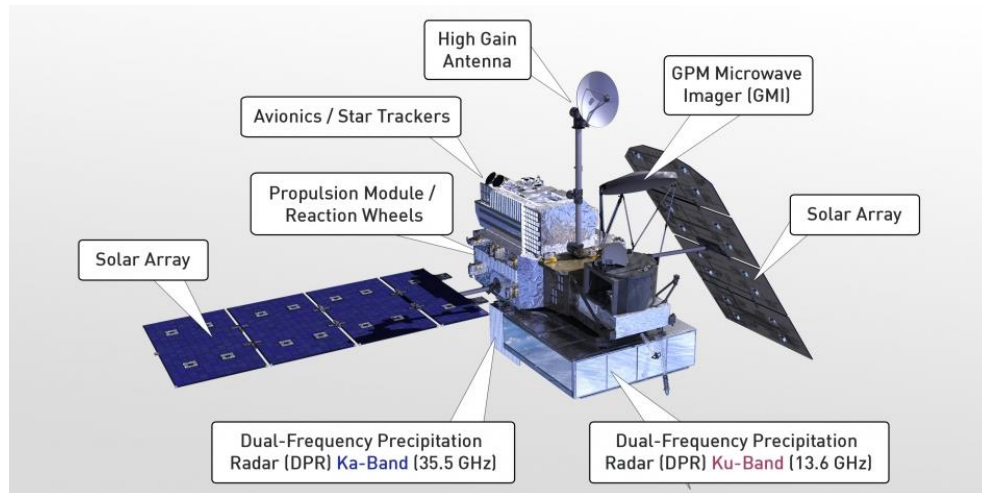
Below right: More complex scientific rain gauges. Credit: Iowa Flood Center



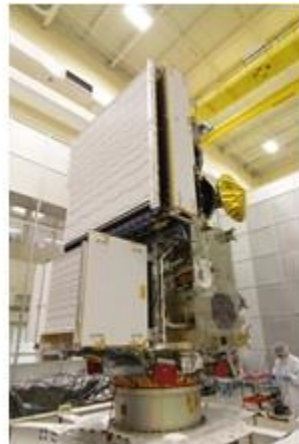
Global Precipitation Measurement Mission

The GPM Core Observatory

The GPM Core Observatory carries two instruments that measure precipitation from space. The data from these two instruments serves as a reference standard to unify precipitation measurements made by an international network of partner satellites. The design and sampling technique of the Core Observatory builds on the concept of the Tropical Rainfall Measuring Mission (TRMM), which was launched in 1997 and continued collecting data until 2015.



The two main instruments on the Core Observatory are the Dual-Frequency Precipitation Radar (DPR) and the GPM Microwave Imager (GMI). The DPR provides three-dimensional information about precipitation particles in the different layers of clouds. It sends energy at two frequencies (Ku- and Ka-band) into the cloud and observes the energy that is reflected from different heights. It is an active radar instrument since it actually sends out energy. The GMI is a passive radiometer – it just observes and measures energy that is emitted by precipitation within clouds. Different types of precipitation, like heavy rain and light snow, emit different frequencies of energy. The GMI measures these frequencies to tell us what kind of precipitation is in the cloud. Other components of the satellite include the solar panels to provide power, a high gain data-relay antenna for communication, a star-field finder for navigation and a control system to manage the satellite.



Left image: GPM Microwave Imager (GMI) is a passive radiometer with a reflector above to receive the microwave energy reflected from precipitation.

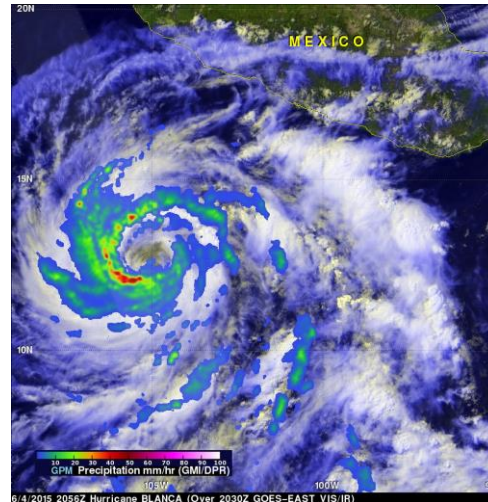
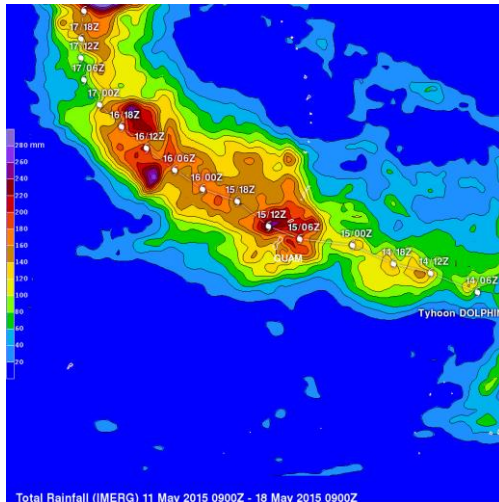
Right images: The Dual-Frequency Precipitation Radar (DPR) is the two boxes on the bottom of the Core Observatory – the small one is the Ka frequency and the larger flat box is the Ku frequency radar

The GPM mission is co-led by NASA and the Japan Aerospace Exploration Agency (JAXA). The GPM Core Observatory launched from the Tanegashima Space Center on Tanegashima Island, Japan in February 2014.

Global Precipitation Measurement Mission

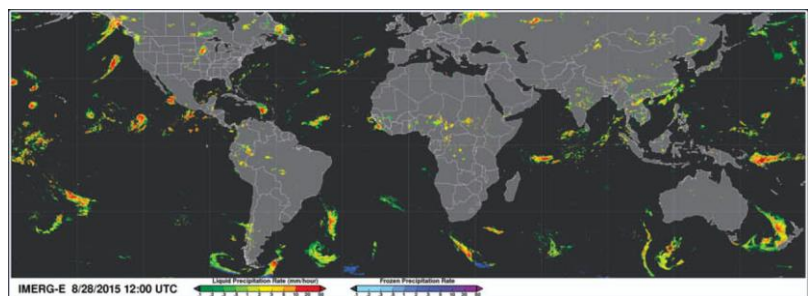
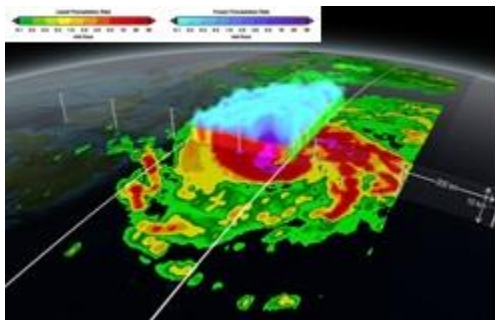
Global Precipitation Data

The GPM Microwave Imager (GMI) can generate 2D images of the rainfall and snowfall rates within storms, similar to an x-ray. This data can then be combined with other satellite data and used to calculate the total precipitation that fell over a period of time.



Left image: Rainfall rates (mm/hour) from Hurricane Blanca on June 4th, 2014 are shown overlaid on top of a GOES satellite image of visible clouds. The red areas have the highest rainfall rate, while the blue areas are the lowest for the storm.

Right image: Rainfall totals (in mm) from Typhoon Dolphin were calculated using GPM IMERG data from May 11th -18th, 2015. The areas of highest total rain are red/pink, while lower accumulation is in blue.



Left image: GPM's Dual-Frequency Precipitation Radar (DPR) can provide 3D images of the intensity of the precipitation within storms, similar to a CAT scan. This image shows precipitation within Typhoon Hagupit on December 5th, 2014. You can see a layer of frozen precipitation in blue above the melting layer, shown in red and pink.

Right: Data from all the satellites in the GPM Constellation is combined to create a global image of precipitation known as IMERG (Integrated Multi-Satellite Retrievals for GPM) which scientists use to study the global water cycle.

For more info: pmm.nasa.gov/data-access

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About the Characters:

GPM: Designed by Japanese comic writer and illustrator Yuki Kiriga, the design for the GPM character was selected as one of the winners of the GPM Anime Challenge, a character creation contest held in 2013. His blond hair and kimono (with snow and rain patterns drawn on it to represent the rain and snow he observes) show that he is half American and half Japanese, just like the real satellite.



TRMM: The Tropical Rainfall Measuring Mission, a joint mission between NASA and the Japan Aerospace Exploration Agency, was launched in 1997 to study rainfall for weather and climate research. After 17 years of productive data gathering, the instruments on TRMM were turned off in April 2015, and the spacecraft re-entered Earth's atmosphere on June 15, 2015 over the South Indian Ocean. In addition to a microwave imager, TRMM carried the first precipitation radar into space, a legacy GPM continues with its improved instruments. The character of TRMM is depicted as an older man, imparting his wisdom to the next generation GPM satellite.



Mizu-chan: From the Japanese word for water, Mizu-chan is the personification of water and precipitation. Designed by then 14-year-old Sabrynne Buchholz of Hudson, Colorado, USA, Mizu-chan was selected as one of the winners of the GPM Anime Challenge, a character creation contest held in 2013. As explained by her creator, her flowing dress in many shades of blue signifies the many forms of water found on Earth, although it can change color to be gray during storms, or white in the winter. Her hemline is surrounded by clouds, showing water vapor condensing as part of the water cycle. Depending on her "mood" (which correlates to temperature, pressure and other atmospheric conditions on Earth), the clouds will also form different types of precipitation – rain, sleet or snow. During storms, her hair may be tousled by the wind or strands may stand out straight to look like lightning bolts. She wears boots to avoid getting her feet wet from run-off, although they may also be covered by frost when the conditions are cold.

The Engineer: The character of the Engineer is based on GPM Deputy Project Manager Candice Carlisle, who works at NASA's Goddard Space Flight Center in Greenbelt, Maryland, USA. Prior to working on GPM, she worked on the Space Technology 5 project built, tested and operated out of Goddard, as well as the Earth Science Data and Information System. Candace holds a B.S. in Computer Science and Physics from the College of William and Mary, in Williamsburg, Virginia, USA and M.S. degrees in Technical Management and Computer Science from Johns Hopkins University in Baltimore, Maryland, USA.



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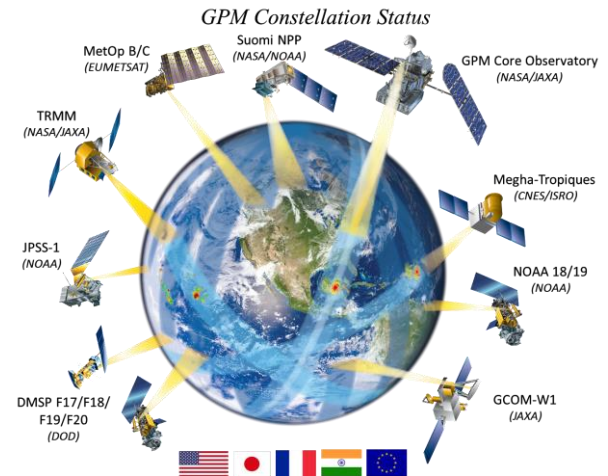
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The GPM Constellation

GCOM-W: The Global Change Observation Mission - Water (GCOM-W) was launched by the Japan Aerospace Exploration Agency on May 18, 2012 from the Tanegashima Space Center on Tanegashima Island, Japan. GCOM-W observes global water and energy circulation using an Advanced Microwave Scanning Radiometer 2 instrument, the world's largest revolving space antenna at time of launch. GCOM-W is one of two satellites in the GCOM mission, along with GCOM-C, which observes climate change with an emphasis on the carbon cycle. The GCOM-W satellite is also known as "Shizuku," and the character in the comic reflects that Japanese heritage.



Megha-Tropiques: Megha-Tropiques was launched on October 12, 2011 from the Satish Dhawan Space Centre in Sriharikota, India. A joint mission between the Indian Space Research Organization (ISRO) and the Centre National D'Études Spatiales (CNES), the French government space agency, Megha-Tropiques studies the water cycle and energy exchanges in the tropics. This satellite holds a microwave imager that observes precipitation and cloud properties, a six channel microwave radiometer that observes water vapor distribution, and a radiometer that measures outgoing radiative fluxes. Because of the joint nature of the Megha-Tropiques mission between ISRO and CNES, two characters were used to represent the satellite.

MetOp: The Meteorological Operational Satellite Program is a series of three meteorological satellites developed jointly by the European Organization for the Exploitation of Meteorological Satellites and the European Space Agency (ESA). MetOp-A and MetOp-B were launched in 2006 and 2012, respectively, both from Baikonur Cosmodrome in Kazakhstan, and MetOp-C is scheduled to be launched in 2017. These satellites provide global weather data services and improve weather forecasting. The MetOp satellites carry 13 different instruments and sensors, supplied by both American and European agencies. Many of the instruments measure similar aspects of climate and weather, but use different measuring techniques to develop more accurate models. Although only one character was used to represent the satellite, ESA is an international organization with 22 member states and centers all over Europe.

