CGMS-36, NASA-WP-01
Prepared by NASA
Agenda Item: WGII/4
Discussed in Working Groups

Status and Plans of GPM

A mission overview, current status, and future plans of the Global Precipitation Measurement (GPM) mission, a NASA/JAXA joint satellite effort is reported as requested in CGMS-35 Action Item 35.21.

1 Introduction to GPM

1.1 Mission Overview

The Global Precipitation Measurement (GPM) Mission is an international satellite mission specifically designed to unify and advance global precipitation measurements from a heterogeneous set of research and operational microwave sensors to provide next-generation precipitation measurements around the world every 2 to 4 hours (http://gpm.gsfc.nasa.gov/). The GPM Mission is currently a partnership between the National Aeronautic and Space Administration (NASA) and the Japan Aerospace and Exploration Agency (JAXA), with participation by other space agencies under development. The mission is, first and foremost, a scientific undertaking to understand the physics and space-time variability of global precipitation as a key component of the weather, climate, and hydrological systems. As such, the GPM concept centers on the deployment of a Core Spacecraft carrying advanced active and passive microwave sensors to serve as a "physics observatory" to gain better insights into precipitation systems and as a "calibration reference" to improve precipitation estimates from a constellation of research and operational satellites. The GPM Core Observatory is scheduled for launch in mid-2013 from Tanegashima, Japan, followed by the 2014 launch of the GPM Low-Inclination Observatory with a second advanced passive microwave sensor.

1.2 Science Overview

The GPM mission will provide observations for characterizing changes in the cycling of water in the Earth system, quantifying freshwater fluxes in terms of precipitation inputs, and advancing predictive capability for natural hazards and extreme weather events. In NASA's Science Plan, GPM has been identified as a priority "systematic measurement" mission to answer the question: "How is the Earth changing and what are the consequences for life on Earth?" In Japan, GPM is a key element of the Japanese earth monitoring satellite program to provide advanced global precipitation observations. By making data available in near real-time to operational agencies and stakeholders beyond the traditional science community, GPM will also facilitate the use of space-based precipitation observations in a wide range of practical applications to directly benefit the society by extending current capabilities in weather/climate forecasting, natural hazard prediction, and freshwater resource management.

The GPM Science Objectives therefore encompass not only scientific discovery but also application-oriented research. The GPM mission objectives include:

Advancing precipitation measurement from space by
- o Providing measurements of microphysical properties and vertical structure information of precipitating systems using active remote-sensing techniques over a broad spectral range.
- o Combining active and passive remote-sensing techniques to provide a calibration standard for unifying and improving global precipitation measurements by a constellation of research and operational sensors.

Improving knowledge of precipitation systems, water cycle variability, and freshwater availability by
- o Providing 4-D measurements of space-time variability of global precipitation to better understand storm structures, water/energy budget, freshwater resources, and interactions between precipitation and other climate parameters.

Improving climate modeling and prediction by
- o Providing estimates of surface water fluxes, precipitation microphysics, and atmospheric latent heat release to improve Earth system modeling and analysis.

- Improving weather forecasting and 4-D climate reanalysis by
  - Providing accurate and frequent measurements of precipitation-affected radiances and instantaneous precipitation rates with quantitative error character -izations for integration into weather forecasting and data assimilation systems.
- Improving hydrological modeling and prediction by
  - Providing high-resolution precipitation data through downscaling and innovative hydrological modeling to advance predictions of high-impact natural hazard events (e.g., flood/drought, landslide, and hurricanes).

1.3 Mission Architecture

The GPM Mission comprises three major elements: (1) a space segment comprising a constellation of active and passive microwave precipitation sensors, (2) a ground segment that includes mission operations, data processing systems, and ground validation systems, and (3) international science teams for satellite inter-calibration, algorithm development, product evaluation, scientific investigation, and research for improved use of precipitation data in applications.

1.3.1 Space segment

The GPM space segment consists of (1) a NASA-JAXA Core Observatory carrying the JAXA-provided Dual-frequency Precipitation Radar (DPR) and the NASA-provided GPM Microwave Imager (GMI), (2) a NASA-provided Low-Inclination Satellite carrying a second GMI, and (3) dedicated and operational passive microwave radiometers provided by a consortium of additional partners. As an on-orbit physics observatory and a calibration reference for the GPM constellation, the Core Observatory will be in a non-Sun-synchronous orbit at approximately 65^o inclination and 407 km (mean altitude) to provide coincident measurements with constellation radiometers for inter-sensor calibrations - both in terms of radiometric measurements and precipitation retrievals - using Core Observatory sensor data as a reference standard. This non-Sun-synchronous orbit also provides remote sensing of precipitation at different hours of the day allowing for observations of the diurnal variability of precipitation. In this orbit, GPM Core sensor measurements will still cover more than 90% of the globe. Since the majority of GPM constellation satellites are polar orbiters, GPM will also provide a Low-Inclination Observatory (LIO) carrying a GMI in a non-Sun-synchronous orbit at 40^o inclination and 635 km altitude to improve the overall sampling by the GPM constellation and the near real-time monitoring and prediction of hurricanes and mid-latitude storms.

The DPR instrument consists of a Ka-band precipitation radar (KaPR) at 35.5 GHz and a Ku-band precipitation radar (KuPR) at 13.6 GHz. The latter is an updated version of the unit flown on the Tropical Rainfall Measuring Mission (TRMM). (For more information on TRMM see http://trmm.gsfc.nasa.gov/). The DPR is capable of measurements of the 3-dimensional precipitation structure, with a greater sensitivity than the TRMM PR to signatures of light rain rates and snowfall. DPR will be able to achieve a detection threshold of ~ 12 dBZ (corresponding to a liquid precipitation rate of 0.2 mm hr), an improvement of 6 dBZ over the TRMM PR.

The GMI instrument is a conical-scanning microwave radiometer with thirteen channels and a large 1.2 m diameter antenna to provide better spatial resolution than the TRMM Microwave Imager (TMI) and AMSR-E. The GMI uses a set of frequencies (10-89 GHz) that have been optimized over the last two decades to retrieve heavy, moderate, and light precipitation. In addition, a 166 GHz channel was included for GMI for measuring light precipitation in frontal structures outside the tropics, and two 183 GHz water vapor sounding channels were included for detecting scattering signals from small ice particles for estimating light rain and snowfall rates. By combining channels that are normally flown on imagers (i.e. 10-89 GHz) with those that are generally used for sounding (166 & 183 GHz), GMI will have strong sensing capabilities not only when the surface characteristics are understood but also when the surface interferes with the imaging channels.

Satellites with precipitation sensors identified to be potential members of the constellation during GPM Core operations include: GCOM-W, DMSP, Megha-Tropiques, MetOp-B, NOAA-N', NPP, and NPOESS C1 and C2. These partnerships and those with other agencies are currently under development to incorporate more precipitation-sensing satellites in the GPM constellation and to enhance ground validation capabilities. Space agencies with satellite precipitation sensors can provide additional observations for increased temporal resolution for global precipitation products. Ground validation activities will be enhanced with measurements from multiple precipitation system regimes.

1.3.2 Ground segment

For mission operations, product validation, and data dissemination, the GPM Mission is supported on the ground by (1) a NASA-provided mission operations system for the operations of the GPM Core Observatory and Low-Inclination Satellite, (2) dedicated and cooperative ground validation (GV) sites provided by NASA, JAXA, and GPM partners around the world, and (3) a NASA Precipitation Processing System (PPS) and a JAXA data system in coordination with other GPM partner data processing sites to provide near-real-time and standard global precipitation products. The mission operations system controls satellite operations and collects satellite data, while the PPS processes satellite data through calibration and retrieval algorithms and delivers science products.

The ground validation (GV) effort has been identified as a key component of GPM. The objective is to establish collaborative GV measurement and research activities between the GPM Mission and international partners to support pre-launch satellite algorithm development and post-launch product evaluation. This collaboration is important for coordinating GV assets and facilities around the world within a consistent framework to contribute to the refinement of satellite simulators and retrieval algorithms for GPM. This action is also part of the effort for determining error characteristics of satellite precipitation products for the development and production of the next-generation multi-satellite global precipitation data products and for improved applications in weather forecasting and hydrological prediction.

1.3.3 International science teams

For satellite algorithm development, ground validation, and data applications, GPM is supported by a NASA-selected Precipitation Measurement Missions (PMM) science team and a JAXA-selected PMM science team. Both science teams are open to international investigators through proposals of collaborative research that complement existing science team activities on the basis of no exchange of funds. Activities of these two science teams are coordinated through a NASA-JAXA Joint PMM Science Team. As more nations contribute to GPM science, it is envisioned that the GPM Mission will be supported by multiple national and international science teams.

2 Current Mission Status

The GPM mission is currently in the formulation phase, during which GPM International Planning Workshops are held approximately every year by NASA, JAXA, and partner facilities and will continue into later phases of the mission. The 7th International Planning Workshop was held December 2007 in Japan with 146 participants from 15 countries. International ground validation activities are coordinated at GV workshops, the 3rd of which was held in March 2008 in Brazil with 50 participants from 19 countries. Other activities of interest include

- Participation in the Cloudsat/CALIPSO Ground Validation Program (C3VP) field campaign (winter 2006-2007) to collect data for snowfall algorithm development. (http://c3vp.org/)
- On March 20, 2008, precipitation data made available to the public in GIS TIFF + world file format along with the previously provided HDF format.
- 1st meeting of GPM Algorithm Development Team, April 2008
- 2nd GPM Asia Workshop, June 2-4, 2008 Tokyo, Japan (JAXA, NASA)
- 1st NASA-JAXA Joint PMM Science Team Meeting in Colorado, Aug. 2008

3 Future Plans

Future activities will be:

- Moving the mission into implementation phase (phase C) through NASA review process scheduled for late 2008 and early 2009
- Comparisons of different methods of inter-calibration for generating uniform precipitation estimates from diverse types of precipitation sensors
- Algorithm development for single and multi-sensor/satellite precipitation products
- Continued mission reviews
- Additional field campaigns in partnership with US agencies, Finland, Canada, and other international GV partners for important opportunities.
- JAXA's GV efforts will focus mainly on the development and validation of DPR algorithms using ground-based assets in Japan and Asia.

After launch, GPM will be the first constellation-focused mission that will improve precipitation estimates through extensive intercalibration within a consistent framework using measurements by the GPM Core sensors as a reference. As an international partnership in space hardware, ground assets, and scientific collaboration, GPM is an example of how nations can work together for the benefit of all and has been identified as an outstanding example of peaceful uses of space by the United Nations.

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