CGMS-36, NASA-WP-02
Prepared by NASA
Agenda Item: WGII/4
Discussed in Working Groups

GPM Precipitation Estimation and Validation Activities

Precipitation estimation and validation activities of the Global Precipitation Measurement (GPM) mission, a NASA/JAXA joint satellite effort is reported as requested in CGMS-35 Action Item 35.22. An introduction to GPM, a status of GPM estimation and validation activities, and future plans are provided.

1 Introduction

The center piece of NASA's activities on precipitation estimation and validation is its role in the Global Precipitation Measurement (GPM) mission, being developed primarily by NASA and the Japan Aerospace and Exploration Agency (JAXA). GPM marks an evolution from the current effort built around uncoordinated individual satellite missions towards one coordinated, inter-calibrated satellite constellation providing uniform global precipitation products. An important component as a starting point in creating this coordinated precipitation-measuring constellation already exists, in the form of the highly successful U.S.-Japan Tropical Rainfall Measuring Mission (TRMM), in operation since 1997, which continues to provide first-generation tropical precipitation estimates used in both societal applications and scientific research. The GPM mission will serve as the cornerstone for international collaboration on satellite precipitation algorithm research, ground validation, data processing, and product dissemination.

To these ends, NASA is working with the international science community to develop a consensus reference standard for cross-calibration of microwave radiometers to produce uniform global precipitation products. NASA and JAXA have devoted substantial resources through TRMM and GPM in data processing and science team support, to include the development of Level 1C prototypes for intercalibration of current radiometers using the TRMM PR and TMI as a reference. NASA has supported and will continue to support the production of both real-time and research merged 3-hr global precipitation products available on an ftp server at no cost to the community. NASA has also expended sizeable resources to support ground validation sites and studies to improve the space-based rain retrievals. NOAA also produces rain estimates but based on a different algorithm. NRL provides merged products in real-time openly and freely. Similarly, EUMETSAT provides merged data products in real time. GPM will help unify these disparate satellite precipitation estimates, thereby ensuring consistent 3-hour global rain rate maps. NASA and JAXA have also expended significant efforts in designing new instruments and building international partnerships for the GPM mission. Both agencies facilitate international collaborations on precipitation algorithms, ground validation, and data system development.

2 Status of GPM Precipitation Estimation and Validation Activities

2.1 Data Processing Activities

In regards to current data activities, the NASA Precipitation Processing System (PPS) assumed TRMM data processing in mid-2008. This action allows an early build of and risk reduction for the data processing system to be used for the successor GPM mission. This system will allow testing the architectural characteristics of multi-satellite data merging: flexibility, extensibility, and maintainability. In addition, the action improves the access to the user community of all TRMM-based data including the production merged satellite products.

2.2 Ground Validation Activities

Numerous GPM ground validation (GV) activities were initiated or completed in FY08. These activities spanned topics including development of observational infrastructure requirements, initiation of international and interagency joint research teams, and GV field campaign planning.

In order to support instrument infrastructure development, early in FY08 science and engineering requirements were developed in collaboration with the GPM Project Office to enable procurement/development of a ground-based Ka-Ku Band dual-polarimetric radar. This NASA-owned resource will fill an important gap in current ground-based weather radar frequency availability, and will enable more robust ground-based verification of DPR algorithms- especially in light precipitation and cold-season regimes. Moving to longer wavelengths (S-band radar infrastructure), a multi-stage plan was developed to thoroughly test existing N-POL radar transmitter and receiver components at the CSU-CHILL test site (using the CHILL antenna as a reference) in parallel with the purchase of a new N-POL antenna system and is targeted for completion in 2010.

Under the auspices of international GV activities, in March 2008 GPM GV helped organize/lead the 3rd International GPM Ground Validation Workshop held in Buzios, Brazil. As a result of this workshop numerous joint research topics were discussed and subsequently at least eight pursued in the form of no-cost proposals for submission to NASA PMM for formal participation on the PMM Science Team.

Cold season precipitation studies have continued and expanded using the C3VP observational dataset of 2006-2007 (http://c3vp/org/). In particular, recently a quality-controlled combined common airborne microphysical and ground-based radar microphysical product was developed to support snowfall algorithm retrievals. This dataset will be used by algorithm developers to ascertain microphysical behavior under coincident over flights of polar orbiting AMSU-B and MHS radiometers and by cloud modelers to validate and improve model microphysical descriptions of snow and ice (toward development of model-based satellite simulators) used in initial simulations of C3VP priority cases.

In July, 2008 the first draft of the GPM GV Science Implementation Plan was completed (http://gpm.gsfc.nasa.gov/groundvalidation.html). The plan organizes ground validation activities around three core approaches: statistical/network direct validation, physical process validation and integrated hydrometeorological validation. One issue raised concerning this plan is the need to ensure adequate airborne remote sensing capability to support algorithm validation. All in all, prior GPM GV activities are proving useful for algorithm development, while upcoming GV activities will continue to provide measurements critical for the three core GV approaches for GPM.

2.3 Algorithm Development Activities

For satellite algorithm development, 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.

Current activities for algorithm development have focused on (1) developing a management structure for algorithm development and pre-launch delivery to PPS, (2) organizing teams for the Level 2 radar, radar-radiometer combined, and passive microwave instantaneous precipitation retrieval algorithm schemes, and (3) inter-satellite calibration. To this end, an algorithm planning meeting was held in May 2008 at which teams and leads were formed for each of the Level 2 algorithms. The teams have provided milestones and schedules to meet PPS delivery requirements and are drafting Algorithm Theoretical Basis Documents (ATBD) in order to outline algorithm development. The inter-satellite calibration group has been especially active, meeting in Jan 2008 and Aug 2008, with multiple email exchanges in between. They have performed comparisons using TRMM data and have recently found a calibration fix for TRMM.

3 Future Activities in Algorithm Development and Ground Validation

Planning for GPM GV field campaigns began in earnest in FY08. GPM GV interacted with the NOAA Hydrometeorological Testbed (HMT) activity several times during FY08 to ensure that we would have inputs and access to ground based activities planned for the 2010-2014 timeframe in the HMT Southeast. The Mid-latitude Continental Convective Clouds Experiment (MC3E) in S. Central Oklahoma during the late spring of 2011 is a proposed joint NASA-DOE ARM field experiment devised to address radiometer precipitation retrieval shortcomings over land. In addition to MC3E, preliminary discussions have been initiated in response to a CloudSat request for GPM participation in a cold-season experiment over the Baltic in fall of 2009.

The PMM science team will focus on the following five precipitation estimation and validation activities:

1. Inter-Satellite Calibration
   Develop procedures and algorithms to perform inter-satellite calibration at both the brightness temperature level (initial focus) and precipitation estimate level.
2. Algorithm/Model/Ground Validation (GV)
   Retrieval algorithm development is a critical area that is necessary to ensure reliable and accurate mission products. Modeling of cloud processes and ground validation are considered integral to algorithm development due to the Bayesian approach, number of unknowns, and desire for high quality products with error estimates. Because of the importance of GV, five sub-categories are identified as key areas:
   I. *Precipitation Detection*
      Develop methods that separate precipitating from non-precipitating radiometer footprints, and distinguish between rainfall and snowfall footprints over both land and ocean surfaces.
   II. *Drop Size Distribution (DSD)*
      Examine the different ways the radar, radiometer, and combined schemes adjust DSD and strive toward convergence among the algorithms.
   III. *C3VP/GPM HF (85 - 183 GHz)*
      Exploit the data obtained from Canadian CloudSat/CALIPSO Validation Programme (C3VP) for various studies on falling snow, e.g., algorithm development, winter event CRM modeling, microphysical properties of snowflakes as related to radiative properties.
   IV. *Ice/Mixed-phase Precipitation*
      Develop and test physical parameterizations for modeling ice and mixed-phase particles in precipitation retrieval algorithms.
   V. *Multi-satellite Algorithms*
      Merged multi-satellite algorithms are intended make the best use of all available individual precipitation estimates to create integrated products. The first-generation algorithms now in use provide several alternative paradigms that require a comparative analysis to facilitate progress.
3. Hydrologic Science and Applications
   To explore and define the potential benefits of PMM for Hydrologic Science and Applications as well as recognizing the role of hydrological activities in satellite product evaluations. A longer term goal is to examine and recommend a framework or set of

frameworks for assessing the propagation of retrieval uncertainty at multiple spatial and temporal scales into a variety of hydrological and applications.

4. Weather/Climate Science and Applications
   Develop a set of physically consistent ideas/theories for precipitating cloud systems to assess uncertainties in PMM rainfall and latent heating products through analyzing the data from GV and other existing ground-based observational platforms.
5. Data Assimilation
   Develop technical and programmatic strategies for producing level-4 global and regional precipitation analyses on a routine basis in the GPM era. Level 4 “dynamic” precipitation analyses could provide alternative or complementary products to merged multi-satellite precipitation products at global scales and downscaled high-resolution regional products for hydrological applications.

With contributions by: Ramesh Kakar, Arthur Hou, Gail Skofronick Jackson, Robert Hamilton, Erich Stocker, and Walt Petersen