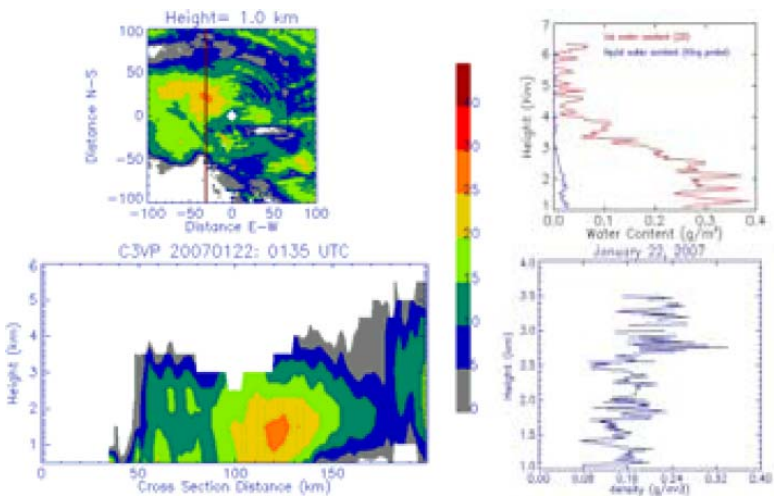
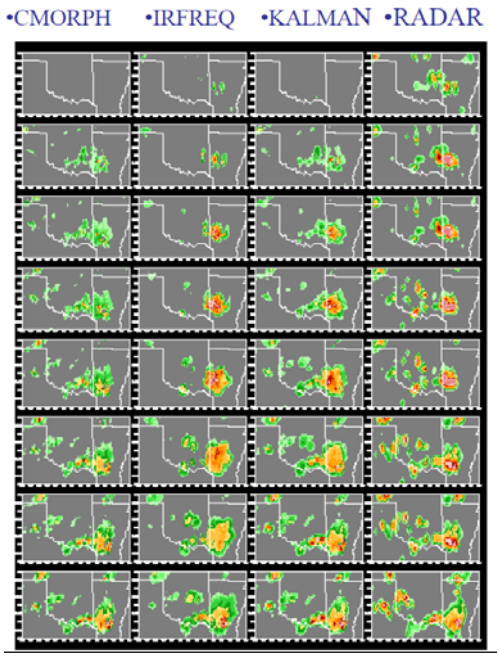
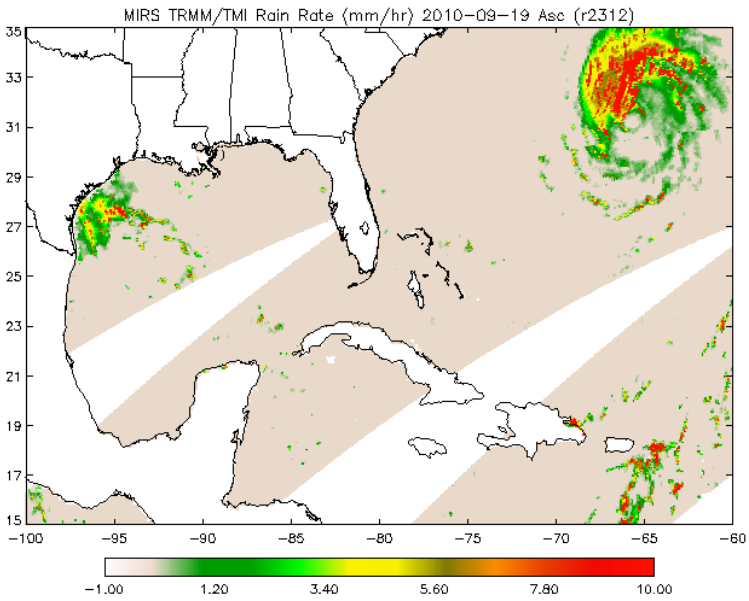


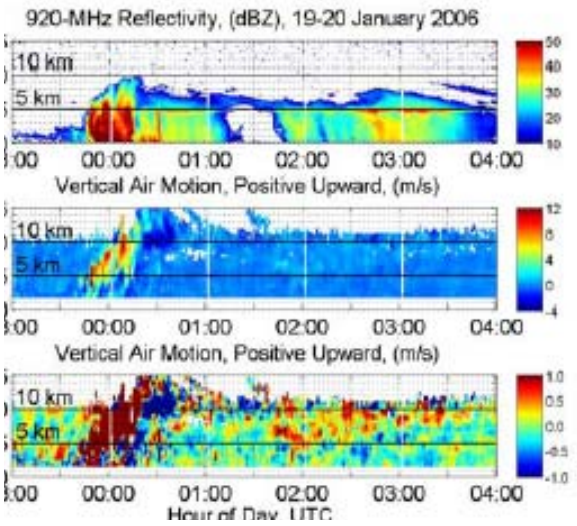


Annual Progress Report:

NOAA's Steering Group on Precipitation Measurement from Space

August 1, 2009 – December 31, 2010





Annual Progress Report:
NOAA's Steering Group on Precipitation Measurement from Space
August 1, 2009 – December 31, 2010

1. Introduction

NOAA's Steering Group on Precipitation Measurement from Space (SGPMS), established through a memorandum from Assistant Administrator for Satellite and Information Services, Mary Kicza, on July 15, 2008, is pleased to submit its second annual progress report, for the period August 1, 2009 through December 31, 2010.

The SGPMS was formed based on a recommendation presented in the 2007 National Research Council (NRC) report *NOAA's Role in Space-based Global Precipitation Estimation and Application."* As indicated in the NRC report, the future success of NOAA's utilization of advanced precipitation sensors such as NASA's Global Precipitation Measurement (GPM) Mission will come from an across-line office coordination of requirements, research and development, and transition into operations.

2. SG Membership

The current membership is in the table below. It is proposed that this membership remain intact through 2011, with some new members being rotated on beginning in January 2012. The balance of membership across line offices should remain essentially the same.

Name	Organization
Ralph Ferraro (Co-Chair)	NESDIS
Chandra Kondragunta	NESDIS
Jim Silva	NESDIS
Fuzhong Weng	NESDIS
David Kitzmiller (Co-Chair)	NWS
James Yoe	NWS
Pingping Xie	NWS
Allen White	OAR
Marty Ralph	OAR
Tim Schneider	OAR
Tilden Meyers	OAR
Christopher Miller	OAR

3. Meetings

The SGPMS met five times during the reporting period – August 27, 2009; December 4, 2009; February 12, 2010; May 11, 2010; October 28, 2010. These meetings were conducted through teleconference, however, some meetings were conducted at locations where several of the members were able to meet face-to-face. Meeting minutes were recorded, and action items assigned and tracked.

4. Major Accomplishments

- **First NOAA User Workshop on the GPM Mission**

On August 18 and 19, 2010, over 50 NOAA and NASA scientists and managers participated at the First NOAA User Workshop on the GPM Mission, which was held at the M-Square Complex of the University of Maryland in College Park, MD. The two-day meeting, which consisted of a series of plenary talks, briefings on NOAA stakeholder interest in GPM, and breakout group discussions, was viewed as a great first step in developing more broadly based NOAA interest and education in the GPM mission. A workshop report is being finalized and will be distributed to the NOAA Assistant Administrators. Several key recommendations came from the working groups and are summarized in the report; the Executive Summary is presented in Appendix A. Information on the workshop can be found at http://www.star.nesdis.noaa.gov/star/meeting_GPM2010_agenda.php. There is a tentative plan to hold a second workshop in late 2011 that will be more application-based.

- **Interactions with NASA**

The SGPMS is the main communicating body between NASA and NOAA on GPM science, validation and data issues. Members meet periodically, and as opportunities arise, with NASA on various topical issues and communicate through email and phone on a regular basis. During the reporting period, the following meetings were held:

Meeting	Purpose	Outcome
October 2009 Salt Lake City, UT	PMM Science Team Meeting	Agreement between NASA and NOAA to continue previous funding arrangement for NOAA PIs on new PMM science team (PIs still TBD at that time).
March 2010 College Park, MD	Develop NASA-NOAA GPM IIA/MOU	MOU is presently undergoing NASA-NOAA general counsel review.
January 2010 Washington, DC	NASA ROSES PMM Science Team Review Panel	Six NOAA-led projects were recommended for funding. A joint funding scenario between NASA and NOAA was agreed upon for the three-year projects beginning in FY10.
November 2010 Seattle, WA	PMM Science Team Meeting	Several scientific collaborations were strengthened during NOAA participation with the 60-member science team. Additionally, NOAA PIs met as a team to enhance across-line office collaborations.
December 2010 San Francisco, CA	AGU Annual Meeting	Agreement reached regarding NOAA's HMT-SE contribution to the GPM Ground Validation program; a pilot study in spring/summer 2013 is planned.

- **Funding and Review of NOAA PIs on PMM Science Team**

NOAA and NASA pooled $802 K (302 K NASA and 500 K NOAA) for FY10 to fund six NOAA-led Precipitation Measurement Mission (PMM) projects. Funds were obtained from NESDIS and OAR. These projects are in their first year of funding; three projects are continuation projects from the previous science team (which is renewed every three years) whereas three are new starts. Appendix B summarizes all of these projects. The SGPMS is assembling funding for the NOAA PIs for FY11.

The current team is in a critical stage of algorithm development in preparation for the GPM core launch in 2013. In addition, algorithms are being finalized for the next TRMM product release (version 7) anticipated in late 2011. The SGPMS held its annual review of the projects in College Park, MD (August 2010), which included those that were completed and the new starts. The progress during the past three years has been excellent and has led to several publications, as well as improved algorithms that resulted in new data sets of instantaneous and hourly rainfall and high quality validation data sets of precipitation microphysics. The research outcome is critical to GPM's success and demonstrates NOAA's preparation for utilizing advanced precipitation data from the mission. Also, NOAA's participation on the PMM science team is a crucial building block for eventual transition of certain components of the GPM processing system from NASA to NOAA.

- **NASA-NOAA MOU on GPM**

Through a working group led by NESDIS, including contributions from NWS and OAR, a NASA-NOAA MOU on GPM has been developed and, at present, is undergoing general counsel review. This MOU will formalize the commitments between the two agencies on the mission. The MOU essentially formalizes ongoing activities, including data distribution, commitments to fund the science teams, and validation assets.

- **NOAA Budgeting Activities**

The SGPMS again actively pursued funding for GPM-related activities during the past two budgeting exercises. Resources are being sought within the Satellite, Water Resources and Climate Programs.

- **Engagement with Other Parts of NOAA**

Successful meetings were held with NWS/OST, NESDIS/NCDC, the GOES-R program office, and JCSDA to discuss the importance of GPM to the goals of their programs. It has led to new opportunities, such as risk reduction activities for GOES-R where synergy between the Advanced Baseline Imager (ABI) and Geostationary Lightning Mapper (GLM) sensors and TRMM are being developed in preparation for GPM-era data. Future meetings with NHC and AOML are planned to determine the needs of GPM-era data for the tropical cyclone research and operations community.

- **Maintenance of Web Site**

A web page for the steering group continues to be maintained, serving as a source for SG documents and providing links to other PMM web resources:

http://www.nws.noaa.gov/oh/hrl/hsmb/GPMSG/index.html

The site presently contains the group charter, most recent membership roster, and annual reports from NOAA's PMM scientists on their projects.

- **GPM Transition Planning**

NESDIS has identified GPM transition leads as R. Ferraro (Transition Scientist) and C. Kondragunta (Transition Manager). A draft transition plan is under review, focusing on the transition of NASA's Precipitation Processing System (PPS) from NASA to NESDIS to provide NOAA users with 24 hour/7 day operational support. Because GPM comprises a constellation of satellites, the PPS includes all relevant U.S. and international satellites. A unique feature of the PPS is the generation of a "Level 1C" input radiance data set, which is intercalibrated among the GPM constellation members. The final transition plan is expected to be briefed to the NOAA Observing Systems Council (NOSC) in 2011.

- **Representation at Relevant Meetings and Workshops**

Members of the steering group also represent NOAA's interests in other relevant scientific meetings and workshops related to GPM. These are summarized below.

Meeting	Purpose	Outcome
2009 PMM Science Team Meeting Salt Lake City, UT – October 2010	Science	NOAA PIs engage NASA on GPM and TRMM science, future plans, etc.
2010 PMM Science Team Meeting Seattle, WA – November 2011	Science	NOAA PIs engage NASA on GPM and TRMM science, future plans, etc.
5th Workshop of the International Precipitation Working Group, Hamburg, Germany - October 2010	Science Programmatic	NOAA researchers engage international precipitation community to discuss topics of mutual interest
Meetings of the GPM X-Cal Working Group – Various locations – October 2009; March 2010; June 2010; October 2010	Science	NESDIS contributes its calibration expertise for GPM (as part of its WMO/GSICS activity)
17th International TOVS Science Conference Monterey, CA – April 2010	Science	Engage with surface science community to develop collaborations to advance the state-of-the-art in precipitation over land retrievals
4th International GPM Ground Validation Workshop Helsinki, Finland – June 2010	Science Programmatic	NOAA/OAR describes its plans to contribute validation assets from the HMT-SE campaign to GPM's validation program beginning in 2013
GPM Precipitation Processing System (PPS) Build 3 Design Review Greenbelt, MD – August 2010	Programmatic	Contribute to the evaluation of NASA's PPS; the backbone of the GPM-era product generation and distribution system.

5. Goals for Upcoming Year

In addition to sustaining the activities just described, SGPMS's major goals for the upcoming year are:

- Execute recommendations from the First NOAA User Workshop on GPM
- Organize and hold the Second NOAA User Workshop on GPM (late 2011)
- Secure FY 11 funding for the NOAA PIs on NASA's PMM Science Team
- Hold an annual review of current NOAA PI lead PMM projects
- Obtain NOSC approval for the GPM Transition Plan; secure funding for transition activities
- Continue joint Ground Validation (GV) activities with NASA, including HMT-SE
- Continue to inform NOAA leadership of SGPMS activities, including engagement with other sectors of NOAA
- Investigate potential post-GPM plans within U.S. and with international partners
- Ratify an MOU between NASA and NOAA on GPM.

Appendix A – Executive Summary from the First NOAA User Workshop on GPM College Park, MD – August 18-19, 2010

Precipitation is both vital to, and a significant hazard to, human life. Satellite estimates are critical to precipitation monitoring over much of the Earth. The upcoming Global Precipitation Measurement (GPM) mission, a joint mission between the United States and Japan, directly relates to NOAA mission goals (i.e., climate, weather and warnings, etc.) and presents an opportunity to prepare NOAA for routine ingest and processing of multiple data streams from satellites containing passive microwave sensors and a core satellite with a spaceborne precipitation radar. The GPM Core Satellite is scheduled for launch in July 2013 while another, low inclination satellite, will be launched in November 2014. GPM represents an expansion to and follow-on of the successful Tropical Rainfall Measurement Mission (TRMM) science mission, which has provided operationally useful data far past its anticipated lifetime. As detailed in a recent National Research Council Study, NOAA's advance preparation for GPM (core-satellite launch in July 2013) must begin immediately if NOAA is to leverage the huge investment being provided by NASA and JAXA and avoid a large gap between mission launch and data utilization at NOAA (NRC 2007). We hope that GPM will point the way toward use and maintenance of an operational satellite constellation for global precipitation.

The ***1st NOAA User Workshop on the GPM Mission*** was organized by NOAA's Steering Group on Precipitation Measurement from Space to update interested NOAA stakeholders about GPM; identify their needs for such information and their current observational gaps; determine ways to accelerate GPM data use at NOAA; and identify other applications of the GPM-era microwave radiances. Over 50 attendees were briefed on the current status of the mission by NASA GPM managers and scientists, and learned that GPM is a "constellation" mission, consisting of a "core" satellite that will anchor a fleet of low-inclination orbiting satellites from domestic and international partners, achieving 3-hourly or less global precipitation measurements. They also learned of accomplishments to date in preparing NASA's Precipitation Processing System (PPS) for GPM Core satellite launch in July 2013. The PPS will ingest GPM core and constellation data in near real-time and generate a host of orbital and gridded products. NASA and NOAA are in the process of formalizing data arrangements for GPM through an interagency agreement. ***Details can be found in Section 3 of this report.***

We also heard from various parts of NOAA, including NESDIS, NWS and OAR, about their current uses and future needs for precipitation and related information. These include precipitation rates, type and intensity; microwave radiances; vertical distribution of liquid and ice; total precipitable water; ocean surface wind vectors. Collectively, the group voiced concern over the current state of the passive microwave satellites, with several missions such as TRMM, the EOS Advanced Microwave Scanning Radiometer (AMSR-E), Polar Orbiting Environmental Satellites (POES) and the Defense Meteorological Satellite Program (DMSP) containing sensors that are well beyond their life expectancy, and the huge observational gap that will be created if future missions such as GPM are not leveraged by NOAA. Additionally, the precessing orbit of the GPM-core will be crucial for maintaining the calibration of the entire constellation, much like the role TRMM has been performing over the past decade. ***Details of these presentations can be found in Section 4 of this report.***

Three working groups were formed: Observational Requirements and Gaps; Accelerating GPM Use at NOAA; and GPM Applications. Each was populated with members from the different NOAA line offices to gather a broad NOAA perspective. The working groups were tasked to assess the current state and needs under each topic, and to develop a specific path forward if the identified needs are not presently being addressed at NOAA. There were several common themes identified by the working groups, which can be captured by the following ***five major recommendations from the working groups, all of equal importance (listed below; details are provided in Section 5 of the workshop report).*** Because of the strong interest in GPM at NOAA, a follow-on workshop will likely be planned for late 2011 or early 2012. The format will be more user-focused

and opened to a broader audience, with specific topical areas being addressed and specific issues being identified. Finally, ***the next steps and plan forward are presented in Section 6 of the report.***

Five Major Recommendations from the Working Groups

1. **Accelerate the use of GPM data at NOAA through the development of a NOAA GPM Proving Ground and use of existing testbeds.** GPM era precipitation products, including winter season precipitation, are vital to NOAA to fill in observational gaps and in ground-based radar and gauge networks, specifically in Alaska, intermountain, and coastal regions, and over the open ocean. These data are also critical for continuity of operations with existing data being used at NOAA, especially at the Tropical Prediction Center, Climate Prediction Center, and the Joint Center for Satellite Data Assimilation (JSCDA) and NESDIS Satellite Analysis Branch (SAB). To accelerate use of GPM-era data at NOAA, a NOAA GPM Proving Ground and corresponding proxy data should be developed to support existing testbeds (e.g., Hydrometeorology, Joint Hurricane, Climate, etc.) and the JCSDA. A series of format conversion tools should be developed. Training is also vital to maximize the greatest benefits of GPM data at NOAA.

2. **Enhance research and development, and encourage scientific and technological innovation to maximize use of GPM-era data at NOAA.** NOAA is urged to support activities to integrate GPM-era satellite data into "merged" products (e.g., Q2, CMORPH, etc.), to move toward a "One NOAA" suite of precipitation products. Additionally, data assimilation in cloudy and precipitating atmospheres is urgently needed for both passive and active microwave measurements. There are other attributes of the GPM-era sensors (e.g., oxygen and water vapor bands) that are presently being under-utilized by the R&D community. To facilitate such advances, NOAA should continue its partnership with NASA on the Precipitation Measurements Mission Science Team and other GPM-related activities, and infuse its own resources to develop GPM-related products for its own needs.

3. **Develop synergy with other existing and developing programs.** NOAA should encourage synergy between GPM and GOES-R to greatly improve flash flood and hydrological forecasting such as those activities already underway at the NWS. Also, synergy between NOAA's Climate Data Record (CDR) program and GPM is encouraged. Additionally, other linkages to operational satellite missions like the Joint Polar Satellite System (JPSS) and research missions like the Soil Moisture Active-Passive (SMAP) are strongly encouraged.

4. **Provide GPM-era data operationally at NOAA with minimal data latency and in a variety of formats.** NOAA should transition NASA's Precipitation Processing System (PPS) to NESDIS operations and develop enhancements (e.g., monitoring tools, data format converters, etc.) to provide 24 hour/day, 7 day/week operational support to NOAA users. The data will need to be freely available, with minimal data latency, and in a wide array of formats to suit NOAA user needs.

5. **Develop a dedicated NOAA budget for GPM and for mission continuity.** NOAA needs to ensure a coordinated budget planning and execution across line offices and its Cooperative Institutes to ensure the proper and timely utilization of GPM-era data to support all its mission goals. Linkages to existing NOAA related programs like the U.S. Weather Research Program (USWRP), the National Climate Service (NCS), CDR, Global Space-based Intercalibration Center (GSICS), Hurricane Forecast Improvement Program (HFIP), Integrated Water Services (IWSS), GOES-R and JPSS are encouraged. NOAA is urged to develop a continuity mission for the GPM Core Satellite to serve as the calibration anchor for the passive microwave constellation, as well to maintain global 3-hourly, or less, passive microwave radiances/precipitation products in the 2020 timeframe.

Appendix B – Summary of NOAA PI-led Projects on NASA's Precipitation Measurement Missions (PMM) Science Team

Completed Projects (FY07 – FY09)

1. **Utilizing TRMM Precipitation Products in Operational Hydrology through Multi-Satellite and Multi-Sensor Quantitative Precipitation Estimation (QPE)**

- Principal Investigator: Bob Kuligowski (NESDIS), Co-Investigator, Yu Zhang (NWS)
- Funding levels: FY07 – 94 K, FY08 – 93 K, FY09 – 124 K (Three year total – 311 K)
- Project Objective: Assess and demonstrate the value of TRMM/GPM precipitation products for quantitative hydrologic forecasting in NOAA/NWS by infusing these data into an integrated framework of multi-satellite and multi-sensor precipitation estimation and hydrologic validation.
- Project Outcomes: TRMM data was incorporated into satellite (GOES) and surface (radar and gauge) products and then used to drive hydrological models; satellite estimates yield modest improvement in flow simulations for basins with few rain gauges.

2. **Improved Microwave Precipitation Retrieval over Land from TRMM through GPM era**

- Principal Investigator: Ralph Ferraro (NESDIS)
- Funding levels: FY07 – 145 K, FY08 – 152 K, FY09 – 157 K (Three year total – 454 K)
- Project Objective: To develop advanced precipitation retrievals over land with an emphasis on cold season precipitation (snow and light rain) using GPM radiometer and other constellation radiometers such as NOAA AMSU/MHS and DMSP SSMIS.
- Project Outcomes: Improved TRMM Microwave Imager (TMI) rain over land algorithm completed and delivered to NASA for TRMM V7 product release (late 2011); improved physical retrieval scheme using AMSU/MHS for snowfall rate retrievals.

3. **Improvement and Validation of a Multi-Satellite, Multi-Sensor Precipitation Algorithms: A Prototype 'Day 1' GPM Product**

- Principal Investigator: Pingping Xie (NWS)
- Funding levels: FY07 – 117 K, FY08 – 121 K, FY09 – 124 K (Three year total – 362 K)
- Project Objective: To create an analysis system of high-resolution precipitation over the globe using all estimates available from GPM and other satellites as well as other sources of information.
- Project Outcomes**:** Enhanced version of the CPC Cloud Morphing (CMORPH) product using AMSU/Sounder data sets was developed; development of Kalman filter approach to improve CMORPH product accuracy.

4. **Vertical Structure of Precipitation Retrieved from Multi-Frequency Profiling Radars for Validating Satellite-Based Precipitation Products**

- Principal Investigator: Christopher Williams (CIRES/OAR)
- Funding levels: FY07 – 154 K, FY08 – 159 K, FY09 – 165 K (Three year total – 478 K)
- Project Objective: Analyze vertically-pointing profiler and polarimetric scanning radar observations to quantify the vertical and spatial structure of raindrop size distributions (DSDs).
- Project Outcomes: Over 30 rain events were observed by profilers near Darwin, Australia, along with uncertainty estimates (these data are accessible by the PMM science team algorithm scientists); uncertainty estimates in raindrop size distributions were developed for the polarimetric radar deployed at Darwin.

New Start Projects (FY10 – FY12)

1. **A Physical Rainfall Rate Algorithm for All Surfaces: Applicability to All Microwave Sensors Including TRMM and GPM**

- Principal Investigator: Sid Boukabara (NESDIS)
- Funding levels: FY10 – 137 K, FY11 – 134 K, FY12 – 141 K (Three year total – 412 K)
- Project Objective: To extend and improve the operational NOAA/NESDIS Microwave Integrated Retrieval System (MIRS) to GPM-era satellites and to advance the quality of the precipitation retrievals with MIRS
- First Year Project Outcomes: Proxy GMI developed and being tested within MIRS; prototype TMI retrieval scheme developed and being tested. MIRS emissivities generated for PMM Science Team intercomparison effort.

2. **Land Surface Characterization for GPM-era Algorithms**

- Principal Investigator: Ralph Ferraro (NESDIS)
- Funding levels: FY10 – 137 K, FY11 – 104 K, FY12 – 107 K (Three year total – 348 K)
- Project Objective: To improve precipitation retrievals over land through better characterization of land surface properties and through a generic scheme applicable to all GPM-era constellation satellites.
- First Year Project Outcomes: Guiding the efforts of the PMM Science Team Land Surface Working Group (LSWG) emissivity intercomparisons study, and providing critical input to the PMM Algorithm teams.

3. **In Situ Precipitation Dataset in High Latitudes of the Northern Hemisphere for the Calibration of GPM Mission Products**

- Principal Investigator: Pavel Groisman (NESDIS)

- Funding levels: FY10 – 106 K, FY11 – 108 K, FY12 – 110 K (Three year total – 324 K)

- Project Objective: To acquire, quality control and develop uncertainty estimates for high latitude surface precipitation reports and provide them for PMM cold season algorithm validation.

- First Year Project Outcomes: Several data sets from Canada and Russia have been obtained and are being closely examined with collaborators from those countries.

4. Development of Microwave Emissivity Models for GPM Applications

- Principal Investigator: Fuzhong Weng (NESDIS)

- Funding levels: FY10 – 148 K, FY11 – 150 K, FY12 – 150 K (Three year total – 448 K)

- Project Objective: To extend ongoing emissivity model development (within JCSDA) for GPM-era satellites, in particular, for high frequencies and over complex surfaces related to cold season precipitation

- First Year Project Outcomes: Data sets prepared for the PMM LSWG emissivity intercomparison project.

5. Temporal and Spatial Correlation of Drop Size Distribution Parameters to Improve Satellite-Based Precipitation Products

- Principal Investigator: Christopher Williams (OAR)

- Funding levels: FY10 – 114 K, FY11 – 114 K, FY12 – 116 K (Three year total – 344 K)

- Project Objective: To up-scale surface measured cloud and precipitation microphysical information for application with the GPM dual frequency precipitation radar (DPR) and the GPM microwave imager (GMI)

- First Year Project Outcomes: Developing algorithms through the use of the TRMM/GPM Kwajalein ground validation site; preparing to participate in the MC3E field campaign in Oklahoma during the spring of 2011.

6. Improvement of a Multi-Instrument, Multi-Satellite Algorithm for High-Resolution Pole-to-Pole Global Precipitation Analysis

- Principal Investigator: Pingping Xie (NWS)

- Funding levels: FY10 – 160 K, FY11 – 165 K, FY12 – 170 K (Three year total – 495 K)

- Project Objective: To improve the CPC Cloud Morphing (CMORPH) product to include regional rain gauges, new satellite sources and to merge CMORPH with other similar products for the GPM product suited.

- First Year Project Outcomes: Developed and tested "Kalman Filter" algorithm to be able to reconstruct the CMORPH time series prior to 2000 when the number of passive MW sensors was limited; testing a scheme to merge rain gauges with CMORPH for improved global estimates.