Plans for Global Precipitation Measurement Ground Validation

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Abstract-This paper introduces plans for ground validation (GV) for the Global Precipitation Measurement. At NASA's request, a Ground Validation Working Group, formed from the meteorological and hydrological communities, is recommending plans to guide the GV program. Ground validation efforts will commence as early as 2003 with the Spring 2003 Pilot Experiment and described herein. The Pilot Experiment is focused on mitigating engineering and scientific risk to the GPM program and, in particular, to the ground validation program.

I. INTRODUCTION

The Global Precipitation Measurement (GPM) [1] is an international effort to improve climate, weather, and hydrological predictions through more accurate and more frequent precipitation measurements. GPM science will be conducted through an international partnership led by the National Aeronautics and Space Administration (NASA) of the United States and the National Space Development Agency (NASDA) of Japan. Measurements will be made with a constellation of Earth observing satellites and a global ground validation program. NASA will provide two spacecraft, a primary and a companion spacecraft, to the constellation. For instrumentation, NASA will provide a conical-scanning, polarization-sensitive, multi-frequency radiometer termed the GMI radiometer for both the primary and companion satellite. NASDA will provide the Dual-frequency Precipitation Radar (DPR) for the primary spacecraft, the launch of the primary spacecraft, and a data stream from the GCOM-B1 spacecraft. The DPR is a cross-track scanning instrument with simultaneous operation at 14 GHz and 35 GHz. It is anticipated that the primary satellite will employ additional instrumentation, the specifics of which are currently not decided.

The primary spacecraft is scheduled for launch in fall 2007 with the companion satellite launch immediately thereafter. Constellation spacecraft data streams will be provided from U.S. government entities, such as the National Polar-orbiting Operational Environmental Satellite System (NPOESS), possibly the European Space Agency, and other international partners. The orbits and instrumentation aboard the constellation spacecraft vary according to their observational goals. Each, however, has radiometric channels capable of rainfall retrieval. As a result of its constellation operation, GPM will provide diurnally-resolved, nearly global coverage, of precipitation at surface resolutions of 10 km.

An integral component to the GPM Mission is the ground validation (GV) program. NASA has created a Ground Validation Working Group from a diverse spectrum of scientists from the meteorological and hydrological communities to guide ground validation through mission formulation. The purpose of the Working Group is to generate specific and comprehensive recommendations so that NASA can implement an effective, product-based, GV program. As with the spacecraft component of GPM, the GV program relies upon international partnerships. International partners will provide GV sites, instrumentation, data, and collaborative research.

This paper briefly describes the present concept of GPM ground validation. Following the discussion on GV, this paper introduces plans for a field experiment, termed the Spring 2003 Pilot Experiment. It is the intent of the Pilot Experiments to provide data necessary for mitigating scientific and engineering risks to the GPM program and particularly the ground validation program. Finally, as a caveat, GPM ground validation is in formulation, and some concepts on implementation may evolve from the description presented herein.

II. GPM GROUND VALIDATION

The overarching goal of GPM ground validation is to provide credibility to the space-borne retrieved rainfall and related products. More specifically, the goals of the GV program are threefold:

(1) Diagnosis to ascertain the causes of errors within satellite precipitation products.

(2) Improvement of satellite precipitation products by refinement of physical assumptions in the satellite algorithms, underlying cloud models, and underlying radiative transfer calculations.

(3) Evaluation to estimate the quality of satellite precipitation products in terms of systematic and random error.

Within the program goals are the physical ground validation objectives. These objectives concern physical phenomena that are integrally linked to each of the satellite precipitation

products. Four physical ground validation objectives have been identified. They are:

(1) Determination of minimum detectable surface precipitation rate.

(2) Horizontal and vertical spatial mapping of hydrometeors into categories such as rain, snow, mixed precipitation, and graupel/hail.

(3) Determination of the spatial pattern of precipitation intensity.

(4) Quantitative estimation of surface precipitation rate.

The GPM GV program can be divided into two sub-programs: (1) Routine Product Sites (RPS), and (2) Focused Observational Programs (FOP). Routine Product Sites are responsible for providing timely GV products to the GPM community, on a regular schedule, during the mission lifetime. Focused Observational Programs will consist of long-term monitoring and field projects with aircraft directed toward specific goals related to physical validation of satellite algorithms. Focused Observational Programs will occur prior to, and during, space-flight operations.

A. Routine Product Site (RPS) Program

The RPS program will be comprised of instrumented sites distributed over the globe with emphasis on covering different climate regimes. NASA will provide two of the sites, one within a continental regime and the other within a tropical oceanic regime. NASA is actively soliciting international partners for the other global sites. It is anticipated that additional sites will be provided by the international partners.

The primary objectives of the RPS program is to provide near real-time products derived from the data from the ground site instrumentation and to provide a regime-relevant algorithm to estimate errors in the globally. The error estimates will include three components: an estimate of mean bias and standard deviation of bias, an estimate of random error, and a functional description of the spatial correlation of errors. Three customers have been identified who desire the GV error products. They are: (1) algorithm specialists, (2) data assimilation specialists, and (3) climate diagnosticians. Algorithm specialists are interested in improving the accuracy of satellite-derived products through improved algorithms. The Routine Product Sites will assist the algorithm specialists through testing and validating assumptions within the physical models which form the basis of the algorithms. Data assimilation specialists study how to best assimilate satellite-derived precipitation measurements into environmental prediction models. Climate diagnosticians try to understand the veracity of trends and variations found in their models.

At the heart of the site will be a scanning Doppler radar capable of resolving the spatial and temporal rainfall structure. At some sites it is proposed to deploy a dual-frequency radar and multi-channel radiometer representative of the core spacecraft instrumentation. This up-looking instrumentation, scanning the satellite resolution volume, would enable estimation of error characteristics of satellite retrievals. Other specific instrumentation for the RPSs are under study and they will be tailored to the precipitation regime and logistical constraints of the individual sites.

B. Focused Observational Program (FOP)

The Focused Observational Program will be a diverse mix of research and experiments whose scientific goals address one or both of the following:

(1) Refinement of specific physical and scaling assumptions within satellite algorithms, underlying cloud models and/or radiative transfer calculations.

(2) Intitalization/data assimilation observations for cloud and regional modeling and/or radiative transfer calculations at climatologically important locations distinct from the RPSs.

FOP activities will span a range of complexity from experiments involving a few researchers with ground-based instrumentation to field campaigns involving research aircraft and ships and a diverse complement of researchers and personnel. FOP experiments and research will begin in the years prior to GPM primary launch and continue throughout the mission lifetime.

III. THE SPRING 2003 PILOT EXPERIMENT

The Spring 2003 Pilot Experiment will be the first experimental activity within the GPM Focused Observational Program. The goals of the pilot experiment are to mitigate scientific and engineering risks. Although the objectives are not finalized, the experiment will likely address the following three areas:

(1) Testing and validation of the dual-frequency radar algorithm to derive characteristics of the rain drop spectra such as the median mass diameter D_o.

(2) Operational demonstration of dual-frequency radar and radiometer in rain. This demonstration will address the prevention of liquid water accumulation on the radar radome and radiometer lens antenna and

the analysis of the affects of any water that does accumulate.

(3) Investigation of ground-based radiometric brightness temperature and reflectivity profile data for constraining the satellite radiometric and radar retrievals.

Instrumentation needs for the Pilot Experiment call for a dual-frequency radar and radiometer with operational characteristics similar to the DPR and GMI instruments of the GPM primary spacecraft. The Pilot Experiment will use existing aircraft instruments modified for ground-based operation. The Pilot Experiment will use the TRMM satellite in lieu of the GPM and will conduct operations in two modes, TRMM overpass and non-overpass periods. The analysis resulting from this experiment will aid in planning the GV Routine Product Sites which are desired to be operational two years prior to primary spacecraft launch.

A. The Joint Polarization Experiment (JPOLE)

The Pilot Experiment will be conducted in conjunction with the Joint Polarization Experiment (JPOLE) [2,3] hosted by the National Severe Storms Laboratory (NSSL), Norman, OK. The intensive observational period of JPOLE is a 12 week period from mid March to mid June, 2003 in central Oklahoma. The Pilot Experiment will conduct operations during this intensive observational period.

Central Oklahoma is located near the upper orbital extreme of the TRMM satellite. At that latitude, the satellite provides good coverage for its radar and radiometer instrumentation, on-average making 2.4 overpasses per day. During overpass events, with coincidental intervening precipitation, the ground dual-frequency radar and radiometer will point toward the satellite in a line-of-sight fashion. The Pilot Experiment ground-based instruments will have limited scanning capability and the data capture can be envisioned as a 'snapshot' event as the satellite paints the ground site.

JPOLE has both demonstrational and scientific objectives. The primary demonstrational goal is to validate the operation of a National Weather Service polarimetric upgrade to its WSR-88D radar, termed the KOUN radar. JPOLE demonstrational and operational goals will be achieved, in part, by siting the Colorado State University (CSU) CHILL polarimetric radar in proximity to the KOUN radar. Other instruments, discussed in [3], will be deployed as a part of JPOLE. The specific advantages of conducting the Pilot Experiment in association with the JPOLE observational program include:

- Access to two polarimetric radars: the CSU-CHILL radar and the NSSL KOUN WSR-88D radar.
- Access to Oklahoma Mesonet Rain Gauge Network.
- Access to good infrastructure and logistics.
- A location with good overpass frequency of the TRMM satellite.
- A location with adequate rainfall statistics and occurring within transition from cold to warm season.
- Complementary scientific objectives.

IV. SUMMARY

The Spring 2003 Pilot Experiment will be the first experimental program of the GPM ground validation program. Its objectives are intended to reduce risks associated with the GPM program. The Pilot Experiment will be conducted in conjunction with the Joint Polarization Experiment in the spring of 2003 to enable sharing of resources and to pursue complementary scientific goals.

REFERENCES

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