PRECIPITATION MEASURING MISSION SCIENCE:

6th RESEARCH ANNOUNCEMENT

Issued: August 10, 2009

Proposals Due: October 15, 2009

Earth Observation Research Center
Japan Aerospace Exploration Agency

Contents

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JAXA

1. Introduction

1.1. About the Research Announcement

In this sixth Precipitation Measuring Mission (PMM) Science Research Announcement (RA), relating to the Global Precipitation Measurement (GPM) mission and the Tropical Rainfall Measuring Mission (TRMM) satellite, the Japan Aerospace Exploration Agency (JAXA) is announcing the opportunity for research. Descriptions of the GPM and TRMM missions, satellites, and sensor systems can be found in Appendix C.

Past PMM RAs were implemented with a focus on research related to the TRMM satellite, which was launched in November 1997. The last RA (the fifth RA), for the period from Japanese Fiscal Year (JFY) 2007 to 2009, focused on the following research issues:

(a) Research to contribute to understanding climate change and the global water cycle;

(b) Synergy of TRMM and other satellite data;

(c) Advanced utilization of TRMM/PR data for GPM;

(d) Climatological research using long-term TRMM data; and

(e) Research for operational purposes.

In the fifth RA, research issues for (a) and (b) using TRMM data have roughly accomplished their objectives. In the coming years, targeting the GPM mission, issues in (c) should be actualized, taking over the results that have been achieved thus far. Furthermore, other issues should be addressed as research focusing on the GPM era.

Therefore, in this RA, JAXA will invite research proposals especially those contributing to the development of GPM algorithms. The GPM core satellite will be scheduled to be launched in summer of 2013. This RA covers a 3-year research period beginning in JFY 2010.

1.2. Research Areas of This RA

Through this RA, JAXA seeks research proposals contributing to the following research areas. Detailed technical descriptions of each area will be provided in Chapter 2.

(1) Algorithm Development

Develop or improve retrieval algorithms, which are DPR, DPR/GMI combined, and Global Precipitation Map algorithms, to produce JAXA GPM standard products, and improve TRMM standard algorithms. JAXA's GPM/DPR project has set the mission success criteria based on the mission requirements (see section 1.3). Therefore, algorithm development and improvement are expected to meet the criteria to make the GPM mission successful.

(2) Validation

Acquire and analyze pre-launch observation data, contributing to the development of JAXA GPM standard algorithms, and prepare methodologies for post-launch validation. Effective validation activities collaborating with other science projects are expected.

(3) Application Research

Perform research relating to climate and global water cycle variation, precipitation system climatology, and research leading to operational data utilization, such as monitoring of wind

and flood damage, and consideration of use of precipitation maps in the Asian region and other areas where ground precipitation observation is not sufficient. Development of new research products of GPM based on new ideas and needs is also solicited.

Among other areas, this RA will mainly focus on "(1) Algorithm Development". In particular, research themes, such as the development of algorithms for the Dual-frequency Precipitation Radar (DPR) on board the GPM core satellite, combined algorithms for DPR and the GPM Microwave Imager (GMI), and Global Precipitation Map algorithms. In addition, improvements of standard algorithms for the Precipitation Radar (PR) on board the TRMM satellite, and acquisition and analysis of basic data necessary for algorithm development, will be included.

The Principal Investigator (PI) of selected proposals will be a member of the Japanese Precipitation Measuring Mission (PMM) Science Team. JAXA will appoint a Lead to the PMM Science Team among PIs after the RA selection. The Lead of the PMM Science Team will also participate in the GPM Utilization Committee, who will discuss overall GPM mission objectives and requirements. JAXA's Earth Observation Research Center (EORC) will work together closely with the PMM Science Team, especially in algorithm development and validation activities.

1.3. Targets of GPM and Mission Success Criteria

GPM is an international mission led by the U.S. and Japan. The U.S. and Japan will jointly develop the GPM core satellite, a successor of the TRMM satellite, and collaborate with several constellation satellites, that will carry microwave radiometers and be launched by international partners.

Similar to a mission for water cycle variation observation under JAXA's Earth Environmental program, mission objectives of GPM are to continue and expand knowledge and outcomes obtained by the TRMM satellite, and to achieve the following targets:

- Highly accurate and frequent global precipitation observation for climate and water cycle change;
- Data utilization method development through distribution of near real time global precipitation maps;
- Development and demonstration of the improved precipitation retrieval method of the multi microwave radiometers (including both imager and sounder) using DPR data;
- Application demonstration for operational use, such as flood prediction, numerical weather forecast, prevention of damage from a storm and flood; and
- Demonstration of DPR technology, which will succeed and expand TRMM/PR technology, to achieve highly accurate precipitation observation.

Figure 1 shows mission requirements for the Japanese GPM mission to achieve the above objectives, and those for the international GPM mission in contrast for reference. This RA invites research to actualize these GPM targets through collaboration with JAXA. Derailed technical description for research will be described in the next chapter.

Table 1 shows targets of accuracy of each algorithm and its evaluation timing. Target accuracies of the Ku-band Radar (KuPR) and Global Precipitation Map algorithms at pre-launch and data release are almost the same as those achieved by the current TRMM/PR standard algorithm and the Global Satellite Mapping of Precipitation (GSMaP) algorithm, and correspond to minimum success. When GPM completes its designed mission period, it is required to achieve full success in Table 1 through improvement of accuracy of each algorithm.

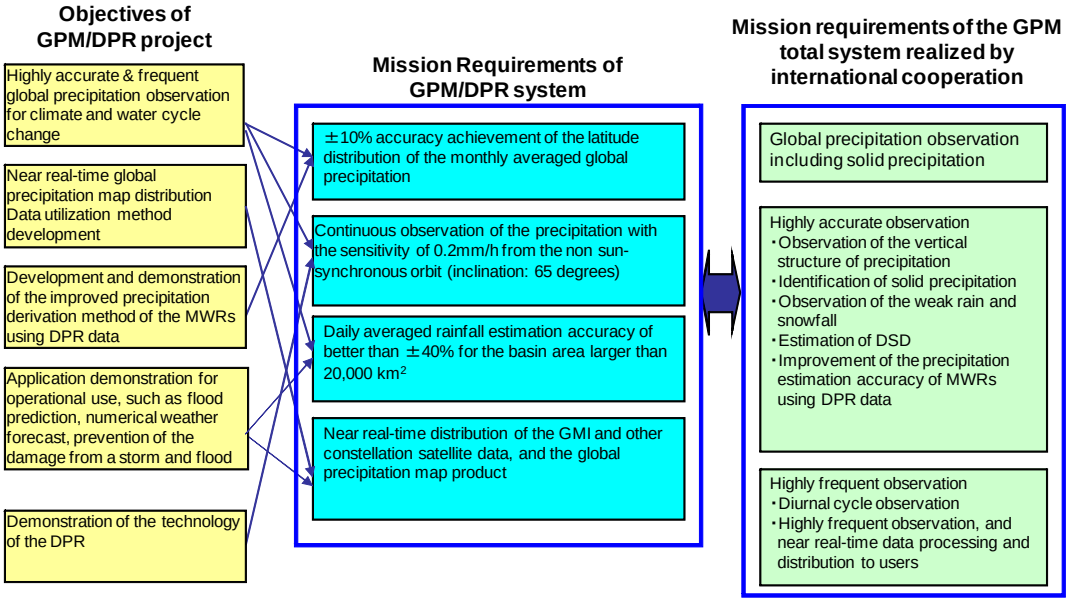

Figure 1 Objectives of JAXA's GPM/DPR Project and Mission Requirements

Table 1 Target Accuracies of JAXA GPM Standard Products

Products \ Review timing		Pre-launch target accuracy at Development Completion Review (4-months before the launch)	Post-launch target accuracy at Confirmation Review for data release (4-months after completion of initial check out)	Full success at completion of designed mission period
L1	KuPR	Output received power of L1 code using L0 simulation data as input will agree within [±0.01 dBm (TBD)] with that of L1 confirmation code. Note that confirmation code will be developed for temperature corrected received power calculation part only, and developed independently.	Calculated value of transmitted and received power of KuPR will agree within ±1 dBm with that of observed value by Active Radar Calibration experiment.	Will be evaluated by DPR Dual-frequency L2 and L3 products.
	KaPR	Same as above.	Same as above.	Same as above.
L2	KuPR	Check operation of each subroutine using L1 simulation data (simulation data for L2 operation check, and synthetic data of simulated nature). Verify distribution of histograms of rain rate, hypothesized by synthetic data of simulated nature, and that estimated by L2 algorithms, within effective rain rates [0.5 - 30 mm/h (TBD)].	Surface scattering factor of KuPR will agree within [±1 dB (TBD)] with that of PR. [for 1 week, for non-rain pixels, over the ocean, at each angle bin (TBD)]. Verify distribution of histograms of rain rate of KuPR and PR within effective rain rates [0.5 – 30 mm/h (TBD)] [for 1 week, over the ocean, within latitudes of ±35°, for all angle bins, at surface (TBD)].	Same as above.
	KaPR	Same as above, but effective rain rate will be [0.2 - 20.0 mm/h (TBD)].	Surface scattering factor of KaPR will agree within [±1 dB (TBD)] with that of PR [for 1 week, for non-rain pixels, over the ocean, at each angle bin (TBD)], but considering differences between KaPR and PR in observation frequency. Verify distribution of histograms of rain rate of KaPR and PR within effective rain rates [0.5 – 20 mm/h (TBD)] [for 1 week, over the ocean, within latitudes of ±35°, for all angle bins, at surface (TBD)].	Same as above.
	DPR Dual-frequency Precipitation	Same as above, but effective rain rate will be [0.2 - 30.0 mm/h (TBD)].	Verify distribution of histograms of rain rate of dual-frequency precipitation product and PR within effective rain rates [0.5 – 20 mm/h (TBD)] [for 1 week, over the ocean, within latitudes of ±35°, for all angle bins, at surface (TBD)].	Continuous observation of the precipitation with the sensitivity of 0.2 mm/hr by DPR, satisfying designed function and capability.
	DPR/GMI combined	Same as above, but effective rain rate will not be defined.	Same as above, but compare with rain rate histograms observed by PR and TMI.	N/A
L3	DPR Dual-frequency Precipitation	Confirmation of statistical processing.	Will be evaluated by L2 product.	Long-term averaged rainfall of DPR will agree within ±10 % accuracy with that obtained by ground-based rain gauge network worldwide. Monthly averaged zonal rainfall of DPR will agree within ±10 % accuracy with that of GMI, over the ocean.
	DPR/GMI combined	Same as above.	Same as above.	N/A
	Global Precipitation Map	Deliver latest GSMaP algorithm applying AMSR2 standard algorithm for precipitation. Check operation of algorithm for GMI using GMI simulation data provided by NASA/PPS. Compare Global Precipitation Map product to RadarAMeDAS data, averaged daily and in a 0.25° latitude-longitude grid box. [RMS will be about 0.7 mm/h on average (TBD)].	Check operation of algorithm for GMI algorithm. Verify inconsistency in horizontal distribution and zonal mean of Global Precipitation Map product, between products including or excluding GMI data. Compare Global Precipitation Map product to RadarAMeDAS data, averaged daily and in a 0.25° latitude-longitude grid box. [RMS will be about 0.7 mm/h on average (TBD)].	Daily averaged rainfall produced by GMI and other microwave radiometers (imager/sounder) will agree within 40% accuracy to that obtained from rain gauges for the larger basin areas

1.4. This RA and GPM Algorithm Development and Validation Phases

This RA covers a 3-year research period from JFY 2010 to JFY 2012 corresponding to initial and pre-launch algorithm development/evaluation phases for algorithm development activities, and pre-launch validation and synthetic data production phases for validation activities, as shown in the schedule in Figure 2. Since the RA period will end before the launch of the GPM core satellite, this RA emphasizes development of standard algorithms, and acquisition and analysis of fundamental data for algorithm development. Following this RA, i.e., 1 year before GPM core satellite launch, we plan to restart conducting research more weighted toward algorithm improvement and product validation during the 3 years before and after the launch of the GPM core satellite.

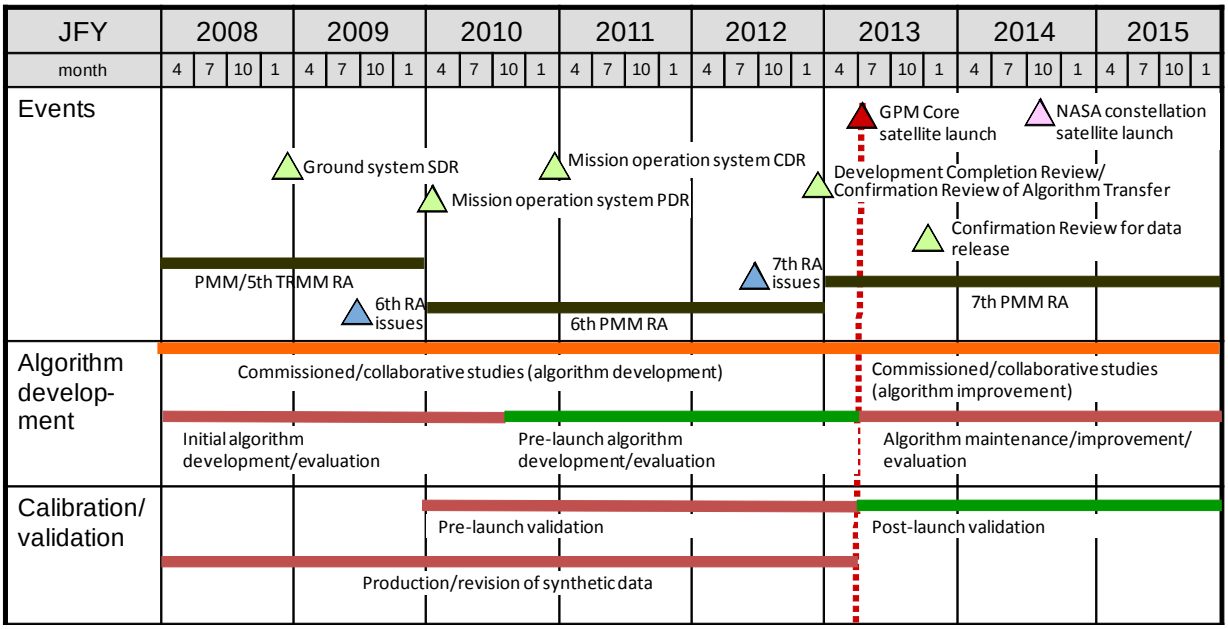

Figure 2 Schedule for RA and GPM Algorithm Development/Validation Phases

1.5. Role of PI and the RA Process

For this RA, JAXA will give budget allocation priority to the areas of algorithm development, and acquisition and analysis of fundamental data needed for algorithm development. If a proposal is highly expected to contribute to the TRMM and GPM missions, JAXA may also select funded-PIs other than priority areas.

Although it will depend on the budget situation, JAXA plans to spend the following in the first year for each research area:

(1) Algorithm Development

(A) GPM algorithm development: 37,000,000 yen (7-8 PIs, funded)

(B) TRMM/PR algorithm improvement: 5,000,000 yen in total (2-3 PIs, funded)

(2) Validation: 38,000,000 yen (2-3 PIs, funded and not)

(3) Application Research: 9,000,000 yen (7-8 PIs, funded and not)

For the second and third years, JAXA plans to spend at the same level as the first year, depending on plans of selected proposals.

In principle, selected PIs in the three research areas of this RA (see section 1.2) will participate in one of following four working groups to exchange information regarding their research results, and to contribute to the Precipitation Measuring Missions. All applicants have to specify the name of the group, to which they want to participate in this RA.

(1) Algorithm Development

(1a) Algorithm Development Group

Encompasses development and improvement of algorithms for the GPM/DPR, the DPR/GMI combined, the Global Precipitation Map and its components, and improvement of TRMM/PR standard algorithms.

(2) Validation

(2a) Validation Group

Encompasses validation activities to contribute to development of standard algorithms, and preparation of methodologies for post-launch validation.

(3) Application Research

(3a) Operational Utilization Group

Encompasses research for operational forecasts, application to river management, and development of utilization methodologies of satellite-based precipitation products in the Asian region and other areas, where ground precipitation observation is not sufficient.

(3b) Precipitation Climatology Group

Encompasses research for precipitation climatology using TRMM and other data, and development of new research products.

JAXA may select a research proposal not pertaining to the above working groups, if it is highly beneficial to JAXA's Precipitation Measuring Missions.

All categories of domestic and foreign organizations with nonprofit and peaceful purposes, except students, may apply under this RA. However, funding may differ for each research category and applicant. Funding by JAXA is basically restricted to domestic PIs, although some exceptions may be made for research necessary to realize JAXA mission success.

Research proposals should be submitted to JAXA by October 15, 2009. Proposals will be selected based on a peer-review process and discussions in science/project evaluation boards. JAXA plans to announce the selection results in December 2009. Descriptions of the GPM and TRMM missions, satellites, and sensor systems can be found in Appendix C.

2. Technical Description

2.1. Purposes of RA

To meet the mission objectives of TRMM and GPM, which are to understand and predict global water cycle variation and to contribute to operational use, this RA seeks to conduct research necessary to generate highly accurate, long-term, uniform and stable global precipitation products, that consider effective utilization and continuous observation by GPM, TRMM and other data sources (i.e., "Algorithm Development" and "Validation") and research related to climate and water cycle variation using those products (i.e., "Application Research") by inviting research themes from both domestic and overseas scientists.

All applicants should keep in mind that JAXA is not a general funding body for the scientific community. This RA seeks to accomplish the GPM mission's goals and to find new possibilities for utilizing GPM and TRMM data. Proposals should clearly describe plans for GPM and TRMM data usage.

2.2. Research Areas

Based on the GPM and TRMM objectives, JAXA seeks proposals in the following three research areas: algorithm development, validation, and application research. In particular, this RA emphasizes development of standard algorithms and research directly contributing to it, because the period corresponds to the 1-year preparation period before the GPM core satellite launch. Details are listed below.

2.2.1 Algorithm Development

As described in (1)-(4), research themes to develop JAXA GPM standard algorithms and to improve previously developed TRMM standard algorithms will be adopted in this RA. In addition, JAXA and PIs will jointly evaluate the algorithms and install these in JAXA computer systems. As described in Chapter 5, this research theme is generally supported through a "Commissioned Research Agreement."

Selected PIs will belong to the Algorithm Development Team under the JAXA PMM Science Team. They are also requested to join or collaborate with the NASA-JAXA Joint Algorithm Team, whose objective is to develop NASA-JAXA joint standard algorithms for the GPM core satellite.

Table 2 lists JAXA standard products of the GPM mission. Table 3 shows standard products of TRMM/PR. Algorithms to produce geophysical products other than those listed in Table 2 and 3 will be considered research products and will be included in Theme 3 "Application Research."

To meet the GPM objectives, retrieval algorithms will require global applicability, robustness, and long-term stability. Algorithms that can be extended and applied for similar instruments (e.g., PR, and microwave radiometers on board the other satellites) and historical data records are preferable for integrated retrieval. Computationally efficient, fast-processing algorithms are important for the operational applications of the products. Products denoted in light grey in Table 3, which are Level 2 the Dual-frequency Precipitation product and the DPR/GMI combined product, and Level 3 Global Precipitation Map product, are also required to process in near real time. Each near-real-time algorithm will be developed based on the standard

algorithm. All near-real-time products have to be produced and distributed within 60 minutes after acquisition of observation data.

Table 2 JAXA GPM Standard Products

Level	Algorithm	Product	Major physical parameter	Unit	Coverage
1	KuPR algorithm	KuPR product	Received power profile	Orbit	245km (swath)
	KaPR algorithm	KaPR product	Received power profile	Orbit	125km (swath)
2	DPR algorithm (Japan-US joint)	KuPR product	Radar reflectivity profile, normalized radar surface cross section (σ^0), rain type, bright-band height, attenuation corrected radar reflectivity profile, rain rate profile	Orbit	245km (swath)
		KaPR product	Radar reflectivity profile, normalized radar surface cross section (σ^0), rain type, bright-band height, attenuation corrected radar reflectivity profile, rain rate profile	Orbit	125km (swath)
		Dual-frequency precipitation product	Rain rate profile, drop size distribution, precipitation status (rain/snow), attenuation profile	Orbit	245km (swath)
	DPR/GMI combined algorithm (Japan-US joint)	DPR/GMI combined product	rain rate profile, surface rain rate	Orbit	245km/800km (swath)
3	DPR algorithm (Japan-US joint)	Dual-frequency precipitation product	Mean rainfall, observation number, rain pixel number, mean bright-band height, storm height	Monthly	Global (Horizontal: 0.5° grid box, Vertical: 250m)
	DPR/GMI combined algorithm (Japan-US joint)	DPR/GMI combined product	Mean rainfall, observation number, rain pixel number,	Monthly	Global (Horizontal: 0.5° grid box)
	Global precipitation map algorithm	Global precipitation map product	Mean rainfall, observation number, rain pixel number	3-hr/ monthly	Global (Horizontal: 0.1° grid box)

NOTE: Products denoted in light grey will also be processed and provided in near real time. Each near-real-time algorithm will be developed based on the standard algorithm.

Table 3 TRMM/PR Standard Product

Level	Product name	Major physical parameters	Unit	Coverage
1	1B21	Calibrated received power profile	Orbit	PR swath
	1C21	Radar reflectivity profile	Orbit	PR swath
2	2A21	normalized radar surface cross section (σ^0)	Orbit	PR swath
	2A23	PR Qualitative	Orbit	PR swath
	2A25	Rain rate profile	Orbit	PR swath
3	3A25	Monthly statistics of rainfall parameters	Monthly	Global (Horizontal: 0.5/5° grid box, Vertical: 250m)
	3A26	Monthly rain rate using a statistical method	Monthly	Global (Horizontal: 5° grid box)

(1) DPR Algorithm

This theme encompasses research to develop or improve algorithms, completely or in part, to produce the GPM Dual-frequency Precipitation Radar (DPR) Level 2 and 3 standard products shown in Table 2.

(i) Principle of Development

DPR Level 2 and 3 algorithms will be developed by the DPR Algorithm Team led by Japan, which is under the NASA-JAXA Joint Algorithm Team. Therefore, PIs, who are selected for this theme, are required to play a central role in the NASA-JAXA Joint Algorithm Team.

In developing DPR algorithms, applicants should pay attention to following points;

- Base algorithms on the TRMM/PR standard algorithms to a maximum extent, and develop them utilizing dual-frequency information;
- Develop algorithms to produce Ku-band Precipitation Radar (KuPR) only products, Ka-band Precipitation Radar (KaPR) only products, and/or Dual-frequency Precipitation products using both KuPR and KaPR data, as DPR Level 2 algorithms;
- Consider one algorithm involving several modules in GPM/DPR Level 2, although TRMM/PR Level 2 standard algorithms are composed of three separate algorithms;
- Develop algorithm applicable to both PR and KuPR in order to produce long-term continuous data set; and
- Develop a near-real-time algorithm based on the standard algorithm for Dual-frequency precipitation products.

(ii) Function and Input/Output of Algorithms

DPR Level 2 algorithms should have the following functions;

- To estimate rain rate profiles by using received power profiles observed by Ku-band Precipitation Radar (KuPR) and Ka-band Precipitation Radar (KaPR) in a complementary style;
- To detect rain or no-rain pixels, and the height of ground clutter; and
- To estimate rain types, storm height, and bright-band height.

Regarding DPR Level 2 algorithms, KuPR product will be produced in a wide swath (about 245 km) using KuPR data only, and KaPR product in a narrow swath (about 125 km) using KaPR data only. Dual-frequency Precipitation products will be composed of narrow swath data produced by both KuPR and KaPR, and wide swath data (excluding overlap with the narrow swath) produced by KuPR and extension of information by KuPR and KaPR in a narrow swath.

DPR Level 3 algorithm will calculate statistics of each Level 2 product.

(iii) Components to be Developed

In producing KaPR and Dual-frequency Precipitation products, the following components have to be developed and evaluated:

- Utilization of KaPR data
  - Correction of attenuation in Ka-band by non-precipitation particles, such as clouds;
  - Development of technology to estimate parameters relating to non-uniform beam filling using high-density observation in Ka-band; and
  - Retrievals of solid precipitation using high-sensitive observation in Ka-band.
- Effective utilization of dual-frequency observation
  - Estimation of drop size distribution by simultaneous observation in dual-frequency; and
  - Evaluation of accuracy of Surface Reference Technique in dual-frequency.

(2) DPR/GMI Combined Algorithm

This theme encompasses research to develop or improve algorithms, completely or in part, to produce Level 2 and 3 combined standard products of the Dual-frequency Precipitation Radar (DPR) and the GPM Microwave Imager (GMI) on board the GPM core satellite, shown in Table 2.

(i) Principle of Development

DPR/GMI combined Level 2 and 3 algorithms will be jointly developed by the DPR/GMI Combined Algorithm Team, which is under the NASA-JAXA Joint Algorithm Team. Therefore, PIs, who are selected for this theme, are required to play a central role in the NASA-JAXA Joint Algorithm Team.

In developing DPR/GMI combined algorithms, applicants should pay attention to following points:

- Emphasize physical consistency between DPR and DPR/GMI combined algorithms, and also consider utilization of DPR Level 2 algorithms, completely or in part, as a DPR component;
- Provide database of rain rate profiles to algorithm development of Global Precipitation Map and GMI for contributing to improving their accuracy; and
- Develop a near-real-time algorithm based on the standard algorithm for Level 2 products.

(ii) Function and Input/Output of Algorithms

DPR/GMI combined algorithms should have following functions:

- To derive rain rate profiles using the DPR and the GMI in a complementary style;

- To estimate atmospheric physical parameters, such as cloud liquid water and water vapor, which cannot be estimated by radar directly but can be estimated by microwave radiometer, and surface characteristic parameters; and
- To produce database of rain rate profiles obtained by the DPR/GMI algorithm.

DPR/GMI combined Level 2 algorithm will use the DPR Level 1 product (received power profile) and the GMI Level 1 product (Brightness Temperature at each channel) as inputs, and produce rain rate profiles.

The DPR/GMI combined Level 3 algorithm will calculate statistics of Level 2 product.

(iii) Components to be Developed

In producing the DPR/GMI combined products, the following components have to be developed and evaluated:

- Methods for improving rainfall estimation accuracy by using GMI Brightness Temperatures; and
- Development and improvement of algorithms for estimating microwave surface emissivity over the land.

(3) Global Precipitation Map Algorithm

This theme encompasses research to develop or improve the following three algorithms, completely or in part, which compose algorithms to produce Global Precipitation Map standard products, shown in Table 2.

- Microwave imager rain retrieval algorithm (MWI algorithm)
- Microwave sounder rain retrieval algorithm (MWS algorithm)
- Microwave-Infrared (IR) combined algorithm (MVK algorithm)

(i) Principle of development

Global Precipitation Map algorithms will be developed in Japan. However, PIs, who are selected for this theme, are required to participate in the NASA-JAXA Joint Algorithm Team, and collaborate with the Radar-Enhanced Passive Microwave Radiometer (RE-PMR) Algorithm Team, who will develop the GMI standard algorithm.

In developing Global Precipitation Map algorithms, applicants should pay attention to following points:

- Develop algorithms based on outcomes from the Global Satellite Mapping for Precipitation (GSMaP) project, which was sponsored by the Japan Science and Technology Agency (JST) under the Core Research for Evolutional Science and Technology (CREST) framework between 2002 and 2007;
- Improve the MWI algorithm, which is being developed as the standard algorithm for precipitation products of the Advanced Microwave Scanning Radiometer 2 (AMSR2) on board the first generation of Global Climate Change Mission – Water (GCOM-W1) satellite, and apply it to GMI and other

microwave imagers on board constellation satellites;

- Develop the MWS algorithm ensuring consistency with the MWI algorithm;
- Improve database of rain rate retrievals using TRMM/PR data, and apply its methodology to DPR data;
- Cooperate with the AMSR2 precipitation group in algorithm development and calibration and validation activities; and
- Develop a near-real-time algorithm based on the standard algorithm.

(ii) Function and Input/Output of Algorithm

Algorithms composing the Global Precipitation Map algorithm should have the following functions;

- The MWI algorithm should retrieve rain rates over land and ocean using Level 1 products (Brightness Temperatures) of microwave imagers on board the GPM core and constellation satellites as inputs;
- The MWS algorithm should retrieve rain rates over land and ocean using Level 1 products (Brightness Temperatures) of microwave sounders on board constellation satellites as inputs; and
- The MVK algorithm should produce microwave and IR combined rainfall (Global Precipitation Map) using rain rate data retrieved by MWI and MWS algorithms and Geostationary IR information as inputs.

(iii) Components to be Developed

In producing Global Precipitation Map products, the following components have to be developed and evaluated:

- Smooth transition from the current PR-based database to the future DPR-based database; and
- Improvement of accuracy of rainfall over high-latitudes using high-frequency channels available in GMI and microwave sounders.

(4) TRMM/PR Standard Algorithm

This theme encompasses research to maintain and/or improve the TRMM Precipitation Radar (PR) standard algorithms shown in Table 3. Currently, PR standard algorithms are version 6 and used for processing. PR algorithms will be updated in JFY 2010 from version 6 to 7. This RA covers research to maintain version 7 algorithms of PR, and improve them toward updating to version 8.

2.2.2 Validation

As described in (1)-(3), research themes to contribute to development of JAXA GPM standard algorithms (hereafter referred as to “algorithm validation”), research themes to prepare test sites and validation methodologies before the launch of GPM core satellite, and research themes that will be effectively implemented by collaborating with other research programs, will be adopted in this RA.

Selected PIs will belong to the Validation Team under the JAXA PMM Science Team.

Validation activities after the launch of the core satellite will be conducted in the next or later RAs. As described in Chapter 5, this research theme is basically supported through a "Collaborative Research Agreement," but some research, which is supposed to be essential to fulfill the GPM mission, may be supported through a "Commissioned Research Agreement."

(1) Algorithm Validation by Ground Observation

This theme encompasses research contributing to the development and improvement of algorithms for DPR, DPR/GMI combined, and Global Precipitation Map products, through validating parameter errors, which are involved in satellite-based precipitation retrieval algorithms, such as attenuation by precipitation particles, raindrop size distribution, and drop velocity and density of snowfall.

To achieve this target, JAXA will put two new field-portable Ka-band Ground Validation (GV) radars in JFY 2009-2010, and they will be available for observation experiments in the winter season of JFY 2010 or later. To use the two GV radars in two-way measurement, it is possible to calculate radar attenuation characteristics of precipitation particles in Ka-band bi-directionally. If the radar is placed to face an upper direction, it can observe a detailed vertical structure of precipitation systems, especially for the melting layer where precipitation particles change from solid to liquid. It is also possible to observe simultaneously with the DPR on-orbit to make direct comparison with DPR observation.

Applicants have to collect observation data targeting the following themes using ground-based instruments, such as Ka-band GV radars provided by JAXA and other instruments prepared by themselves, and produce and analyze database contributing to development or improvement of the GPM standard algorithms:

(i) Observation of Precipitation Profile

A research theme for validation of a precipitation profile in the GPM algorithms is expected.

Examples of research include the following:

- Validation to compare observation by ground-based instruments (2DVD, meteorological instruments, a ground-based microwave imager, etc.), multi-band ground-based radars (JAXA Ka-band GV radars, etc.), and precipitation profiles retrieved by the DPR algorithm.

(ii) Observation of Snowfall

A research theme for observation of snowfall, which is challenge of GPM algorithm development, is expected.

Examples of research includes the following:

- Understanding characteristics of snowfall particles, by both operational observation using ground-based instruments (2DVD, meteorological instruments,

ground-based microwave imager, etc.), and intensive observation using ground-based radars (JAXA Ka-band GV radars, etc.);

- Validating parameter errors, which are involved in precipitation retrieval algorithms, especially for snowfalls, in the long-term period by combining ground-based instruments. Parameters are Z-R relations, Z-M relations, drop size distribution, drop velocity, volume distribution, and mean density of snowflakes, hail, and sleet particles;
- Calculating radar attenuation characteristics of precipitation particles for Ka-band by placing two Ku-band GV radars in two-way, and observing and validating change of attenuation feature parameters from the solid to liquid phase from winter to summer seasons; and
- Consolidating ground-based observation data, compiling a database contributing development and improvement of DPR, DPR/GMI combined and Global Precipitation Map algorithms, and providing them to the Algorithm Development Team.

(iii) Observation of Melting Layer

A research theme for observation of precipitation layers (snowfall, melting, and rainfall layers) to understand radar attenuation characteristics of KaPR, which are essential in developing and improving precipitation retrieval algorithms, is expected.

Examples of research includes the following:

- Observing precipitation layers (snowfall, melting, and rainfall layers), bi-directionally, by placing a Ka-band GV radar to high altitude; and
- Analyzing observation data focused on radar attenuation characteristics of Ka-band radar through a melting layer, providing results to the Algorithm Development Team to contribute to the determination of parameters for radar attenuation correction in precipitation retrieval algorithms of KaPR.

(2) Algorithm Validation Using Synthetic Data

This theme encompasses research contributing to the development of DPR, DPR/GMI combined, and Global Precipitation Map algorithms, using synthetic data, which is a set of physical parameters essential for determining rain rate (e.g., raindrop size distribution, drop velocity, rain type, water vapor content, cloud liquid content, cloud ice content, oxygen, aerosol, sea surface temperature, etc.), and is produced by ground observation data or numerical model outputs. To implement this theme, applicants also have to work closely with the Algorithm Development Team.

Research themes for production of above synthetic data, production of simulated observation data of the DPR and the GMI (received power or brightness temperature, which are equivalent to Level 1 products) by forward calculation using synthetic data, and validation of algorithms by comparing outputs of the DPR Level 2 algorithm and the DPR/GMI combined algorithm using simulated Level 1 data as inputs, with synthetic data.

(3) Other Validation Activities and Data Collection

Research themes related to other validation activities and data collection and preparation other than above (1)-(2) will also be adopted. Research that will be effectively implemented by collaborating with other research programs, or research that will contribute to validation of GPM standard algorithms will be recommended.

2.2.3 Application Research

Research themes related to application research to utilize satellite-based precipitation observation data, such as TRMM data, will be adopted in this RA.

This theme encompasses research contributing to climate and global water cycle variation and precipitation system climatology using long-term satellite data, especially TRMM/PR data, operational utilization research leading to societal benefits in the future GPM era, data utilization research in Asia and other areas, where ground precipitation observation is not sufficient, and development of new research product based on new ideas and needs, or combination of other satellites and/or sensors.

As described in Chapter 5, this research theme will generally be implemented through a "Collaborative Research Agreement."

3. Instructions for Responding to this RA

3.1. Qualifications

If a proposal is for peaceful purposes and has non-commercial objectives, researchers from all categories of domestic and foreign organizations including educational institutions, government offices, public companies, private enterprises and the other groups can apply for this RA.

3.2. Research Agreement Conclusion

After the proposals are selected, a research agreement should be made between JAXA and the organization to which the PI belongs, using associated terms and conditions to be prepared by JAXA. All applicants should carefully read Section 5, which describes detailed information on contract matters, and associated terms and conditions of the research agreement attached as Appendix D.

3.3. Research Period

The total research period of this RA will be 3 years from JFY 2010. However, performance will be evaluated based on an interim report at the end of each Japanese fiscal year in order to verify and decide whether the research is to be continued the following year.

3.4. Resources

(1) Funding

JAXA will reserve funds to support selected proposals. The basic policy for funding is as follows.

A) Based on the purpose of this RA, funding will be mainly available for the "Algorithm Development" category, within JAXA's budget limitation. Proposals related to "Validation" and to "Application Research" may be funded if they contribute directly to algorithm development or improvement, or are highly expected to contribute to the GPM and TRMM missions.

B) JAXA funding is restricted to domestic PIs, although some exceptions may be made for research that is necessary for GPM mission success.

C) JAXA funding is restricted to the direct cost of research ("Direct Cost") and does not bear any overhead costs, indirect costs, general costs, or whatsoever ("Overhead Cost") of the organization to which an applicant belongs. However, if this is impossible or requires special procedures, an applicant may fill in the prescribed remarks column of the Resource Requirement (Appendix B) as such.

D) If funding is not available for an applicant, the applicant may be selected as a non-funded PI upon consultation with JAXA.

(2) Data Sets

Necessary for conducting research and owned by JAXA, "data sets", will be provided free of charge within the limitations of the distribution capability. Available data sets are listed in Appendix B. Provision of data sets that JAXA is not authorized to disclose will be discussed separately. Participants using satellite, in-situ, and other data sets provided through this RA shall

observe the following policy:

A) Data sets shall be used only for research purposes that are proposed and selected under this RA; and

B) Data sets shall not be disclosed to a third party or parties.

3.5. Obligations

PIs have different obligations depending on the funding status.

(1) Funded PIs shall submit to JAXA an interim report on the results at the end of each JFY and a final report at the end of the 4-year research period. Furthermore, funded PIs are required to participate in the accomplishment debriefing meeting organized by JAXA once a year and present a status report. PIs must cover necessary travel expenses for participating in this meeting using funds provided by this RA.
(2) Non-funded PIs shall also submit an interim report and a final report. However, such reports can be substituted with papers published during the term. Participation in the accomplishment debriefing meeting is highly recommended but not mandatory. Support of travel expenses will depend on JAXA's budget.

3.6. Selection

Selection of proposals will be based on a peer-review process and discussions in science/project evaluation boards. JAXA selection officials make the final decisions. The principal elements considered in evaluating a proposal are its relevance to the objectives, intrinsic merit and cost. Evaluation of its intrinsic merit includes consideration of the following equally important factors:

(1) Overall scientific and technical merit of the proposal or unique and innovative methods, approaches, or concepts demonstrated by the proposal;

(2) Proposer's capabilities, related experience, facilities, techniques, or unique combinations of these that are integral factors for achieving the proposal objectives;

(3) The qualifications, capabilities, and experience of the proposed PI and CI; and

(4) Overall standing among similar proposals and/or evaluation against state-of-the-art techniques.

3.7. Late Proposals

Proposals or modifications received after the date specified in this RA may be considered if the selecting official deems them to offer JAXA a significant scientific and/or technical advantage or cost reduction.

3.8. Withdrawal of Proposal

Proposals may be withdrawn by the applicant at any time. To withdraw a proposal, the applicant should immediately notify JAXA.

3.9. Cancellation and Postponement

JAXA reserves the right to cancel this RA upon notice delivered by JAXA. In addition, JAXA assumes no liability for canceling this RA or for postponing the RA schedule.

3.10. Important Dates

August 10, 2009	Research Announcement issued
October 15, 2009	**Proposal Due Date**
December, 2009	Notification of Selection Results

3.11. Proposal Submission and Contact Point

Proposals with complete sets of attachments, such as reprints of papers, should be converted to **PDF and sent via E-mail** to the PMM RA Office. The maximum file size acceptable by E-mail is 10MB.

E-mail address of PMM RA Office: PMM_RA@jaxa.jp

In case of difficulty sending via E-mail, five copies of both proposals and the complete set of attachments should be sent via postal mail to:

Mr. Kenichi Komachi (PMM RA Office)
Earth Observation Research Center (EORC)
Tsukuba Space Center
Japan Aerospace Exploration Agency
2-1-1, Sengen, Tsukuba, Ibaraki, 305-8505, Japan

The point of contact is:

Mr. Kenichi Komachi (PMM RA Office)
Earth Observation Research Center
Tel: +81-29-868-2564
Fax: +81-29-868-2961
E-mail address: PMM_RA@jaxa.jp

4. Instructions for Proposal Contents

4.1. General

(1) Proposals received in response to this RA will be used only for evaluation purposes.
(2) The following types of proposals are not acceptable.
   A) Proposals that include restrictions or patents from other institutions.
   B) Proposals that are restricted when distributed or published.
(3) Proposals will not be returned to applicants.

4.2. Format

(1) It is highly recommended that applicants send their proposals and complete sets of all attachments, such as reprints of papers, in **PDF via E-mail.**
(2) Forms for cover sheet, work plan, and resource requirements can be found in Appendices A and B. No mandatory formats are applied to other parts of the proposal except the following.
   A) The page or paper size should be A4 or letter size.
   B) The page number must appear at the middle of the bottom of each page, and the name of the applicant must appear in the upper right corner.
   C) Proposals should be word-processing documents in English, with a font size not smaller than 12 points.
(3) Proposals should be brief and to the point, concentrating on substantive materials. The main body of the proposals should not exceed 20 pages in length. Necessary detailed information, such as reprints, should be included as attachments. A complete set of attachments must accompany each copy of a proposal when submitting via postal mail.

4.3. Proposal Contents

(1) Cover sheet

A) Research title

State your research title precisely and clearly. The title should be brief, reflecting an especially valid project intelligible to a science-literate reader and suitable for use in the public process.

B) Research category

Choose the relevant category to which the proposal belongs.

D) Information of applicants

- Identifying information of PI.
  State the name, job title, organization, address, E-mail address, and telephone and facsimile numbers of the PI.
- Identifying information of Co-investigator.
  State the name, organization, telephone number, and E-mail address of each Co-investigator (CI). One research team should consist of only one PI, or one PI and several CIs.

E) Budget

Provide a 3-year budget broken down by year and the 3-year total amount in Japanese Yen (from JFY 2010 through 2012).

F) Endorsement

Signature of a responsible official or authorized representative of the proposing organization, or any other person authorized to legally bind the organization.

(2) Abstract

Include a concise, one-page abstract describing the objective, significance, method of approach, and anticipated results.

(3) Description of proposal

This is the main body of the proposal and it should not exceed 20 pages in length. This main body shall be a detailed statement of the work to be undertaken, including its objectives and significance, relation to the present state of knowledge, and relation to previous work done on the project and to related work in progress elsewhere. The statement should outline the plan of work, including the broad design of experiments to be undertaken and a description of experiment methods and procedures. The project description should address the evaluation factors in these instructions and any specific factors in the RA. Any substantial collaboration with individuals not referred to in the budget or use of consultants should be described. Subcontracting significant portions of a research project is discouraged.

(4) Work plan (Research schedule)

The research schedule should be outlined in the form indicated in Appendix A.

(5) Management approach

For large or complex efforts involving interactions among numerous individuals or other organizations, plans for distribution of responsibilities and arrangements for ensuring a coordinated effort should be described.

(6) Personnel

A) Biographical information, experience, papers in related fields

A short biographical sketch, a list of publications, experiences related to this RA, and professional qualifications of the PI should be included. Also provide similar biographical information on each CI.

B) Role of CI

The PI is responsible for supervising the work and CIs in the research. State each CI's role in the proposed research.

(7) Resource requirements

Resource requirements should be described in the form indicated in Appendix B. Information of required resources will be considered during the selection process. After deciding the total amount of funding for each PI, JAXA will send more detailed forms for resource requirements to selected PIs for the final adjustment of funding. Before beginning the second and third years, JAXA will send the same forms for resource requirements again. Instructions for the budget summary and data request are also included in Appendix B.

5. Description of Research Agreement

5.1. Contractual Procedure

(1) After selecting the proposal and the PI, JAXA will send the PI guidelines and an application form for making an agreement. Please note that JAXA will make an agreement with the organization to which the PI belongs ("the Research Organization"), not with the PI or CI.
(2) A research agreement will be made in accordance with 'associated terms and conditions' attached herein as Appendix D. The Research Organization shall submit the application form with necessary documents according to the guidelines within the submission due date. The submission of the application form will be regarded as definite intention of making an agreement with JAXA in full consent to all of the terms and conditions stipulated in Appendix D, and the agreement will be effective upon issuance of the confirmation sheet by JAXA.
(3) If JAXA determines that an extension of a research project is justified by the interim report at the end of the Japanese Fiscal Year (JFY), the research agreement will be extended for 1 year, but no later than March 31, 2013. Funded organizations should submit the continuing agreement application form to JAXA at the beginning of every JFY.
(4) The Research Organization shall comply with the terms and conditions defined in the research agreement.

5.2. Research Agreement Summary

There are two types of associated terms and conditions of research agreements based on the applicable category of research: Commissioned Research Agreement and Collaborative Research Agreement. There are also two types of agreements for Collaborative Research Agreement: funded or not funded by JAXA.

(1) Commissioned Research Agreement (Funded)

- In principle, the Commissioned Research Agreement will be applied to research in the development or improvement of algorithms and some research in the validation category. The Research Organization shall conduct the research according to the Statement of Work provided by JAXA.
- JAXA will provide to the Research Organization the funds and the data sets necessary to conduct the research as described in the Statement of Work.
- JAXA will own research results that the Research Organization shall deliver to JAXA in accordance with the Statement of Work (Deliverable Research Results).
- JAXA will retain royalty-free rights to use all of the results derived from these research activities other than Deliverable Research Results only for its own research and development purposes.
- In the event JAXA provides prior written consent, the Research Organization may use Deliverable Research Results for its own research and development purposes.
- If the Agreement is terminated, the Research Organization shall refund to JAXA any unexpended research funds that have already been paid by JAXA.

(2) Collaborative Research Agreement (Funded/Non-funded)

- In principle, the Collaborative Research Agreement will be applied to research in the "Validation"

and "Application Research" categories.

- JAXA will provide to the Research Organization funds the finds (for funded cases) and the data sets necessary to conduct the research.
- In principle, the research results will be jointly owned by the parties: the share of which shall be determined in proportion to the contribution of the parties.
- JAXA will retain the right to use all results including results belonging to the Research Organization (if any), and the Research Organization will retain the right to use jointly-owned research results, only for each party's own research and development purposes, without prior consent of the other.

The difference between funded agreement and non-funded agreements:

- Collaborative Research Agreement (Funded)
  JAXA provides part of the research funds and the data sets. The Research Organization shall submit an interim report and a final report to JAXA, and shall participate in the workshops to report research progress. If this agreement is canceled or terminated, the Research Organization shall refund to JAXA any unexpended funds that have already been paid by JAXA.
- Collaborative Research Agreement (Non-funded)
  JAXA provides only the data sets. The Research Organization shall submit an interim report and a final report to JAXA. However, such reports can be substituted with papers published during the research term. Participation in the workshops is highly recommended, but not mandatory.

(3) Publication of results

A PI who wishes to release his or her research results derived from these research activities to a third party shall

- Provide JAXA with a copy of the publication before release,
- State in the publication that he or she obtained the results through participating in this RA research, and
- Grant JAXA an irrevocable and royalty-free right to use the provided publications, unless an academic society responsible for its publication requires the PI to transfer the copyright to it.

APPENDIX A
PROPOSAL COVER SHEET AND SCHEDULE

Proposal Cover Sheet
JAXA PMM Research Announcement

Proposal No.	_____ (Leave Blank for JAXA Use)			
Title				
Research category /group (check one)	**(1)Algorithm**	**(2)Validation**	**(3)Application**	
	☐ **(1a) Algorithm development**	☐ **(2a) Validation**	☐ **(3a) Operational utilization**	☐ **(3b) Precipitation climatology**

Principal Investigator

Name		**Job Title**	
Department			
Institution			
Address			
Country			
E-mail			
Telephone			
Facsimile			

Co-Investigator

Name	Institution	Telephone	E-mail

Budget (yen in thousands) (Direct Cost only)

JFY2010	JFY2011	JFY2012	TOTAL

(Leave Blank for JAXA Use)

Authorizing Official: _____ _____
(Name and Title) (Institution)

Research Schedule

JFY	2010				2011				2012			
Month	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3
Milestone												
Activities												

APPENDIX B
RESOURCE REQUIREMENTS

BUDGET SUMMARY

Direct Cost only

1. Personnel Expenses **(unit: yen in thousands)**

	2010	2011	2012	Total

2. Purchases

2.1 Computers / Peripheral Equipment **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total

2.2 Software **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total

2.3 Expendable Materials and Supplies **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total

3. Subcontracts **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total

4. Travel Expenses **(unit: days / times or days / travelers)**

Departure Point – Destination	2010	2011	2012

5. Observation Equipment **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total

6. Satellite Data **(unit: yen in thousands)**

Name of Satellite / Sensors	Distributor	Purpose	Cost			
			2010	2011	2012	Total

7. Other Data **(unit: yen in thousands)**

Name of Data Sets	Distributor	Purpose	Cost			
			2010	2011	2012	Total

8. Others **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total

TOTAL (unit: yen in thousands) (Except "4.Travel Expenses")				

*** Remarks "Overhead Cost" (q.v. 3.4(1)C) of this RA)**

Please check either of the following boxes:

☐ **Unnecessary**

☐ **Deductible with special procedures (e.g. submission of certain application form from JAXA)**

☐ **Indispensable (Reason(s):**)

BUDGET SUMMARY (***EXAMPLE***)

1. Personnel Expenses **(unit: yen in thousands)**

	2010	2011	2012	Total
Part-time job for DSD data analysis	*320 (40x8)*	*160 (20x8)*	*800 (100x8)*	*1280*

2. Purchases

2.1 Computers / Peripheral Equipment **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total

2.2 Software **(unit: yen in thousand)**

ITEM	2010	2011	2012	Total

2.3 Expendable Materials and Supplies **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total
8mm tape (112m)	*50*	*50*	*50*	*150*
CD-R	*100*	*120*	*120*	*340*
MO (640MB)	*15*	*10*	*10*	*35*
A4 Paper (package of 500 sheets)	*2*	*1*	*1*	*4*
CD-RW Drive	*50*			*50*

3. Subcontracts **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total
Software development for DSD data analysis	*1,500*	*600*	*600*	*2,700*

4. Travel Expenses **(unit: days / times or days / travelers)**

Departure Point – Destination	2010	2011	2012
Tokyo - Washington, D.C.	*7/1*		
Tokyo - Paris	*5/1*	*8/1*	
Tokyo - Paris		*6/1*	*6/1*
Tokyo - Osaka			*3/1*

5. Observation Equipment **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total
Micro Rain Radar	*1,500*			*1,500*

6. Satellite Data **(unit: yen in thousands)**

Name of Satellite / Sensors	Distributor	Purpose	Cost			
			2010	2011	2012	Total

7. Other Data **(unit: yen in thousands)**

Name of Data Sets	Distributor	Purpose	Cost			
			2010	2011	2012	Total

8. Others **(unit: yen in thousands)**

ITEM	2010	2011	2012	Total

TOTAL (unit: yen in thousands) (Except "4.Travel Expenses")	*3,537*	*941*	*1,581*	*6,059*

JAXA DATA REQUIREMENTS

1. JAXA-Archived Satellite Data Sets
(ADEOS, JERS-1, ERS, MOS, LANDSAT, TRMM, Aqua, ADEOS-II, ALOS)

Name of Satellite / Sensor	Quantity (scenes)	Purpose

B.1 Instructions for Budget Summary

Provide a budget summary by cost element (Personnel Expenses, Computers/Peripheral Equipment, Software, Expendable Materials and Supplies, Subcontracts, Travel Expenses, Observation Equipment, Satellite Data, Other Data, and Others), sorted by Japanese fiscal year as in the example attached to this form. An annual summary budget should also appear on the last line.

(1) Personnel Expenses
Enter expenses for part-time workers here as the total cost calculated by multiplying the unit cost per day by the number of days. For part-time workers, use your own cost estimates.

(2) Computers/Peripheral Equipment/Software
Enter the lease and rental cost of computers and/or peripheral equipment. Note that JAXA has the right to change specifications of all equipment. Also enter the cost of software here.

(3) Expendable Materials and Supplies
Enter the quantity of each item, following the example.

(4) Subcontracts
Provide the cost of subcontracts to outside companies or organizations here.

(5) Travel Expenses
Describe proposed domestic and/or international travel including information on destination and number of days/number of times (or travelers).

(6) Observation Equipment
Enter costs of observation equipment including installation cost.

(7) Satellite Data
Investigators requesting satellite data other than JAXA-owned or archived data (listed in the next section) should provide cost information here.

(8) Other Data
Enter costs for data other than satellite data.

(9) Others
Enter costs for publication and others here.

B.2 Instructions for Data Requirements

JAXA-owned satellite data includes TRMM data and other satellite data listed below. JAXA will provide requested data judged necessary for the proposed research, subject to availability of data processing.

- Marine Observation Satellite (MOS) (only around Japan)
- LANDSAT (only around Japan)
- European Remote-sensing Satellite (ERS)-1, 2 (only around Japan; for Japanese researchers only; available until JFY2002)
- Japanese Earth Resources Satellite (JERS)-1 (global)
- Tropical Rainfall Measuring Mission (TRMM)
- Advanced Earth Observing Satellite (ADEOS)
- Advanced Microwave Scanning Radiometer for EOS (AMSR-E) aboard EOS-Aqua Satellite
- Advanced Earth Observing Satellite-II (ADEOS-II)
- Advanced Land Observing Satellite (ALOS) (10 scenes from JAXA archives)

Data availability can be checked on JAXA's Earth Observation Satellite Data Distribution Service (linked from EORC website, http://www.eorc.jaxa.jp/en/about/distribution/index.html).

APPENDIX C
OVERVIEW OF
THE GLOBAL PRECIPITATION MEASUREMENT (GPM)
AND
THE TROPICAL RAINFALL MEASURING MISSION (TRMM)

1. Introduction

“Precipitation” is one of most important environmental parameters. Changes in its amount and distribution may affect our everyday life, and they may cause serious damages to human lives and properties. Too much precipitation causes floods, and too less of it causes droughts. Agricultural production depends on precipitation. It is one of the three foremost weather prediction variables along with temperature and wind. Precipitation is a true global variable that determines the general circulation through latent heating, which is an "engine" for circumglobal winds, and reflects climate changes. It is a key component of air-sea interaction and eco-hydrometeorological modeling.

Although there is no doubt that precipitation is such an important component of our environment, it is one of the least known physics components of cloud, weather and climate prediction models. Because of its large variability in space and time, its distribution over the globe is not accurately known. Knowledge of the spatial and temporal distribution of global precipitation is a key to improving our understanding of weather and climate systems.

The Tropical Rainfall Measuring Mission (TRMM) satellite, which is still flying and archiving tropical/subtropical rainfall data more than 11 years, is a joint Japan-US mission. TRMM, launched in the end of November 1997 by the Japanese H-II rocket, focuses on measuring tropical/subtropical rainfall and their diurnal variations, and covers latitude from 35S to 35N. TRMM has three precipitation sensors: the Precipitation Radar (PR), the world first space-borne precipitation radar developed by Japan, and the TRMM Microwave Imager (TMI) and the Visible Infrared Scanner (VIRS) developed by the U.S., which enables observation of rainfall structures by multiple sensors, simultaneously.

Because of the success of the TRMM satellite, several requirements for the successor mission emerged from the science and operational user community. The Global Precipitation Measurement (GPM) mission was proposed to fulfill those requirements. GPM is a satellite program to measure the global distribution of precipitation accurately in a sufficient frequency so that the information provided by this program can drastically improve weather predictions, climate modeling, and understanding of water cycles. Its feasibility has been studied at Goddard Space Flight Center of the National Aeronautics and Space Administration (NASA) and the Japan Aerospace Exploration Agency (JAXA). Accurate measurement of precipitation will be achieved using the Dual-frequency Precipitation Radar (DPR) installed on the GPM core satellite. The DPR on the GPM core satellite is being developed by JAXA and the National Institute of Information and Communications Technology (NICT).

2. The Tropical Rainfall Measuring Mission (TRMM)

The Tropical Rainfall Measuring Mission (TRMM) satellite (Figure 1) was launched by H-II rocket No. 6 in November 1997, and continues its observation more than 11 years later.

Major characteristics of the TRMM satellite are described in Table 1. TRMM is joint mission between Japan (JAXA (former NASDA) and NICT (former CRL)) and the U.S. (NASA). The major objective of TRMM is to determine accurate rainfall amount associated with tropical convective activities, which is a drive source of global atmospheric circulation. To this purpose, the TRMM satellite focuses on rainfall observation, and carries the world's first satellite-borne Precipitation Radar (PR) developed by Japan, in addition to conventional instruments such as infrared imager and microwave imager (TRMM Microwave Imager: TMI). The combination use of PR and TMI has greatly improved the estimation of rainfall amount and has succeeded in observing climate changes, as with El Niño and La Niña. Since the three-dimensional structure of rainfall over the land and ocean can be derived from PR, TRMM has also revealed the three-dimensional structure of typhoons over the ocean, which was rarely observed before TRMM. The success of TRMM shows the potential of satellite remote sensing contributions for understanding the water cycle on Earth and improving weather forecasts.

The TRMM satellite also targets rainfall observation in the tropics and sub-tropics. In order to measure

tropical rainfall that has large diurnal variation, it flies in non-sun-synchronous orbit with an inclination angle of 35°. Although the designed lifetime of the satellite was about 3 years, the satellite altitude was boosted from 350 km to 402.5 km in August 2001 to extend the lifetime by reducing atmospheric drag. In March 2009, more than 11 years after the satellite's launch, it continues its excellent observation and provides valuable meteorological and climatological data relating to precipitation, through long-term observation of the current status of rainfall in the tropics and sub-tropics, for understanding water cycle mechanisms.

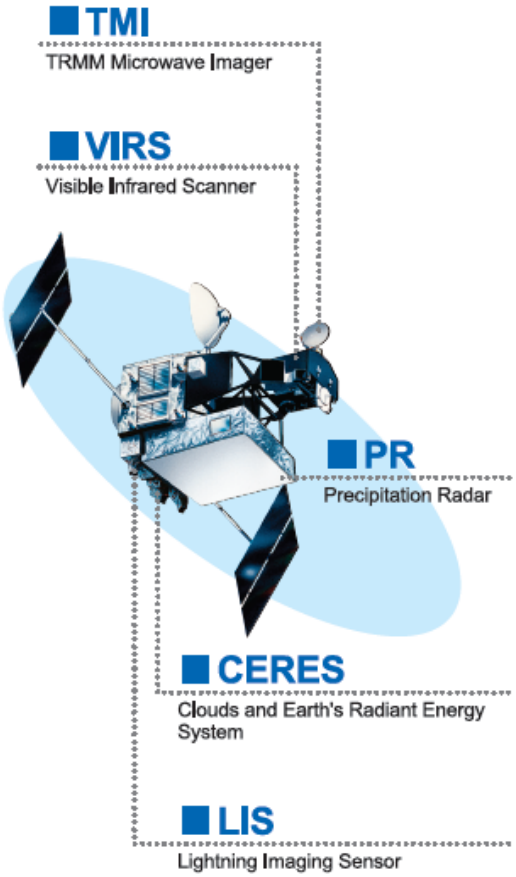

Figure 1 Overview of the TRMM Satellite and the Five on board Sensors

Table 1 Major Characteristics of the TRMM Satellite

Launch weight	Approx. 3.62 ton
Launcher	H-II rocket
Launch date	November 28, 1997 6:54 AM (JST)
Altitude	Approx. 350 km (402.5 km since August 24, 2001)
Orbit	Circular orbit (Non-sun-synchronous)
Inclination	Approx. 35 degrees
Shape	At lift-off: 5.1 m (length), 3.7 m (diameter) In orbit: 5.1 m (length), 14.6 m (in paddle direction)
Weight	Total: 3,524 kg Fuel: 890 kg Dry weight: 2,634 kg
Power	Ave. 850 W Attitude control Zero momentum three-axis stabilized
Attitude control	Zero momentum three-axis stabilized
Data transmission	Via TDRS 32 Kbps (real time), 2 Mbps (play back)
Design life	3 years and 2 months
Mission instrument	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS) Clouds and Earth's Radiant Energy System(CERES)

3. The Global Rainfall Measurement (GPM)

3.1 From TRMM to GPM

As accuracy of satellite precipitation estimates improves and observation frequency increases, application of those data to societal benefit areas, such as weather forecasts and flood predictions, is expected, in addition to research of precipitation climatology to analyze precipitation systems. There is, however, limitation on single satellite observation in coverage and frequency. Currently, the Global Precipitation Measurement (GPM) mission is scheduled under international collaboration to fulfill various user requirements that cannot be achieved by the single TRMM satellite.

One major characteristic of GPM as follow-on and expansion of TRMM is to operate the GPM core satellite, which will carry an active precipitation radar and a passive microwave radiometer, with a non-sun-synchronous orbit as a calibrator to other satellites. The other is a collaboration with a constellation of several satellites developed by each international partner (space agency) that will carry passive microwave radiometers and/or microwave sounders, to increase observation frequency. Although the TRMM satellite focused on observation of the tropics, the GPM mission covers broader areas, including high latitudes.

3.2 Concept of the GPM Mission

TRMM is single satellite mission for scientific research. On the other hand, the GPM mission (Fig. 2) is an international mission to achieve high-accurate and high-frequent rainfall observation over a global area. GPM is composed of a TRMM-like non-sun-synchronous orbit satellite (GPM core satellite) and multi-satellites carrying microwave radiometer instruments (constellation satellites). The GPM core satellite carries the Dual-frequency Precipitation Radar (DPR), which is being developed by JAXA and

NICT, and the GPM Microwave Imager (GMI) provided by NASA, and will achieve more accurate but narrower observation as a calibrator to other constellation satellites. Constellation satellites, which carry a microwave imager and/or sounder and are planned to be launched around 2013 by each partner agency for its own purpose, and will contribute to extending coverage and increasing frequency.

To take over the results that have been achieved by TRMM and to facilitate development of those results, the GPM mission is planned to meet user requirements that cannot be achieved by TRMM or are expected to be improved in GPM: 1) expansion of observation coverage; 2) increase of observation frequency; and 3) improvement of observation accuracy.

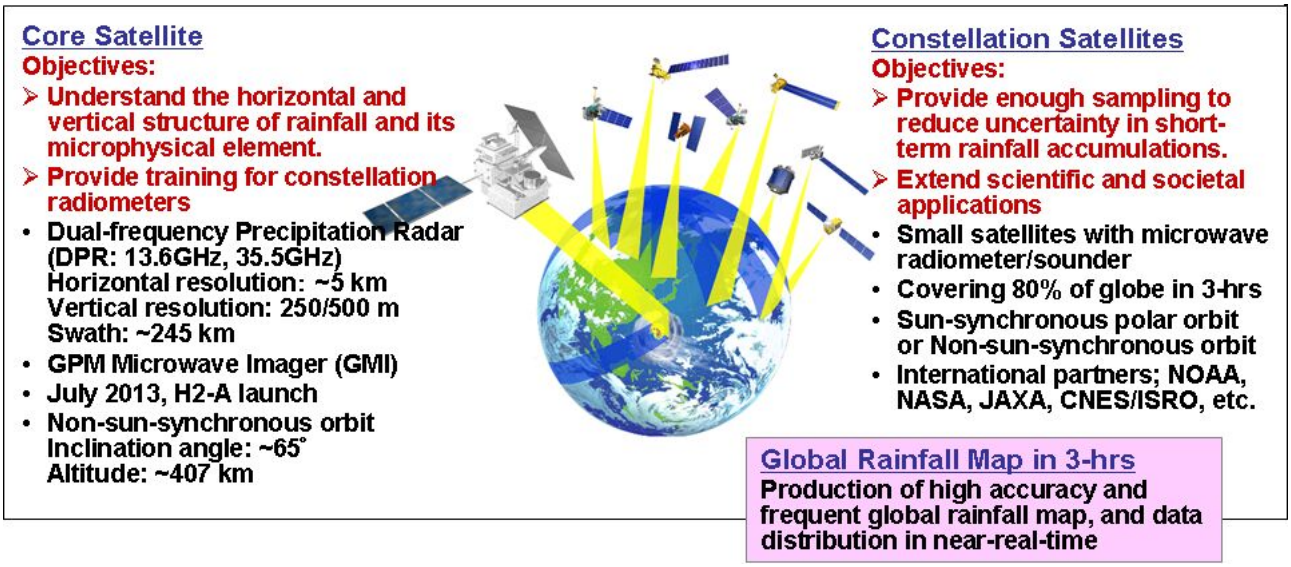

Figure 2 Overview of the GPM Mission

3.3 **Overview of the GPM Core Satellite**

The GPM core satellite (Table 2 and Figure 3), which is being jointly developed by Japan and the U.S., is scheduled to be launched in 2013. The core satellite carries a Dual-frequency Precipitation Radar (DPR) developed by Japan, and a GPM Microwave Imager (GMI) developed by U.S. The orbit of the core satellite is non-sun-synchronous with an inclination angle of about 65°. This orbit was selected to meet certain requirements, such as to measure diurnal variation of rainfall in mid- and high-latitudes as well as the tropics for around 2 months.

Table 2 Major Characteristics of the GPM Core Satellite

Orbit	Non-sun-synchronous
Inclination	Approx. 65degrees
Altitude	Approx. 400 km
Mission instrument	Dual-frequency Precipitation Radar (DPR) GPM Microwave Imager (GMI)
Mission life	3 years (target: 5 years)
Launch date	2013

The Dual-frequency Precipitation Radar (DPR) on board the GPM core satellite is composed of two radars: a Ku-band (13.6-GHz) Precipitation Radar (KuPR) and a Ka-band (35.5-GHz) Precipitation Radar (KaPR). KaPR aims at sensitive observation, and can detect weaker rainfall and snowfall that cannot be measured by KuPR. Since KuPR can detect heavier rainfall, simultaneous observation of KaPR and KuPR will enable accurate measurement of precipitation from heavy rainfall in the tropics to weak snowfall in high latitudes. Rain echo is affected by precipitation attenuation, and its amount depends on radar frequency and raindrop size. By matching position of radar beams and timing of transmitted pulses for KuPR and KaPR, and measuring precipitation particles at the same place simultaneously by dual-frequency, size of precipitation particles (raindrop size distribution) can be estimated by differences in precipitation attenuation. This information cannot be obtained by single-frequency radar, such as TRMM's PR, and will improve accuracy of precipitation estimation. It is also expected to identify rainfall and snowfall by using differences in precipitation attenuation for dual-frequency.

The GPM Microwave Imager (GMI) instrument on board the GPM core satellite is a multi-channel conical-scanning microwave radiometer developed by NASA, and it is based on the TMI on board the TRMM satellite. The major role of the GMI is to improve accuracy of rainfall/snowfall estimates by simultaneous observation with the DPR, and to work as a bridge between highly accurate observation by the core satellite and frequent observations by the constellation satellites. GMI is also expected to serve as a 'radiometric standard' for the other microwave radiometers on board the GPM constellation satellites, and to reduce differences in rain rate estimation arising from biases of instruments. The GMI is characterized by thirteen microwave channels ranging in frequency from 10 GHz to 183 GHz. In addition to carrying channels similar to those on the TRMM Microwave Imager (TMI), the GMI carries four high frequency, millimeter-wave, channels of about 166-GHz ('window' channel) and 183-GHz (water vapor channel). Addition of those high frequency channels is expected to contribute to improvements in accuracy of weak rainfall and snowfall estimates, especially over the ocean and land in high-latitudes. With a 1.2 m diameter antenna, the GMI will provide significantly improved spatial resolution over TMI.

The roles of the GPM primary satellite are to collect as much microphysical information as possible for accurate rain estimation by performing synchronous observation with the GMI and the DPR and to provide calibration standards for the other microwave radiometers on the constellation satellites.

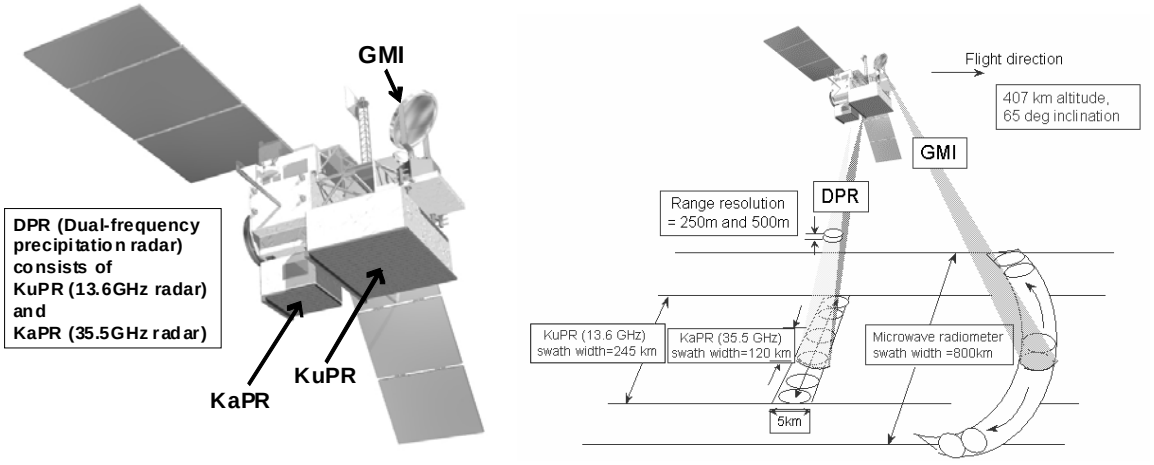

Figure 3 Overview of the GPM Core Satellite and Concept of Precipitation Observation

3.4 Collaboration with Constellation Satellites

In the case of low orbital satellites, such as TRMM and Aqua, single-satellite cannot observe frequently at each local point. To overcome this weakness and achieve frequent observation, the GPM mission will work with other satellite missions in the world. Figure 4 shows how the observation area covered in 3 hours by microwave radiometers on polar-orbiting satellites increases with the number of satellites. As the number increases, the coverage for a given time increases, and hence the sampling interval at a given point decreases. In the GPM era, eight sun-synchronous polar-orbiting satellites enable global observation of precipitation every 3 hours. In the GPM era, one primary satellite and eight constellation satellites will produce 3-hour global precipitation maps that will be delivered to users in near real time.

Constellation of several satellites developed by each international partner (space agency) will carry passive microwave radiometers and/or microwave sounders and be in operation around 2013. The DPR and GMI instruments on board the core satellite will serve as a 'calibrator' for data obtained by constellation satellites.

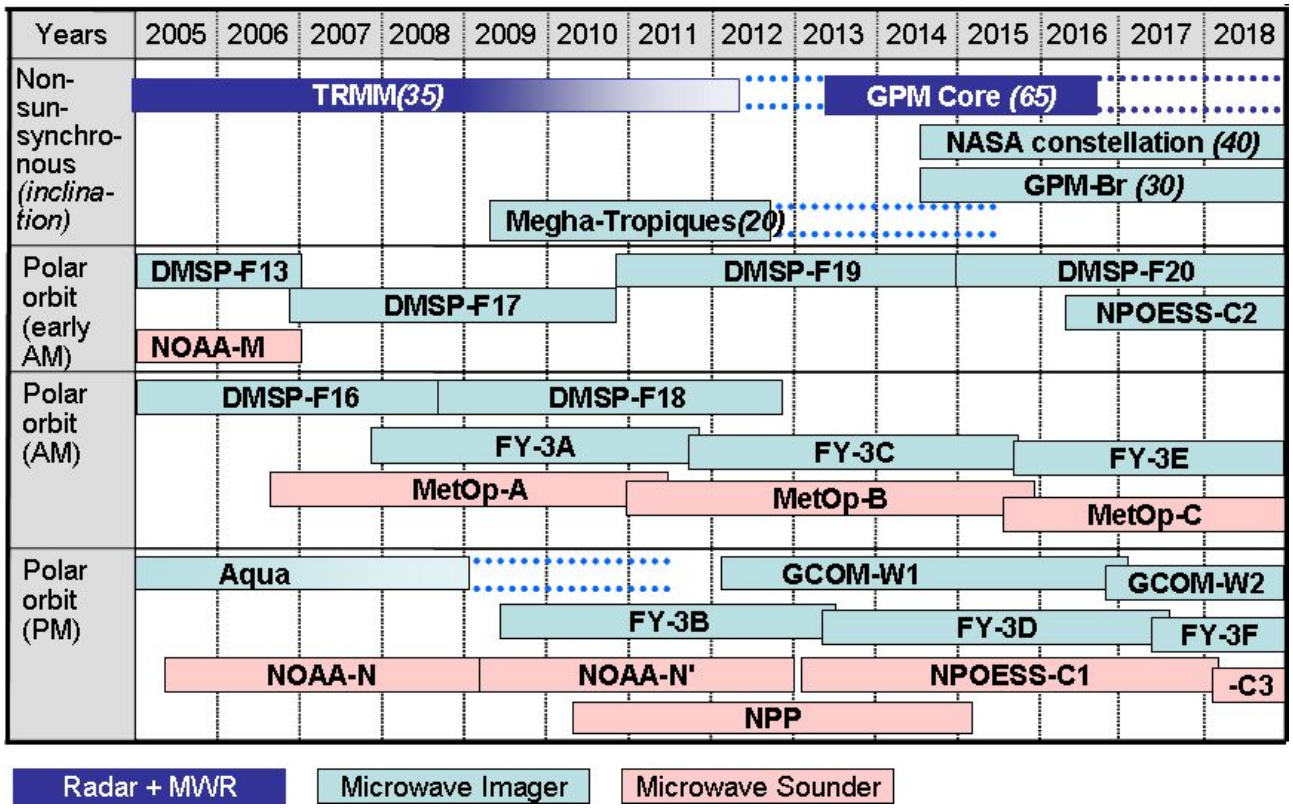

Figure 4 Worldwide Missions for Satellite Precipitation Observation (2005-2018) as of March 2009

APPENDIX D
ASSOCIATED TERMS AND CONDITIONS OF RESEARCH AGREEMENTS
(FOR THE PMM RESEACH ANNOUNCEMENT)

COMMISSIONED RESEARCH AGREEMENT

FOR

THE PRECIPITATION MEASURING MISSION

BETWEEN

THE JAPAN AEROSPACE EXPLORATION AGENCY (JAXA)

AND

THE RESEARCH ORGANIZATION

(FOR THE RESERACH ANNOUNCEMENT)

JAPAN AEROSPACE EXPLORATION AGENCY

COMMISSIONED RESEARCH AGREEMENT

This agreement ("Agreement") is entered into between the Japan Aerospace Exploration Agency, established under the provision of the Law Concerning the Japan Aerospace Exploration Agency on October 1, 2003, represented by its President and having its principal office at 7-44-1 Higashimachi, Jindaiji, Choufu-shi, Tokyo, Japan ("JAXA") and a research organization ("Research Organization") that submitted an application form for the research activities described below to JAXA,

WITNESSETH

WHEREAS, the Precipitation Measuring Mission ("PMM") aims to construct, use, and verify systems that enable highly accurate and frequent global precipitation observation for understanding climate and water cycle change, and contributing to operational use;

WHEREAS, JAXA issued the Research Announcement ("RA") to engage in research activities directly related to development or improvement of standard algorithms, validation, and data application of PMM, and the Research Organization applied pursuant to such RA;

WHEREAS, JAXA accepted the Research Organization's proposal that was in response to the RA, delivered the confirmation sheet and JAXA further desires to utilize such proposal in JAXA's project; and

WHEREAS, JAXA desires to commission the Research Organization to engage in the above-cited research activities.

NOW, THEREFORE, in consideration of the mutual agreements hereinafter set forth, and for other good and reasonable consideration, the receipt and adequacy of which are hereby acknowledged, JAXA and the Research Organization (hereinafter collectively referred to as "the Parties") agree as follows:

Article 1. Definitions

The following capitalized terms shall have the following meanings:

"Annual Evaluation" means JAXA's annual review, which is scheduled by JAXA at the end of

each Japanese fiscal year, of the Research Results (as defined below) obtained under this Agreement.

"Application Form" means the application form for the Research Projects (as defined below) submitted by the Research Organization.

"Co-Investigator" ("CI") means a person who supports the PI (as defined below) in performing the Research Projects (as defined below) with approval by JAXA.

"Commissioned Research Plan" means the plan described in Attachment A of the Application Form.

"Confirmation Sheet" means the confirmation sheet or the acceptance form prescribed by JAXA with regard to the Application Form.

"Earth Observation Satellite Data" means data sets obtained from satellites which are retained by JAXA at the time of execution of this Agreement. The available data sets (including names of satellites, sensors, observation period that can be offered, and observation areas) are listed in Attachment A of this Agreement.

"Industrial Property Rights" means all domestic and foreign patents, utility models and industrial designs.

"Potential Industrial Property Rights" means all domestic and foreign application rights for patents, utility models, or industrial designs.

"Principal Investigator" ("PI") means the Research Organization employee who was selected to be responsible for the Research Projects, and who is named in the " Commissioned Research Plan" (as defined below).

"Program/Data Copyrights" means all domestic and foreign copyrights related to computer programs, software and databases.

"Research Funding" means the total amount of funds payable to the Research Organization by JAXA under Article 8 of this Agreement.

"Research Projects" is defined in Article 2, Paragraph 2.

"Research Results" means the technical results and scientific knowledge derived from the implementation of the Research Projects pursuant to this Agreement, including all inventions, ideas, designs, literary works, algorithms, and technological developments, such as programs, that can execute the algorithm(s).

Article 2. Purpose and Scope of Research Projects

1. Under the terms and conditions of this Agreement, JAXA hereby commissions the Research Organization and the Research Organization hereby accepts the commission to engage in the research activities as set forth in the RA and/or the statement of work issued by JAXA ("Statement of Work"), and/or the commissioned research plan (“Commissioned Research Plan)) and/or otherwise under this Agreement.
2. The Research Organization's research activities ("Research Projects") shall be carried out in accordance with (i) the Statement of Work, and (ii) the Commissioned Research Plan.

Article 3. Effective Term

1. The Agreement shall become effective as of the date of the issuance of the Confirmation Sheet prescribed by JAXA and shall continue in effect until the end of each Japanese Fiscal Year ("Agreement Term").
2. The Agreement may be renewed annually under the same terms and conditions provided that JAXA approves an extension of the research period in the Annual Evaluation; provided, however, that the Parties mutually agree upon the amount to be paid by JAXA for such extended period; further provided, however, the Research Organization shall submit a renewal Application Form to JAXA and JAXA shall issue a new Confirmation Sheet; further provided, however, that the Agreement Term shall not extend beyond March 31, 2013.
3. Termination of this Agreement shall not affect a Party’s continuing obligation under Paragraph 3 of Article 9, Article 13, Paragraph 3 of Article 14, Article 15, Article 16, Article 27, and Article 28.

Article 4. Researchers

1. In the event that the Research Organization intends to select or add CIs, the Research Organization shall first obtain the consent of JAXA for such personnel. The Research Organization shall submit to JAXA the list of such candidates of CIs and consult with JAXA in

order to obtain JAXA's consent.

2. The Research Organization shall supervise the PI's and CI's engaging in the Research Projects and shall ensure all PI's and/or CI's engaging in the Research Projects in accordance with the terms and conditions of the Agreement. For avoidance of doubt, with regard to this Agreement, the PIs and CIs shall not be deemed to be third parties.
3. In the event that the PI dies, retires from the RO, takes a leave absent from work, or come to be no longer engaged in.the Research Projects, the RO shall immediately notify to JAXA as such and JAXA may at its sole discretion terminate this Agreement; provided however, if the RO designates a reseacher who belongs to the RO as the PI's successor and JAXA approves the succession, the Parties may amend this Agreement, with the succeeding researcher being a new PI. The terms and conditions of the amendement to this Agreement shall be determined upon mutual consultation and consent.

Article 5. JAXA's Performance for Research Projects

JAXA shall make reasonable efforts to perform the following tasks related to the Research Projects:

a) Deliver the Earth Observation Satellite Data in the Attachment A to the PI;
b) Provide satellite operation data, ground validation data and meteorological data; and
c) Hold workshops and meetings to evaluate the Research Results and the Progress Reports (as defined below) and to promote information exchange among PIs and JAXA.

Article 6. The Research Organization's General Responsibilities for Research Projects

1. The Research Organization shall conduct and complete the Research Projects in accordance with the Commissioned Research Plan and the Statement of Work. The progress and results of the Research Projects by the Research Organization shall be subject to the review of JAXA.
2. For the purpose of ensuring the Research Organization's performance of the above obligations, the Research Organization shall perform certain actions including, but not limited to:
   a) Participate in necessary workshops and meetings for the Research Projects and report upon request from JAXA;
   b) Deliver periodically to JAXA the Research Results and the reports ("Progress Reports") upon JAXA's request in the form specified by JAXA, and in all instances, at least one (1) month before the Annual Evaluation;
   c) Deliver the reports as a final report ("Final Reports") by the end of the Agreement Term; and
   d) Take necessary measures to ensure the PI's and/or CI's compliance with this Agreement.

Article 7. Subcontract

The Research Organization shall not subcontract the Research Projects to a third party, without prior written approval of JAXA. JAXA may provide and Research Organization shall adhere to instructions regarding the terms and conditions of any subcontract entered into by the Research Organization in relation to this Agreement and the activities contemplated herein. If the Research Organization subcontracts the Research Projects to a third party, any act of such third party in connection with the subcontract shall be deemed to be an act of the Research Organization and the Research Organization shall be responsible therefor.

Article 8. Research Funding

1. The Confirmation Sheet identifies the amount of funding to be provided by JAXA to the Research Organization for the Research Projects ("Research Funding"). JAXA shall, within thirty (30) days from the date when JAXA receives an invoice duly issued by the Research Organization, make payment for the Research Funding by wire transfer. All payments stipulated in this Agreement shall include any charges, taxes or duties levied by any official authorities of the country where the Research Organization exists.
2. If JAXA fails to pay the Research Funding within the period above, JAXA shall pay to the Research Organization default interest of six (6) percent per annum on such unpaid amount for the period from the immediately succeeding day of due date for payment to the date of actual payment; provided, however, that if such nonpayment was due to an Act of God or any other reasons outside of the control of JAXA, the period for which such reasons exist shall not be counted in the number of days subject to payment of default interest.
3. Throughout the performance of the Agreement, the Research Organization shall maintain books, records, logs, documents and other evidence sufficient to record all actions taken with respect to the completion of the Research Projects. The Research Organization shall agree to allow JAXA to inspect, copy, and audit such books, records, documents and other evidence at any reasonable time.

Article 9. Providing of Earth Observation Satellite Data by JAXA

1. JAXA will provide the Research Organization with the Earth Observation Satellite Data for the Research Projects free of charge subject to the following conditions:
   a) The Research Organization agrees and accepts that JAXA may not provide all the Earth Observation Satellite Data which the Research Organization may request;

b) JAXA does not guarantee a specific quality or the timely provision of the Earth Observation Satellite Data;

c) The Advance Land Observing Satellite data, which is one portion of the Earth Observation Satellite Data and is to be provided to the Research Organization, shall be limited to ten scenes every Japanese Fiscal Year; and

d) JAXA reserves the right to curtail or suspend Earth Observation Satellite Data supply to the Research Organization due to faults or difficulties relating in the satellites, limitations on their operations, or any other reasons.

2. With respect to the Earth Observation Satellite Data provided by JAXA, the Research Organization shall:

a) Only use the Earth Observation Satellite Data for the singular purpose of advancing the efforts of these Research Projects;

b) Not duplicate the Earth Observation Satellite Data except for distributing to authorized CIs the necessary data backups;

c) Not distribute the Earth Observation Satellite Data to any third party without JAXA's prior written consent; and

d) Return or otherwise appropriately manage the Earth Observation Satellite Data upon completion of this Agreement, according to the directives of JAXA.

3. Any rights regarding the Earth Observation Satellite Data provided by JAXA shall conform to the following:

a) Any rights relating to the Earth Observation Satellite Data shall belong to JAXA or to an institute designated by JAXA except in the case mentioned in b) below; and

b) If value-added products, which means highly processed products that do not retain the original pixel structure and that cannot be converted back to the primary Earth Observation Satellite Data, are developed in the course of executing the Research Projects, the ownership of such products shall be determined upon mutual agreement between the Parties, taking into consideration the degrees of contribution by JAXA and the Research Organization.

Article 10. Providing of Meteorological Data by JAXA

1. For the purpose of performing the Research Projects, JAXA will attempt to provide the Research Organization with the meteorological data provided by the Japan Meteorological Agency pursuant to the agreement between JAXA and the Japan Meteorological Agency ("Meteorological Data"). The Research Organization agrees that JAXA's provision of the Meteorological Data may be limited or otherwise affected by the fact that some rights to the

Meteorological Data belong to the Japan Meteorological Agency.

2. The Research Organization shall use the provided Meteorological Data solely for the purpose of conducting Research Projects. The Research Organization may not disclose the provided Meteorological Data to any party.
3. The Research Organization shall return or otherwise appropriately keep the Meteorological Data in accordance with the instructions of JAXA upon the termination of this Agreement.

Article 11. Disclosure of Technical Data

1. To the extent feasible, each party may disclose all necessary technical data ("Technical Data") which does not include the Earth Observation Satellite Data and the Meteorological Data. The Parties will undertake to handle expeditiously any request for the Technical Data presented by the other party.
2. The Technical Data shall be used and/or disclosed by the receiving party only for the purpose of fulfilling the receiving party's responsibilities under this Agreement. The receiving party shall protect Technical Data from unauthorized use and/or disclosure.
3. The Technical Data shall not be disclosed, duplicated or used by persons or entities other than the receiving party, or for any other purpose, without the prior consent of the furnishing party.
4. According to directives of the furnishing party, the receiving party shall return or otherwise dispose of Technical Data provided under the Agreement upon completion of the activities under the Agreement.

Article 12. Review and Confirmation of Research Results

1. The Research Organization shall deliver the Deliverable Research Results (as defined below) before the expiration of the Agreement Term. After receiving all Deliverable Research Results, JAXA may examine the Deliverable Research Results and the performance of the Research Organization to confirm the completion of the Research Projects.
2. If JAXA reasonably determines that 1) the Deliverable Research Results are not of the required quality and/or 2) the performance of the Research Organization is inadequate, JAXA may request the Research Organization to perform remedial activities during a period specified by JAXA and within the amounts of the Research Funding.
3. The failure to perform the remedial activities contemplated in the foregoing paragraph shall constitute a default under the Agreement; hence Article 21 of the Agreement shall apply.

Article 13. Ownership and Usage of the Research Results

1. All Research Results required by the Statement of Work to be delivered to JAXA ("Deliverable Research Results") shall be owned solely by JAXA unless the Research Organization has reasonably proven that rights related to the Deliverable Research Results were already owned by the Research Organization on the date of execution of this Agreement. The Research Organization may not use in any way JAXA's Deliverable Research Results unless JAXA provides the Research Organization prior written consent. In the event JAXA provides prior written consent to use JAXA's Deliverable Research Results, the Research Organization may use such Deliverable Research Results only for its own non-militaristic (i.e., peaceful) and non-commercial purposes.
2. With regard to copyrights in the written documents related to the Deliverable Research Results including Progress Reports and Final Reports, the Research Organization shall assign such copyrights to JAXA at the time of delivering the Deliverable Research Results. Such assigned copyrights include, but not limited to, the rights to translate, transform or otherwise adapt works and to use derivative works. The Research Organization agrees not to exercise and to cause its directors, officers, employees including PIs and CIs, regardless of whether such persons are employed by the Research Organization, to agree not to exercise, any related moral rights to the assigned copyrights in the written documents related to Deliverable Research Results including Progress Reports and Final Reports and agrees not to rescind such non-exercise and to cause such directors, officers, employees including PIs and CIs to agree not to rescind such non-exercise.
3. The Research Results other than the Deliverable Research Results ("Non-Deliverable Research Results") shall be owned by the Research Organization. The Research Organization hereby grants and will be deemed to have granted to JAXA and JAXA's affiliates a perpetual, irrevocable, royalty-free, non-exclusive, worldwide right to use the Non-Deliverable Research Results (and derivative works thereof); provided, however, JAXA shall use such Non-Deliverable Research Results (and derivative works thereof) for its own research and development work including, but not limited to, the granting to commissioned research organizations and/or collaborating research organizations the use of such Non-Deliverable Research Results (and derivative works thereof)
4. JAXA may request the Research Organization to disclose any Research Results including the Non-Deliverable Research Results and other related materials to JAXA.
5. The Research Organization may not disclose the Deliverable Research Results to a third party without prior written consent of JAXA.

Article 14. Publication of Research Results

1. If the Research Organization intends to publish the JAXA's Deliverable Research Results, the Research Organization shall provide JAXA with a written document regarding the description of the subjected JAXA's Deliverable Research Results to be published and obtain a written consent of JAXA. JAXA will not unreasonably withhold consent from the publishing party's request for such publication.
2. Before publishing, the Research Organization shall provide JAXA with a copy of the publication. JAXA is entitled to an irrevocable and royalty-free right to use the provided publications, unless the copyright of such publication is owned or held by an academic society.
3. The Research Organization shall state in the publication that such JAXA's Deliverable Research Results have been obtained pursuant to this Agreement and identify the owner of the rights to the Earth Observation Satellite Data and Meteorological Data used in such publication.
4. In the event that a PI or CI wishes to publish or disclose the JAXA's Deliverable Research Results, the Research Organization shall cause the PI and/or CI to act in accordance with the terms and conditions of this Article and shall cause the PI and/or CI to grant JAXA an irrevocable and royalty-free right to use the provided publications, unless the copyrights to such publication belongs to an academic society.

Article 15. Industrial Property Rights

1. The Research Organization shall report the existence of Potential Industrial Property Rights generated in the course of the Research Projects, if any, to JAXA without delay and take the necessary procedures to file and prosecute applications in JAXA's name, if possible, for the registration of the resulting Industrial Property Rights, at JAXA's expense and with the approval of JAXA. The Research Organization shall consult with JAXA and seek JAXA's instructions in advance regarding every material matter concerning the application for the registration of the resulting Industrial Property Rights. If the Research Organization is successfully granted such Industrial Property Rights it shall notify JAXA without delay.
2. The Research Organization shall institute rules,and/or agreements with its employees which provide that any Potential Industrial Property Rights and/or Industrial Property Rights owned by and/or held by the employees shall be transferred by such employees to the Research Organization in the event the employees' inventions and Potential Industrial Property Rights and/or the Industrial Property Rights related thereto were created or otherwise arose within the scope of the Research Organization's business, unless the Research Organization has such work rules as of the conclusion date of this Agreement,.
3. If the technology developed by the Research Organization in the course of the Research Projects

has Potential Industrial Property Rights, JAXA may make an application for such Potential Industrial Property Rights to be registered Industrial Property Rights in JAXA's name. In this case, the Research Organization shall submit to JAXA the materials required for the application and otherwise cooperate with JAXA in accordance with JAXA's instructions.

4. The Research Organization shall assign any Potential Industrial Property Rights and/or Industrial Property Rights contemplated in Paragraph 1 and 2 of this Article 15 to JAXA immediately after their acquisition, if acquired in the name of the Research Organization. For the avoidance of doubt, the consideration for such assignment of Potential Industrial Property Rights and/or the Industrial Property Rights is included in the Research Funding.
5. If the Research Organization requests a license to use the Industrial Property Rights assigned to JAXA under the preceding paragraph, JAXA will grant the Research Organization a nonexclusive license unless it is reasonably deemed to be inappropriate. The conditions for the approval shall be determined by mutual agreement between the Parties as necessary.
6. The Research Organization shall obtain approval of JAXA in advance if the Research Organization wishes to grant to a third party a license to use the Industrial Property Rights.
7. JAXA shall bear the total or a portion of the costs which the Research Organization paid to the Research Organization's employee who created the technology which is subject of the Potential Industrial Property Rights and/or the Industrial Property Rights and transferred such Potential Industrial Property Rights and/or Industrial Property Rights to the Research Organization in accordance with Paragraph 2 of this Article 15. The amount to be paid by JAXA shall be determined solely by JAXA in accordance with JAXA’s standard.

Article 16. Program/Data Copyrights

1. The Research Organization shall notify JAXA without delay in the event that the Research Organization creates a program, software and/or database that may potentially constitute the Program/Data Copyrights.
2. The Research Organization shall assign to JAXA all Program/Data Copyrights required by the Statement of Work to be delivered to JAXA ("Deliverable Program/Data Copyrights") including, but not limited to, rights to translate, transform or otherwise adapt works and to use derivative works. The Research Organization agrees not to exercise and to cause its directors, officers, and employees including PIs and CIs, regardless of whether such persons are employed by the Research Organization, to agree not to exercise any related moral rights to the Deliverable Program/Data Copyrights and agrees not to rescind such non-exercise and to cause such directors, officers, employees including PIs and CIs to agree not to rescind such non-exercise. For avoidance of doubt, the consideration for such assignment of the Deliverable Program/Data Copyrights is included in the Research Funding. Provided, however, that the Research

Organization may retain the Deliverable Program/Data Copyrights, if the Research Organization has reasonably proven that it owned on the date of execution of this Agreement; further provided, however that the Research Organization may retain the Deliverable Program/Data Copyrights regarding the know-how, routine, subroutine and modules, if the Research Organization designate some portion of it. In this case, JAXA is entitled to an irrevocable and royalty-free right to use such know-how, routine, subroutine and modules in the form as it is provided to JAXA, even if such know-how, routine, subroutine and modules whose ownerships are retained by the Research Organization. Such use by JAXA includes the right of JAXA to grant a third party the right to use the know-how, routine, subroutine and modules in the form as it is provided to JAXA without paying royalties to the Research Organization.

3. Notwithstanding the preceding Paragraph, and in JAXA's sole discretion, the Research Organization may own the Deliverable Program/Data Copyrights solely or jointly with JAXA.
4. The Research Organization shall take necessary measures to extend the terms and conditions of this Article to its researcher who created the copyrightable item and shall prevent that researcher from executing the related Deliverable Program/Data Copyrights.
5. If the Research Organization requests of JAXA a license to use the assigned Deliverable Program/Data Copyrights, JAXA will grant the Research Organization such rights unless it is reasonably deemed to be inappropriate. The conditions for the approval shall be determined upon mutual agreement between the Parties as necessary.
6. After such Deliverable Program/Data Copyrights has been assigned to JAXA, JAXA may modify a program, software and/or database which is subject of the Deliverable Program/Data Copyrights and shall bear the risk and responsibility related to such modification.
7. The Program/Data Copyrights other than the Deliverable Program/Data Copyrights ("Non-Deliverable Program/Data Copyrights ") shall be owned by the Research Organization. The Research Organization hereby grants and will be deemed to have granted to JAXA and JAXA's affiliates a perpetual, irrevocable, royalty-free, non-exclusive, worldwide right to use the Non-Deliverable Program/Data Copyrights (and derivative works thereof); provided however, JAXA shall use such Non-Deliverable Program/Data Copyrights (and derivative works thereof) for its own research and development work including, but not limited to, the granting to commissioned research organizations and/or collaborating research organizations the use of programs, software and databases related to Non-Deliverable Research Results (and derivative works thereof).

Article 17. Impossibility of Performance

In the event it becomes impossible for the Research Organization to carry out all or any part of the Agreement due to reasons attributable to the Research Organization, such failure to carry out its

duties shall constitutes a default and JAXA may terminate all or any part of the Agreement.

Article 18. Delay of Performance

1. In the event there is a reasonable basis for which the Research Organization is unable to complete the Research Projects by the due date set forth in this Agreement, the Research Organization may make a written request to JAXA for its consideration to extend the due date.
2. If the Research Organization fails to submit the Final Reports and deliverables to JAXA by the extended due date, such failure shall constitute a default and JAXA may terminate all or any part of the Agreement.

Article 19. Termination and Refund

1. Either party may terminate the Agreement:
   a) When the other party commits a dishonest and/or inequitable act that irreparably harms the mutual trust between the Parties provided that breaching party fails to offer any effective and satisfactory remedial measures within seven (7) days after getting demands for corrective action from the harmed party;
   b) When the other party violates any of the terms and conditions of this Agreement provided that the breaching party fails to offer any effective and/or satisfactory remedial measures within seven (7) days after getting demands for corrective action from the harmed party; and
   c) When the events stipulated in Article 22 ocurrs
   d) When the Parties consent to terminate.
2. In addition to the preceeding Paragraph, JAXA may terminate the Agreement at its sole direction upon the occurrence of:
   a) The events contemplated in Article 4 Paragraph 3, Article 11 Paragraph 3, Articles 17, and Article 18 ("Agreement Termination Events"); and
   b) Any other material breach of this Agreement by the Research Organization, PI and CI.
3. Upon the termination of the Agreement, the Research Organization shall promptly deliver to JAXA all work including, but not limited to, all works in progress and all work that is completed and otherwise ready for delivery.
4. If the Agreement is terminated as set forth in the Paragraph 1 and Paragraph 2 of this Article, the Research Organization shall refund to JAXA any unexpended Research Funding. The Research Organization shall remit such funds within thirty (30) days from the date when the Research Organization receives an invoice issued by JAXA with regard to such funds.

Article 20. Ownership of the Rights to the Acquired Equipments

The Research Organization shall transfer, upon the expiration of this Agreement, all rights and ownership in the equipment acquired by the Research Organization with the Research Funding; provided, however, that JAXA may determine that any or all such rights and ownership will be retained by the Research Organization.

Article 21. Liquidated Damages

If the Agreement is terminated by reasons attributed to the Research Organization, PI and/or CI including, but not limited to, the occurrence of the Agreement Termination Events, the Research Organization shall pay liquidated damages to JAXA in the amount of ten (10) percent of the portion of the remaining Research Funding in addition to any amount to be refunded under Article 19 Paragraph 4.

Article 22. Force Majeure

Neither party is liable for failure, delay or suspension to perform its part of the Agreement when such failure is due to circumstances including, but not limited to, fire, war, unavoidable accidents, government acts or policies, or legal restrictions beyond the reasonable control of the party.

Article 23. Confidentiality

1. In this Agreement, "Confidential Information" means any information that a party discloses or presents in writing or by other media, to the other party in the course of these Research Projects; provided however, Confidential Information does not include the following:
   a) Information that is already known to the public when disclosed by the disclosing party;
   b) Information that becomes known to the public after the disclosure by the disclosing party without intentional misconduct or negligence of the receiving party;
   c) Information that the receiving party already had before the disclosure by the disclosing party;
   d) Information that the receiving party acquires from a duly authorized third party not subject to confidentiality obligations;
   e) Information that the receiving party independently develops without utilizing information obtained from the disclosing party;
   f) Information with a prior written consent of the disclosing party for the disclosure and the publication; or
   g) Information that is required to be disclosed by applicable laws, judgment or order of a

competent court. In this case, the receiving party shall promptly notify the disclosing party of the necessity of disclosure.

2. The receiving party shall keep the Confidential Information secret and shall not disclose or divulge any Confidential Information to a third party without a prior written consent of the disclosing party.
3. The confidentiality obligation under this Article shall remain effective for a period of five (5) years after the termination of the Agreement. However this period of keeping confidentiality may be extended or shortened by mutual agreement.

Article 24. Government Approvals

Each party shall obtain such permits, licenses, and other government authorizations as are required for it to perform its responsibilities under the Agreement, and shall comply with all respective laws and regulations.

Article 25. Language

All communications between the Research Organization and JAXA under this Agreement shall be in English.

Article 26. Special Agreement

Any supplement, modification or amendment of this Agreement shall only be binding if made upon the Parties' mutual written agreement which makes specific reference to this Agreement.

Article 27. Dispute Resolution

The Parties agree to put forth their best efforts to solve amicably any dispute, controversy, or difference arising out of, in connection with, or resulting from this Agreement.

Article 28. Arbitration

All disputes that cannot be amicably settled by the method defined in the previous Article hereof will be settled by arbitration in Tokyo in accordance with the Commercial Arbitration Rules of the Japan Commercial Arbitration Association.

Attachment A "Earth Observation Satellite Data"

Name of Satellite or Sensor	Observation Period (YY/MM/DD)	Observable Area
ALOS (Advanced Land Observation Satellite)	2006/05/16～	Global
MOS (Marine Observation Satellite)	1987/02/23～1996/04/19	Around Japan, Antarctic and Southeast Asia
JERS (Japanese Earth Observation Satellite)	1992/09/01～1998/10/11	Global
ADEOS (Advanced Earth Observation Satellite)	1996/10/15～1997/6/29	Global
ADEOS-Ⅱ (Advanced Earth Observation Satellite-Ⅱ)	2003/01/18～2003/10/24	Global
AMSR-E (Advanced Microwave Scanning Radiometer for EOS-Aqua satellite)	2002/06/19～	Global
TRMM (Tropical Rainfall Measuring Mission)	1997/12/01～	Global
ERS (European Remote-Sensing Satellite)	1991/08/18～2003/03/29	Around Japan and Antarctic
LANDSAT* (Land Satellite)	1979/02/19～2002/03/31	Around Japan

* LANDSAT-5 data received by 2001/3/31 will be available in the dataset.

COLLABORATIVE RESEARCH AGREEMENT (FUNDED)

FOR

THE PRECIPITATION MEASURING MISSION

BETWEEN

THE JAPAN AEROSPACE EXPLORATION AGENCY (JAXA)

AND

THE RESEARCH ORGANIZATION

(FOR THE RESERACH ANNOUNCEMENT)

JAPAN AEROSPACE EXPLORATION AGENCY

COLLABORATIVE RESEARCH AGREEMENT

This agreement ("Agreement") is entered into between the Japan Aerospace Exploration Agency, established under the provision of the Law Concerning the Japan Aerospace Exploration Agency on October 1, 2003, represented by its President and having its principal office at 7-44-1 Higashimachi, Jindaiji, Choufu-shi, Tokyo, Japan ("JAXA") and a research organization ("Research Organization") that submitted an application form for the research activities described below to JAXA.

WITNESSETH

WHEREAS, the Precipitation Measuring Mission ("PMM") aims to construct, use, and verify systems that enable highly accurate and frequent global precipitation observation for understanding climate and water cycle change, and contributing to operational use;

WHEREAS, JAXA issued the Research Announcement ("RA") to engage in collaborative research activities directly related to development or improvement of standard algorithms, validation, and data application of PMM, and the Research Organization applied pursuant to such RA;

WHEREAS, JAXA accepted the Research Organization's proposal that was in response to the RA, delivered the confirmation sheet to the Research Organization and JAXA further desires to utilize such proposal in JAXA's project; and

WHEREAS, JAXA desires to engage in the above research activities in collaboration with the Research Organization.

NOW, THEREFORE, in consideration of the mutual agreements hereinafter set forth, and for other good and reasonable consideration, the receipt and adequacy of which are hereby acknowledged, JAXA and the Research Organization (hereinafter collectively referred to as “the Parties” agree as follows:

Article 1. Definitions

The following capitalized terms shall have the following meanings:

"Annual Evaluation" means JAXA's annual review, which is scheduled by JAXA at the end of

each Japanese fiscal year, of the Research Results (as defined below) obtained under this Agreement.

"Application Form" means the application form for the Research Projects (as defined below) submitted by the Research Organization.

"Co-Investigator" ("CI") means a person who supports the PI (as defined below) in performing the Research Projects (as defined below) with approval by JAXA.

"Collaborative Research Plan" means the plan described in Attachment A of the Application Form.

"Confirmation Sheet" means the confirmation sheet or the acceptance form prescribed by JAXA with regard to the Application Form.

"Earth Observation Satellite Data" means data sets obtained from satellites which are retained by JAXA at the time of execution of this Agreement. The available data sets (including names of satellites, sensors, observation period that can be offered, and observation areas) are listed in Attachment A of this Agreement.

"Industrial Property Rights" means all domestic and foreign patents, utility models, and industrial designs.

"Intellectual Property Rights" means the following:
(i) Industrial Property Rights (as defined above);
(ii) Potential Industrial Property Rights (as defined below); and
(iii) Program/Data Copyrights (as defined below).

"Potential Industrial Property Rights" means all domestic and foreign application rights for patents, utility models, or industrial designs.

"Principal Investigator" ("PI") means the Research Organization employee who was selected to be responsible for the Research Projects, and who is named in the Collaborative Research Plan.

"Program/Data Copyrights" means all domestic and foreign copyrights related to computer programs, software and databases.

"Research Funding" means the total amount of funds payable to the Research Organization by JAXA under Article 7 of this Agreement.

"Research Projects" is defined it in Article 2, Paragraph 2.

"Research Results" means the technical results and scientific knowledge derived from the implementation of the Research Projects pursuant to this Agreement, including all inventions, ideas, designs, literary works, algorithms, and technological developments, such as programs, that can execute the algorithm(s).

Article 2. Purpose and Scope of Research Projects

1. Under the terms and conditions of this Agreement, the Parties agree to work in collaboration with regard to the research activities as set forth in the RA, and/or the Collaborative Research Plan and/or otherwise under this Agreement.
2. The Parties' research activities ("Research Projects") shall be carried out in accordance with the Collaborative Research Plan.

Article 3. Effective Term

1. The Agreement shall become effective as of the date of the issuance of the Confirmation Sheet prescribed by JAXA and shall continue in effect until the end of each Japanese Fiscal Year ("Agreement Term").
2. The Agreement may be renewed annually under the same terms and conditions provided that JAXA approves an extension of the research period in the Annual Evaluation; provided, however, that the Parties mutually agree upon the amount to be paid by JAXA for such extended period; further provided, however, the Research Organization shall submit a renewal Application Form to JAXA and JAXA shall issue a new Confirmation Sheet; further provided, however, that the Agreement Term shall not extend beyond March 31, 2013.
3. Termination of this Agreement shall not affect a Party’s continuing obligation under Paragraph 3 of Article 8, Article 11, Paragraph 3 of Article 12, Article 13, Article 14, Article 23, and Article 24.

Article 4. Researchers

1. In the event that the Research Organization intends to select or add CIs, the Research Organization shall first obtain the consent of JAXA for such personnel. The Research

Organization shall submit to JAXA the list of such candidates of CIs and consult with JAXA in order to obtain JAXA's consent.

2. The Research Organization shall supervise the PI's and CI's engaging in the Research Projects and shall ensure all PI's and/or CI's engaging in the Research Projects in accordance with the terms and conditions of the Agreement. For avoidance of doubt, with regard to this Agreement, the PIs and CIs shall not be deemed to be a third party.
3. In the event that the PI dies, retires from the RO, takes a leave absent from work, or come to be no longer engaged in.the Research Projects, the RO shall immediately notify to JAXA as such and JAXA may at its sole discretion terminate this Agreement; provided however, if the RO designates a reseacher who belongs to the RO as the PI's successor and JAXA approves the succession, the Parties may amend this Agreement, with the succeeding researcher being a new PI. The terms and conditions of the amendement to this Agreement shall be determined upon mutual consultation and consent.

Article 5. JAXA's Performance for Research Projects

JAXA shall make reasonable efforts to perform the following tasks related to the Research Projects:

a) Deliver the Earth Observation Satellite Data in the Attachment A to the PI;
b) Provide satellite operation data, ground validation data and meteorological data;
c) Evaluate the Research Result and the Progress Reports (as defined below) for the Annual Evaluation and send the results to the PI; and
d) Hold workshops and meetings to evaluate the Research Results and the Progress Reports and to promote information exchange among PIs and JAXA.

Article 6. The Research Organization's General Responsibilities for Research Projects

1. The Research Organization shall conduct and complete the Research Projects in accordance with the Collaborative Research Plan.
2. For the purpose of ensuring the Research Organization's performance of the obligations above, the Research Organization shall perform certain actions including, but not limited to:
   a) Participate in necessary workshops and meetings for the Research Projects and report upon request from JAXA;
   b) Deliver periodically to JAXA the Research Results and the reports ("Progress Reports") upon JAXA's request in the form specified by JAXA , and in all instances, at least one (1) month before the Annual Evaluation;

c) Deliver the reports as a final report ("Final Reports") by the end of the Agreement Term; and
d) Take necessary measures to ensure the PI's and/or CI's compliance with this Agreement.

Article 7. Research Funding

1. The Confirmation Sheet identifies the amount of funding to be provided by JAXA to the Research Organization for the Research Projects ("Research Funding"). JAXA shall, within thirty (30) days from the date when JAXA receives an invoice duly issued by the Research Organization, make payment for the Research Funding by wire transfer. All payments stipulated in this Agreement shall include any charges, taxes or duties levied by any official authorities of the country where the Research Organization exists.
2. If JAXA fails to pay the Research Funding within the period above, JAXA shall pay to the Research Organization default interest of six (6) percent per annum on such unpaid amount for the period from the immediately succeeding day of due date for payment to the date of actual payment; provided, however, that if such nonpayment was due to an Act of God or any other reasons outside of the control of JAXA, the period for which such reasons exist shall not be counted in the number of days subject to payment of default interest.
3. Throughout the performance of the Agreement, the Research Organization shall maintain books, records, logs, documents and other evidence sufficient to record all actions taken with respect to the completion of the Research Projects. The Research Organization shall agree to allow JAXA to inspect, copy, and audit such books, records, documents and other evidence at any reasonable time.

Article 8. Providing of Earth Observation Satellite Data by JAXA

1. JAXA will provide the Research Organization with the Earth Observation Satellite Data for the Research Projects free of charge subject to the following conditions:
   a) The Research Organization agrees and accepts that JAXA may not provide all the Earth Observation Satellite Data which the Research Organization may request;
   b) JAXA does not guarantee a specific quality or the timely provision of the Earth Observation Satellite Data;
   c) The Advance Land Observing Satellite data, which is one portion of the Earth Observation Satellite Data and is to be provided to the Research Organization, shall be limited to ten scenes every Japanese Fiscal Year; and
   d) JAXA reserves the right to curtail or suspend Earth Observation Satellite Data supply to the Research Organization due to faults or difficulties relating to the satellites, limitations on their operations, or any other reasons.

2. With respect to the Earth Observation Satellite Data provided by JAXA, the Research Organization shall:
   a) Only use the Earth Observation Satellite Data for the singular purpose of advancing the efforts of the Research Projects;
   b) Not duplicate the Earth Observation Satellite Data except for distributing to authorized CIs the necessary data backups;
   c) Not distribute the Earth Observation Satellite Data to any third party without JAXA's prior written consent; and
   d) Return or otherwise appropriately manage the Earth Observation Satellite Data upon completion of this Agreement, according to the directives of JAXA.
3. Any rights regarding the Earth Observation Satellite Data provided by JAXA shall conform to the following:
   a) Any rights relating to the Earth Observation Satellite Data shall belong to JAXA or to an institute designated by JAXA except in the case mentioned in b) below; and
   b) If value-added products, which mean highly processed products that do not retain the original pixel structure and that cannot be converted back to the primary Earth Observation Satellite Data, are developed in the course of executing the Research Projects, the ownership of such products shall be determined upon mutual agreement between the Parties, taking into consideration the degrees of contribution by JAXA and the Research Organization.

Article 9. Providing of Meteorological Data by JAXA

1. For the purpose of performing the Research Projects, JAXA will attempt to provide the Research Organization with the meteorological data provided by the Japan Meteorological Agency pursuant to the agreement between JAXA and the Japan Meteorological Agency ("Meteorological Data"). The Research Organization agrees that JAXA's provision of the Meteorological Data may be limited or otherwise affected by the fact that some rights to the Meteorological Data belong to the Japan Meteorological Agency.
2. The Research Organization shall use the provided Meteorological Data solely for the purpose of conducting the Research Projects. The Research Organization may not disclose the provided Meteorological Data to any party.
3. The Research Organization shall return or otherwise appropriately keep the Meteorological Data in accordance with the instructions of JAXA upon the termination of this Agreement.

Article 10. Disclosure of Technical Data

1. To the extent feasible, each party may disclose all necessary technical data ("Technical Data") , which does not include the Earth Observation Satellite Data and the Meteorological Data. The Parties will undertake to handle expeditiously any request for the Technical Data presented by the other party.
2. The Technical Data shall be used and/or disclosed by the receiving party only for the purpose of fulfilling the receiving party's responsibilities under this Agreement. The receiving party shall protect any such Technical Data from unauthorized use and/or disclosure.
3. The Technical Data shall not be disclosed, duplicated or used by persons or entities other than the receiving party, or for any other purpose, without the prior consent of the furnishing party.
4. According to directives of the furnishing party, the receiving party shall return or otherwise dispose of Technical Data provided under the Agreement upon completion of the activities under the Agreement.

Article 11. Ownership and Usage of Research Results

1. All Research Results shall be jointly owned by the Parties ("Jointly-Owned Research Results") unless one party reasonably proves that it solely generates the Research Results solely in the course of the Research Projects. For avoidance of doubt, only if the product is the result of the Research Organization's sole work and sole funding shall such product be deemed to be the solely generated Research Results by the Research Organization.
2. Generally, JAXA and the Research Organization shall enter into a separate agreement and obtain the consent of the other party with regard to the usage of Jointly-Owned Research Results. However, if each party uses such Jointly-Owned Research Results peacefully (i.e., non-militaristic purposes) and for non-commercial purposes, consent of the other party is not required. In the event that a party intends to grant a third party a license to use such Jointly-Owned Research Results, the party shall obtain the prior written consent from the other party.
3. In the event that the Research Organization solely owns some portion of the Research Results, the Research Organization hereby grants and will be deemed to have granted to JAXA an irrevocable, royalty-free, non-exclusive, worldwide right to use such Research Results (and derivative works thereof including Progress Reports and Final Reports); provided, however, JAXA shall use such Research Results (and derivative works thereof including Progress Reports and Final Reports) for its own research and development work including, but not limited to, the granting to commissioned research organizations and/or collaborating research organizations the use of such Research Results (and derivative works thereof).

4. With regard to copyrights in the Progress Reports and Final Reports, regardless of whether they relates to the Research Organization's Research Result or not, the Research Organization agrees not to exercise and to cause its directors, officers, employees including PIs and CIs, regardless of whether such persons are employed by the Research Organization, to agree not to exercise any related moral rights to the copyrights in the Progress Reports and Final Reports and agrees not to rescind such non-exercise and to cause such directors, officers, employees including PIs and CIs to agree not to rescind such non-exercise.

Article 12. Publication of Research Results

1. Regardless of whether the Research Results are owned solely or jointly, if either party intends to publish the Research Results which are owned by the other party, the publishing party shall provide the other party with a written document regarding the description of the subjected Research Results to be published and request a written consent of the other party. The other party will not unreasonably withhold consent from the publishing party's request for such publication.
2. Before publishing, the publishing party shall provide the other party with a copy of the publication.Each party is entitled to an irrevocable and royalty-free right to use the provided publications, unless the copyright of such publication is owned or held by an academic society.
3. The Research Organization shall state in the publication that such Research Results have been obtained pursuant to this Agreement and identify the owner of the rights to the Earth Observation Satellite Data and Meteorological Data used in such publication.
4. In the event that a PI or CI wishes to publish or disclose the Research Results, the Research Organization shall cause the PI and/or CI to act in accordance with the terms and conditions of this Article and shall cause the PI and/or CI to grant JAXA an irrevocable and royalty-free right to use the provided publications, unless the copyright to such publication belongs to an academic society.

Article 13. Jointly-Owned Intellectual Property Rights

1. All Intellectual Property Rights generated in the course of the Research Projects shall be jointly owned by the Parties unless such rights are deemed to be Solely-Owned Intellectual Property as defined in Article 14 below. JAXA or the Research Organization Results shall give the other party prompt written notice of Intellectual Property Rights generated and discuss the ownership of such generated Intellectual Property Rights, as well as whether it is necessary to submit an application for registration of such Intellectual Property Rights.

2. JAXA and the Research Organization shall enter into a separate joint ownership agreement ("Joint Ownership Agreement") unless they decide not to make an application for the registration of the resulting Intellectual Property Rights. The Joint Ownership Agreement shall provide the allocation of Intellectual Property Rights related to, or the allocation of an interest in, such joint innovation or work.
3. After entering into the Joint Ownership Agreement, JAXA and the Research Organization shall take the necessary procedures to secure the joint ownership of the Intellectual Property Rights.
4. JAXA and/or Research Organization shall take any necessary procedures for any Industrial Property Rights owned by and/or held by each employees to be transferred by such employee to JAXA or the Research Organization in the event the employees' inventions and the Industrial Property Rights related thereto were created or otherwise arose within the scope of the Research Organization's business.
5. If a party alters or improves the Jointly-Owned Intellectual Property within one (1) year from the completion of this Agreement, the party shall provide a written notice to the other party describing the alterations or improvements.
6. A party may grant to any third party a license to use the Jointly-Owned Intellectual Property Rights, provided, however that the relevant party shall obtain the written prior consent of the other party, and determine the licensing terms after discussion with the other party. In this case, the relevant party shall collect the usage fee from such third party as set forth in the separate usage agreement. The usage fee to be collected from the third party shall be distributed between JAXA and Research Organization pro rata in proportion to their respective interests in those rights.
7. JAXA and the Research Organization may transfer their respective interests to the Jointly-Owned Intellectual Property Rights only to their respective designees after discussion between JAXA and the Research Organization pursuant to a separate transfer agreement. In this event, the relevant party shall cause its designee to succeed to all of its rights and obligations with respect to those Intellectual Property Rights.
8. If JAXA or the Research Organization disclaims its interests in the Jointly-Owned Intellectual Property Rights, the relevant party shall give the other party prior notice thereof and transfer its interests to the other party, only if the other party wishes to acquire it.
9. Any expenses, costs and charges required for the application procedure and protection of the Jointly-Owned Intellectual Property Rights shall be borne by JAXA and Research Organization pro rata in proportion to their respective interests.

Article 14. Solely-Owned Intellectual Property Rights

1. If a party solely generates Potential Intellectual Property Rights in the course of the Research

Projects ("Solely-Owned Intellectual Property Rights") the party shall notify such fact to the other party without delay. In this case, the party may take steps to apply for the registration of the resulting Intellectual Property Rights as solely-owned ones at its own expense, provided that it shall obtain prior confirmation of the other party. For the avoidance of doubt, only if Potential Intellectual Property Rights are generated or created by the Research Organization's sole work and sole funding shall such Potential Intellectual Property Rights be deemed to be solely generated or created by the Research Organization.

2. In the event of an emergence of Solely-Owned Intellectual Property Rights, the Research Organization and/or the PI shall grant JAXA an irrevocable, royalty-free and non-exclusive right to use such Intellectual Property Rights for JAXA's own research and development.

Article 15. Termination and Refund

1. Either party may terminate the Agreement:
   a) When the other party commits a dishonest and/or inequitable act that irreparably harms the mutual trust between the Parties; provided, that breaching party fails to offer any effective and satisfactory remedial measures within seven (7) days after getting demands for corrective action from the harmed party;
   b) When the other party violates any of the terms and conditions of this Agreement provided that the breaching party fails to offer any effective and/or satisfactory remedial measures within seven (7) days after getting demands for corrective action from the harmed party; and
   c) When the Parties consent to terminate.
2. Upon the termination of the Agreement, the Research Organization shall promptly deliver to JAXA all work including, but not limited to, all works in progress and all work that is completed and otherwise ready for delivery.
3. If the Agreement is terminated as set forth in the preceding paragraph, the Research Organization shall refund to JAXA any unexpended Research Funding. The Research Organization shall remit such funds within thirty (30) days from the date when the Research Organization receives an invoice issued by JAXA with regard to such funds.
4. Paragraph 2 and Paragraph 3 of this Article shall apply to termination upon the occurence of the events contemplated in Article 4 Paragraph 3.

Article 16. Ownership of the Rights to the Acquired Equipments

The Research Organization shall transfer, upon the expiration of this Agreement, all rights and ownership in the equipment acquired by the Research Organization with the Research Funding; provided, however, that JAXA and the Research Organization may determine through mutual

agreement that any or all such rights and ownership will be retained by the Research Organization.

Article 17. Limitations on Liabilities

JAXA and the Research Organization agree to waive any claim against the other with respect to damage of any kind, or any loss of its own property or property of its related entities arising out of activities under this Agreement ("Damages"), except such Damages which arise through willful misconduct and except Industrial Property Rights.

Article 18. Confidentiality

1. In this Agreement, "Confidential Information" means any information that a party discloses or presents in writing or by other media, to the other party in the course of these Research Projects, provided however, Confidential Information does not include the following:
   a) Information that is already known to the public when disclosed by the disclosing party;
   b) Information that becomes known to the public after the disclosure by the disclosing party without intentional misconduct or negligence of the receiving party;
   c) Information that the receiving party already had before the disclosure by the disclosing party;
   d) Information that the receiving party acquires from a dully authorized third party not subject to confidentiality obligations;
   e) Information that the receiving party independently develops without utilizing information obtained from the disclosing party;
   f) Information with a prior written consent of the disclosing party for the disclosure and the publication; or
   g) Information that is required to be disclosed by applicable laws, judgment or order of a competent court. In this case, the receiving party shall promptly notify the disclosing party of the necessity of disclosure.
2. The receiving party shall keep the Confidential Information secret, and shall not disclose or divulge any Confidential Information to a third party without prior written consent of the disclosing party.
3. The confidentiality obligation under this Article shall remain effective for a period of five (5) years after the termination of the Agreement. However this period of keeping confidentiality may be extended or shortened by mutual agreement.

Article 19. Designation of Know-How

1. After mutual agreement by the Parties, JAXA and the Research Organization shall promptly designate as know-how the Research Results which are appropriately to be treated as know-how ("Know-How").
2. After designating the Know-How, such Know-How should be kept in confidence in principle, for five (5) years commencing on the day immediately following the date of the completion of this Agreement; provided, however, that JAXA and the Research Organization may extend or shorten that period upon mutual agreement.

Article 20. Government Approvals

Each party shall obtain such permits, licenses, and other government authorizations as are required for it to perform its responsibilities under the Agreement, and shall comply with all respective laws and regulations.

Article 21. Language

All communications between the Research Organization and JAXA under this Agreement shall be in English.

Article 22. Special Agreement

Any supplement, modification or amendment of this Agreement shall only be binding if made upon the Parties' mutual written agreement which makes specific reference to this Agreement.

Article 23. Dispute Resolution

The Parties agree to put forth their best efforts to solve amicably any dispute, controversy, or difference arising out of, in connection with, or resulting from this Agreement.

Article 24. Arbitration

All disputes that cannot be amicably settled by the method defined in the previous Article hereof will be settled by arbitration in Tokyo in accordance with the Commercial Arbitration Rules of the Japan Commercial Arbitration Association.

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BETWEEN

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AND

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Article 6. The Research Organization's General Responsibilities for Research Projects

1. The Research Organization shall conduct and complete the Research Projects in accordance with the Collaborative Research Plan.
2. For the purpose of ensuring the Research Organization's performance of the obligations above, the Research Organization shall perform certain actions including, but not limited to:
   a) Participate in necessary workshops and meetings for the Research Projects and report upon request from JAXA;
   b) Deliver periodically to JAXA the Research Results and the reports ("Progress Reports") upon JAXA's request in the form specified by JAXA , and in all instances, at least one (1) month before the Annual Evaluation;
   c) Deliver the reports as a final report ("Final Reports") by the end of the Agreement Term; and
   d) Take necessary measures to ensure the PI's and/or CI's compliance with this Agreement.

Article 7. Research Funding

There will be no exchange of funds under this agreement. Each party shall bear necessary costs to fulfill its own responsibilities under this agreement.

Article 8. Providing of Earth Observation Satellite Data by JAXA

1. JAXA will provide the Research Organization with the Earth Observation Satellite Data for the Research Projects free of charge subject to the following conditions:
   a) The Research Organization agrees and accepts that JAXA may not provide all the Earth Observation Satellite Data which the Research Organization may request;
   b) JAXA does not guarantee a specific quality or the timely provision of the Earth Observation Satellite Data;
   c) The Advance Land Observing Satellite data, which is one portion of the Earth Observation Satellite Data and is to be provided to the Research Organization, shall be limited to ten scenes every Japanese Fiscal Year; and
   d) JAXA reserves the right to curtail or suspend Earth Observation Satellite Data supply to the Research Organization due to faults or difficulties relating to the satellites, limitations on their operations, or any other reasons.
2. With respect to the Earth Observation Satellite Data provided by JAXA, the Research Organization shall:
   a) Only use the Earth Observation Satellite Data for the singular purpose of advancing the efforts of the Research Projects;
   b) Not duplicate the Earth Observation Satellite Data except for distributing to authorized CIs the necessary data backups;
   c) Not distribute the Earth Observation Satellite Data to any third party without JAXA's prior written consent; and
   d) Return or otherwise appropriately manage the Earth Observation Satellite Data upon completion of this Agreement, according to the directives of JAXA.
3. Any rights regarding the Earth Observation Satellite Data provided by JAXA shall conform to the following:
   a) Any rights relating to the Earth Observation Satellite Data shall belong to JAXA or to an institute designated by JAXA except in the case mentioned in b) below; and
   b) If value-added products, which mean highly processed products that do not retain the original pixel structure and that cannot be converted back to the primary Earth Observation Satellite Data, are developed in the course of executing the Research Projects, the ownership of such products shall be determined upon mutual agreement between the Parties, taking into consideration the degrees of contribution by JAXA and the Research

Organization.

Article 9. Providing of Meteorological Data by JAXA

1. For the purpose of performing the Research Projects, JAXA will attempt to provide the Research Organization with the meteorological data provided by the Japan Meteorological Agency pursuant to the agreement between JAXA and the Japan Meteorological Agency ("Meteorological Data"). The Research Organization agrees that JAXA's provision of the Meteorological Data may be limited or otherwise affected by the fact that some rights to the Meteorological Data belong to the Japan Meteorological Agency.
2. The Research Organization shall use the provided Meteorological Data solely for the purpose of conducting the Research Projects. The Research Organization may not disclose the provided Meteorological Data to any party.
3. The Research Organization shall return or otherwise appropriately keep the Meteorological Data in accordance with the instructions of JAXA upon the termination of this Agreement.

Article 10. Disclosure of Technical Data

1. To the extent feasible, each party may disclose all necessary technical data ("Technical Data") which does not include the Earth Observation Satellite Data and the Meteorological Data. The Parties will undertake to handle expeditiously any request for the Technical Data presented by the other party.
2. The Technical Data shall be used and/or disclosed by the receiving party only for the purpose of fulfilling the receiving party's responsibilities under this Agreement. The receiving party shall protect any such Technical Data from unauthorized use and/or disclosure.
3. The Technical Data shall not be disclosed, duplicated or used by persons or entities other than the receiving party, or for any other purpose, without the prior consent of the furnishing party.
4. According to directives of the furnishing party, the receiving party shall return or otherwise dispose of Technical Data provided under the Agreement upon completion of the activities under the Agreement.

Article 11. Ownership and Usage of Research Results

1. All Research Results shall be jointly owned by the Parties ("Jointly-Owned Research Results") unless one party reasonably proves that it solely generates the Research Results solely in the course of the Research Projects. For avoidance of doubt, only if the product is the result of the Research Organization's sole work and sole funding shall such product be deemed to be the

solely generated Research Results by the Research Organization.

2. Generally, JAXA and the Research Organization shall enter into a separate agreement and obtain the consent of the other party with regard to the usage of Jointly-Owned Research Results. However, if each party uses such Jointly-Owned Research Results peacefully (i.e., non-militaristic purposes) and for non-commercial purposes, consent of the other party is not required. In the event that a party intends to grant a third party a license to use such Jointly-Owned Research Results, the party shall obtain the prior written consent from the other party.
3. In the event that the Research Organization solely owns some portion of the Research Results, the Research Organization hereby grants and will be deemed to have granted to JAXA an irrevocable, royalty-free, non-exclusive, worldwide right to use such Research Results (and derivative works thereof including Progress Reports and Final Reports); provided, however, JAXA shall use such Research Results (and derivative works thereof including Progress Reports and Final Reports) for its own research and development work including, but not limited to, the granting to commissioned research organizations and/or collaborating research organizations the use of such Research Results (and derivative works thereof).
4. With regard to copyrights in the Progress Reports and Final Reports, regardless of whether they relates to the Research Organization's Research Result or not, the Research Organization agrees not to exercise and to cause its directors, officers, employees including PIs and CIs, regardless of whether such persons are employed by the Research Organization, to agree not to exercise any related moral rights to the copyrights in the Progress Reports and Final Reports and agrees not to rescind such non-exercise and shall cause such directors, officers, employees including PIs and CIs to agree not to rescind such non-exercise.

Article 12. Publication of Research Results

1. Regardless of whether the Research Results are owned solely or jointly, if either party intends to publish the Research Results which are owned by the other party, the publishing party shall provide the other party with a written document regarding the description of the subjected Research Results to be published and request a written consent of the other party. The other party will not unreasonably withhold consent from the publishing party's request for such publication.
2. Before publishing, the publishing party shall provide the other party with a copy of the publication. Each party is entitled to an irrevocable and royalty-free right to use the provided publications, unless the copyright of such publication is owned or held by an academic society.
3. The Research Organization shall state in the publication that such Research Results have been obtained pursuant to this Agreement and identify the owner of the rights to the Earth

Observation Satellite Data and Meteorological Data used in such publication.

4. In the event that a PI or CI wishes to publish or disclose the Research Results, the Research Organization shall cause the PI and/or CI to act in accordance with the terms and conditions of this Article and shall cause the PI and/or CI to grant JAXA an irrevocable and royalty-free right to use the provided publications, unless the copyright to such publication belongs to an academic society.

Article 13. Jointly-Owned Intellectual Property Rights

1. All Intellectual Property Rights generated in the course of the Research Projects shall be jointly owned by the Parties unless such rights are deemed to be Solely-Owned Intellectual Property as defined in Article 14 below. JAXA or the Research Organization Results shall give the other party prompt written notice of Intellectual Property Rights generated and discuss the ownership of such generated Intellectual Property Rights, as well as whether it is necessary to submit an application for registration of such Intellectual Property Rights.
2. JAXA and the Research Organization shall enter into a separate joint ownership agreement ("Joint Ownership Agreement") unless they decide not to make an application for the registration of the resulting Intellectual Property Rights. The Joint Ownership Agreement shall provide the allocation of Intellectual Property Rights related to, or the allocation of an interest in, such joint innovation or work.
3. After entering into the Joint Ownership Agreement, JAXA and the Research Organization shall take the necessary procedures to secure the joint ownership of the Intellectual Property Rights.
4. JAXA and/or Research Organization shall take any necessary procedures for any Industrial Property Rights owned by and/or held by each employees to be transferred by such employee to JAXA or the Research Organization in the event the employees' inventions and the Industrial Property Rights related thereto were created or otherwise arose within the scope of the Research Organization's business.
5. If a party alters or improves the Jointly-Owned Intellectual Property within one (1) year from the completion of this Agreement, the party shall provide a written notice to the other party describing the alterations or improvements.
6. A party may grant to any third party a license to use the Jointly-Owned Intellectual Property Rights, provided, however that the relevant party shall obtain the written prior consent of the other party, and determine the licensing terms after discussion with the other party. In this case, the relevant party shall collect the usage fee from such third party as set forth in the separate usage agreement. The usage fee to be collected from the third party shall be distributed between JAXA and Research Organization pro rata in proportion to their respective interests in

those rights.

7. JAXA and the Research Organization may transfer their respective interests to the Jointly-Owned Intellectual Property Rights only to their respective designees after discussion between JAXA and the Research Organization pursuant to a separate transfer agreement. In this event, the relevant party shall cause its designee to succeed to all of its rights and obligations with respect to those Intellectual Property Rights.
8. If JAXA or the Research Organization disclaims its interests in the Jointly-Owned Intellectual Property Rights, the relevant party shall give the other party prior notice thereof and transfer its interests to the other party, only if the other party wishes to acquire it.
9. Any expenses, costs and charges required for the application procedure and protection of the Jointly-Owned Intellectual Property Rights shall be borne by JAXA and Research Organization pro rata in proportion to their respective interests.

Article 14. Solely-Owned Intellectual Property Rights

1. If a party solely generates Potential Intellectual Property Rights in the course of the Research Projects ("Solely-Owned Intellectual Property Rights") the party shall notify such fact to the other party without delay. In this case, the party may take steps to apply for the registration of the resulting Intellectual Property Rights as solely-owned ones at its own expense, provided that it shall obtain prior confirmation of the other party. For the avoidance of doubt, only if Potential Intellectual Property Rights are generated or created by the Research Organization's sole work and sole funding shall such Potential Intellectual Property Rights be deemed to be solely generated or created by the Research Organization.
2. In the event of an emergence of Solely-Owned Intellectual Property Rights, the Research Organization and/or the PI shall grant JAXA an irrevocable, royalty-free and non-exclusive right to use such Intellectual Property Rights for JAXA's own research and development.

Article 15. Termination

1. Either party may terminate the Agreement:
   a) When the other party commits a dishonest and/or inequitable act that irreparably harms the mutual trust between the Parties; provided, that breaching party fails to offer any effective and satisfactory remedial measures within seven (7) days after getting demands for corrective action from the harmed party;
   b) When the other party violates any of the terms and conditions of this Agreement provided that the breaching party fails to offer any effective and/or satisfactory remedial measures within seven (7) days after getting demands for corrective action from the harmed party;

and

c) When the Parties consent to terminate

2. Upon the termination of the Agreement, the Research Organization shall promptly deliver to JAXA all work including, but not limited to, all works in progress and all work that is completed and otherwise ready for delivery.
3. The preceeding paragraph shall apply to termination upon the occurence of the events contemplated in Article 4 Paragraph 3.

Article 16. Limitations on Liabilities

JAXA and the Research Organization agree to waive any claim against the other with respect to damage of any kind, or any loss of its own property or property of its related entities arising out of activities under this Agreement ("Damages"), except such Damages which arise through willful misconduct and except Industrial property rights.

Article 17. Confidentiality

1. In this Agreement, "Confidential Information" means any information that a party discloses or presents in writing or by other media, to the other party in the course of these Research Projects, provided however, Confidential Information does not include the following:
   a) Information that is already known to the public when disclosed by the disclosing party;
   b) Information that becomes known to the public after the disclosure by the disclosing party without intentional misconduct or negligence of the receiving party;
   c) Information that the receiving party already had before the disclosure by the disclosing party;
   d) Information that the receiving party acquires from a dully authorized third party not subject to confidentiality obligations;
   e) Information that the receiving party independently develops without utilizing information obtained from the disclosing party;
   f) Information with a prior written consent of the disclosing party for the disclosure and the publication; or
   g) Information that is required to be disclosed by applicable laws, judgment or order of a competent court. In this case, the receiving party shall promptly notify the disclosing party of the necessity of disclosure.
2. The receiving party shall keep the Confidential Information secret, and shall not disclose or divulge any Confidential Information to a third party without prior written consent of the disclosing party.

3. The confidentiality obligation under this Article shall remain effective for a period of five (5) years after the termination of the Agreement. However this period of keeping confidentiality may be extended or shortened by mutual agreement.

Article 18. Designation of Know-How

1. After mutual agreement by the Parties, JAXA and the Research Organization shall promptly designate as know-how the Research Results which are appropriately to be treated as know-how ("Know-How").
2. After designating the Know-How, such Know-How should be kept in confidence in principle, for five (5) years commencing on the day immediately following the date of the completion of this Agreement; provided, however, that JAXA and the Research Organization may extend or shorten that period upon mutual agreement.

Article 19. Government Approvals

Each party shall obtain such permits, licenses, and other government authorizations as are required for it to perform its responsibilities under the Agreement, and shall comply with all respective laws and regulations.

Article 20. Language

All communications between the Research Organization and JAXA under this Agreement shall be in English.

Article 21. Special Agreement

Any supplement, modification or amendment of this Agreement shall only be binding if made upon the Parties' mutual written agreement which makes specific reference to this Agreement.

Article 22. Dispute Resolution

The Parties agree to put forth their best efforts to solve amicably any dispute, controversy, or difference arising out of, in connection with, or resulting from this Agreement.

Article 23. Arbitration

All disputes that cannot be amicably settled by the method defined in the previous

Article hereof will be settled by arbitration in Tokyo in accordance with the Commercial Arbitration Rules of the Japan Commercial Arbitration Association.

Attachment A "Earth Observation Satellite Data"

Name of Satellite or Sensor	Observation Period (YY/MM/DD)	Observable Area
ALOS (Advanced Land Observation Satellite)	2006/05/16～	Global
MOS (Marine Observation Satellite)	1987/02/23～1996/04/19	Around Japan, Antarctic and Southeast Asia
JERS (Japanese Earth Observation Satellite)	1992/09/01～1998/10/11	Global
ADEOS (Advanced Earth Observation Satellite)	1996/10/15～1997/6/29	Global
ADEOS-Ⅱ (Advanced Earth Observation Satellite-Ⅱ)	2003/01/18～2003/10/24	Global
AMSR-E (Advanced Microwave Scanning Radiometer for EOS-Aqua satellite)	2002/06/19～	Global
TRMM (Tropical Rainfall Measuring Mission)	1997/12/01～	Global
ERS (European Remote-Sensing Satellite)	1991/08/18～2003/03/29	Around Japan and Antarctic
LANDSAT* (Land Satellite)	1979/02/19～2002/03/31	Around Japan

* LANDSAT-5 data received by 2001/3/31 will be available in the dataset.