2nd Research Announcement on the Earth Observations

JAXA Satellite Project Research

GCOM-W, GCOM-C,
GPM, ALOS-2, ALOS-3, ALOS-4
MOLI, EarthCARE, AMSR3

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Earth Observation Research Center
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1. Introduction

1.1. About the second Research Announcement on the Earth Observations

The Japan Aerospace Exploration Agency (JAXA) / Earth Observation Research Center (EORC) now conducts the second Research Announcement on the Earth Observations (EO-RA2) for its Earth observation satellite projects.

In the Japanese fiscal year (JFY) 2015, EORC started the first EO-RA that provide an opportunity to promote research for the current and the planned JAXA Earth Observation satellite projects. On the second EO-RA, EORC calls for research proposals that should contribute to the mission objectives or mission assurances for each satellite mission, develop new applications or promote Earth science by using single or multiple JAXA Earth Observation satellites data.

EORC intends to apply the following philosophy on the EO-RA2:

- By providing an opportunity to be able to access to multiple satellites data together, even though targeting research on single satellite mission, EORC considers promoting multidisciplinary application research, bridging mutual knowledge among missions, and developing more effective research collaboration for the missions.
- EORC focuses, in the EO-RA2, on the research for the product development and assurance, for the applications to match or enhance mission objectives of the JAXA satellite missions, and for the Earth science or applications to contribute to the society by using single or multiple satellites data.

By announcing widely to researchers/engineers of various research areas from domestic and foreign organizations, EORC will effectively conduct research and product development on technologies and new insights required to achieve mission success criteria for JAXA satellite projects.

1.2. About the second Research Announcement on the Earth Observations

1.2.1 Target Missions

The target JAXA missions of the EO-RA2 are GCOM-W, GCOM-C, GPM, ALOS-2, ALOS-3, ALOS-4, MOLI, EarthCARE and AMSR3.

The research proposals for the Greenhouse Gases Observing Satellite (GOSAT) and its successor (GOSAT-2) will be excluded from the scope of this EO-RA2, since the dedicated RA for these satellites has been conducted in collaboration with the Ministry of the Environment and the National Institute for Environmental Studies.

The objectives and overview of the missions are described in the APPENDIX 1~7.

Each research proposal on submission must be identified by the satellite mission name and the research category to apply.

1.2.2 Research Categories

In the EO-RA2, EORC invites the following research categories, as described in the following section 1.3. On the Application Research category, such research proposals are desirable as effectively use JAXA Earth observation satellite data, strengthen and evolve of the existing output, and/or find the new values that will increase the scientific and social significance of the satellite data.

(1) Algorithm Development

(2) Standard Algorithm Calibration/validation, and Provision of Validation Data

(3) Application Research

Applicants should consider that JAXA is not a general funding body for the scientific community. This EO-RA2 seeks to accomplish the Earth Observation mission's goals and to discover new possibilities for utilizing Earth Observation data. Proposals should clearly describe plans for the data usage of JAXA Earth Observation data.

1.2.3 Research Period

April or later 2019 (after conclusion of the research agreement) － March 2022

The progress of each selected proposal will be evaluated for its continuation by the annual progress report submitted to JAXA in the end of each JFY.

1.3. About the JAXA Satellite Project Research

A) Objective

JAXA satellite project research aims to maximize the outcome of the JAXA Earth Observation (EO) satellite projects, and the EO-RA2 calls for the research proposals in three research categories, (1) Algorithm Development, (2) Standard Algorithm Calibration/validation and Provision of Validation Data, and (3) Application Research.

B) Research Category

(1) Algorithm Development

- Development and Maintenance of Standard Algorithm

In this category, JAXA seeks for research proposals on maintenance and improvement of the standard algorithms, which will be used for processing standard products after the launch. In principle, to utilize the existing results of the first EO-RA directly, proposals from applicants whose algorithms were selected as the standard algorithm after the launch through the previous RA research activity will continue to be selected. Selected Principal Investigator (PI) and JAXA will work together in maintaining, evaluating, implementing, and validating the algorithms, as well as in preparing the Algorithm Theoretical Basis Document (ATBD) and validation plans.

- Development of Research Algorithm

Research algorithms will include a new algorithm to produce standard products with further improved accuracy, and ones to produce research products. The former ones have the potential to be selected as standard algorithms at the time of the future product revision through the inter-comparison study with other algorithms. Therefore, the research needs to be carried out with the required accuracy by each mission in mind. Other preferable characteristics are the same as those of standard algorithms. Regarding the latter ones, those research products will have the potential to be candidates of new standard products after certain evaluation process.

(2) Standard Algorithm Calibration/validation, and Provision of Validation Data

JAXA seeks research proposals contributing to the calibration and the validation of standard products and to the acquisition of basic datasets, which are necessary to improve algorithms. It is also expected to feed back the validation results to improve sensor calibration. Regarding the field campaigns and experiments, obtaining both effective validation results and scientific outputs by collaborating with other research programs is expected. Particularly, measurements and validation studies of geophysical parameters, for which obtaining the global and operational validation dataset is difficult, are highly desired.

To apply for improving the algorithms, obtained validation data and knowledge need to be provided to JAXA. Furthermore, JAXA intends to open these data to the public, after consulting with the PIs about their disclosure level and release timing. Proposals including both algorithm development and validation can be submitted to the category of algorithm development.

(3) Application Research

In this category, JAXA seeks research proposals for applications to match or enhance mission objectives by using products from the current following satellite missions; GCOM-W, GCOM-C, GPM, and ALOS-2.

The research categories applied to each satellite mission are shown in the following table.

	Algorithm Development	Standard Algorithm Calibration/validation	Application Research
GCOM-W	✔ (algorithms for the current standard products are excluded)	✔	✔
GCOM-C	✔ (algorithms for the current standard products are excluded)	✔	✔
GPM	✔ (algorithms for the current standard products are excluded)	✔	✔
ALOS-2	-	-	✔
ALOS-3	-	✔	-
ALOS-4	-	✔	-
MOLI	✔	✔	-
EarthCARE	-	✔	-
AMSR3	✔	-	-

✔: Applicable

- : Not Applicable

2. Technical descriptions

2.1. JAXA Satellite Project Research

2.1.1 The Global Change Observation Mission – Water (GCOM-W)

GCOM seeks to establish and demonstrate a global, long-term satellite observing system to measure essential geophysical parameters for understanding global climate change and the water cycle mechanism, and eventually contribute to improving future climate projections through a collaborative framework with climate model institutions. Demonstrating capabilities of operational applications through the provision of continuous data to operational agencies is another important objective. GCOM will take over the Advanced Earth Observing Satellite-II (ADEOS-II) mission and transition into long-term monitoring of the Earth. To achieve global, comprehensive, long-term, and homogeneous observation, GCOM consists of two satellite missions, GCOM-W and GCOM-C (see section 2.1.2). The GCOM-W satellite "SHIZUKU" was launched in May 2012, and carries the Advanced Microwave Scanning Radiometer-2 (AMSR2) to contribute to understanding the water and energy cycle. The AMSR2 instrument on board GCOM-W is a multi-frequency, dual-polarized, passive microwave radiometer for observing water-related geophysical parameters. AMSR2 was designed and manufactured based on the experience of the AMSR aboard ADEOS-II and the AMSR for EOS (AMSR-E), which completed its scientific observation in October 2011, and is the latest instrument of the AMSR series. AMSR-E had restarted its observation in slow rotation mode at 2rpm since December 2012 in order to implement cross-calibration with AMSR2 on orbit but completed its operation in December 2015. All AMSR-E brightness temperature data obtained during the slow rotation period are open to public via internet (https://suzaku.eorc.jaxa.jp/GCOM_W/research/resdist.html). Currently, the GCOM-W satellite has been in Post Mission Phase and will continue its operation during this RA period.

Table 2.1.1-1 is mission objectives of the GCOM and targets of GCOM-W. Details of the GCOM sensor and satellite specification are presented in APPENDIX 1.

Table 2.1.1-1 GCOM Objectives and Targets of GCOM-W

GCOM Objectives	GCOM-W Targets
Build a long-term observation system that can observe effective physical parameters (e.g., sea surface temperature, soil moisture, and so on.) continuously for 10 to 15 years to solve the mechanism of global climate change and water cycle, and establish its usability.	Produce and distribute satellite-observed brightness temperature, two land, three atmosphere, two ocean, and one cryosphere products as standard products
Improve the prediction accuracy of long-term climate change by improving the process research on the climate-change mechanism and numerical models, and provide information service in support of national policy decisions through cooperation with user organizations that have climate models.	Process and provide satellite data to the Data Integration and Analysis System established by the University of Tokyo, JAMSTEC, and JAXA.
Establish an Earth-observation satellite system to obtain important physical parameters to assess the global environment and seek integrative use with other observation systems.	Improve the accuracy of short-range forecasts by assimilating data, such as brightness temperature, water vapor and precipitation, and improving model parameters with the cooperation of application research organizations. Through the above activities, confirm the quality of GCOM data and demonstrate its ability to contribute to predicting long-term climate change. Contribute to predicting the global environment response to climate change by observing sea ice concentration and snow depth in cryosphere and sea surface temperature in ocean, and so on.
Contribute directly to operational fields, such as predicting intense weather that may bring disasters by distributing data to operational organizations that provide weather forecasts, fishery information service, sea-route information control, etc.	Improve weather forecast accuracy including typhoon forecast and fishery management by providing data to the Japan Meteorological Agency and the Japan Fisheries Information Service Center within the required time frame.
Develop new products for effectively clarifying climate change and the water cycle mechanism, which is difficult to do with current analysis technology	Produce new research products by cooperating with research and application organizations.

(1) GCOM-W Algorithm Development

JAXA seeks proposals on maintenance and improvement of the GCOM-W research algorithms, which were defined in TABLE 7 of APPENDIX 1. Proposals regarding the GCOM-W standard algorithms, which were defined in TABLE 6 of APPENDIX 1 and already adopted and is in operation as standard product, is out of targets of this RA, but proposals of algorithms with new view points and/or methods will be accepted as research algorithm. Proposals on development of other research algorithm that is not defined in TABLE 7 should be applied to the category of GCOM-W Application in Section 2.1.1(3). As described in Chapter 5, proposals in research algorithm development under the "Collaborative Research Agreement (Funded/Non-funded)," in principle. Depending on its budget status, JAXA plans to spend 20 million yen per year for total of the GCOM-W project researches (GCOM-W Algorithm Development, GCOM-W Calibration & Validation, GCOM-W Application, and Earth Observation Priority Researches focused on GCOM-W data).

Research algorithms will include a new algorithm to produce standard products, which were defined in TABLE 6 of APPENDIX 1, with further improved accuracy, and ones to produce research products defined in TABLE 7 of APPENDIX 1. The former ones have the potential to be selected as standard algorithms at the time of future product revision through the inter-comparison study with other algorithms. Therefore, the research needs to be carried out with the goal accuracy in mind. Other preferable characteristics are the same as those of standard algorithms. Regarding the latter ones, once after the proposed products are selected as research

products, those research products will have the potential to be candidates of new standard products.

(2) GCOM-W Calibration & Validation

JAXA seeks proposals contributing to the validation of standard and research products. It is also expected to feed back the validation results to improve AMSR2 algorithms and calibration. Regarding the field campaign and experiments, obtaining both effective validation results and scientific outputs by collaborating with other research programs is expected. Particularly, in-situ measurements and validation studies of geophysical parameters, for which obtaining the global and operational validation dataset is difficult, are highly desired as indicated below.

- Land

  JAXA maintains test sites to obtain validation data such as soil moisture and meteorological measurements are already established and maintained in the Mongolian plateau (semi-arid area) and the Murray-Darling basin in Australia (humid to arid area). JAXA seeks proposals which will actively utilize these validation datasets.

- Atmosphere

  JAXA seeks proposals to validate precipitation and integrated water vapor products by utilizing operational observation data such as ground-based rain radars. For the validation of precipitation and integrated cloud liquid water, cooperation with other research projects which can provide us validation data, and the research on quantitative validation by comparing with other satellite observations are expected.

- Ocean

  JAXA seeks proposals to validate sea surface temperature and sea surface wind speed products by using operational observation data such as mooring and floating buoys and ships. Cooperation with other research projects which can provide us validation data, and the research on quantitative validation by comparing with other satellite observations are expected.

- Cryosphere

  Participation to the validation activities using operational ground observation data of snow depth, and cooperation with other research projects, in which snow pit observations are being conducted under a variety of snow condition, is expected. For sea ice validation, cooperation with research projects operating research vessels in various sea areas, as well as validation using high spatial resolution satellite images, are expected.

To apply for improving the algorithms, obtained in-situ data and knowledge need to be provided to JAXA. Providers of in situ data can define the disclosure levels specified in the following Table: for EORC members only, EORC and PIs for algorithm development, calibration and validation, registered users, and open to the public. The provider will define the disclosure level for data and provide this information to EORC, which will share the data via EORC/GCOM-C Web pages (The disclosure level is required to be open wider user levels as much as possible). It is asked to provide in-situ data which was not funded by JAXA, if the policy of the in-situ data is allowed with appropriate disclosure levels.

Proposals including both algorithm development and validation can be submitted to the category of algorithm development.

As described in Chapter 5, the research themes in this category will be implemented under the "Collaborative Research Agreement (Funded/Non-funded)," in principle. Depending on its budget status, JAXA plans to spend 20 million yen per year for total of the GCOM-W project researches (GCOM-W Algorithm Development, GCOM-W Calibration & Validation, GCOM-W Application, and Earth Observation Priority Researches focused on GCOM-W data).

Table 1 Definition of the disclosure level (DL)

Disclosure level (A-D) to be set by data provider	EORC researchers	GCOM PI	Other Mission PI	Registered users	General users	Usage
(A) EORC Internal use only	OK	-	-	-	-	1) Cal & Val of SGLI products and/or applications for Earth sciences (such as scatter plots, statistics from which raw data cannot be reproduced) are possible to be published. It is necessary to describe the use of JAXA's database and the organization of data acquisition in the acknowledgement *1 2) Redistribution of the raw data is prohibited.
(B1) GCOM related PIs only	OK	OK	-	-	-	1) Cal & Val of GCOM products and/or applications for Earth sciences are possible to be published. It is necessary to agree with data provider about how to acknowledge the favor (e.g., including data provider as a co-author or in the acknowledgement) and to describe the use of JAXA's database and the organization of data acquisition in the acknowledgement*1. 2) Data use beyond the objectives of the GCOM mission is prohibited. 3) Redistribution of the raw data is prohibited.
(B2) GCOM & other PIs only	OK	OK	OK	-	-	1) Cal & Val of GCOM and other environmental missions (GPM, EarthCARE, etc) products and/or applications for Earth sciences are possible to be published. It is necessary to agree with data provider about how to acknowledge the favor (e.g., including data provider as a co-author or in the acknowledgement) and to describe the use of JAXA's database and the organization of data acquisition in the acknowledgement *1. 2) Data use beyond the objectives of the GCOM and other mission is prohibited. 3) Redistribution of the raw data is prohibited.
(C) Registered users	OK	OK	OK	OK	-	1) User registration is required. 2) Applications for Earth sciences are possible to be published. It is necessary to submit an application form to JAXA prior to the publication. Also, it is necessary to to describe the use of JAXA's database and the organization of data acquisition in the acknowledgement*1. 3) Redistribution of the raw data is prohibited.
(D) Open to the public (no limitation)	OK	OK	OK	OK	OK	1) It is necessary to describe the use of JAXA's database when using the data and publishing results. It is also necessary to report the results of publication to JAXA*1. 2) Redistribution of the raw data is prohibited.

*1 follow the JAXA's policy on data use

(3) GCOM-W Application

In this category, JAXA seeks application researches, which will contribute to the GCOM-W mission purposes and its follow-on mission, by utilizing the GCOM-W data and AMSR series. Especially, JAXA will be intensely focused on following research themes that will emphasize scientific and/or social values of the GCOM-W mission;

- development of new GCOM-W research products;
- development of Climate Data Records with central focus on data from the AMSR series;
- researches that monitor status of Earth system and improve accuracy of future prediction utilizing data from the AMSR series;
- researches that relate mitigation of and adaptation to climate change utilizing data from the AMSR series;
- researches that lead to new operational utilization of the GCOM-W data; and
- researches that enhance synergies by combined utilization of GCOM-W data with other missions, such as GCOM-C and GPM.

Other than existing research products that will be solicited in Section 2.1.1(1) "GCOM-W Algorithm Development," JAXA seeks new research product that will retrieve new geophysical parameters, which contribute to purposes of GCOM-W mission and new target fields, such as marine navigation and resource development in Polar Regions, in its follow-on mission. Those new research products may include algorithms that are challenging and need further research efforts to develop. Each proposal regarding new research product is expected to target production or submission of new research product when this RA period is completed.

As described in Chapter 5, the research themes in this category will be implemented under the "Collaborative Research Agreement (Funded/Non-funded)," in principle. Depending on its budget status, JAXA plans to spend 60 million yen per year for total of the GCOM-W researches (GCOM-W Algorithm Development, GCOM-W Calibration & Validation, GCOM-W Application, and Earth Observation Priority Researches focused on GCOM-W data).

2.1.2 The Global Change Observation Mission – Climate (GCOM-C)

2.1.2.1 GCOM-C mission

The GCOM-C satellite will be equipped with the Second-generation Global Imager (SGLI) to observe the Earth's atmosphere and surface to elucidate the carbon cycle and the radiation budget. The GCOM-C mission seeks to establish and to demonstrate a global, long-term satellite observation system to measure essential geophysical parameters for understanding global climate change, and the carbon cycle mechanism in cooperation with GCOM-W and other sensors. Its ultimate objectives are to improve future climate projection through a collaborative framework with climate model researches and to demonstrate the capabilities of operational applications by providing continuous data to operational agencies (see Tables 2.1.2-1 and 2.1.2-2).

Table 2.1.2-1

GCOM Objectives	GCOM-C Targets
Build a long-term observation system that can observe effective physical parameters (e.g., sea surface temperature, soil moisture, and so on.) continuously for 10 to 15 years to solve the mechanism of global climate change and water cycle, and establish its usability.	Produce and distribute satellite-observed radiance, nine land, eight atmosphere, seven ocean, and four cryosphere products as standard products
Improve the prediction accuracy of long-term climate change by improving the process research on the climate-change mechanism and numerical models, and provide information service in support of national policy decisions through cooperation with user organizations that have climate models.	Process and provide satellite data to the Data Integration and Analysis System established by the University of Tokyo, JAMSTEC, and JAXA.
Establish an Earth-observation satellite system to obtain important physical parameters to assess the global environment and seek integrative use with other observation systems.	Improve the accuracy of climate change prediction by assimilating data and improving model parameters with the cooperation of application research organizations. Through the above activities, confirm the quality of GCOM data and demonstrate its ability to contribute to predicting long-term climate change. Contribute to predicting the global environment response to climate change by observing snow surface temperature, snow grain size, ocean chlorophyll-a concentration, and so on.
Contribute directly to operational fields, such as predicting intense weather that may bring disasters by distributing data to operational organizations that provide weather forecasts, fishery information service, sea-route information control, etc.	Improve fishery management by providing data to the Japan Fisheries Information Service Center within the required time frame.
Develop new products for effectively clarifying climate change and the water cycle mechanism, which is difficult to do with current analysis technology	Produce five land, three atmosphere, seven ocean, and eight cryosphere research products by cooperating with research and application organizations.

Table 2.1.2-2

Assessment condition \ Success level		***Minimum success***	***Full success***	***Extra success***
data production	***Standard product***[*1] *(Set release threshold/ standard/ target accuracies)*	Complete calibration and validation phase and start data distribution of more than 20 products[*3] achieving the release threshold accuracy[*2] about 1 year after launch.	Achieve standard accuracies of all standard products, within 5 years after launch,	Achieve the target accuracy of one or more products within 5 years after launch.
	Research product[*1] *(Set only target accuracy)*	NA	NA	Achieve the target accuracy of one or more products within 5 years after launch or add new important products for climate change research.
data distribution	*Real-time availability*	When the products achieve the release threshold accuracy, confirm ability to distribute the data within the required time.	Continue required-time data distribution during the operation period from confirmation of the release threshold accuracy to 5 years after launch.	NA
	Continuity	When the products achieve the release threshold accuracy, confirm ability to continuously observe and distribute products.	Continue observation[*4] and data distribution from confirmation of release threshold accuracy to 5 years after launch.	NA

*1 Standard products are defined as products that are especially important for achieving the mission goal, sufficiently confirm the application reality from ADEOS-II results etc. and are suitable for operational data distribution. Research products are defined as products still in the research phase of development and application or are unsuitable for operational data distribution.
*2 Release threshold accuracy: Minimum accuracy for release as available for climate research
*3 The threshold number of products, 20, corresponds to the number of ADEOS-II GLI standard products in the GCOM-C standard products.
*4 This means to obtain observation data continuously during the planned Earth-observation operation period

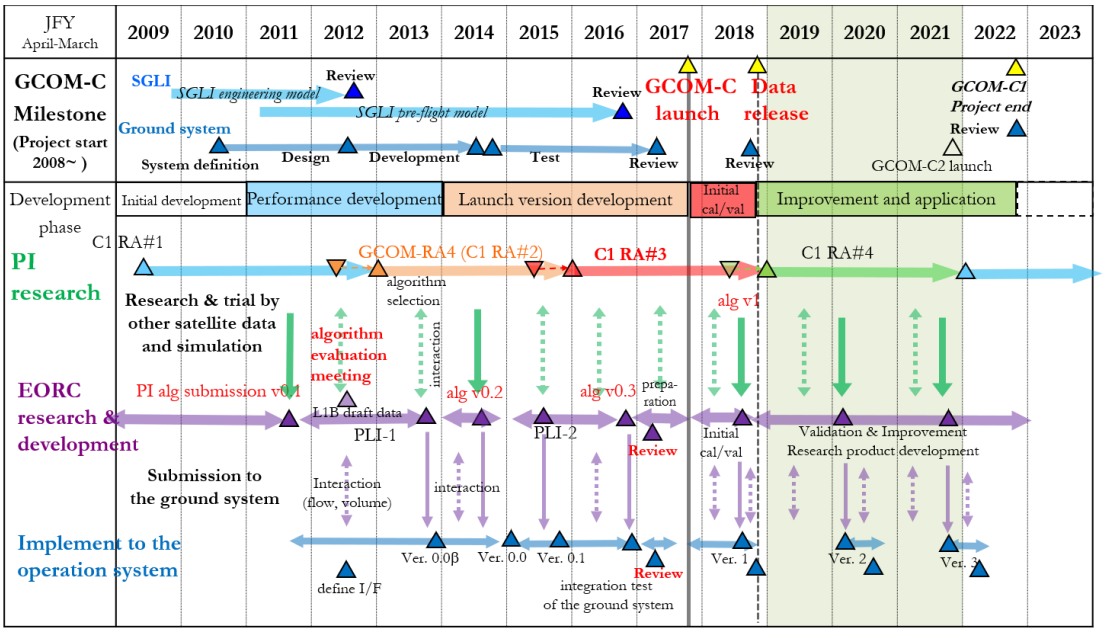

Fig. 2.1.2-1 Time table of GCOM-C research plan

The GCOM-C PI team has been organized in summer 2009 as the first research period (Sep. 2009 - Mar. 2013), followed by the second research period (Apr. 2013 - Mar. 2016), and continued as the third research period (Apr. 2016 - Mar. 2019; see APPENDIX 1-C table C5) which includes launch time, the initial Cal/Val phase, and the first product release. It will be continued after FY2019 (C1RA#4 in Fig. 2.1.2-1) for the achievement of the product accuracy targets and the mission objectives as the "2nd Research Announcement on the Earth Observations" (Apr. 2019 – Mar. 2022). This RA includes GCOM-C project studies to achieve the mission success criteria (Table 2.1.2-2) in the post-paunch improvement phase, and seeks following proposals based on effective use of the GCOM-C data.

(1) GCOM-C product development

(a) New approaches for improving accuracy of the standard and research products
(b) New GCOM-C products contribute to the mission targets and social needs

(2) GCOM-C product validation

(a) In-situ measurement, collection, and supply to JAXA for the product evaluation and improvement
(b) Validation and characterization of the GCOM-C products, and feedback to the algorithm version ups

(3) GCOM-C application

(a) Researches about the current state of the earth system, improvement of the future prediction, and the global change mitigation and adaptation
(b) Basic researches for social implementation in fishery, agriculture, weather forecast, public health, environmental disaster monitoring and so on

2.1.2.2 Focus of the GCOM-C project research

(1) Development of GCOM-C Algorithms

This area seeks research for standard and research algorithms for GCOM-C product development.

JAXA defines the GCOM-C algorithm product development objectives by the following points. Proposals are expected to conform to these objectives.

- Develop algorithms effectively by applying broad knowledge obtained through RA.
- Develop algorithms efficiently by an in-house algorithm integration team in JAXA/EORC (Fig. 2.1.2-2)
- Develop algorithms to construct long-term, stable, and highly accurate datasets
- Develop stable and effective algorithms that consider research on the operational use
- Developing new data analysis and application schemes to enhance future possibility of remote sensing in the Earth environment observation
- Achieve the product accuracy targets by developing the algorithms as a part of the

observation system including satellite/sensor design and manufacturing, and feed the results to the next satellite and sensor development

- Publish the algorithms as algorithm theoretical basis documents (ATBD) in the JAXA web site

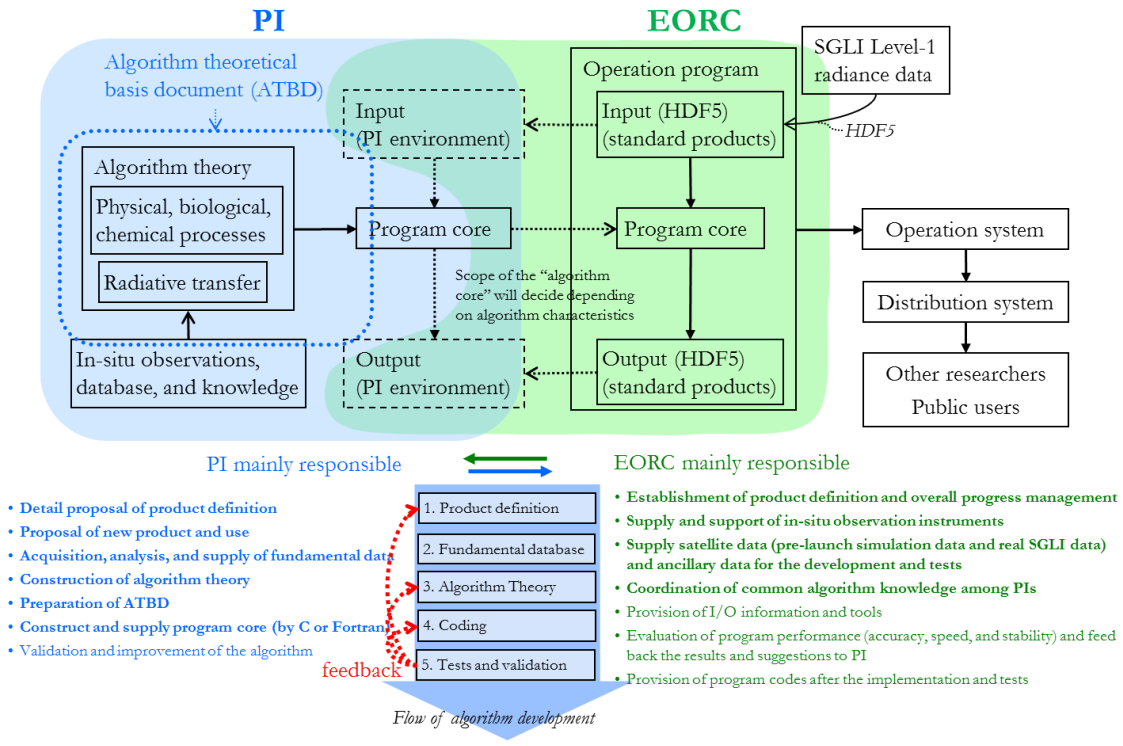

Fig. 2.1.2-2 Example of collaboration and sharing between PI and JAXA in algorithm development. The map should be modified according to algorithm characteristics and volume of the code (C or Fortran code).

As shown in Figure 2.1.2-2, selected PIs are requested to collaborate with JAXA to develop algorithms, implement their codes, validate the output products, and update the algorithm and the algorithm theoretical basis documents. Details on currently defined standard and research products and expected research themes are listed in the following part of this section.

Standard algorithms required to meet requirements of the GCOM-C mission: release criteria at one year after the launch, and standard and target accuracy at five years after launch. The proposals of algorithms are required to include strategies for algorithm improvement in cooperation with validation activities.

Applicants may propose a new algorithm to produce a standard product at a higher quality than the standard algorithms in the previous RA. Through comparative validation of performance, the new algorithm may become the new standard algorithm at the point of product revision. Therefore, research should meet the requirements of target accuracy. Performance of the algorithm codes (processing speed, stability etc.) are expected to be better than existing standard ones.

Research algorithms will be evaluated by additional success criteria (target accuracy) for five years after the satellite launch, and their development must meet requirements. Research

products produced by these algorithms could become new candidates for the standard products after completion of a specific evaluation process.

The science areas, product groups, and research items deemed particularly important in this RA are described below.

L. Land

L-1 Precise Geometric Correction Group: Precise Geometrically Corrected Image (PGCI) [standard product]

- ✓ JAXA will take initiatives in developing algorithms for the PGCI and their validations.

L-2 Land Atmospheric Correction Group: Atmospherically Corrected Land Surface Reflectance [standard product], Vegetation Index [standard product], Land Surface Albedo [research product]

- ✓ JAXA will take initiatives in the development of the standard products
- ✓ Collaboration with the above development is desired that relates to surface radiance, and multi-directional reflectance by vegetation, atmospheric radiance including aerosol scattering and absorption

L-3 Land Net Primary Production Group: Leaf Area Index (LAI) [standard product], fraction of Absorbed Photosynthetically Active Radiation (fAPAR) [standard product], Water Stress Trend [research product], Land Net Primary Production [research product]

- ✓ JAXA will take initiatives in the development of LAI and fAPAR
- ✓ Modeling of relationship between the satellite observed reflectance and the radiative transfer process of the vegetation in various conditions is needed.
- ✓ Data acquisition is needed for algorithm development and cooperation with ground observation programs such as flux tower observation networks.
- ✓ Collaboration with studies of carbon cycle and ecological models (C-4) is encouraged to estimate land CO_2 fixation.
- ✓ Collaboration with activities of L-2, L-4, L-6, and A-3 is desired.
- ✓ Water stress trend should cooperate or integrate with evapotranspiration researches. Collaboration with researches of biological processes and agriculture is encouraged through knowledge of vegetation water stress.

L-4 Above-Ground Biomass Group: Above-Ground Biomass (AGB) [standard product], Vegetation Roughness Index (VRI) [standard product], Shadow Index [standard product]

- ✓ AGB algorithm will be developed by basing on the previous RA
- ✓ Modeling of three-dimensional structures and directional reflectance of the various shapes of canopies is needed.
- ✓ Collaboration is needed with a ground observation networks that continuously measures of biomass such as the diameter at breast-height.
- ✓ Cooperation with satellite SAR and canopy height LIDAR measurements is encouraged for improvement of the GCOM-C AGB

- ✓ Establishment of a method to estimate above-ground biomass from 3D laser scanner measurements which have been conducted by JAXA and other groups is expected.
- ✓ Comparison and validation between the temporal change of the biomass and NPP (L-3) are desired.
- ✓ Collaboration with activities of the land cover group (L-6) is desired for global applicability; VRI is expected to improve land cover classification.

L-5 Land Surface Temperature Group: Land Surface Temperature (LST) [standard product], Fire Detection Index (FDI) [research product]

- ✓ LST will be based on the algorithm developed by the previous RA
- ✓ Collaboration of the heat-budget process and model researches are expected for improvement of the accuracy and enhancement of product usage.
- ✓ FDI should be available for real-time processing (short processing time).
- ✓ Fire power and burned areas estimation is encouraged because FDI is expected to be used as an information of aerosol source.

L-6 Land Cover Group: Land Cover Type [research product]

- ✓ Effective construction of validation dataset and collaboration with JAXA/EORC land cover classification are desired.
- ✓ Algorithms are desired that use 3D information (L-4) and temporal change analysis by SGLI high-frequency observation.

A. Atmosphere

A-1 Cloud Product Group: Cloud Flag [standard product], Classified Cloud Fraction [standard product], Cloud-Top Temperature and Height [standard product], Water Cloud Optical Thickness and Particle Effective Radius [standard product], Ice Cloud Optical Thickness [standard product], Water Cloud Geometrical Thickness [research product]

- ✓ The standard cloud retrieval algorithms will be based on the algorithm developed until previous RA
- ✓ Collaboration with common subject C-1 is needed.
- ✓ Effective use of polarization, multi-angle, near-UV, and O_2A band is encouraged
- ✓ Validation study of cloud coverage using the all-sky camera system which has been developed by JAXA is encouraged.
- ✓ Cooperation with other JAXA satellite missions (e.g., research collaboration, work sharing, and participation in workshops) is desired for investigating the cloud radiative forcing by integrated analysis of the multiple satellite data.
- ✓ Combined analysis with the numerical model through a radiative transfer model and extension to model assimilation is desired.

A-2 Aerosol Product Group: Aerosol over the Ocean and Land [standard product]

- ✓ The standard aerosol algorithms will be based on the algorithms developed until previous RA; JAXA will take initiatives in devolvement of generalized algorithm and integrated use of aerosol products from multiple sensors
- ✓ New algorithm by effective use of the SGLI features is encouraged
- ✓ Algorithm development is needed with global applicability and considerations

for locality aerosol characteristics, as well as the global applicability.

- ✓ Contribution is needed in defining an aerosol candidate model and improving and validating the radiative transfer process for aerosol correction over the land and the ocean.
- ✓ Effective algorithms for unifying the ocean and land algorithms and for estimating parameters such as aerosol size distribution and component ratio are desired.
- ✓ For aerosol by polarization, including land aerosol estimation through SGLI polarization observation, collaboration with polarization radiative transfer research is desired.
- ✓ Cooperation with AHI and EarthCARE such as research partnerships, work sharing, and participation in workshops is desired for investigating cloud-aerosol interaction.
- ✓ Combined analysis with a numerical model through a radiative transfer model and its extension to model assimilation are desired.

A-3 Surface Radiation Flux Group: Short-Wave Radiation Flux [research product], Long-Wave Radiation Flux [research product]

- ✓ JAXA will take initiatives in developing algorithms for the satellite-basis downward shortwave radiation.
- ✓ Downward long-wave radiation will be estimated by using Cloud Geometrical Thickness.
- ✓ BRDF consideration is encouraged for the upward short- and long-wave radiation
- ✓ Combined analysis with a numerical model through a radiative transfer model and its extension to model assimilation are desired.

O. Ocean

O-1 Ocean Atmospheric Correction Group: Normalized Water-Leaving Radiance (NWLR) [standard product], Atmospheric Correction Parameters [standard product], Photosynthetically Available Radiation [standard product]

- ✓ The standard atmospheric correction algorithms will be based on the algorithms developed until previous RA
- ✓ New algorithm using SGLI features, such as 250-m resolution, 380nm band, multi-angle, and polarimetry, is encouraged.
- ✓ Improvement in the aerosol estimation and water-leaving reflectance (sharing of knowledge from C-2) corresponding to in-water algorithms is necessary.
- ✓ Because ocean color requires particularly high calibration accuracy, algorithm adaptation to SGLI sensor features and collaboration with calibration activities including in situ observations for vicarious calibration and NWLR, C-5, are required.
- ✓ Inter-comparison of international products and algorithms are encouraged to contribute to the ocean color ECV.

O-2 Ocean Color Group: Chlorophyll-a Concentration (CHLA) [standard product], Total Suspended Matter Concentration (TSM) [standard product], Colored Dissolved Organic Matter (CDOM) [standard product], Inherent Optical Properties

[research product], Phytoplankton Functional Type [research product], Red Tide [research product]

- ✓ The standard algorithms (CHLA, TSM and CDOM) will be based on the algorithms developed until previous RA
- ✓ Redtide should consider use of fishery and coastal environmental monitoring
- ✓ Coastal algorithm development is planned to be based on characterization of IOP spectra observed in each coastal region. Therefore, a systematic measurement of IOP and researches using the IOP (plankton type and optical modeling) is required.
- ✓ Combined analysis with a numerical model through in-water bio-optical models and its extension to model assimilation is encouraged.
- ✓ Inter-comparison of international products and algorithms are encouraged to contribute the ocean color ECV.

O-3 Temperature Group: Sea-Surface Temperature (SST) [standard product]

- ✓ JAXA will take initiatives in developing the SST algorithm.
- ✓ New products that effectively use coastal 250 m spatial resolution and numerical modeling research are desired.

O-4 Primary Productivity Group: Ocean Net Primary Productivity [research product]

- ✓ Acquisition of highly accurate in situ data is needed.
- ✓ Combined analysis of a numerical model through in-water bio-optical models and its extension to model assimilation are desired.
- ✓ In order to contribute to CO_2 absorption estimation, cooperation with research activities of carbon-cycle and marine-ecosystem models and in-situ biogeophysical measurement programs(C-4) is desired.

O-5 Multi-Sensor Merged Product: Multi-sensor Merged Ocean Color Parameters [research product], Multi-sensor Merged Sea-Surface Temperature [research product]

- ✓ A combination of products is desired that overcomes differences such as channel wavelengths, sensor characteristics, algorithms, and data formats and utilizes SGLI features such as 250-m resolution and time frequency.
- ✓ Studies of GCOM-C data assimilation to bio-geo-chemical models are encouraged.

S. Cryosphere

S-1 Snow Area Discrimination Group: Snow- and Ice-Covered Area [standard product], Okhotsk Sea-Ice Distribution [standard product], Snow and Ice Classification [research product], Snow-Covered Area in Forests and Mountains [research product], Ice Sheet Boundary Monitoring [research product]

- ✓ The standard algorithms will be based on the ones developed by the previous RA
- ✓ New algorithm researches using the SGLI features is encouraged
- ✓ Contribution to other groups through C-1 activities such as discrimination between cloud and snow/ice areas is needed.
- ✓ Acquisition of in situ data for effective validation and cooperation with in situ

monitoring by other groups is needed.
- ✓ Contribution to aerosol models and weather models (as a boundary condition) is encouraged.

S-2 Snow-Surface Properties Group: Snow and Ice Surface Temperature [standard product], Snow Grain Size of Shallow Layer [standard product], Snow Grain Size of Subsurface Layer [research product], Snow Grain Size of Top Layer [research product], Snow Impurity [research product]
- ✓ The standard algorithms will be based on the ones developed by the previous RA
- ✓ New algorithm researches using the SGLI features is encouraged
- ✓ Because opportunities for in situ measurements are generally limited, product validation must be conducted through effective in situ measurement in cooperation with domestic and foreign institutions, and theoretical evaluation of error budget.
- ✓ In order to contribute to research on Earth environment changes and climate prediction, cooperation with research on snow/ice physical processes and albedo (S-3) with numerical models (C-4) is desired.

S-3 Snow Albedo Group: Snow and Ice Albedo [research product], Ice Sheet Surface Roughness [research product]
- ✓ Cooperation with the S-2 group, which measures snow grain size and impurities that significantly influence albedo, is desired.
- ✓ Developments that consider application by numerical modeling are needed.

C. Common Issues

Common issues that encourage collaboration among PI activities are coordinated by JAXA EORC.

C-1 Cloud and Snow/Ice Discrimination
- A common task in most products and algorithms is to distinguish clear-sky, cloud, and snow/ice areas from SGLI TOA radiance data. However, the development of an appropriate discrimination scheme specific to each application is necessary. JAXA will encourage PI teams to share their knowledge of spectral features of each observation target and discrimination schemes and to effectively implement the individual algorithms.
- A mini workshop in 2011 was the basis for consolidation of the knowledge of each area for cloud discrimination algorithms and for evaluating the validation scheme by using whole-sky camera systems. The cloud amount was estimated with a high degree of accuracy from whole-sky camera data; research that effectively integrates such data into algorithm improvement and validation is encouraged.

C-2 Aerosol Correction
- The light reflected from observation targets from atmospherically scattered light must be separated and corrected to estimate land, ocean, and snow surface reflectance from satellite-observed radiances, particularly those related to aerosol

properties A-2. For this purpose, JAXA promotes sharing and exchange of knowledge and processing techniques for the radiative transfer process of the atmosphere–surface system.

- Direction of the development of an atmospheric correction algorithm has been discussed in the mini-workshop in 2012 and we are developing the algorithm by cooperation among researches on the land surface and the atmosphere. This RA will continue to promote activities for sharing knowledge of surface and aerosol products from each area among JAXA and PI groups.

C-3 Polarization Study

- Polarimetry is a unique function of SGLI. Besides aerosol estimation (A-2), the development of new products and their applications are encouraged through polarization observation.
- Because polarimetry is an unique function in sensor development, collaboration between JAXA's radiance calibration activity and the knowledge and skill on atmospheric and earth surface polarization is encouraged.

C-4 Integrated Analysis of Global Environmental Change

- Cooperation with research on monitoring and predicting the carbon cycle and radiative forcing is needed to achieve the GCOM mission targets. The new requirements and knowledge from the researches should be reflected to the next satellite product development. This common group encourages exchange of knowledge and skill from research of model assimilation and combined analysis in each area and group.

C-5 Consideration of SGLI Calibration Performance

- Accuracy of products depends on combination between performance of the SGLI sensor and the algorithm error. It is necessary, therefore, to develop algorithms optimized for the SGLI performance along with the progress of SGLI characterization and calibration. For example, cooperation is promoted between the team evaluating the radiative transfer process in the algorithms and the team conducting ground truth observations and vicarious calibration. In addition, evaluation and correction of the impact of SGLI characteristics on geophysical products are encouraged.

(2) Validation Observation and Product Validation

This research area seeks proposals of validation observation and effective product validation through cooperation with other ground and satellite observation researches. Table C1 in APPENDIX 1-C details the definition and validation methods for each product.

The validation category proposals are required to consider the current validation plan including observation parameters, instruments, and site locations (see Tables C2 and C3 in APPENDIX 1-C) which has been established by previous RAs.

The results must be applied directly to the post-launch in-situ data acquisition, validation analysis, which includes evaluation of product accuracy for confirming success criteria achievement, and the algorithm improvement.

Special emphasis will be placed on researches that effective validation data acquisition and collaboration with JAXA's validation analysis. Because GCOM-C is a global observation mission, validation observation and analysis for accuracy evaluation and improvement on a global coverage is a particular requirement.

Proposals of in-situ data acquisition through collaboration with observation activities by other funds are also encouraged for enhancement of in-situ data coverage for the GCOM-C product validation. New observation plans, which include in-situ data acquisition and product evaluation methods, and will improve the GCOM-C product evaluation, can be proposed in addition to the Tables C2 and C3 in APPENDIX 1-C.

Error budget analysis for pixel error approximation and estimation of error-budget models for each product are also important for products with limited points of observation or products that utilize numerical models.

Obtained in situ observation data and knowledge must be provided to JAXA and the PI in charge of algorithms for application of algorithm improvement and post-launch validation. Providers of in situ data can define the disclosure levels specified in APPENDIX 1-C TABLE C4: for EORC members only, EORC and PIs for algorithm development, calibration and validation, registered users, and public open. The provider will define the disclosure level for data and provide this information to EORC, which will share the data via EORC/GCOM-C Web pages (The disclosure level is required to be open wider user levels as much as possible). It is asked to provide in-situ data which was not funded by JAXA, if the policy of the in-situ data is allowed with appropriate disclosure levels.

(3) Application Research

Perform research on monitoring environmental changes and improving future prediction and research leading to social benefits including practical applications such as monitoring fishery management, agricultural use, biological carbon fixation, environment and disaster monitoring, and so on.

Integrated use of GCOM-C data with other satellite data and ground measurements can be proposed to achieve the application researches as well as the above algorithm and validation researches effectively.

2.1.2.3 Notes about the GCOM-C research proposals

The GCOM-C project research seeks to accomplish the GCOM-C mission's goals and to discover new possibilities for utilizing GCOM-C data. Proposals should clearly describe plans for GCOM-C data usage.

JAXA plans to select about 40 proposals under this RA, including both funded and non-funded. The principal investigator (PI) of each selected proposal will become a science team member of GCOM-C. The PI will conduct frequent discussions and collaborations with JAXA Earth Observation Research Center (EORC) staffs for the algorithm development, validation, and application studies. PIs will be able to receive prioritized distribution of the new version of the GCOM data under the collaboration. The PI must attend and present the research statuses at annual PI workshops. The science team leader and sub-leaders will participate in the GCOM Advisory Committee and SGLI application working group to feed back our activities to the

GCOM overall objectives and mission requirements.

Depending on its budget status, JAXA plans to spend 80 million yen/year for total PI within the three years of this RA period. The budget for each PI may change for the following year depending on the results of PI research evaluation held at the annual GCOM workshop. JAXA may also select non-funded PIs for researches without the requirement of additional costs or researches not directly related to the success criteria of GCOM.

2.1.3 Global Precipitation Measurement (GPM)

Global Precipitation Measurement (GPM) is an international mission led by the U.S. and Japan. The U.S. and Japan will jointly develop the GPM Core Observatory, 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.

Descriptions of the GPM and TRMM missions, satellites, and sensor systems can be found in later Appendix.

From the first to the fifth PMM RAs were implemented with a focus on research related to the TRMM satellite, which was launched in November 1997. The last two RAs (the sixth and seventh RAs,) for the period from Japanese Fiscal Year (JFY) 2010 to 2012 (for the sixth), from 2012 to 2015 (for the seventh) and from 2016 to 2018 (for the eighth) focused on research themes especially those contributing to the development of GPM algorithms.

The GPM Core Observatory was launched in February 2014, completed the Prime mission phase on June 2017 and moved to the extended mission phase. This RA covers a 3-year research period beginning in JFY 2019, which corresponds to the extended mission phase.

In this RA, JAXA will continue to invite research proposals for model utilization and data assimilation, as well as those contributing to the development and improvement of GPM algorithms needed for producing long-term data sets and will focus more on application studies.

The Principal Investigator (PI) of selected proposals will be a member of the Japanese Precipitation Measuring Mission (PMM) Science Team. JAXA's Earth Observation Research Center (EORC) will work together closely with the PMM Science Team, especially in algorithm development and validation activities.

Although it will depend on the budget situation, JAXA plans to spend 30,000,000 yen as annual total budget. 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.

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.

Based on the GPM and TRMM objectives, JAXA seeks proposals in the following three research areas: algorithm development, validation, and application research. Please see Section 1.5 for priorities in selection of proposal. Details are described in Sections 2.1.3.1 to 2.1.3.3.

2.1.3.1 Algorithm Development

As described in (1)-(4) below, research themes to develop and improve JAXA GPM 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. 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 (the DPR and DPR/GMI combined) for the GPM Core Observatory.

Table 2.1.3-1 lists JAXA standard products of the GPM mission, and Table 2.1.3-2 is same but for near-real-time products. In addition, as a "TRMM / GPM standard climate product", there are products created by applying the GPM standard algorithm to the data of the TRMM to create a consistent long-term data set between TRMM and GPM. Algorithms to produce geophysical products other than those noted here will be considered new products and will be included in Theme 3 “Application Research.”

Table 2.1.3-1 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	125km/ 245km (swath)
	DPR latent heating algorithm	DPR latent heating product	Latent heating profile, rain type	Orbit	245km (swath)
3	DPR algorithm (Japan-US joint)	Dual-frequency precipitation product	Mean surface rainfall, time information, Ascending/Descending flag	Daily	Global
			Mean rainfall (dual), observation number, rain pixel number, mean bright-band height, storm height, rain/snow determination, time information	Daily (Asc/ Dsc)	Global
			Mean rainfall (single, dual), observation number, rain pixel number, mean bright-band height, storm height, mean attenuation corrected radar reflectivity profile, mean DSD parameters, histogram	Monthly	Global
	DPR/GMI combined algorithm (Japan-US joint)	DPR/GMI combined product	Mean rainfall, observation number, rain pixel number,	Monthly	Global
	DPR latent heating algorithm	DPR latent heating product	Latent heating profile, number of latent heating pixel	Orbit	Global
				Monthly	Global
	Global precipitation map algorithm	Global precipitation map product	Mean rainfall, observation number, rain pixel number	Hourly	Global
				Monthly	Global

Table 2.1.3-2 JAXA GPM near-real-time products

Level	Algorithm	Product	Major Physical Parameters	Unit	Coverage
1R	Depends on each sensor	Microwave radiometer product	Brightness temperature	arbitrarily	Depends on each sensor
2R	DPR algorithm (Japan-US joint)	Dual-frequency precipitation product	Rain rate profile, drop size distribution, precipitation status (rain/snow), attenuation profile	arbitrarily	245km
	DPR/GMI combined algorithm (Japan-US joint)	DPR/GMI combined product	rain rate profile, surface rain rate	Orbit	125km/ 245km
3R	Global precipitation map algorithm	Global precipitation map product	Mean rainfall, observation number, rain pixel number	Hourly	Global

(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 2.1.3-1.

The 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.

Furthermore, algorithm development will include following components and their evaluation.

- Utilization of KaPR data;
  - Development and improvement in correction of attenuation in Ka-band by non-precipitation particles, such as clouds, and detection of bright band in Ka-band, precipitation-type classification in Ka-band;
  - Development and improvement of technology to estimate parameters relating to non-uniform beam filling using high-density observation and/or full swath (245km) observations 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 dual-frequency observation; and

- Development and improvement in detection of bright band in dual-frequency observation, and precipitation-type classification in dual-frequency observation; and
- Evaluation of accuracy of Surface Reference Technique in dual-frequency observation.

(2) Global Precipitation Map (GSMaP) Algorithm

This theme encompasses research to develop or improve the following five algorithms, completely or in part, which compose algorithms to produce the Global Precipitation Map (GSMaP) standard products, shown in Table 2.1.3-1;

- Microwave imager rain retrieval algorithm (MWI algorithm);
- Microwave sounder rain retrieval algorithm (MWS algorithm) **;**
- Microwave imager/sounder rain retrieval algorithm (MWIS algorithm);
- Microwave-Infrared (IR) combined algorithm (MVK algorithm); and
- Rain gauge correction algorithm (Gauge algorithm.)

Furthermore, algorithm development will include following components and their evaluation;

- Development and improvement of the DPR-based precipitation physics databases;
- Development and improvement of accuracy of sold precipitation over high-latitudes using high-frequency channels available in GMI and microwave sounders;
- Development and improvement of the near-real-time Gauge algorithm applying rainfall correction method by using rain gauges; and
- Development and improvement of precipitation estimation technique using new methodology such as machine learning

(3) DPR Latent Heating Algorithm

This theme encompasses research to develop algorithms, completely or in part, to produce the DPR Latent Heating Level 2 and 3 standard products shown in Table 2.1.3-1.

The DPR Latent Heating algorithm will be developed in Japan.

In developing the DPR Latent Heating algorithm, applicants should pay attention to following points;

- Use algorithms on the TRMM/PR Latent Heating standard algorithms to the extent possible; and
- Develop algorithm applicable to both PR and DPR in order to produce long-term continuous data set.

Furthermore, the following components have to be developed and evaluated to produce the DPR Latent Heating products;

- Development and improvement of estimation method of latent heating profiles in mid- and high-latitudes; and
- In the case of utilizing numerical models, evaluation of algorithms along with evaluation of reproducibility in precipitation (latent heating) profiles.

2.1.3.2 Validation

As described in (1)-(4) below, research themes to contribute to development and improvement of the JAXA GPM standard algorithms (hereafter referred as to "Algorithm Validation,"), research themes to evaluate accuracy of the GPM and TRMM Level 2 and 3 standard products, in particular, in terms of precipitation rate (hereafter referred as to "Product Validation"), research themes to conduct inter-comparisons of precipitation datasets, and research themes that will be effectively implemented by collaborating with other research programs, will be adopted in this RA.

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

This theme encompasses researches related to validation of the algorithm to produce the DPR Level 2 standard product (DPR algorithm). Particularly, researches to compare and evaluate models and parameters relating precipitation estimates in the algorithm using ground observations will be recommended. In addition, since observation of solid precipitation is one of major target of the GPM mission, which covers latitude of 65 degree, researches to propose knowledge obtained by ground observation of snowfall to algorithm developers.

Applicants have to acquire and analyze data obtained by observation experiments combining ground-based instruments and creating databases that contribute to development or improvement of the GPM standard algorithms.

JAXA can rental some ground observation instruments (*) owned by JAXA and provide data obtained by past campaign observations to selected PIs. Please contact to the PMM RA Office (PMM_RA @ ml.jaxa.jp) for further details. (*: two Optical Rain Gauges, two Laser-Optical Present Weather Sensors, etc.)

Examples of research include the following;

- Validation to compare ground data obtained by the past campaign observations by ground-based instruments (2DVD, meteorological instruments, sondes, etc.) and multi-band ground-based radars (JAXA Ka-band ground radars and/or other radars) with precipitation profiles retrieved by the GPM/DPR algorithms;
- Examination of adequacy of the DPR algorithms by consolidating and analyzing existing data;

- Routine observations of snowfalls and melting layers by ground observation instruments (radars, 2DVD, meteorological instruments, microwave radiometers, etc.,) understanding characteristics of snow and melting particles by them, and comparisons with profiles estimated by DPR; and
- Collecting observation data of various parameters related to precipitation rate estimate algorithms, especially related to snowfall, such as Z-R relationship, Z-M relationship, drop size distribution (DSD,) fall velocity, volumetric distribution, mean density, and shapes of snowflake, hail and sleet, consolidating observation data of various parameters related to precipitation rate, especially snowfall, estimate algorithms, creating databases using them to contribute to algorithm development and/or improvement, and providing those databases to the Algorithm Development Teams.

(2) Product Validation

This theme encompasses researches contributing to validation of parameters, such as precipitation, precipitation profile, rain/snow specification, precipitation type, etc., included in the GPM Level 2 and 3 standard products. Especially, verification of the products using ground instrument (rain gauge, radar, and etc.) network worldwide such as in Asian countries, validation from hydrological aspects will be recommended.

Followings are examples of research to evaluate accuracy of precipitation;

- Collecting long-term and widely distributed ground operational observations by rain gauge and radar, and validating the GPM and TRMM products by instantaneous and statistical values such as averages, trends, and histograms;
- Validating the GPM and TRMM products using the ground instruments for detection of heavy precipitation, in particular, in extreme precipitation events; and
- Comparing river runoff rates when the GPM and TRMM products are used as inputs in hydrologic models, with actual river runoff rates.

(3) Inter-comparison of Precipitation Datasets

This theme encompasses researches conducting inter-comparison of various precipitation datasets, which are produced by using satellite and/or ground observations, with central focuses on the GPM, TRMM and GSMaP, and contributing to improvement of the GSMaP products.

(4) Other Validation Activities and Data Collection

Research themes related to other validation activities and data collection and preparation other than above (1)-(3) will also be adopted. Research that will be effectively implemented by collaborating with other research programs, or research

that will contribute to validation of the GPM standard products will be recommended.

2.1.3.3 Application Research

Research themes related to application research to utilize satellite-based precipitation observation data, such as the GPM and TRMM data, will be adopted in this RA. For example, following research themes are included;

- research to utilize the GPM and TRMM data into atmospheric, climate, land, hydrological, and other models, and/or by data assimilation;
- development and evaluation of new research products, such as data assimilation using the GPM and TRMM data, or combination of other satellites and/or sensors with them;
- creation of long-term and continuous data set using the GPM and TRMM products;
- research contributing to climate and global water cycle variation and precipitation system climatology using long-term satellite data, necessarily including the GPM and TRMM data;
- operational utilization research leading to societal benefits at present and in the future GPM era, for example, flood prediction, water resource management, weather forecast, agricultural field, etc.;
- data utilization research in Asia, Africa and other areas, where ground precipitation observation is not sufficient; and
- research contributing EORC's cross-cutting research themes (see Section 1.1) mainly using GPM and TRMM data

This research theme will generally be implemented through a "Collaborative Research Agreement."

2.1.4 Advanced Land Observing Satellite-2 (ALOS-2)

The Research Announcement (RA) related to the Advanced Land Observing Satellite-2 (ALOS-2) have been called the 4th and 6th RAs and the 1st RA on the Earth Observations (EO-RA1) so far. This research announcement (EO-RA2) seeks research proposals on "Application Research" (Priority Themes) utilizing ALOS-2, which is looking ahead to post operational phase since May 2019, and the accepted proposal will contract as a "non-funded Collaborative Research Agreement". Therefore, same research theme approved in the past RAs are not allowed in EO-RA2.
Approximately 150 proposals will expect to accept as maximum in EO-RA2.

(1) ALOS-2 Application Research (Priority Themes)

To create further achievement of ALOS-2 mission and based on the current priority JAXA's satellite utilization program, EO-RA2 seeks research proposals on "Application Research" (Priority Themes) as follows. Please select and indicate the preferred "Research Theme" in your proposal.

■ALOS-2 Application Research (Priority Themes)

I. Natural disaster preventions, crustal and land surface deformations measurement, and their sophisticated method development,
II. Forest management, forest, wetland and ecosystem related parameters measurement, and their sophisticated method development, and
III. Oceanography, sea-state condition, ship detection and environmental parameters measurement, and their sophisticated method development.

■ Expected "Research Theme" (Indicate the preferred one to three numbers in the proposal)

I. Natural disaster prevention, crustal and land surface deformations measurement:

① Conditions and damage estimations due to natural disasters i.e. flooding, landslide, earthquake and volcanic activity, especially a robust and automatic analysis method development, and quantitative evaluation between processing time and estimated accuracy.
② SAR Interferometry analysis and sophisticated research: multi-temporal method, correction methods, application of InSAR coherence.
③ SAR polarimetric utilizations (single-, dual-, and quad-pol) in retrieving disaster related information.
④ Predictions of volcanic activities and landslides etc.
⑤ Infrastructure monitoring: sophisticated method and practical usage.
⑥ Improvement of extraction of disaster related information by combined use of ALOS-2 and other satellites.
⑦ ALOS-2 and ALOS-4 mutual usage and time series analysis method.
⑧ Research group on the PALSAR Interferometry Consortium to Study our Evolving Land surface (PIXEL).

II. Forest management, forest, wetland and ecosystem related parameters measurement

① Forest area monitoring, and early detection of its change.

② Practical usage of forest management issues using ALOS-2 i.e. deforestation, forest degradation, above ground biomass and carbon stock estimation.
③ Precise estimations of land-use and land-cover including vegetation type classification and their change using polarimetry and phase information.
④ Ecosystem related parameters estimation and its sophisticated method.
⑤ Improvement of extraction of forest, wetland and ecosystem related information by combined use of ALOS-2 and other satellites.
⑥ ALOS-2, ALOS-4 and MOLI mutual usage and time series analysis method.
⑦ Research Group on the Kyoto & Carbon Initiative

III. Oceanography, ocean-state condition, ship detection and environmental parameters measurement
① Improvement of understanding of ocean-state conditions i.e. ocean wind speed and waves.
② Polar environment observations e.g. sea ice, ice sheet, glacier and permafrost etc. and their sophistications.
③ Sophisticated methods of maritime traffic monitoring and ship detection.
④ Improvement of extraction of ocean-state condition and environmental information by combined use of ALOS-2 and other satellites.
⑤ ALOS-2 and ALOS-4 mutual usage and time series analysis method.

■Additional Points
For review process, the research proposals that include the following items effectively will be added the points.
① Sharing the own reference data i.e. validation data on the ground with JAXA.
② Research proposal in group and share ALOS-2 data within the group to contribute streamlining of data provision from JAXA.
③ Plan on publication of higher level- and research-products and analysis tools developed and verified by the proposer.
④ Publication plan of active achievements in Web sites, media, papers, academic societies, committees, etc.
⑤ Combined use of ALOS-2 with other satellite data, products, numerical models etc., and proposal of new analysis method using machine learning, deep learning, artificial intelligence (AI).
⑥ Research proposals aimed at ALOS-4 applications.
⑦ Regarding the technology of the proposal, the current Application Readiness Level, (ARL)[*1] of application, and aiming ARL for this research announcement (EO-RA2).

(2) Notes on data provision request of ALOS-2 and ALOS

In past the ALOS-2 RAs, the accepted research proposal could be used up to 50 scenes of ALOS and ALOS-2 standard products per fiscal year free of charge. However, data orders from PIs tend to concentrate at the end of the fiscal year. It was occasionally exceeding the capacity of processing systems and affected not only RA activities but also general users. From this reflection, please be aware that the ALOS and ALOS - 2 standard products data will be provided under this policy as follows.

① Validity evaluation of the number of data requests of ALOS and ALOS-2

To validate the number of data requests of ALOS and ALOS-2, please indicate your area of interests (AOIs) clearly i.e. name of location, area, latitude and longitude), analysis method, summary of the availability of ALOS and/or ALOS-2 data for your research proposal and requested scene numbers in your proposal. For each research proposal up to 20 scenes in a fiscal year as a guide and following conditions, JAXA will evaluate your data requests for ALOS and ALOS-2.

You can confirm availability of ALOS and ALOS-2 archived data using "ALOS-2/ALOS User Interface Gateway" (AUIG2) system on
https://auig2.jaxa.jp/openam/UI/Login?

You can also see the Basic Observation Scenario (BOS) of ALOS-2 as future observation plan on
https://www.eorc.jaxa.jp/ALOS/en/top/obs_top.htm

Note that the BOS may be subject to changes and revisions by JAXA, and future observation should therefore not be considered.

② Regulation of data order timing

In order to avoid concentrating orders at the end of the fiscal year, JAXA will ask PI to divide the number of offerings and set a provision deadline individually (for example, to be able to order 1/4 of the planned number of all quarterly in each quarter of the year etc.).

③ Recommendation of group proposal

JAXA recommends you submit a research proposal in groups with the same research purpose. JAXA will sign a contract with the research organization (RO) of the principle researcher (PI), and group member will involve as Co-Investigators (CIs). The provided ALOS and ALOS-2 data will be shared within the group.

We appreciate your understanding and cooperation.

*1: Definition of the Application Readiness Level (ARL)

Level	Definition	Phase
9	Approved, operational deployment and use in decision making (Sustained use).	Integration into User's System
8	Application completed and qualified (Functionality proven).	
7	Application prototype in user's decision making (Functionality demonstrated).	
6	Demonstration in relevant environment (Potential demonstrated).	Development, Testing and Validation
5	Validation in relevant environment (Potential determined).	
4	Initial integration and verification (Prototype/Plan).	
3	Proof of application concept (Viability established).	Discovery and Feasibility
2	Application concept (Invention).	
1	Basic research (Baseline ideas).	

2.1.5 Advanced Optical Satellite（ALOS-3）

The Advanced Optical Satellite (ALOS-3) is the next high-resolution optical mission as a successor of the Advanced Land Observing Satellite (ALOS, "Daichi"), and is now under developing in the Critical Design Review (CDR) phase. The major mission objectives of ALOS-3 are (1) to contribute safe and secure social including provisions for natural disasters, and (2) to create and update geospatial information. The wide-swath and high-resolution optical imager (WISH, as a tentative name) is designed to be achieved the mission objectives, and consists of the panchromatic band and multispectral bands by six channels.

The specifications of ALOS-3 as well as the onboard instrument WISH are considered to improve and enhance a fine resolution and global observation capabilities achieved by the Panchromatic Remote Sensing for Stereo Mapping (PRISM) and the Advanced Visible and Near Infrared Radiometer type-2 (AVNIR-2) onboard ALOS. For example, the ground sampling distance (GSD) is 0.8 m of WISH's panchromatic band compared with 2.5 m of PRISM, and 3.2 m for multi-bands with 10 m of AVNIR-2, even the observation swath widths are same as 70 km at nadir, respectively. For multispectral observation, two channels are added from AVNIR-2 i.e. Coastal and RedEdge that will contribute to bathymetry and environmental monitoring in coast regions, and to activation level monitoring in forests, vegetation and agricultural areas. A detailed description of ALOS-4 is given in Appendix 5.

This research announcement seeks research proposals on "Standard Algorithm Calibration/validation, and Provision of Validation Data" (Cal/Val) for ALOS-3, which will be launched in Japanese Fiscal Year 2020. Approximately 20 proposals will expect to approve as maximum.

(1) ALOS-3 Standard Algorithm Calibration/validation, and Provision of Validation Data (Cal/Val)

This research announcement seeks research proposals contributing to calibration, validation, image quality evaluation, and their accuracy improvement of ALOS-3 standard products to satisfy the specified accuracies as well as to development and sharing reference data.

The approved researchers may be able to participate as a member of the Calibration/Validation and Science Team (CVST) to be established by JAXA, therefore that sufficient results may be obtained during the initial Cal/Val phase scheduled within the first six months after the launch. Proposals that plan to share the information of your reference data for Cal/Val among CVST members, own developed high-level products or analysis tools will be preferentially accepted.

Expected research themes are as follows:

- Methods of calibration, validation, and accuracy improvement for standard products
- Assessing accuracy and applicability of standard products from the initial Cal/Val phase to the beginning of the operational phase
- Development and sharing of high-level products and analysis tools for fundamental applications
- Experiment and demonstration using new features and methods of ALOS-3 i.e. application development using two new multispectral channels, improvement of cloud detection, sophisticated atmospheric correction, 3-D location measurement

using two observation paths data or large base-to-height ratio, sophisticated multi-temporal analysis, automatic image interpretation, robust method using machine learning/deep learning)

- Research on new technology for future missions

(2) Notes on application for ALOS-3 RA

This research announcement of ALOS-3 will be implemented under the "non-funded Collaborative Research Agreement".

The approved research themes will be accessible to relevant ALOS and ALOS-2 data (limited amount) and simulated ALOS-3 images before the satellite launch. After ALOS-3 is launched and the initial Cal/Val phase starts, uncalibrated standard products will be available for calibration and assessment. In order to acquire essential data such as calibration sites, accepted researchers may submit observation requests under discussions with JAXA. Technical information on ALOS-3 and its products will be provided in advance of its launch.

If you require provisions of the ALOS and ALOS-2 standard products, please refer "2.1.4 Advanced Land Observing Satellite-2 (ALOS-2)" for the policy.

Please note that the research plan may have to be changed according to the satellite development schedule.

2.1.6 Advanced Land Observing Satellite-4（ALOS-4）

The Advanced Land Observing Satellite-4 (ALOS-4) is a mission aiming at precise monitoring of crustal and ground deformations using high-resolution and wide-swath observation by L-band SAR technology, which has continuously been developed in Japan. For the continuity and expansion of its predecessor mission ALOS-2, ALOS-4 also targets advancing weather-independent monitoring of disaster, forest, sea ice, ship, and infrastructure. These will be realized by the L-band SAR aboard ALOS-4, called PALSAR-3, which is capable of high-resolution observation with a 4 times wider swath width compared to PALSAR-2 aboard ALOS-2. ALOS-4 will be launched in the same orbit as ALOS-2 to enable continuous interferometric analysis using both the satellites. A detailed description of ALOS-4 is given in Appendix 6.

This research announcement seeks research proposals on "Standard Algorithm Calibration/validation, and Provision of Validation Data" (Cal/Val) for ALOS-4, which will be launched in Japanese Fiscal Year 2020. Approximately 20 proposals will expect to approve as maximum.

(1) ALOS-4 Standard Algorithm Calibration/validation, and Provision of Validation Data (Cal/Val)

This research announcement seeks research proposals contributing to calibration, validation, and accuracy improvement of ALOS-4/PALSAR-3 standard products to satisfy the specified accuracies and to development and sharing reference data.

The approved researchers may be able to participate as a member of the Calibration/Validation and Science Team (CVST) to be established by JAXA, therefore that sufficient results may be obtained during the initial Cal/Val phase scheduled within the first six months after the launch.

Proposals that plan to share the information of your calibration equipment, ground sites, products, or analysis tools will be preferentially accepted.

Expected research themes are as follows:

- Methods of calibration, validation, and accuracy improvement for standard products
- Assessing accuracy and applicability of standard products from the initial Cal/Val phase to the beginning of the operational phase
- Development and sharing of high-level products and analysis tools for fundamental applications
- Experiment and demonstration using new features of ALOS-4 such as ionospheric correction mode, extended swath width, and frequent time-series data.
- Research and assessment on cross-calibration between ALOS-2 and ALOS-4
- Research on new technology for future missions

(2) Notes on application for ALOS-4 RA

This research announcement of ALOS-4 will be implemented under the "non-funded Collaborative Research Agreement".

The approved research themes will be accessible to relevant ALOS-2 data (limited amount) before ALOS-4 launch. After ALOS-4 is launched and the initial Cal/Val phase starts,

uncalibrated standard products will be available for calibration and assessment. In order to acquire essential data such as calibration sites, accepted researchers may submit observation requests under discussions with JAXA. Technical information on ALOS-4 and its products will be provided in advance of its launch.

Please note that the research plan may have to be changed according to the satellite development schedule.

2.1.7 Multi-footprint Observation Lidar and Imager (MOLI)

MOLI stands for Multi-footprint Observation Lidar and Imager which observes forests. MOLI will be installed in the Exposed Facility (EF) of the Japanese Experiment Module (JEM; also known as “Kibo”) on the International Space Station (ISS). The launch target of MOLI is around 2021. The operation period of MOLI is basically one year and extended one-year operation is planned, therefore 2 years operation is planned in total. MOLI can observe highly precise forest parameters i.e. canopy heights and Above Ground Biomass (AGB) at the laser footprint from 51N to 51S, which depends on the ISS orbit. AGB is used as a measurement unit to understand a carbon stock of the forests because it is the dry weight of the tree above ground and approximately a half weight of it is carbon. The canopy heights are also used for many studies because these are comparatively easy to observe and well known that there is strong correlation with canopy heights and AGB. MOLI will provide accurate observation data of forest biomass in semi-global scale, and its objectives are to reduce the uncertainty of forest carbon budget in the global carbon cycle process study, and to contribute as a monitoring tool for the “Reducing Emissions from Deforestation and forest Degradation+” (REDD+) scheme in developing countries, which is one of measures against the climate change.

MOLI has two features, and the first is that it will set multi-footprints for improving the precision of canopy height and the second is that it has a multi band imager. LiDAR, the main sensor, emits two laser beams with 43 m intervals. The pulse repetitions frequency is 150 Hz, therefore the intervals of next footprint is about 50 m. Each footprint has 50 m distance with the adjacent footprint. The ground inclination angle can be estimated comparing elevation value at each footprint observed by MOLI. As estimation of the canopy height or AGB from spaceborne LiDAR waveform, a pulse broadening affects by ground slope significantly. We will correct this effect using estimated ground inclination angle. This function can be expected to contribute to the improvement of the estimation accuracy of the canopy height and AGB. In addition, MOLI has imager and can observe ground around the laser footprint at the same time as LiDAR observation. It has a makes us possible to understand forest conditions around the footprint. For more information on MOLI, please refer to Appendix 7.

(1) Algorithm development for MOLI standard products

This category seeks research proposals contributing to algorithm development for MOLI standard products, especially on the following themes.

- Development of cloud discrimination algorithm (L2)

  This theme is a research to develop an algorithm to determine the presence or absence of cloud influence for each footprint using MOLI LiDAR and imager data.

- Development of ground elevation and slope angle estimation algorithms (L2)

  This theme is a research to develop algorithms to estimate ground elevation from MOLI LiDAR waveform data analysis, and to estimate slope angle from the neighboring footprints' elevation data analysis.

- Development of canopy height and AGB biomass estimation algorithms (L2)

  This theme is a research to develop algorithms to estimate canopy height and AGB using MOLI LiDAR waveform data. JAXA can provide (i) waveform simulator capable of generating waveform data, which simulates MOLI waveform from

airborne LiDAR point cloud data, (ii) airborne large-footprint LiDAR data acquired in November 2016 at five areas in central Japan (Muroto, Ise-Shima, Gero, Izu-Shimoda, Mie-gun), which simulate MOLI observation. In this research we assume the following procedure: (i) developing algorithms to estimate canopy height and AGB from airborne LiDAR point cloud data, (ii) using the estimated values as training and validation data to develop algorithms to estimate canopy height and AGB from MOLI-simulated waveform data (e.g., generated by the above-mentioned MOLI's waveform-simulator, acquired by the airborne large-footprint LiDAR observation, and acquired by other spaceborne LiDAR). In addition, this theme contains other researches: (i) developing a methodology to adjust the estimation parameters for each forest type which will be necessary for applying on the global scale, (ii) collecting airborne LiDAR point cloud data which will be necessary as a reference data for Cal/Val. Furthermore, this theme also contains an algorithm development to estimate canopy height and AGB using not only the MOLI LiDAR data but also the MOLI imager data simultaneously to improve the estimation accuracy.

(2) Algorithm development of MOLI research products

This category seeks research proposals contributing to algorithm development for MOLI research products, especially on the following themes.

- Development of canopy height and AGB maps using MOLI image (L3)

  The MOLI imager will acquire image with an observation swath of 1,000 m, a spatial resolution of 5 m, and 3 bands (green, red, and near infrared), simultaneously with LiDAR observation. This theme is a research to develop algorithms of mapping canopy height and AGB using the MOLI imager data and the L2 products (estimated values from LiDAR waveform data).

- Development of canopy height and AGB maps using other satellite image (L4)

  This theme is a research to develop algorithms of mapping canopy height and AGB using the L2 products (estimated values from LiDAR waveform data) and other satellite image i.e. ALOS-2/PALSAR-2, ALOS-4/PALSAR-3, and GCOM-C/SGLI.

(3) Notes about the MOLI research proposals

On this Research Announcement, proposals will be implemented under the “Commissioned Research Agreement (Funded)” or the “Collaborative Research Agreement (Funded/Non-funded)”. However, Funded agreement is planned to be started from the next fiscal year when budget demands and the development of MOLI are accepted. Currently, we plan to start Funded Agreement from Japanese Fiscal Year 2020, however there are possibilities to change depending on the progress of the MOLI project. In the meantime, please be aware that research will be basically implemented without funding.

2.1.8 Earth Clouds, Aerosols, and Radiation Explorer (EarthCARE)

2.1.8.1 JAXA's Targets of EarthCARE and Mission Success Criteria

The objectives of the Earth Cloud, Aerosol and Radiation Explorer (EarthCARE) mission are to evaluate the radiative forcing of clouds and aerosols, which are great uncertainties in climate change prediction, and to observe the interactions between clouds and aerosols. JAXA EarthCARE satellite which will be launched on JFY2021 defines the success criteria as outputs that clarify the baselines of mission accomplishment (see Table 2.1.8-1). In addition, EarthCARE defines the list of the products and their accuracy criteria (Table 2.1.8-2). This RA invites validation research to confirm these targets through collaboration with JAXA. Detailed technical descriptions for research topics will be described in the next sub-chapter.

Table 2.1.8-1. JAXA EarthCARE/CPR Project Success Criteria

Minimum Success (Decision : at the end of Commissioning and Cal/Val Phase evaluation : at 6 months from launch)	Full Success (Decision : at the end of planned operation evaluation : at 3 years from launch)	Extra Success (Decision : at the end of planned operation evaluation: at 3 years from launch)
• Complete Commissioning and Cal/Val Phase and publish an image data of the observed vertical cloud profile*	• Accomplish with the standard accuracy requirement of CPR-only standard product and produce a dataset which covers over 90% of nominal operation for more than 2 years** • Capable to release more than one research product of CPR • Accomplish with the standard accuracy requirement of a synergy product	• Accomplish with the target accuracy requirement of a CPR standard product , OR • Accomplish with the target accuracy requirement of a synergy product***, OR • Capable to use with data of other satellites, with good integrity

* In Commissioning and Cal/Val Phase, the confirmation of the CPR flight hardware and the ground processing are conducted. Uncorrected absolute value (i.e. relative value) of consecutive Level1 (quicklook) data that last more than one orbit is defined as an image to be published for the minimum success.
** The requirements of the satellite attitude accuracies are to be accomplished for Doppler products.
*** On the premise that the performance requirements of ESA sensors are satisfied for synergy products.

Table 2.1.8-2. JAXA EarthCARE/CPR Product List

Standard L1b, L2a and L2b Products

Sensor(s)	Processing Level	Product Name	Primary Parameters	Resolution Horizontal	Resolution Vertical	Release Accuracy	Standard Accuracy	Target Accuracy	Total Volume (/orbit)
CPR	L1b	CPR one-sensor Received Echo Power Products and Doppler Product	Received Echo Power	0.5km	0.1km	< 4.7dB	< 2.7dB	-	340MB
			Radar Reflective Factor			< 4.7dB	< 2.7dB	< 2.7dB	
			Surface Radar Cross Section		-	-	-	-	
			Doppler Velocity		0.1km	-	< 1m/s (Doppler Vel.)	< 0.2m/s (Doppler Vel.)	
			Covariance of Pulse Pair						
			Spectrum Width						
CPR	L2a	CPR one-sensor Echo Product	Integrated Radar Reflective Factor/Integrated Doppler Velocity/Gas Correction Factor	① 1km / ② *10km*	① 0.1km / ② *0.5km*	-	< 1m/s (Integrated Doppler Vel.)	< 0.2m/s (Integrated Doppler Vel.)	300MB
CPR	L2a	CPR one-sensor Cloud Products	Cloud Mask	① 1km / ② *10km*	① 0.1km / ② *0.5km*	±30%	±10%	±5%	550MB
			Cloud Particle Type			±100%	±50%	±20%	
			Radar Reflective Factor with attenuation correction	*1km*	*0.1km*	< 7.6dB	< 5.7dB	< 4.5dB	
			Reff./LWC/IWC			-	±100% (LWC)	±50% (LWC)	
			Optical Thickness		-	-	±100%	±50%	
MSI	L2a	MSI one-sensor Cloud Poducts	Cloud Flag/Cloud Phase	*0.5km*	-	±15% Ocean ±20% Land	±15%	±10%	630MB
			Optical Thickness of Liquid Cloud			±10%	±100% (converting to LWP)	±50% (converting to LWP)	
			Reff. of Liquid Cloud			±30%			
			Cloud Top Temp./Pressure/Altitude			±1K (CTT)	±3K (CTT)	±1.5K (CTT)	
ATLID	L2a	ATLID one-sensor Cloud Poducts	Feature Mask	0.2km/1km / *10km*	*0.1km*	±100%	±40%	±10%	1200MB
			Target Mask	1km / *10km*		±100%	±40%	±10%	
			Aerosol Extinction Coeff./Backscat. Coeff./Lidar Ratio/Dep. Ratio	*10km*		±60% / ±90%, ±150%/±150%	±40% / ±70%, ±110%/±130%	±20% / ±50%, ±70%/±100%	
			Cloud Extinction Coeff./Backscat. Coeff./Lidar Ratio/Dep. Ratio	1km / *10km*		±50% / ±90%, ±140%/±150%	±30% / ±70%, ±100%/±130%	±15% / ±50%, ±65%/±100%	
			Planetary Boundary Layer Height			±500m	±300m	±100m	
CPR + ATLID	L2b	CPR-ATLID synergy Cloud Poducts	Cloud Mask / Cloud Particle Type	① 1km / ② *10km*	① 0.1km / ② *0.5km*	-	root mean square of errors of one-sensor products	-	520MB
			Reff./LWC/IWC			-		±2μm(Liquid)/ ±20%/±30%	
			Optical Thickness	1km	-	-		-	
CPR + ATLID + MSI	L2b	CPR-ATLID-MSI synergy Cloud Poducts	Cloud Mask / Cloud Particle Type	① 1km / ② *10km*	① 0.1km / ② *0.5km*	-	root mean square of errors of one-sensor products	-	550MB
			Reff./LWC/IWC			-		±2μm(Liquid)/ ±20%/±30%	
			Optical Thickness/LWP/IWP		-	-		-	
CPR+ ATLID+ MSI+BBR	L2b	Four-sensors Synergy Radiative Products	SW/LW Radiative Flux	*10km*	-	-	±25W/m2	±10W/m2	6MB
			SW/LW Radiative Heating Rate		0.5km	-	-	-	

① and ② in the resolution row specifies the combination of horizontal and vertical resolultion. JAXA will produce both ①- and ②-pair resolution products.
The accuracies are defined using the "product resolution" in red italic numbers.
The accuracies of CPR L1b are defined by 10km integration.
Those accuracies except for CPR are assumed under the condition that sensors developed by ESA functioned as expected.
The accuracies of ATLID are based on the information before the change of specifications.
The length of a scene is defined as the length of an orbit divided equally (default : 1scene = 1 orbit)

CPR-ATLID-MSI Synergy Cloud Products and Four Sensors Synergy Radiative Product is the final goal of the EarthCARE mission.
Therefore, they are defined as the standard products, although they will be released one year after the start of MOP.

Table 2.1.8-2. JAXA EarthCARE/CPR Product List (Cont.)

Research L2a&L2b Products

Sensor(s)	処理レベル	Product Name	Primary Parameters	Resolution		Total Volume (/orbit)
				Horiziontal	Vertical	
CPR	L2a	CPR one-sensor Doppler Products	Doppler Velocity/Multiple Scattering Effect	1km / 10km	0.1km / 0.5km	870MB
		CPR one-sensor Rain & Snow Products	LWC*/IWC*/ Rain Rate/Snow Rate			
		CPR one-sensor Vertical Velocity Products	Vertical air motion/ Sedimentation Velocity			
MSI	L2a	MSI one-sensor Ice Cloud Products	Ice Optical Thickness/Effetive Radius of Ice/Ice Cloud Top Temperature/Pressure/Altitude	0.5km	-	500MB
		MSI one-sensor Aerosol Products	Aerosol Optical Thickness (Ocean/Land)/ Angst. Exp.			
ATLID	L2a	ATLID one-sensor Aerosol Extinction Products	Aerosol Extinction Coefficient (Water Soluble/Dust/SS/BC)	1km / 10km	0.1km	400MB
BBR	L2a	BBR one-sensor Radiative Flux Products	Radiative Flux at TOA/BOA	10 km	-	1MB
CPR + ATLID	L2b	CPR-ATLID synergy Particle Mass Ratio Products	Mass Ratio (2D_Ice/IWC)	1km / 10km	- / 0.1km / 0.5km	720MB
		CPR-ATLID synergy Rain & Snow Products	LWC*/IWC*/ Rain Rate/Snow Rate			
		CPR-ATLID synergy Vertical Velocity Products	Vertical air motion/ Sedimentation Velocity			
ATLID + MSI	L2b	CPR-MSI synergy Aerosol Components Products	Aerosol Extinction Coefficient (Water Soluble/Dust/SS/BC)	10km	0.1km	600MB
CPR + ATLID + MSI	L2b	CPR-ATLID-MSI Synergy Cloud Products	Cloud Mask/Cloud Particle Type/Effective Radius (Liquid/Ice)/LWC (with Doppler)/IWC(with Doppler)	1km / 10km	0.1km / 0.5km	1240MB
			Optical Thick./LWP(with Doppler)/IWP(with Doppler)	1km / 10km	-	
		CPR-ATLID-MSI Synergy Rain & Snow Products	LWC*/IWC*/ Rain Rate/Snow Rate	1km / 10km	0.1km / 0.5km	
		CPR-ATLID-MSI Synergy Vertical Velocity Products	Vertical air motion/ Sedimentation Velocity			
		CPR-ATLID-MSI Synergy Ice Cloud Products	Effective Radius (Ice)/Optical Thickness	0.5km	-	

The length of a scene is defined as the length of an orbit divided equally (default : 1scene = 1 orbit)

* in the table : includes with and without Doppler

2.1.8.2 Role of PI and the RA Policy

For this RA, JAXA will fund about 5 research proposals in relation to the validation. The PIs of the selected 5 research topics will belong to the Japanese EarthCARE science team, and will conduct validation activities in collaboration with JAXA Earth Observation Research Center (EORC). Those selected PIs are expected to join in the meetings organized by JAXA and the corresponding research groups, as well as to attend and make an accomplishment briefing at the workshops held approximately once a year.

Although it is still dependent on the budget status, JAXA is planning to distribute up to

approximately 7,000,000 yen per a year, which is the total for all research proposals during the 3-year RA period. As long as they are nonprofit and peaceful organizations, all categories of both domestic and foreign organization may apply to this RA, but funding may differ for each research category and applicant. According to the contribution toward the JAXA mission, JAXA will select funded and non-funded PIs, and will distribute the budget after confirming of the appropriateness of the expenses. JAXA funding is basically restricted to domestic PIs. The selection of the proposals will be conducted through a peer-review process that includes discussions in science/project evaluation boards.

2.1.8.3 Purposes of RA

By recruiting new knowledge and techniques, this RA intends to invite researchers who can efficiently carry out validation activities. The researchers selected in this RA will work in collaboration with JAXA/EORC/EarthCARE group. The selected PIs will belong to the validation team in the Japanese EarthCARE science team.

During the proposal submission, please identify in the proposal, which EarthCARE products the proposed research intends to validate. See Table 2 for the EarthCARE Product List and its accuracy criteria.

2.1.8.4 Research Areas

JAXA seeks proposals for the validation. This RA covers a 3-year research period from JFY 2019 to JFY 2021. Since this RA period will include the launch of EarthCARE, JAXA invites proposals that directly contribute to the validation study of EarthCARE Standard and Research Products. Those researches proposals that are expected to conduct validation efficiently by collaborating with other research plans are also taken into account.

At the end of JFY2019, the validation implementation plan must be submitted. At the end of September 2020, the validation results of JAXA EarthCARE Research A-Train Product must be submitted. For the JAXA EarthCARE Research A-Train Product, please see a homepage (https://www.eorc.jaxa.jp/EARTHCARE/research_product/ecare_monitor_e.html).

At the end of the last year, the initial validation results of the products must be submitted when the satellite is launched as scheduled. Some validation plans may be conducted considering the collaboration with the ESA. This will be discussed during this RA period and reflected to the validation implementation plan.

The EarthCARE mission, through calibration and validation activities, aspires to distribute products whose quality and reliability are assured. Therefore, the validation plans should be highly feasible (i.e., reliable observation instruments and valid data being available, good cost performance being maintained, etc.).

On any of the themes listed below, research applicants are required to directly contribute to the validation of the EarthCARE products by collaborating with JAXA:

(i) Utilization of the existing observation network

The methods to validate EarthCARE products by using long-term/broad coverage data

are invited. By using data from observation sites and networks with instruments such as radars, lidars, sky cameras, sky radiometers, sunphotometers, pyranometers, infrared radiometer, wind profiler, and microwave radiometers, JAXA calls for validation research proposals that quantitatively evaluate the product accuracies, as well as the effect of inhomogeneity in observation variables and errors induced from satellite sampling on the validation. Furthermore, marine observations by research vessels are also one of the possibilities.

(ii) Campaign observation

After the launch, JAXA is planning to conduct campaign observations that aim to compare the satellite products in various ways and call for research proposals that contribute to this activity. Currently, the Headquarters (HQ) of The National Institute of Information and Communications Technology (NICT) (4-2-1, Nukui-Kitamachi, Koganei, Tokyo 184-8795, Japan) is assumed to be a site for this, and instruments such as radars, lidars, sky cameras, wind profiler, and microwave radiometers will be collocated in the NICT HQ.

(iii) Cross comparison with other satellite data

Research proposals on validation by cross comparison of the EarthCARE sensors with other satellite sensors are invited. For example, the products from CPR onboard CloudSat satellite, CALIOP onboard CALIPSO satellite, VIIRS/CERES onboard Suomi NPP satellite, MODIS/CERES onboard Terra/Aqua satellite, AMSR2 onboard GCOM-W, SGLI onboard GCOM-C, and Geostationary satellites such as Himawari-8/9 are assumed for this cross comparison.

(iv) Other validation observation, data acquisition

Research proposals that are not listed above in (i) to (iii), such as other validation activities and acquisition and maintenance of observation data, are also welcome. The topic must directly contribute to the EarthCARE validation.

2.1.9 AMSR2 follow-on mission (AMSR3)

AMSR3 has been proposed as follow-on mission of AMSR2 instrument on board the GCOM-W satellite, and in Pre-Project Phase (or Phase A), as of October 2018. AMSR3 is successor of the AMSR series, including AMSR, AMSR-E and AMSR2, and will continue high-spatial resolution with large real aperture antenna of 2.0 m diameter, passive microwave observation with multi-frequency and multi-polarization of 6.9-89 GHz, and early afternoon orbit. Furthermore, additional high-frequency channels of 166 and 183 GHz enables solid precipitation retrievals and improvement of water vapor analysis in numerical weather prediction system. Figure 2.1.9-1 is mission objectives of AMSR3.

JAXA seeks proposals on development of AMSR3 standard algorithms shown in Table 2.1.9-1. Selected PIs and JAXA will work together in evaluating, implementing, and validating the algorithms, as well as revision of the algorithm theoretical basis document (ATBD) and validation plans. To meet the AMSR3 objectives, retrieval algorithms will require global applicability, robustness, and long-term stability. Algorithms that can be extended and applied to similar microwave radiometers including the AMSR series and historical data records are preferable for integrated retrieval. Computationally efficient, fast-processing algorithms are important for the operational applications of the products.

The "data release" accuracy denotes the minimum accuracy for the data release and the "standard" accuracy is defined as the valuable and standard accuracy. AMSR3 minimum success under success criteria is defined as "all standard products are released one year after the launch with satisfying data release accuracy," and AMSR3 full success is defined as "all standard products achieve standard accuracy three years after the launch."

As described in Chapter 5, the research themes in this category will be implemented under the "Collaborative Research Agreement (Funded/Non-funded)," in principle. Depending on its budget status, JAXA plans to spend about 5 million yen for the first year (JFY2019) for total of the AMSR3 project researches, and about 10 million yen per year for the second and third year (JFY2020-2021).

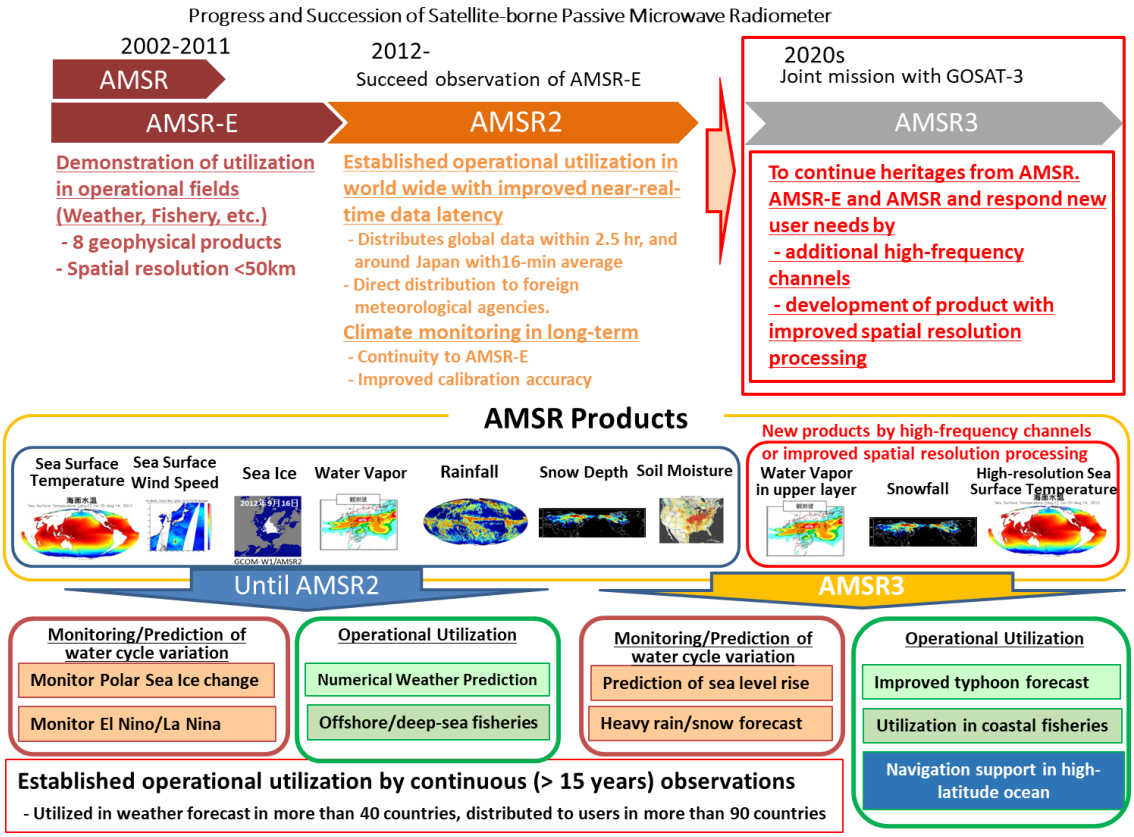

Figure 2.1.9-1 Mission Objectives of AMSR3

Table 2.1.9-1 List of AMSR3 Standard Products (as of October 2018)

Flag	Product	Area	Resolution*1	Range	Release Accuracy	Standard Accuracy	Note
	Brightness Temperature (6-89GHz)	Global	5-50 km	2.7-340 K	±1.5 K	±0.3 K	Global average of differences between Ascending and descending orbits after removing biases from AMSR2 or brightness temperature simulated from numerical prediction model over ocean and clear sky condition.
	High-frequency Brightness Temperature (166,183GHz)	Global	10 km	2.7-340 K	±1.5 K	±1.0 K (TBD)	
N	High-resolution Brightness Temperature (6-10GHz)	Global	20km (10GHz) 30km (6GHz)	2.7-340 K	±1.5 K	±0.4 K	
I	Integrated Water Vapor	Global Ocean	15 km	0-70 kg/m^2	3.5 kg/m^2	3.0 kg/m^2	RMSE VS. GPS and/or radiosonde
N	Integrated Water Vapor over Land	Global Land*	15 km	0-70 kg/m^2	6.5 kg/m^2	3.5 kg/m^2 (TBD)	RMSE VS. GPS and/or radiosonde *sparse vegetation area
	Integrated Cloud Liquid Water	Global Ocean	15 km	0-1.0 kg/m^2	0.10 kg/m^2	0.05 kg/m^2	RMSE VS. optical imager
	Liquid Precipitation (Rainfall)	Global	15 km	0-20 mm/h	Ocean 50 % Land 120 %	Ocean 50 % Land 120 %	Relative error VS. GPM/DPR and/or ground-based radar with 0.5 degree grid average
N	Solid Precipitation (Snowfall)	Global	10 km	0-4mm/h (TBD)	Ocean 80%* Land 150%*	Ocean 80%* Land 150%* (TBD)	Relative error VS. GPM/DPR and/or ground-based radar with 0.5 degree grid average. * Evaluated as monthly accumulation more than 1mm/month
U	Sea Surface Temperature	Global Ocean	50 km (6GHz)	-2 -35 ℃	0.8 ℃	0.5 ℃	RMSE VS. buoy
			30 km (6+7+10GHz)			0.6 ℃	
N	High-resolution Sea Surface Temperature	Global Ocean	20 km*	-2 -35 ℃	0.8 ℃	0.8 ℃ (TBD)	RMSE VS. buoy * Input is high-resolution brightness temperature
	Sea Surface Wind Speed	Global Ocean	15 km	0-30 m/s	1.5 m/s	1.0 m/s	RMSE VS. buoy
U	All-weather Sea Surface Wind Speed	Global Windy Ocean	50 km	0-70 m/s	7 m/s	5 m/s	RMSE VS. dropsonde (wind speed higher than 15 m/s)
	Sea Ice Concentration	Polar Ocean	15 km	0-100 %	10 %	10 %	RMSE VS. optical imager
N	High-resolution Sea Ice Concentration	Polar Ocean	5 km	0-100 %	15 %	15 % (TBD)	RMSE VS. optical imager
	Soil Moisture	Global Land	50 km	0-40 %	10 %	5 %	MAE VS. in-situ observation
	Snow Depth	Global Land	30 km	0-100 cm	20 cm	20 cm	MAE VS. in-situ observation

*1 Resolution depends on orbit altitude that will be defined. At present, the GCOM-W orbit (altitude 699km) is set tentatively.

N: Newly defined products in AMSR3, U: Upgraded to standard products in AMSR3 (release as research product in AMSR2), I: Improved accuracy compared to AMSR2

3. Instructions for responding to this EO-RA2

3.1. Qualifications

If the proposal is for peaceful purposes and has non-commercial objectives, researchers from all categories, except students, of domestic and foreign organizations, including educational institutions, government offices, public companies, private enterprises, and other groups can apply for this EO-RA2.

3.2. Research agreement conclusion

After the proposals are selected, a research agreement should be made between JAXA and the organization to which the Principal Investigator (PI) belongs, using associated terms and conditions to be prepared by JAXA. In principle, the associated terms and conditions of research agreements attached in APPENDIX C will be used. However, JAXA may coordinate with a PI to use a standard contract document depending on the contents of the proposal and its research phase.

All applicants should read Chapter 5 carefully, which describes detailed information on contract matters and the associated terms and conditions of the research agreement in APPENDIX C.

3.3. Research period

The maximum research duration of this EO-RA2 will be 3 years from JFY 2019. However, the progress will be evaluated based on the interim report submitted by the PI at the end of each JFY, 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. Funding may differ for each research category and applicant. The basic policy for funding is as follows:

A) Based on the purpose of this EO-RA2, funding will be partially available for proposals applies to the research on GCOM-W (Algorithm development, Cal/Val, Application), GCOM-C (Algorithm development, Cal/Val, Application), GPM (Algorithm development, Cal/Val, Application), MOLI (Algorithm development, Cal/Val), EarthCARE (Cal/Val) and AMSR3 (Algorithm development), within JAXA's budget limitation. Proposals submitted to other areas may be funded if they provide a substantial contribution to each satellite mission.

B) JAXA funding is basically restricted to domestic PIs, although some exceptional decisions may be made for research of foreign PIs that is necessary to the success of each satellite mission.

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

(2) Earth observation satellite data, etc.

Earth observation satellite data and meteorological data necessary for conducting research and owned by JAXA will be provided free of charge within the authorization and the limitations of distribution capability of JAXA. Available data are listed in Appendix B.

If the provisions of the ALOS and ALOS-2 standard products are necessary for conducting the proposing research, refer to the descriptions in the "2.1.4 Advanced Land Observing Satellite-2 (ALOS-2)" for the policy.

Those who receive Earth observation satellite data shall comply with terms and conditions described in the chapter titled "Providing of Earth Observation Satellite Data by JAXA" in the research agreement.

3.5. Obligations

PIs have different obligations depending on their funding status.

(1) Funded PIs shall submit to JAXA the yearly progress report on the results at the end of each JFY and the final report at the end of the entire research period. Furthermore, funded PIs are required to participate in the workshop organized by JAXA once a year and present the status report. PIs must cover necessary travel expenses to participate in the workshop within the funds provided in this EO-RA2.

(2) Non-funded PIs shall also submit the yearly progress report and the final report. However, such reports can be substituted with papers published during the term. Participation in the workshop is highly recommended. Support of travel expenses to attend the workshop may be considered by JAXA on a case-by-case basis depending on the research content, results, and its progress.

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, technical and societal merits 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) Qualifications, capabilities, and experience of the proposed PI and Co-Investigator (CI)

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

3.7. Late proposals

Proposals or modifications received after the due date specified in this EO-RA2 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 notify JAXA immediately. If the withdrawal is after the agreement conclusion, it is necessary to follow the procedures described in the agreement.

3.9. Cancellation and postponement

JAXA reserves the right to cancel or postpone this EO-RA2 for reasons of JAXA's own. In addition, JAXA assumes no liability for canceling this EO-RA2 or for postponing this EO-RA2 schedule.

3.10. Important dates for selection of proposals

October 17, 2018	2nd Earth Observation Research Announcement Issued
November 30, 2018	**Proposal Due Date**
Mid. March 2019 (planned)	Notification of Selection Results
April or later 2019 (after conclusion of Research Agreement)	Start of Selected Research

3.11. Proposal submission and contact point

Please access to the following web site for the research proposals submission.

Please use the format A and B for the research proposal information in the MS-Word document format (Proposal_Form_E&J.docx). The information is also required to fill in the forms on the web site.

The filled sheets of the proposal cover, schedule, budget summary and data requirements, and the research proposal with complete sets of attachments, such as reprints of papers, should be converted to **PDF (Portable Document Format) and uploaded through the following web site.**

In case of any problems upon upload, such an applicant can send the above complete set via E-mail to the Earth Observation RA Office. The maximum file size acceptable by E-mail is **10 MB**.

Proposal Submission Web Site:

http://eo-ra.jp/2nd_eo_ra_entry_step1_e.html

* Note that proposal submission web site is located outside of JAXA.

Proposal Submission by E-mail:

Earth Observation RA Office E-mail address: Z-EO_RA@ml.jaxa.jp

For any inquiries, please contact the following RA Office:

Earth Observation RA Office
Earth Observation Research Center (EORC)
Tsukuba Space Center
Japan Aerospace Exploration Agency
2-1-1 Sengen, Tsukuba, Ibaraki, 305-8505, Japan
Fax: +81-29-868-2961
E-mail address: Z-EO_RA@ml.jaxa.jp

4. Instructions for proposal contents

4.1. General

(1) Proposals received in response to this EO-RA2 will be used only for evaluation purposes.

(2) The following types of proposals are not acceptable:
   A) Proposals that include restrictions from other institutions or have the potential to infringe on third-party rights.
   B) Proposals that are restricted when distributed or published.
   C) Proposals that are already accepted by the past Research Announcements for the Advanced Land Observing Satellite (ALOS) and the Advanced Land Observing Satellite-2 (ALOS-2). .

(3) Proposals will not be returned to applicants.

4.2. Format

(1) It is highly recommended that applicants make the filled proposal forms, the research proposal descriptions and complete sets of all attachments, such as reprints of papers, in **PDF for the submission.**

(2) Instructions for making the cover sheets, research schedule, budget summary and data requirements can be found in Section 4.3, APPENDIX A and APPENDIX B. Only the following formatting is mandatory in other parts of the proposal:
   A) The page or paper size should be A4 or letter size.
   B) The page number must appear at bottom center of each page, and the name of the applicant must appear in the upper right corner.
   C) Proposals should be word-processed (MS Word) documents in either English or Japanese, with a font size no smaller than 12 points.

(3) Proposals should be brief and to the point, concentrating on substantive material. The main body of the proposal (content described in Section 4.3 (3) Description of proposal) should not exceed 20 pages. 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 one relevant category to which the proposal belongs. Even if more than one category is relevant, choose the most relevant one.
   C) Information of applicants

- Identifying information of the Principal Investigator (PI)
  State the name, job title, organization, address, E-mail address, and telephone and facsimile numbers of the PI.
- Identifying information of the Co-Investigator (CI)
  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.

D) Budget
If the proposal is submitted as a Funded case, provide a budget broken down by year and the total amount in Japanese yen. If the organization of PI needs a certain amount of the overhead, such amount must be identified and added to the direct cost total amount. Otherwise, JAXA will not consider the overhead as necessary.

E) Abstract
Include a concise abstract with less than 500 words in English (or 1,500 characters in Japanese) describing the objective, significance, method of approach, and anticipated results.

F) Endorsement
Provide a signature of a responsible official or authorized representative of the proposing organization for the Research Agreement conclusion.

(2) Description of research proposal
This is the main body of the proposal and should not exceed 20 pages. 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 EO-RA2. 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.
Items (4) and (5) below also should be described in this document.

(3) Work plan (Research schedule)
The research schedule with major milestones and periods of the main and the ramified research activities should be outlined in the form as indicated in APPENDIX A.

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

(5) Personnel

A) Biographical information, experience, papers in related fields
A short biographical sketch, a list of publications, experiences related to this EO-RA2, 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 the CIs in the research. State each CI's role in the proposed research.

(6) Resource requirements (for Funded cases only)
Resource requirements should be described in the form as indicated in APPENDIX B (Budget Summary). Information regarding required resources will be considered and evaluated within the selection process.
If the organization of PI needs a certain amount of the overhead, such ratio and amount must be identified. Otherwise, JAXA will not consider the overhead as necessary.
After the selection and decision on the total amount of funding for each PI, JAXA will send detailed forms for resource requirements to the selected PIs for the final adjustment of funding.
Also, after starting of the selected research, and before the beginning of each subsequent fiscal year, JAXA will send the same forms for resource requirements again, in order to adjust the total budget of each fiscal year.

(7) Data requirements
Instructions for the data requirements by the proposed research 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 Organization"), not to the PI or CI.

(2) A research agreement will be made using associated terms and conditions, such as those in APPENDIX C. The Organization should submit the application form with the necessary documents according to the guidelines by the submission due date. Submission of the application form will be regarded as definite intention of making an agreement with JAXA in accordance with the terms and conditions as stipulated in APPENDIX C, and the agreement will be effective upon issuance of the confirmation sheet by JAXA.

(3) If JAXA determines that extension of a research project is qualified by the annual report at the end of the Japanese Fiscal Year, the research agreement will be extended for 1 year, and up to March 31, 2022. Funded organizations should submit the continuing agreement application form to JAXA at the beginning of every JFY.

(4) Organizations shall comply with the terms and conditions defined in the research agreement.

(5) JAXA may coordinate to make an agreement with the Organization using JAXA's standard contract document if JAXA thinks it appropriate in consideration of the research content and phase.

5.2. Research agreement summary

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

(1) Commissioned Research Agreement (Funded)

- In principle, the Commissioned Research Agreement will be applied to research in the "Algorithm Development" and a part of "Calibration and Validation" category. The Organization shall conduct the research according to the Statement of Work provided by JAXA;
- JAXA will provide the necessary funds and Earth observation satellite data to the Organization to conduct the research as described in the Statement of Work;
- JAXA will own the research results required to be delivered by the Statement of Work (Deliverable Research Results);
- JAXA will retain royalty-free rights to use research results other than the Deliverable

Research Results only for its own research and development purposes;

- In the event JAXA provides prior written consent, the Organization may use the Deliverable Research Results for its own research and development purposes;
- If the Agreement is terminated, the Organization will refund to JAXA any unexpended research funds that have already been paid by JAXA; and
- JAXA will adjust the amount of the research funds based on a fiscal financial statement at the end of a year-on-year contract.

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

- In principle, the Collaborative Research Agreement will be applied to research in categories of "Calibration and Validation" and "Application";
- JAXA will provide the necessary funds (for funded cases) and Earth observation satellite data to the Organization to conduct the research;
- In principle, the research results will be jointly owned by the parties; and
- JAXA will retain the right to use all results including results belonging to the Organization (if any), and the Organization will retain the right to use jointly-owned research results only for its own research and development purposes, without prior consent by the other party.

The difference between a funded agreement and non-funded agreement:

A) Collaborative Research Agreement (Funded)
   - JAXA provides part of the research funds and the Earth observation satellite data. JAXA adjusts the amount of the research funds based on a fiscal financial statement at the end of a year-on-year contract;
   - The Organization shall submit yearly interim reports and the final report to JAXA, and shall participate in the workshops to report research progress; and
   - If this agreement is canceled or terminated, the Organization shall refund to JAXA any unexpended funds that have already been paid by JAXA.

B) Collaborative Research Agreement (Non-funded)
   - JAXA provides the Earth observation satellite data. The Organization shall submit yearly interim reports and the final report to JAXA. However, such reports can be substituted with papers published during the research term; and
   - Participation in the workshops is highly recommended.

(3) Publication of results (both for Funded and Non-funded)
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 and obtain JAXA's consent;
- State in the publication that the results are obtained in this RA research and identify the owner of the rights to the Earth Observation Satellite Data and Meteorological Data

used in such publication; 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.