# 3rd Research Announcement on the Earth Observations (EO-RA3)

## JAXA Satellite Project Research

***AMSR3 & GCOM-W, GCOM-C,***
***GPM & PR-FO, ALOS-2/-4***
***MOLI, EarthCARE***

## Multidisciplinary Application Research

**For EO-RA3 Late Proposals**

Issued: June 10th, 2021
Amendment B: July 25th, 2023
Proposal Due: September 10th, 2023

**Earth Observation Research Center (EORC)**
**Space Technology Directorate I**
**Japan Aerospace Exploration Agency (JAXA)**

空へ挑み、宇宙を拓く
JAXA
宇宙航空研究開発機構
Japan Aerospace Exploration Agency

# Contents



空へ挑み、宇宙を拓く

JAXA

宇宙航空研究開発機構
Japan Aerospace Exploration Agency

B

# 1. Introduction

## 1.1. About the third Research Announcement on the Earth Observations

The Japan Aerospace Exploration Agency (JAXA) / Earth Observation Research Center (EORC) now conducts the third Research Announcement on the Earth Observations (EO-RA3) for its Earth observation satellite projects to enhance the research, utilization, and social implementation of the data from JAXA Earth observation satellites.

In this EO-RA3, we are soliciting research with combined utilization of data from multiple satellites for solving global issues and social issues, in addition to the project research for each satellite as shown below.

- For the individual JAXA Satellite Project Research, EORC calls for the research for algorithm development, Calibration/Validation, and application to enhance the mission objectives of the JAXA satellite missions.
- For the multidisciplinary application research, EORC calls for various research using data from multiple satellites, one combining satellite date with numerical model, artificial intelligence (AI) technology, Big-Data, Geospatial Information, and so on, for industrial promotion and expansion of satellite utilization fields and other social utilization fields such as education.

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 and maximize the outcome for the benefits of the human society.

## 1.2 Outline of the third Research Announcement on the Earth Observations

### 1.2.1 Target Satellite Missions and Data

The target JAXA satellite missions and data of the EO-RA3 are AMSR3/GOSAT-GW & GCOM-W, GCOM-C, GPM & Precipitation Radar Follow-on mission (PR-FO), ALOS-2/-4, MOLI and EarthCARE.

Regarding the JAXA satellite missions that are planned to launch in the future, the launch dates and the planned dates for the data release are based on the current plans and may be changed in the future. And the rules of data provision in this EO-RA3 will be set aligned with the data policy of each satellite mission.

The research proposals for the TANSO series on the Greenhouse Gases Observing Satellite (GOSAT) and its successors GOSAT-2 and GOSAT-GW will be excluded from the scope of this EO-RA3, since the dedicated RAs for these satellites has been conducted in collaboration with the Ministry of the Environment and the National Institute for Environmental Studies.

The research proposals targeted only for the “Himawari”, the Geostationary Meteorological Satellites of Japan Meteorological Agency (JMA), will be also excluded from the scope of this EO-RA3, even though “Himawari” data can be used together with the JAXA satellites data above.

The objectives and overview of the missions are described in the APPENDIX 1~8.

A research proposal applied for the JAXA Satellite Project Research will be evaluated from the viewpoints of its satellite mission objectives/goals. A research proposal applied for the Multidisciplinary Application Research will be evaluated from such viewpoints as effective social benefits and also the satellite mission objectives/goals mainly used.

Multiple JAXA satellites data can be used in one research proposal, however, such a research proposal on submission needs to identify the JAXA satellite/mission mainly used in the research category to apply.

### 1.2.2 Research Categories

In the EO-RA3, 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 Reference Data

(3) Application Research to contribute to satellite mission objectives/goals

(4) Application Research to contribute to better understanding of Earth system science and developing solutions for social and environmental issues

Applicants should consider that JAXA is not a general funding body for the scientific community. This EO-RA3 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 2024 (after conclusion of the research agreement) － March 2025 B

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 Japanese Fiscal Year (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-RA3 calls for the research proposals in three research categories, (1) Algorithm Development, (2) Standard Algorithm Calibration/Validation and Provision of Reference Data, and (3) Application Research to contribute to satellite mission objectives/goals.

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 Reference Data

JAXA seeks research proposals contributing to the calibration and the validation of standard products and to the acquisition of reference 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 reference 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 to contribute to satellite mission objectives/goals

In this category, JAXA seeks research proposals for applications to match or enhance mission objectives by using products from the current following satellite missions; AMSR3 & GCOM-W, GCOM-C, GPM & Precipitation Radar Follow-on mission (PR-FO), ALOS-2/-4, MOLI and EarthCARE.

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

| | Algorithm Development | Standard Algorithm Calibration/validation | Application Research |
|---|---|---|---|
| AMSR3 & GCOM-W | ✔ | ✔ | ✔ |
| GCOM-C | ✔ | ✔ | ✔ |
| GPM & PR-FO | ✔ | ✔ | ✔ |
| ALOS-2/-4 | - | ✔ | ✔ |
| MOLI | ✔ | ✔ | - |
| EarthCARE | - | ✔ | ✔ |

✔: Applicable

- : Not Applicable

## 1.4 About Multidisciplinary Application Research

A) Objective

This research targets "Application Research to contribute to better understanding of Earth system science and developing solutions for social and environmental issues" by utilizing multiple data. Mainly using satellite data provided by JAXA, research that uses satellite data by other organizations as well in a cross-sectional and complex ways, research that utilizes and integrates numerical models such as Earth system models, and research that multiply uses other Big-Data are applicable. Also, important issues related with water cycle research described "Grand Plan for Space-based Water Cycle Observation" (Figure 1. 4-1) are included in this research.

We expect research to contribute to the solution for global issues through medium- to long-term predictions, such as countermeasures for climate changes, as well as for social issues through assessing current state and short-term predictions, such as understanding of land and ocean conditions, countermeasures for disaster prevention, industrial use of agriculture, forestry, and fisheries, application for countermeasures related with public health including infection, application for educational field etc.

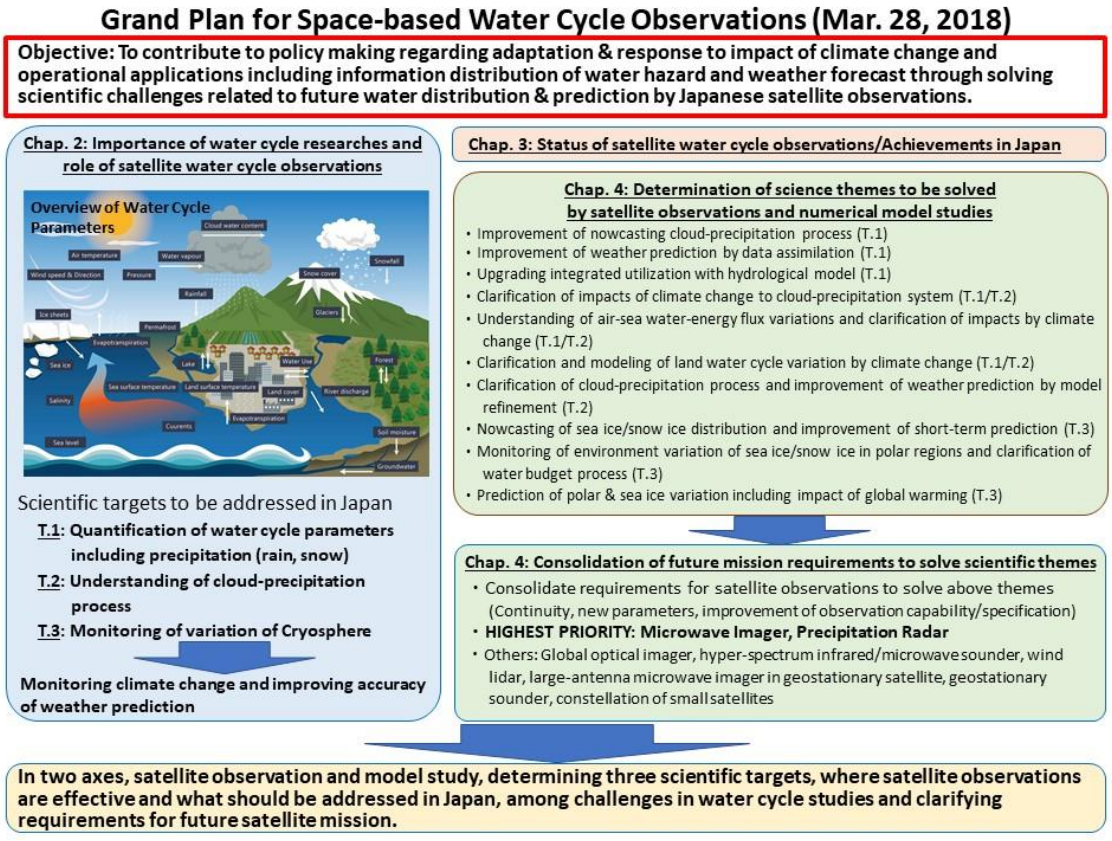


Figure 1.4-1 Overview of "Grand Plan for Space-based Water Cycle Observations": JAXA established committee of experts of satellite observations and model studies in 2018 to develop the Grand Plan to determine three scientific targets, where satellite observations are effective and what should be addressed in Japan, among challenges in water cycle studies and clarifying requirements for future satellite mission.

B) Research Category

Application Research to contribute to better understanding of Earth system science and developing solutions for social and environmental issues

(1) Application research for comprehensive understanding of the Earth system

Global warming and its countermeasures are popular topic in recent years and considered to be one of the important social issues. EORC calls for research themes related to long-term monitoring of the Earth system change, analysis of climate and water cycle change to improve future prediction accuracy, clarification of these mechanism, process research etc. For example, we assume following themes contributing to the construction and improvement of the Earth system model using satellite observation data focusing on JAXA satellites.

・Research that combines various satellites data for aerosol, clouds and precipitation

・Quantitative research on global water cycle

・Quantitative research on material cycle, such as carbon cycle etc.

・Research on monitoring of long-term variation and mechanism clarification of polar region, oceans etc.

(2) Application research to contribute to the solution of social issues

In order to construct a sustainable society minimizing bad effect of global environmental changes such as global warming, we believe it is effective to monitor current condition of environment utilizing earth observation satellite data and improve short-term prediction technology for social implementation. To proceed the utilization of JAXA satellite data on research of earth environmental changes contributing the Sustainable Development Goals (SDG's) and policy making and on research of multidisciplinary application research contributing social implementation and solution of social issues, EORC calls for following research themes.

・Research that multiply utilize JAXA satellite data, etc.

・Technical development to integrate JAXA satellite data, etc. with numerical model

・Application research in the fields of environmental monitoring, meteorology and disaster prevention, agriculture, forestry and fisheries, and public health etc. utilizing new dataset that integrate JAXA satellite data, etc. with numerical model. (see the details on Section 2.2)

・Technical development and application research that proceed coordination between JAXA satellite data etc. and Big-Data or geospatial information

We assume the fields, such as meteorology and disaster prevention, agriculture, forestry and fisheries, public health, and education for these themes.

Research category is as follows,

| Research themes | Application research |
|---|---|
| Application research for comprehensive understanding of the Earth system | ✔ |
| Application research to contribute to the solution of social issues | ✔ |

# 2 Technical descriptions

## 2.1 JAXA Satellite Project Research

### 2.1.1 The Advanced Microwave Scanning Radiometer 3 (AMSR3) and Global Change Observation Mission – Water (GCOM-W)

#### 2.1.1.1 Overview of research targets of AMSR3 and GCOM-W

The Advanced Microwave Scanning Radiometer (AMSR) series includes currently operating AMSR2 on board the GCOM-W satellite and its follow-on sensor, AMSR3. Its targets are long-term and continuous observation for understanding of global water cycle variation/and prediction and operational utilization. Since the launch of AMSR3 is scheduled during the research period of EO-RA3, we call for researches targeting both regarding AMSR3 and GCOM-W.

The GCOM-W satellite, which has been in post-mission period, is one of satellite systems that consist the Global Change Observation Mission (GCOM) along with the GCOM-C satellite (see section 2.1.2). 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 takes over the Advanced Earth Observing Satellite-II (ADEOS-II) mission and transition into long-term monitoring of the Earth.

The GCOM-W satellite "SHIZUKU" was launched in May 2012, and carries the second generation of AMSR series, 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, and. AMSR2 was designed and manufactured based on the experience of the first generation of AMSR series, AMSR on aboard the ADEOS-II and the AMSR for EOS (AMSR-E), which completed its scientific observation in October 2011, on board the Aqua satellite, and is the latest instrument of the AMSR series.

AMSR3, the third generation of AMSR series, is under development to be installed on the Global Observation SATellite for Greenhouse gases and Water cycle (GOSAT-GW), which is scheduled to be launched in Japanese Fiscal Year (JFY) 2023, during this EO-RA3 period. AMSR3 is a 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.

Table 2.1.1-1 shows mission objectives of AMSR3, Table 2.1.1-2 is success criteria of AMSR3 mission, and Table 2.1.1-3 shows mission targets of the GCOM-W satellite. Details of the AMSR3 and GCOM-W satellite and sensor are presented in APPENDIX 8 (for AMSR3) and APPENDIX 1 (for GCOM including GCOM-W).

Table 2.1.1-1 Mission Objective of AMSR3

| Objectives | Area | Mission targets of AMSR3 |
|---|---|---|
| Understanding and prediction of water cycle variation | | Understanding water cycle variation related to climate change and utilizing prediction of impacts to societal life and its response |
| Operational application and contribution to society | Weather | Operationally utilizing AMSR data forecast activities in meteorological agencies, and contributing to improvement of prediction accuracy of tropical cyclones and heavy rainfalls |
| | Fishery | Providing sea surface temperature information, and contributing in search of fishery fields |
| | Navigation support | Providing sea ice concentration and sea surface temperature information, and contributing to production of sea status and sea ice maps related to safety navigation of ships and selection of optimum shipping routes |

Table 2.1.1-2 Success Criteria of AMSR3

| | | Minimum Success | Full Success | Extra Success |
|---|---|---|---|---|
| Evaluation regarding data processing | Product | To achieve release accuracy of all standard products within 1-year after the launch and distribute them to public | To achieve standard accuracy of all standard products within 3-year after the launch | New product is utilized in and contributed to operational application areas (weather, fishery, ship navigation, etc.) during the mission period [Evaluation: at the end of normal mission period] |
| Evaluation regarding data distribution | Latency | - | To achieve latency requirements during system operation period after the release of standard products throughout the mission period [Evaluation: at the end of normal mission period] | - |
| | Operation rate | - | To achieve operation rate of more than 95% throughout the mission period after the release of standard products [Evaluation: at the end of normal mission period] | - |
| Technology development | | To establish technology to observe brightness temperature (TB) in wide frequency ranges from 7 to 183 GHz including new high-frequency channels, and achieve sensor capability in orbit needed to generate TB products | - | - |

Table 2.1.1-3 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. |

In this research category, we call following researches regarding the AMSR series, especially for AMSR3. Please also refer Section 2.1.1.2 for more details.

(1) AMSR3 & GCOM-W Algorithm Development

(a) Maintenance/development/improvement of the AMSR3 standard algorithm including AMSR2

(b) Maintenance/development/improvement of the AMSR3 research algorithm including AMSR2

(c) Development of algorithm from new viewpoint toward AMSR3

(2) AMSR3 & GCOM-W Calibration & Validation

(a) Calibration and validation activities before and after the launch of AMSR3

(b) Validation and evaluation of the AMSR3 standard/research products including AMSR2

(c) Campaign experiments to contribute development and/or validation of AMSR3 standard/research products

(3) AMSR3 & GCOM-W Application

(a) Creation of new research product that could contribute to achieve mission targets add

new values, and/or expand data utilization

(b) Development of Climate Data Record (CDR) with a central focus on the AMSR series

(c) Researches that could contribute to data utilization of the AMSR series in areas of operational, commercial, etc.

(d) Researches that could contribute to the Sustainable Development Goals (SDGs) and/or policy making using the AMSR series

(e) Researches that could interconnect to new societal areas in operational utilization of data from the AMSR series

(f) Researched that could contribute to scientific themes in monitoring of water cycle variation defined for AMSR3

Though it will depends on its budget status, JAXA plans to spend 95 million yen per year during JFY2022 and 110 million yen per year during JFY2023-2024 (after the launch of GOSAT-GW/AMSR3) for total of the AMSR3 & GCOM-W researches (Algorithm Development, Calibration & Validation, Application, Multidisciplinary Application Research mainly focused on the AMSR series).

### 2.1.1.2 Focus of the AMSR3 & GCOM-W project researches

#### (1) AMSR3 & GCOM-W Algorithm Development

JAXA defines the AMSR3 algorithm product development objectives by the following points based on past experiments in GCOM-W. Proposals are expected to conform to these objectives;

- Developing algorithm effectively by utilizing outcomes and data from existing AMSR series, and improving reliability of its quality by using the experiences in AMSR2 that the outside Principal Investigators and internal EORC members have collaborated closely in algorithm development;
- Reflecting calibration/validation results to algorithm improvements by developing algorithms that are considered to establish homogeneous, stable, and highly accurate AMSR series-centered datasets in long-term. Activities to develop and improve algorithms will be conducted continuously to provide uniform products throughout the mission period;
- Developing processing algorithms and/or software respecting stability and immediacy considering expansion of datasets of the AMSR series by considering expansion of use of dataset by the AMSR series, reflecting additional needs and obtained knowledges to algorithm development, and collaborating and sharing information with operational agencies;
- Developing algorithm to correspond the design and/or satellite and sensor as needed in order to secure accuracy and quality of products and sharing those outcomes with

satellite project.

- Publish algorithm theoretical basis documents, list of related papers and information of simulation data, which are obtained as outcomes of algorithm development, through the web site along with general information of the project and calibration/validation information as appropriate; and
- Implementing development of new methods of data analysis and/or utilization and reflecting them to expand possibility of future Earth environmental observation by satellite remote sensing.

JAXA seeks proposals on algorithms to develop and/or improve the following AMSR3 & GCOM-W research products. Please refer APPENDIX 1 for GCOM-W and APPENDIX 8 for AMSR3 for required accuracy of each product and its details. Proposals on development of other research algorithm that is not defined in AMSR3 nor GCOM-W should be applied to the category of AMSR3 & GCOM-W Application in Section 2.1.1.2(3).

I. Atmosphere
   - **Defined in AMSR3 & GCOM-W:** integrated water vapor over land and ocean (TPW), integrated cloud liquid water (CLW), precipitation (PRC)

II. Ocean
   - **Defined in AMSR3 & GCOM-W:** sea surface temperature (SST), sea surface wind speed (SSW), all-weather sea surface wind speed (ASW)
   - **Defined in AMSR3 only:** high-resolution sea surface temperature (HST)

III. Land
   - **Defined in AMSR3 & GCOM-W:** snow depth (SND), soil moisture content (SMC), land surface temperature (LST), vegetation water content (VWC), soil moisture and vegetation water content by land data assimilation technique (LDA)

IV. Cryosphere
   - **Defined in AMSR3 & GCOM-W:** sea ice concentration (SIC), high-resolution sea ice concentration (HSI), sea ice motion vector (SIM), thin ice thickness detection (TSI)
   - **Defined in GCOM-W only:** sea ice thickness (<20cm), sea ice thickness (=>20cm)

V. Long-term dataset by multiple satellites
   - **Defined in AMSR3 only:** Climate Data Record (CDR) for each geophysical parameter defined as standard product by using the AMSR series and other sensors

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 and GCOM-W mission 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.

As shown in Table 2.1.1-2, 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." The "data release" accuracy denotes the minimum accuracy for the data release and the "standard" accuracy is defined as the valuable and standard accuracy.

Research algorithms will include a new algorithm to produce geophysical parameters defined as standard product with further improved accuracy, and ones to produce new geophysical parameters defined as research products. 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.

As described in Chapter 5, proposals in research algorithm development under the "Commissioned Research Agreement (Funded)" or "Collaborative Research Agreement (Funded/Non-funded)," in principle. Depending on its budget status, JAXA plans to spend 59 million yen per year for total of this research category (AMSR3 & GCOM-W Algorithm Development).

### (2) AMSR3 & GCOM-W Calibration & Validation

JAXA seeks proposals contributing to the validation of AMSR3 & GCOM-W standard and research products. It is also expected to feedback information from those calibration/validation activities to develop and improve algorithms and Level 1 calibration activities conducted by JAXA. Merging of proposals might be considered if it is advantageous to human/equipment/financial resources and/or beneficial to achieve the AMSR3 mission targets.

We seek following proposals that contribute to development of AMSR3 standard/research products and/or validation of their accuracy as new priority area in this RA;

(a) Validation targeting before (JFY2022-2023) and after (2024) launch of AMSR3;

(b) Operation of in-situ validation sites of geophysical parameters, for which obtaining the global and operational validation dataset is difficult, and implementation of validation campaign experiments;

(c) Researches to obtain both effective validation results and scientific outputs by collaborating with other research programs and/or campaign experiments is expected; and

(d) Proposals of new validation site that can fill gaps of current in-situ observation data.

Selection and funding will be decided considering total priorities in each area, land, atmosphere, ocean, and cryosphere

I. 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 to maintain and/or expansion of those validation sites and to actively utilize these validation datasets.

II. 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.

III. 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.

IV. 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 Table 2.1.1-4; 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 JFY2022 and 35 million yen

per year for JFY2023-2024 (after launch of GOSAT-GW/AMSR3) for total of this research category (AMSR3 & GCOM-W Calibration & Validation).

Table 2.1.1-4 Definition of the disclosure level (DL)

| Disclosure level (A-D) to be set by data provider | EORC researchers | GCOM & AMSR3 PI | Other Mission PI | Registered users | General users | Usage |
|---|---|---|---|---|---|---|
| (A)<br>EORC Internal use only | OK | - | - | - | - | 1) Cal & Val of AMSR3 & GCOM-W 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<br>2) Redistribution of the raw data is prohibited. |
| (B1)<br>AMSR3 & GCOM related PIs only | OK | OK | - | - | - | 1) Cal & Val of AMSR3 & GCOM-w 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.<br>2) Data use beyond the objectives of the GCOM & AMSR3 mission is prohibited.<br>3) Redistribution of the raw data is prohibited. |
| (B2)<br>AMSR3, GCOM & other PIs only | OK | OK | OK | - | - | 1) Cal & Val of AMSR3, 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.<br>2) Data use beyond the objectives of the AMSR3 & GCOM and other mission is prohibited.<br>3) Redistribution of the raw data is prohibited. |
| (C)<br>Registered users | OK | OK | OK | OK | - | 1) User registration is required.<br>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 describe the use of JAXA's database and the organization of data acquisition in the acknowledgement*1.<br>3) Redistribution of the raw data is prohibited. |
| (D)<br>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.<br>2) Redistribution of the raw data is prohibited. |

*1 follow the JAXA's policy on data use.

**(3) AMSR3 & GCOM-W Application**

In this category, JAXA seeks application researches, which will contribute to the AMSR3 and GCOM-W mission purposes and its follow-on mission, by utilizing the AMSR series data. Especially, JAXA will be intensely focused on following research themes that will emphasize scientific and/or social values of the AMSR series. Research that enhance synergies by combined use of the AMSR series and other satellite missions, such as GCOM-C and GPM, is also appreciated;

(a) Creation of new research product that could contribute to achieve mission targets add new values, and/or expand data utilization

(b) Development of Climate Data Record (CDR) with a central focus on the AMSR series

(c) Researches that could contribute to data utilization of the AMSR series in areas of operational, commercial, etc.

(d) Researches that could contribute to the Sustainable Development Goals (SDGs) and/or policy making using the AMSR series

(e) Researches that could interconnect to new societal areas in operational utilization of data from the AMSR series

(f) Researches that correspond to following research themes, which could contribute to three priority themes in monitoring of water cycle variation defined for AMSR3, such as "Monitoring and Prediction of Extreme Events", "Monitoring of Variation in Polar Region and Short-to-Mid-Term Prediction", and "Long-Term Prediction of Atmosphere-Hydrosphere Variation Accompanied by the Climate Change".

i. Highly-developed observation of cloud-precipitation microphysics and prediction of extreme events related to cloud and precipitation, advancement of GSMaP (refinement of rain/snow observation)

ii. Highly-developed land model and land surface microwave radiative transfer computation, improvement of prediction of water cycle over land by refined rain/snow observation

iii. Monitoring of variation in Polar environment and clarification of water budget mechanism, improvement of prediction of sea ice/land snow in short and middle range time scale

iv. Prediction of variation of Polar region and sea ice in middle-long time scale including impacts by global warming

v. Improvement of cloud-precipitation process in numerical model, impacts of global warming to typhoons

vi. Clarification and modeling of ecosystem-water cycle process over land

vii. Quantitative understanding of atmosphere-ocean fluxes, impacts of air-sea interactions to local scale

Other than existing research products that will be solicited in Section 2.1.1.2(1) "AMSR3 & GCOM-W Algorithm Development," JAXA seeks new research product that will retrieve new

geophysical parameters. 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 16 million yen per year for total of this category (AMSR3 & GCOM-W Application, Multidisciplinary Application Research which is mainly focused on the AMSR series).

### 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).

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. |

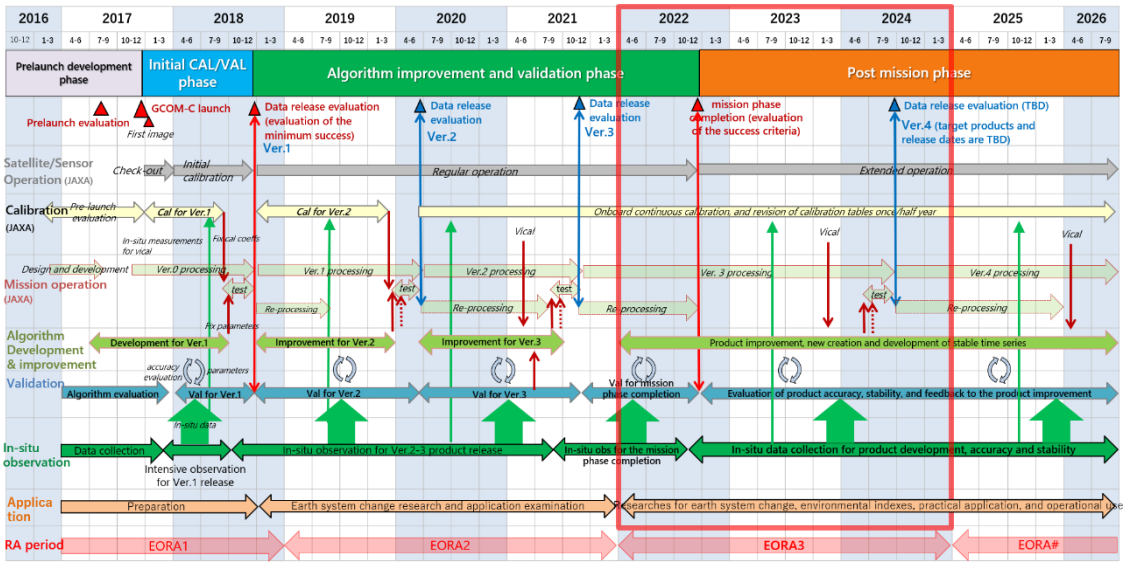

Fig. 2.1.2-1 Timetable of GCOM-C research plan

The GCOM-C PI team focused on the pre-launch preparation in the early phases, Sep. 2009 - Mar. 2013 and Apr. 2013 - Mar. 2016, then has shifted to at-launch product development and validation (Apr. 2016 - Mar. 2019), and currently aims to achievement of the mission targets (Apr. 2016 - Mar. 2019; see Fig. 2.1.2-1 and APPENDIX 1-C). The 17 standard products (totally 29) have been indicated the level of the standard accuracy at the Ver.2 release in June 2020, and remaining products have to be achieved until the end of the regular operation phase (Dec. 2022). Currently we are conducting researches such as vegetation phenology, aerosol-cloud-precipitation processes, their comparison with numerical models, aerosol assimilation, coastal environmental monitoring including red tides, and development of new products such as albedo.

Toward the post mission phase, the GCOM-C target will be deepened, and the GCOM-C researches are more focus on the application researches to be recognized widely the GCOM-C data as a fundamental data of the earth environmental observation through the research collaboration In the period of EORA3 (Fig. 2.1.2-1). The target researches will include application researches relating to the earth system change, environmental monitoring indexes, practical application, and connection to the operational uses. Researches supporting the applications such as product improvement, new creation and development of stable time series, evaluation of product accuracy, stability, and feedback to the product improvement will be continued.

### (1) GCOM-C product development

(a) Maintaining, improving and development of algorithms to produce the highly accurate and stable standard and research products

(b) Creation of new GCOM-C products contributing to the mission goals and solution of the social issues

### (2) GCOM-C product validation

(a) In-situ measurements, collection, and supply to JAXA for the product accuracy and stability improvement
(b) Validation and characterization of the GCOM-C products, and feedback to the algorithm version ups and development contributing to the sensor synergetic use and the numerical model applications

**(3) GCOM-C application**

(a) Researches to develop, analysis and publication of the earth environmental observation data and indexes (e.g., ECV) with long, continuous and stable accuracy mainly using GCOM-C data
(b) Researches to improve knowledge of the earth system and the future prediction, and contribute to the global change mitigation and adaptation through analysis of various GCOM-C products
(c) Researches for the environmental monitoring and near-future prediction about human activities including living environment, agriculture and fishery, and application examination researches to expand operational applications in various areas such as fishery, agriculture, weather forecast, public health, environmental disaster monitoring and so on
(d) Researches contributing SDGs and political decision such as the climate change issues (including the above researches), preservation and sustainable application of ocean and land biological resources, and air pollution

### 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 objectives of the GCOM-C algorithm product development as the followings. 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

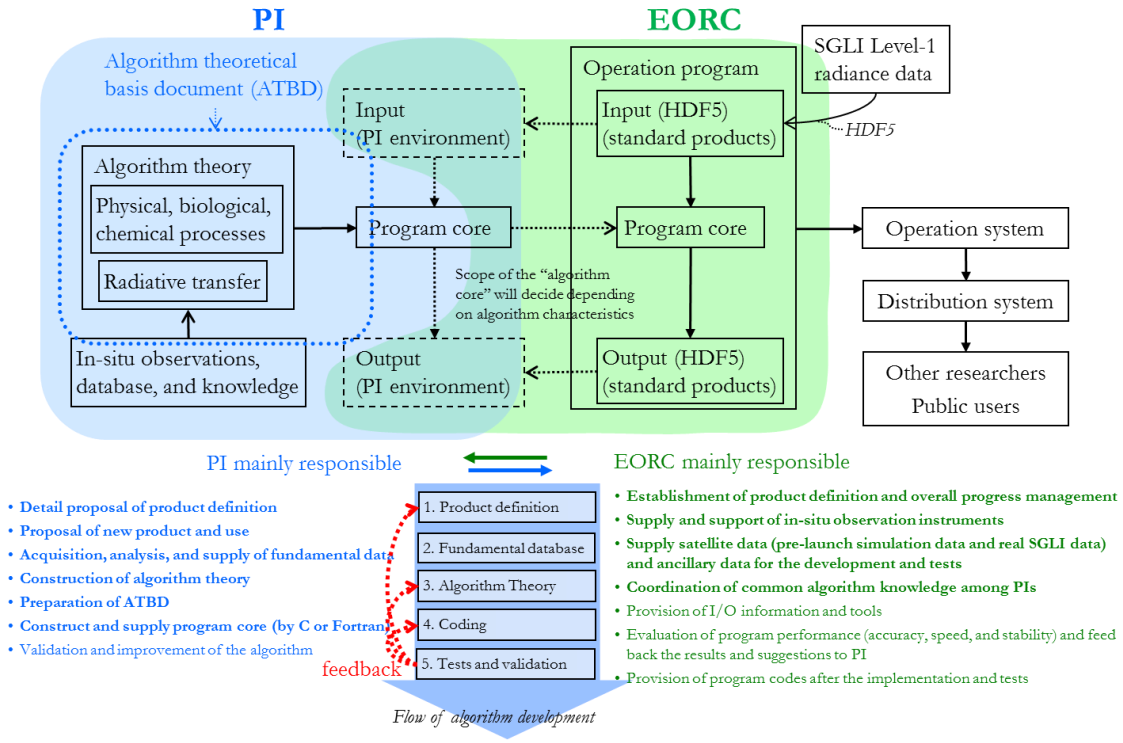


Fig. 2.1.2-2 Example of collaboration and sharing between PI and JAXA in algorithm development. The map should be modified according to algorithm characteristics and volume of the code (C or Fortran code).

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. Plan of the work sharing has to be described in the proposal, and can be optimized according to the progress of the researches. Details on currently defined standard and research products (ref. https://suzaku.eorc.jaxa.jp/GCOM_C/data/index.html) 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 the algorithm improvement in cooperation with the 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, the 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 consider the 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
- Related researches to improve accuracy and stability of spectral and multi-directional surface reflectance, 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], Evapotranspiration index or information about water stress [research product], Land Net Primary Production [research product]

- Development and improvement of stable time series of LAI and fAPAR by effectively using SGLI channels, multi-angle observation, and the canopy radiative transfer
- 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) relating to the land $CO_2$ fixation is encouraged.
- Collaboration with activities of L-2, L-4, L-6, and A-3 is desired.
- Evapotranspiration index (information relating to the vegetation water stress) should cooperate with researches about biological, water cycle processes and agriculture is encouraged.

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

- 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
- Validation of above-ground biomass by UAV and laser scanner measurements considering the canopy radiative transfer 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 improvement of global applicability.

L-5 Land Surface Temperature Group: Land Surface Temperature (LST) [standard product], Fire Detection Index (FDI) [research product]
- LST product development using SGLI thermal infrared channels by quantitatively considering the atmospheric influence and the land surface emissivity
- Collaboration of the heat/water-budget process and model researches are expected for improvement of the accuracy and enhancement of product usage.
- FDI and fire power algorithm will be developed and improved by JAXA.

L-6 Land Cover Group: Land Cover Type [research product]
- Effective construction of validation dataset in collaboration with the research activity of JAXA/EORC land cover classification and its validation are desired.
- Algorithms that use 3D information (L-4) and temporal change analysis by SGLI high-frequency observation are desired.

## 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]
- Stable accuracy of the standard cloud retrieval algorithms applicable to the long-term environmental change analysis will be based on the algorithm developed until previous RA
- Effective use of polarization, multi-angle, near-UV, and $O_2$A band is encouraged
- Collaboration with common subject C-1 is needed.
- 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]
- JAXA will take initiatives in development of the generalized algorithm and integrated use of aerosol products from multiple sensors
- synthetic analysis with numerical models and collaboration with assimilation researches are encouraged
- Contribution to defining candidate aerosol models and improving and validating the radiative transfer process (including polarization) are needed for the atmospheric correction over the land and the ocean.

- Cooperation with AHI and EarthCARE such as research partnerships, work sharing, and participation in workshops is desired for investigating cloud-aerosol interaction.

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 radiative transfer models, its extension to model assimilation, and synthetical estimation with other sensors (e.g., AHI) 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]

- Algorithm improvement 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 for contribution to the ECVs.

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]

- JAXA will take initiatives in development of the standard algorithms of global CHLA
- 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 spectral property modeling) is required.
- Red tide should consider use of fishery and coastal environmental monitoring
- 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 for contribution to the ECVs.

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

- JAXA will take initiatives in developing the SST algorithm.
- Development of model assimilation products by effectively use the SGLI 250 m spatial resolution are desired

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

- Estimation of the carbon-cycle related variables including primary productivity through combined analysis with numerical models or data assimilation mainly using GCOM-C data are desired.
- Researches about acquisition of highly accurate in situ data is needed.
- In order to contribute to $CO_2$ absorption estimation, cooperation with research activities of carbon-cycle of the land and the ocean areas, 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]

- Development and improvement of the algorithm to make long-term accurate products 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.
- International comparison with other sensor products/algorithms to construct long-term datasets of ECVs, and contribution to aerosol models and weather models 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]

- Development and improvement of the algorithm to make long-term accurate products 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 in the individual algorithms (which was the conclusion in the mini workshop in 2011).
- The cloud amount was estimated from whole-sky camera systems which have prepared by JAXA; 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 workshops in 2012 and 2020, and we are developing the algorithm by cooperation with radiative transfer researches in the earth 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, polarization radiation process in the atmosphere, land and ocean surface are encouraged through polarization observation.

C-4 Integrated Analysis of Global Environmental Change

- Cooperation with research on monitoring and predicting the carbon cycle and radiative forcing is needed important to achieve the GCOM mission targets. The new requirements and knowledge from the researches should be reflected to the next satellite product development (development of highly accurate and spatiotemporally stable products or establishment of new variables for the needs). 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/improvement methods can be proposed in addition to the Tables C2 and C3 in APPENDIX 1-C.

Analysis and modeling of the error budget for each pixels/product are also important.

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 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 requested to be open wider user levels as much as possible). The disclosure level can be set with appropriate disclosure levels according to the policy of the provider if the in-situ measurements were ones not funded by JAXA.

### (3) Application Research

This area seeks proposals about application researches contributing to the GCOM-C targets including climate change and practical applications. Especially researches using various information from GCOM-C, collaborating with the multidisciplinary application research (2.2), and demonstrating GCOM-C data to be fundamental data for the Earth environmental monitoring are focused in this RA as follows.

U-1 Continuous monitoring of the global environmental (Earth system) changes relating with the global warming

Development, analysis, and dissemination of observational index (e.g., ECVs) with long-term stable accuracy

U-2 Improving knowledge about the Earth system and future prediction

Researches contributing to improve knowledge of the earth system and the future prediction, mitigation and adaptation through analysis of various GCOM-C products (e.g., vegetation, snow cover, ocean color, cloud, aerosol, albedo, and so on)

U-3 Real-time monitoring and short-term prediction of the large-scale environmental change

Real-time environmental monitoring and near-future prediction to expand operational applications in various areas, such as the atmospheric quality, coastal ocean, snow, sea-ice, vegetation, fishery, agriculture, weather forecast, public health, environmental disaster and so on

U-4 Researches contributing SDGs and political decision such as the climate change issues (including the above researches), preservation and sustainable application of ocean and land biological resources, and air pollution

## 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.

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. Some PI team leaders and sub-leaders will participate in the SGLI subcommittee under the JAXA science advisory committee on the earth observation to feed back our activities to JAXA.

Depending on its budget status, JAXA plans to spend 120 million yen/year for total PI within

the three years of this RA period. The research plan and budget for each PI may revise for the following year depending on the results of PI research evaluation held at the annual PI workshop in winter. JAXA may also select non-funded PIs for researches without the requirement of additional costs or researches indirectly related to the targets of GCOM-C mission.

### 2.1.3 Global Precipitation Measurement (GPM) & Precipitation Radar Follow-on (PR-FO) mission

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.

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.

Currently, the Precipitation Radar Follow-on (PR-FO) mission has been discussed in Japan. In this RA, JAXA calls for the applied research that will lead to increased mission significance and value.

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 95,000,000 yen as annual total budget in the GPM. Partly, some may be covered by the PR-FO mission, depending on its budget status. 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.

#### 2.1.3.1 Algorithm Development

As described in (1)-(3) below, research themes to develop and improve JAXA GPM standard algorithms will be adopted in this RA. In order to directly reflect the results of past developments, research that has been selected as the standard algorithm at launch in the course of the RA will be selected based on continuity. JAXA and PIs will jointly maintain, improve and evaluate the algorithms and install these in JAXA computer systems with appropriate Algorithm Theoretical Basis Document (ATBD). 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 ($\sigma^0$), 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 ($\sigma^0$), 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.

In this theme, we are especially looking for the following research topics.

- 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;
  - 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.

  Development of methods from new perspectives such as machine learning algorithms, and creation of new DPR products such as dramatically improved spatio-temporal resolution and accuracy, and calculation of new precipitation physics.

### (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 radiometer-Infrared combined algorithm (MVK algorithm); and
- Rain gauge correction algorithm (Gauge algorithm.)

In this theme, we are especially looking for the following research topics.

- Development and improvement of the DPR-based precipitation physics databases, development of precipitation estimation methods that take into account its characteristics such as orographic rain, and improvement of databases of precipitation types and profiles;
- 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 Microwave radiometer-Infrared (IR) combined algorithm and the Gauge algorithm applying rainfall correction method by using rain gauges;
- Construction of a common precipitation physics database with DPR and;
- Development of new methods based on new perspectives, such as machine learning algorithms, and creation of new GSMaP products, such as dramatic improvements in spatio-temporal resolution and accuracy

### (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.

The DPR Latent Heat algorithm has the following functions.

- Function to estimate the latent heating rate profile using the precipitation profile of DPR level 2 products as input.

In this theme, we are especially looking for the following research topics

- 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 (GPM_CNT@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 and extreme precipitation phenomenon.
- 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 in the GPM & PR-FO mission

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 using data assimilation of GPM and TRMM in conjunction with numerical models, or in combination with other satellites, sensors, etc.;
- creation of long-term data sets with high continuity using GPM and TRMM data, and creation of products with new added value;
- 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 by combining GPM and TRMM data with other satellite sensors such as cloud profiling radar and atmospheric lidar, for improving the accuracy of precipitation estimation, improving precipitation prediction by the data assimilation, and studying the relationship between cloud/aerosol particles and precipitation processes.

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

### 2.1.4 Advanced Land Observing Satellite-2 (ALOS-2) & ALOS-4

The Advanced Land Observing Satellite-2 (ALOS-2) carries an L-band Synthetic Aperture Radar, called PALSAR-2, as its primary sensor. It was launched in May 2014, and after five years of the regular operation phase and two years of the post-operation phase, ALOS-2 is still in nominal operation. It is expected to continue and upgrade its missions of monitoring disaster, forest, ecosystem, ice and ocean by utilizing its capabilities of high resolution, rapid response for disaster, precise measurement of land displacement, and long-term data archive with the upcoming Advanced Land Observing Satellite-4 (ALOS-4). A detailed description of ALOS-2 is given in Appendix 4.

ALOS-4 is a follow-on mission of ALOS-2. It 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, named PALSAR-3, which is capable of high-resolution observation with 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 satellites. A detailed description of ALOS-4 is given in Appendix 6.

This research announcement (EO-RA3) seeks “non-funded Collaborative Research Agreement” on “ALOS-4 Cal/Val” and “ALOS-2/4 Application Research”, which are looking ahead to the continuing operation of ALOS-2 and the launch of ALOS-4. Proposals may include new research topics through the simultaneous operation of ALOS-2 and ALOS-4 in a limited period of time, although the feasibility of the operation is uncertain.

#### (1) ALOS-4 Calibration and Validation (Cal/Val)

EO-RA3 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, so 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 on “Cal/Val” are as follows:

① Methods of calibration, validation, and accuracy improvement for standard products.
② Assessing accuracy and applicability of standard products from the initial Cal/Val phase to the beginning of the operational phase.
③ Development and sharing of high-level products and analysis tools for fundamental applications.
④ Experiment and demonstration using new features of ALOS-4 such as ionospheric correction mode, extended swath width, and frequent time-series data.
⑤ Research on new technology for future missions.

⑥ New research themes utilizing the simultaneous operation of ALOS-2 and ALOS-4.

For review process, the research proposals that include the following items effectively will be added the points.

① Sharing the information about your calibration equipment, ground measurement data with JAXA.
② Development and sharing of high-level products and analysis tools.

**(2) ALOS-2/-4 Application Research**

To create further achievement of ALOS-2 and ALOS-4, EO-RA3 seeks research proposals on "Application Research" as follows. Please select and indicate the number of the preferred "Research Theme" (I to IV) in your proposal.

Expected research themes on ALOS-2/-4 "Application Research" are as follows;

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.
III. Oceanography, sea-state condition, ship detection and environmental parameters measurement, and their sophisticated method development.
IV. Research for expanding the field of satellite data utilization.

The details are as follows;

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

- 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.
- SAR Interferometry analysis and sophisticated research: multi-temporal, multi-dimensional, and error correction methods.
- Predictions of volcanic activities and landslides etc.
- Infrastructure monitoring: sophisticated method and practical usage.
- SAR polarimetry and interferometry for retrieving disaster related information.
- Improvement of extraction of disaster related information by combined use of ALOS-2 and other satellites.
- ALOS-2 and ALOS-4 mutual usage and time series analysis method.

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

- Forest area monitoring, and early detection of its change.
- Practical usage of forest management issues, i.e., deforestation, forest degradation, reforestation, above-round biomass and carbon stocks estimation.
- Precise estimations of land-use and land-cover including vegetation type classification and their change using polarimetry and phase information.
- Ecosystem related parameters estimation and its sophisticated method.

- Improvement of extraction of forest, wetland and ecosystem related information by combined use of ALOS-2 and other satellites.
- ALOS-2 and ALOS-4 mutual usage and time series analysis method.
- Research Group on the Kyoto & Carbon Initiative.

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

IV. Research for expanding the field of satellite data utilization
- Researches that are significantly value-adding for new research/application fields, such as public health (e.g., infection disease), agriculture and natural resource exploration, geoinformatics, art and cultural science.
- New value-adding researches by combined use with other satellites, e.g., small satellites.
- ALOS-2 and ALOS-4 mutual usage and time series analysis method.

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 artificial intelligence (AI) e.g. deep learning.
⑥ Research proposals fully using the uniqueness of ALOS-2/-4 among other L-band SARs, e.g., fully-polarimetric data and 3-meter resolution data.
⑦ Regarding the technology of the proposal, the current Application Readiness Level, (ARL)[*1] of application, and aiming ARL for this research announcement (EO-RA3).

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

This research announcement of ALOS-2/-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). Details of ALOS-4 data provision will be

announced after the data policy is decided. At the time of this announcement, there is no commitment to ALOS-4 data provision.

For researchers who accepted for the "ALOS-4 Calibration/Validation" theme, uncalibrated ALOS-4 standard products will be available for calibration and assessment from the initial Cal/Val phase. 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.

In past the ALOS-2 RAs, data orders from PIs tend to concentrate at the end of the fiscal year, and 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 "Globe Portal System (G-Portal)" system on

https://gportal.jaxa.jp/gpr/?lang=en

You can also see the Basic Observation Scenario (BOS) of ALOS-2 as future observation plan on

https://www.eorc.jaxa.jp/ALOS/en/alos-2/obs/pal2_obs_guide_e.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 Missing number

B

### 2.1.6 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 JFY2024. 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 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 and improving the accuracy of digital elevation models using ground elevation information. As for the MOLI research products, the following themes are especially encouraged.

- 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 2022, 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.

### 2.1.7 Earth Clouds, Aerosols, and Radiation Explorer (EarthCARE)

#### 2.1.7.1 JAXA's EarthCARE Mission Objectives and Outline of RA target

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.

Two active sensors and two passive sensors will be equipped with EarthCARE satellite. The active sensors will be the Cloud Profiling Radar (CPR), developed by Japan, and the Atmospheric Lidar (ATLID), developed by ESA. The passive sensors will be the Multispectral Imager (MSI) and the BroadBand Radiometer (BBR) developed by ESA. More details about the EarthCARE mission can be found in the Appendix 3.

In this research announcement, we will focus on validation researches of the initial products of EarthCARE scheduled to be launched in JFY2022, and application researches that will lead to developments of utilization methods contributing to the objectives of EarthCARE such as improvements of weather and climate models.

For this RA, JAXA will fund proposals to the validation and application researches. The representative researchers of the selected the research topics (PIs) will belong to the Japanese EarthCARE science team and will conduct validation and application research 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.

Depending on its budget status, JAXA is planning to spend approximately 35 million yen on JFY2022 and approximately 50 million yen per a year (from JFY2023 to 2024) in total for all research proposals. 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. The selection of the proposals will be conducted through a peer-review process that includes discussions in science/project evaluation boards.

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

Table 2.1.7-1 JAXA EarthCARE/CPR Product List

Standard L1b, L2a and L2b Products

| Processing Level | Product Name | Primary Parameters | Resolution Horizontal | Resolution Vertical | Release Accuracy | Standard Accuracy | Target Accuracy | Total Volume (/orbit) |
|---|---|---|---|---|---|---|---|---|
| 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 | | | | | | |
| 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 |
| 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% | |
| 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) | |
| 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 2.1.7-1 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

### 2.1.7.2 Purposes of RA in the JAXA EarthCARE mission

The JAXA EarthCARE seeks the proposals to carry out validation and application research activities of JAXA's EarthCARE standard and research products by new knowledge and effective techniques.

In the proposal submission, please identify which EarthCARE products the proposed research intends to use. See Table 2.17-1 for the EarthCARE Product List.

#### 2.1.7.2.1 EarthCARE Validation research

This RA covers a 3-year research period from JFY 2022 to JFY 2024. 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.

The validation researches are required to follow or enhance the EarthCARE Scientific Validation Implementation Plan (VIP) described by JAXA and ESA. The VIP can be found on the JAXA EarthCARE homepage (https://bit.ly/3bR5Kbi).

In addition, validation activities in the JAXA EarthCARE Research A-Train Product are recommended as a pre-launch validation preparation. For the JAXA EarthCARE Research A-Train Product, please see a homepage (https://www.eorc.jaxa.jp/EARTHCARE/research_product/ecare_monitor_e.html).

When the EarthCARE satellite is launched as planned, initial evaluation results of the EarthCARE products will be required in JFY2023. Some validation plans may be conducted considering the collaboration with the ESA. This will be discussed during this RA period and reflected to the VIP.

The EarthCARE mission, through 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.). Research applicants are required to directly contribute to the validation of the EarthCARE products by collaborating with JAXA.

The following research themes (i)-(iii) were listed in the VIP volume 3. Research proposals that are not listed in (i) to (iii) are also welcome when their topics can directly contribute to the EarthCARE validation.

(i) Utilization of the existing observation network

Long-term/broad coverage data are necessary to validate EarthCARE products. Quantitatively evaluations of the product accuracies will be performed by using data from observation sites and networks with ground instruments.

(ii) Campaign observation

After the launch, JAXA will conduct campaign observations that aim to compare the EarthCARE products. 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 will be collocated in the NICT HQ. The instruments shown in Table 2.1.8-2 are expected to be collocated in the NICT HQ.

Table 2.1.7-2 Instruments expected to be collocated in the NICT HQ for the campaign observations

| |
|---|
| W-band cloud radars |
| L-band wind profiler |
| X-band Multi Parameter Phased Array Radar (MP-PAR) |
| Lidar systems including several wavelength and polarization property measurement |
| Incoherent and coherent Doppler Lidar |

(iii) Cross comparison with other satellite data

Cross comparison of the EarthCARE products with other satellite products will provide good evaluations over the global coverages. 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.

#### 2.1.7.2.2 EarthCARE Application Research

To achieve the mission objectives of EarthCARE, JAXA seeks a wide range of application researches on evaluation and practical use of weather and climate models. Application researches in the following research themes are invited utilizing various information obtained by EarthCARE observation.

(i) Understanding the cloud, aerosol, and radiation processes

Research activities that will be contributed to understanding of the cloud, aerosol, and radiation processes will be invited.

・Progress in understanding of the cloud, aerosol, and radiation processes through integrated highly accurate information using the EarthCARE satellite with global observations of vertical motion in clouds using the Doppler cloud radar (CPR).

・Progress in assessments of climate impacts from various factors, such as black carbon, by enabling quantification of impacts of aerosols on cloud and climate through more detailed identification of cloud and aerosol particles obtained from the ATLID which is the High Spectral Resolution Lidar.

・Progress in atmospheric science through a new description of an atmospheric general circulation from a viewpoint of global vertical motions, using vertical atmospheric winds estimated from the CPR (research product).

・Monitoring climate change by long-term observation of clouds and aerosols using data from CloudSat/CALIPSO and EarthCARE satellites

・Contribution to the comprehensive monitoring of meteorological and environmental elements through synergistic products by linking EarthCARE satellite observations with existing geostationary satellites, polar-orbiting satellites, and other satellite observations.

(ii) Contributing to international frameworks such as the Intergovernmental Panel on Climate Change (IPCC) report through collaboration with climate change projections

Research activities for evaluations and improvements of climate models and contributions to the IPCC report will be invited.

・Climate model validation using EarthCARE observation data and satellite data

simulators such as Joint-Simulator (Hashino et al. 2013, 2016), and model improvement methods based on the validation results and understanding of cloud, aerosol, and radiation processes will be invited.

・In climate change modeling studies, cloud, aerosol, and radiative processes are the largest sources of model uncertainty. Research activities for reducing the uncertainty by using the EarthCARE satellite will be invited.

・In particular, the vertical motion in clouds, which was previously an unknown parameter used for model tuning, will be able to be constrained from EarthCARE observations, and research activities by numerical modeling will be invited toward contributions of future IPCC reports (in particular, the next AR7).

(iii) Implementation in the numerical weather prediction (NWP) and atmospheric quality monitoring

Research activities which will be contributed to implementations in the NWP and atmospheric quality monitoring using EarthCARE observation data will be invited.

・Improvement for the prediction accuracy of operational NWP models

Progress in the understanding of cloud and precipitation processes and improvements in cloud physics schemes using EarthCARE satellite observations are expected to improve the accuracy of precipitation and vertical velocity of the atmosphere. This is also expected to improve the prediction accuracy of operational NWP models (global, meso, and local models, etc.). In addition, by assimilating cloud observation data from the EathCARE satellite, improving initial values and prediction accuracy can be expected.

・Applications in atmosphere quality monitoring system

By assimilating the observation data from ATLID, it is expected to improve aerosol prediction. The ATLID observation data is also expected to be used for Asian dust forecasting and research on volcanic ash.

## 2.2 Multidisciplinary Application Research

### 2.2.1 Objective for Multidisciplinary Application Research

This research targets "Application Research to contribute to better understanding of Earth system science and developing solutions for social and environmental issues" by utilizing multiple data. Mainly using satellite data provided by JAXA, research that uses satellite data by other organizations as well in a cross-sectional and complex ways, research that utilizes and integrates numerical models such as Earth system models, and research that multiply uses other Big-Data are applicable. Also, important issues related with water cycle research described "Grand Plan for Space-based Water Cycle Observation" (Figure 1. 4-1) are included in this research. This grand plan was established in order to contribute to policy making regarding adaptation and response to impact of climate change and operational applications including information distribution of water hazard and weather forecast through solving scientific challenges related to future water distribution and prediction by Japanese satellite observations. In two axes, satellite observations and model studies, the plan determines three scientific targets, "Quantification of water cycle parameters including precipitation (rain, snow)", "Understanding of cloud-precipitation process" and "Monitoring of variation of Cryosphere" where satellite observations are effective and what should be addressed in Japan, among challenges in water cycle studies and clarifying requirements for future satellite mission.

We expect research to contribute to the solution for global issues through medium- to long-term predictions, such as countermeasures for climate changes, as well as for social issues through assessing current state and short-term predictions, such as understanding of land and ocean conditions, countermeasures for disaster prevention, industrial use of agriculture, forestry, and fisheries, application for countermeasures related with public health including infection etc.

Research category is as follows,

| Research themes | Application research |
|---|---|
| Application research for comprehensive understanding of the Earth system | ✔ |
| Application research to contribute to the solution of social issues | ✔ |

### 2.2.2 Evaluation criterion and guidance etc. for Multidisciplinary Application Research

EORC calls for application research themes that contribute to the solution of social issues, mainly using satellite data provided by JAXA. In the selection process, we focus on problem-solving researches that apply for the characteristic of JAXA Earth observation satellites, for example, researches utilizing satellite data provided by other organizations, data obtained by the combination of various numerical models, and information by the combination of Big Data including other humanity and social science fields.

The principal investigator (PI) of each selected proposal will become a science team member of Multidisciplinary Application Research or each satellite mission.

Depending on the budget status, we are planning to spend 20 million yen per year in total at the maximum. With the exception of students, all categories of domestic and foreign nonprofit and peaceful organizations can apply under this RA. However, funding may differ for each research category and applicant. JAXA will select Funded and Non-Funded PI and allocate

the budget based on the novelty of the research and its contribution to the JAXA missions. Funding by JAXA is essentially restricted to domestic PIs.

Applicants should consider that JAXA is not a general funding body for the scientific community. This RA seeks to accomplish the Earth Observation mission's goals and to discover new possibilities for utilizing Earth Observation data.

### 2.2.3 Details of research category calls for Multidisciplinary Application Research

#### 2.2.3.1 Application research for comprehensive understanding of the Earth system

Global warming and its countermeasures are popular topic in recent years and considered to be one of the important social issues. EORC calls for research themes related to long-term monitoring of the Earth system change, analysis of climate and water cycle change to improve future prediction accuracy, clarification of these mechanism, process research etc.

For example, we assume following themes contributing to the construction and improvement of the Earth system model using satellite observation data focusing on JAXA satellites.

・Research that combines various satellites data for aerosol, clouds and precipitation

Aerosols, clouds, and precipitation processes in global warming are considered to be parts of high uncertainty for improving prediction accuracy. Multiple earth observation satellites including JAXA have obtained a certain amount of data on observation of each geophysical quantity so far, however, research to treat them as a series of process in an integrated way has just started. We call for the proposals to clarify this kind of process based on the observation, moreover, to contribute process improvement on climate model.

・Quantitative research on global water cycle

In global warming, global water cycle is also considered to be changed. It is necessary to see the picture of global distribution and changes in water resources in a more quantitative and long-term perspective. We call for the proposals that conduct quantitative assessment of global water cycle utilizing output result of Today's Earth-Global, which is developed by JAXA and the University of Tokyo and operated/provided by JAXA. This is one example of the combined use of satellite data, or combined data of satellite observations and models.

・Quantitative research on material cycle, such as carbon cycle etc.

In order to understand complex Earth system and predict future global warming and its effect, the Earth system models combining various process including land, ocean and atmosphere are developing. As a countermeasure for climate change or diagnostic information to measure its effect, additional improvement of prediction accuracy of the models is expected. In this Earth system process, carbon fixation by vegetation on land and phytoplankton in the ocean and related material cycles play an important role in ecosystem changes caused by greenhouse gases and global warming. It also has mutual effect to human activities such as industry and living environments. This theme calls for proposals to conduct quantitative evaluation and model improvement regarding material cycle of carbon cycle etc. in the model utilizing JAXA provided data.

・Research on monitoring of long-term variation and mechanism clarification of polar region, oceans etc.

Ocean plays an important role in the change of five to several tens of year scales since it has large thermal capacity. In many cases, global-mean variation is small, however, locally, large satellite-detectable variation may appear. It is important for validation and improvement of models to monitor the changes though construction and analysis of high accuracy time series dataset of sea surface temperature, ocean color etc., detect as soon as possible and analyze with numerical models. On the other hand, the polar region responds relatively largely toward variations in heat and energy circulation associated with climate change, such as sea ice and snow cover. Since it is also expected to bring feedbacks for global warming through the radiation budget and changes in sea levels caused by ice sheet melting, the polar region is important monitoring area to trace global warming. In this theme, we call for proposals to conduct quantitative evaluation regarding long-term variation of polar region, oceans etc. and model improvement though understanding of its change mechanism by utilizing JAXA provided data.

#### 2.2.3.2 Application research to contribute to the solution of social issues

In order to construct a sustainable society minimizing bad effect of global environmental changes such as global warming, we believe it is effective to monitor current condition of environment utilizing earth observation satellite data and improve short-term prediction technology for social implementation. To proceed the utilization of JAXA satellite data on research of earth environmental changes contributing the Sustainable Development Goals (SDG's) and policy making and on research of multidisciplinary application research contributing social implementation and solution of social issues, EORC calls for following research themes.

- Research that multiply utilizes JAXA satellite data, etc.
- Technical development to integrate JAXA satellite data, etc. with numerical model
- Application research that utilize new dataset* that integrate JAXA satellite data, etc. with numerical model
- Technical development and application research that proceed coordination between JAXA satellite data etc. and Big-Data or geospatial information

We assume the fields, such as meteorology and disaster prevention, agriculture, forestry and fisheries, public health, and education for these themes.

* JAXA has conducted development of information by combining satellite observation data and numerical models or construction of processing system in cooperation with other organizations. Some of them are already in regular operation and dataset and information are provided. As for its output, information which cannot be obtained only by satellite observations or numerical models is included, so satellite observations and numerical models have a role to complement each other. This research theme assumes proposals that actively utilizes such data sets and information. The systems in operation as of May 2021 are down below.

✧ Today's Earth :
Today's Earth is JAXA's land surface and river simulation system developed under the joint research with University of Tokyo. The system integrates earth observation

technology and models.

The object of Today's Earth is both hydrological research and disaster monitoring. For information on various physical quantities on land related to the water cycle and information on rivers such as river discharge and rate of inundation area, we provide the global version with resolution of 50 km (rivers: resolution of 25 km) and the Japan area version with resolution of 1 km. Archive of past periods, regular operation, data and images are available. Japan area version with resolution of 1 km can provide data at real-time. More details are as follows.
https://www.eorc.jaxa.jp/water/

✧ NEXRA :

NICAM-LETKF JAXA Research Analysis (NEXRA) is a meteorological data assimilation system that utilizes the large-scale computing performance of JAXA's supercomputer (JAXA Supercomputer System Generation 3; JSS3), and the products calculated utilizing this system (Kotsuki et al. 2019).

JAXA has developed NEXRA jointly with the University of Tokyo, Institute of Physical and Chemical Research, and Chiba University. The system of NEXRA is based on the method of Local Ensemble Transform Kalman Filter (LETKF, Kotsuki et al. 2017a, 2017b; Terasaki and Misyohi, 2017) using Nonhydrostatic Icosahedral Atmospheric Model (NICAM, Satoh et al. 2014). More details are as follows.
https://www.eorc.jaxa.jp/theme/NEXRA/index_j.htm

✧ Aerosol Assimilation Data:

This dataset product is the forecast of aerosol properties (Global, hourly, 0.375 degree Gaussian grid) by Model of Aerosol Species IN the Global AtmospheRe (MASINGAR), which is numerical simulation model of aerosols developed by the Meteorological Research Institute, Japan Meteorological Agency.

This product is assimilated by Himawari L3 aerosol optical depth released on Himawari Monitor at 00, 03, 06, and 09UTC. The area lacking aerosol retrievals by Himawari is assimilated at 12 and 18UTC using MODIS/Terra+Aqua Level-3 Value-added Aerosol Optical Depth - NRT dataset.

Processed products are provided on JAXA Himawari Monitor P-Tree System. For the details about assimilation methods etc., please see the reference described on user's guide of Himawari Monitor.
https://www.eorc.jaxa.jp/ptree/userguide_j.html

✧ Ocean Weather Forecast Data

This dataset product is developed by JAXA-JAMSTEC joint research and a part of the Japan Coastal Ocean Predictability Experiment (JCOPE). The product is constructed by data assimilation using high resolution regional ocean model "JCOPE-T" developed by JAMSTEC and observation data including the 6 types* satellite SST data provided by JAXA.

The area covers around Japan (117E-150E, 17N-50N), Temporal resolution is 1-hour and Spatial resolution is about 3km (1/36 deg.) (Pixel number: 1190, Line number: 1190）

* Himawai-8/AHI, GCOM-W/AMSR2, GPM-Core/GMI, Windsat/Colioris, GCOM-C/SGLI, NPP/VIIRS

SGLI and VIIRS SSTs have been added to the assimilation system since Nov. 14, 2019.

For the details about frequency of data update etc., please see the reference described on user's guide of Himawari Monitor.
https://www.eorc.jaxa.jp/ptree/userguide_j.html

When the data assimilation is conducted, we make the bias correction of satellite SST data using GCOM-W/AMSR2 SST data as refer to reference value, because the bias in observation data is undesirable for data assimilation. Near Real-Time data (analysis and forecast) and Best Estimate data are included in this product. Update frequency and period are as follows.

Near Real-Time data: Daily update.
- Analysis (ANAL): recent 7-day (replaced at every update)
- Forecast (FCST): future 10-day (replaced at every update)

Best Estimate data: Weekly update
(update in the beginning of week; Sunday or Monday)
- This is delay mode data which is provided with latency of about two weeks.
- 7-day data are added at every update.

## 3 Instructions for responding to this EO-RA3

### 3.1 Qualifications

If the proposal is for peaceful purposes and has non-commercial objectives, researchers in a certain official research position of 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-RA3.

### 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 the selected proposal, submitted in this EO-RA3 Late Proposal, will be one year in JFY 2024. B

### 3.4 Resources

(1) Funding

Funding will not be applicable, basically, for this EO-RA3 Late Proposal. B

In the case of a newly open RA, JAXA reserves 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-RA3, funding will be partially available for proposals applied to the JAXA Satellite Project Research on AMSR3 & 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, Application) and Multidisciplinary Application Research, within JAXA's budget limitation and the status of approval. Proposals submitted to other areas than above will not be funded.

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

C) Even under the above exceptional decisions, the available funding is basically limited

to the direct research expenses, and not paid for the general administrative expenses as the overhead. If a foreign applicant, with considerations of this rule, intends to submit a funded research proposal, use Form C-1 to describe the detailed items of expenses and the status of agreement on the overhead treatment.

D) 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, multidisciplinary application datasets 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 A/B.

If the provisions of the 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) & ALOS-4" 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-RA3.

(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 Proposals submitted after the due date

B

Proposals or modifications submitted after the due date specified in this EO-RA3 Late Proposal, basically, will not be accepted.

### 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-RA3 for reasons of JAXA's own. In addition, JAXA assumes no liability for canceling this EO-RA3 or for postponing this EO-RA3 schedule.

### 3.10 Important dates for selection of proposals

B

| | |
|---|---|
| August 1st, 2023 | Open call for the 3rd EO-RA Late Proposal |
| **September 10th, 2023** | **Proposal Due Date** |
| February 2024 (planned) | Notification of Selection Results |
| April or later 2024 (after conclusion of Research Agreement) | Start of Selected Research |

The updated schedule of this EO-RA3 Late Proposal will be announced in the JAXA EORC web site (https://earth.jaxa.jp/en/research/cooperation/ra3/index.html).

### 3.11 Proposal submission and contact point

Please access to the following web site for the ID registration before submission of a research proposal and register your e-mail address for this RA Office to send farther information on the Proposal Submission Web Site. Please do NOT use any free-mail address such as Gmail, Yahoo! Mail and etc. to avoid any problems in the mutual communication.

On the submission of your research proposal, please use the document formats (Form A, Form B, and Form C (C-1 or C-2)) for the research proposal information in the MS-Word document format. The information on the proposal is also required to fill in the forms on the web site.

The **filled sheets of the Forms A, B and C**, and the **detailed research proposal document**

**with complete sets of attachments**, such as reprints of papers, **must be uploaded through the Proposal Submission Web Site.**

**Proposal ID Registration Web Site:**

Please refer to the JAXA EORC web site.
(https://earth.jaxa.jp/en/research/cooperation/ra3/index.html)

* Note that the web site to submit proposals, to be informed by e-mail after the registration, is located outside of JAXA's web site.

**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

## 1.1 General

(1) Proposals received in response to this EO-RA3 will be used only for evaluation and selection 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.

(3) Proposals will not be returned to applicants.

## 1.2 Format

(1) Applicants make the filled proposal forms in the prepared MS-Word file formats, the detailed research proposal descriptions and complete sets of all attachments, such as reprints of papers, convert into the **PDF** document formats and **upload them through the Proposal Submission Web Site**. It is **NOT accepted** to be sent **by e-mail:**
   A) Form A needs to describe the proposal title, the information of PI, CIs and the responsible officer for the conclusion of the research agreement. The information is also required to fill in the form on the Proposal Submission Web Site and necessary to be identical to each other.
   The file name to be uploaded should be renamed by using PI's name and the acronym of affiliation, for example, "EORA3_FormA_name_ABC.pdf".
   B) Form B needs to describe the research schedule with a breakdown of the period of each research item.
   The file name to be uploaded should be renamed by using PI's name and the acronym of affiliation, for example, "EORA3_FormB_name_ABC.pdf".
   C) Form C (C-1 or C-2; depending on 'C-1: Funded' or 'C-2: Non-Funded' proposal) need to describe the resources necessary for the proposed research.
   The file name to be uploaded should be renamed by using PI's name and the acronym of affiliation, for example, "EORA3_FormC-1_name_ABC.pdf".
   D) The detailed research proposal document and attachments should be written in align with the following instructions (2) and item 4.3, although JAXA does not set any specifically designed format to be used, and converted into the PDF document format before upload.
   The file name to be uploaded should be named by using PI's name and the acronym of affiliation, for example, "EORA3_Main_name_ABC.pdf" for the detailed proposal descriptions and "EORA3_Ref_name_ABC.pdf" for the attachments.

(2) Instructions for making the cover sheet (Form A), research schedule (Form B), budget summary and data requirements (Form C-1 or C-2) 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 one proposal when submitting via the Proposal Submission Web Site. If more than one proposal is to submit, it is necessary to make an individual ID for each proposal and set up each page on the Proposal Submission Web Site.

### 1.3 Proposal contents

(1) Cover sheet (Form A) and input form on the Proposal Submission Web Site
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 and Funded/Non-funded proposition (Web Site only)
Choose one relevant category to which the proposal belongs. Even if more than one category is relevant, choose the most relevant one.
And choose either Funded or Non-funded proposition. Please note that 'Funded' cannot be chosen in the Non-funded only research category.
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). (Name and organization are only in Form A)
One research team should consist of only one PI, or one PI and several CIs.
D) Information of the person in charge of the endorsement (Form A only)
Identify the information of a responsible official or authorized representative at the proposing organization/institution for the Research Agreement conclusion.

Please note that the descriptions on the above item from A) to C) are also required to put in the page of the Proposal Submission Web Site, and these descriptions must be identical to each other.
And note that any proposals without endorsement by the responsible officials must not be submitted and, at the time of submission, need to check the "Endorsed proposal" box on the Submission Web Site.

(2) Work plan (Research schedule) (Form B)
The research schedule with major milestones and periods of the main and the ramified research activities should be outlined in this form.

(3) Resource requirements (for Funded cases only) (Form C-1)
Resource requirements, in the case of any research budget is preferred to provide for the proposed research activities, should be described in the form as indicated in APPENDIX A (Budget Summary). It is necessary to provide a budget broken down by year and the total amount in Japanese yen. 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.
It is also necessary to input the total budget information of the resource requirements on the page of the Proposal Submission Web Site.
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, prior to the conclusion of the research agreement on one Japanese fiscal year basis.
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.

(4) Data requirements (Form C-1 or Form C-2)
Instructions for the data requirements by the proposed research are also included in APPENDIX A/B.

(5) Detailed descriptions 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-RA3. 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 (6) and (7) below also should be described in this document.

Abstract should be described also on the page of the Proposal Submission Web Site.
It should include a concise summary with less than 500 words in English (or 1,500 characters in Japanese) describing the objective, significance, method of approach, and anticipated results.

(6) 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.

(7) Personnel
A) Biographical information, experience, papers in related fields
A short biographical sketch, a list of publications, experiences related to this EO-

RA3, 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.

## 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. So, a signature of a responsible official or authorized representative of the proposing organization for the Research Agreement conclusion is necessary as the endorsement by the organization.

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

(4) JAXA may coordinate to make an agreement with the Organization using JAXA's other 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.
   - 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.