# 4th Research Announcement on the Earth Observations

## Earth Observation Research Program

## JAXA Satellite Project Research

***AMSR3 & GCOM-W*、*GCOM-C*、*GPM & PMM*、*ALOS-2/ALOS-4*、*MOLI*、*EarthCARE***

**For EO-RA4 Late Proposals**

Amendment A: April 14th, 2025
Proposal Due: June 18th, 2025

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

# Contents

# 1. Introduction

## 1.1 The Fourth Research Announcement on the Earth Observations

The Japan Aerospace Exploration Agency (JAXA)/Earth Observation Research Center (EORC) now conducts the Fourth Research Announcement on the Earth Observations (EO-RA4) for its Earth observation satellite projects to enhance the research, utilization, and social implementation of the data from the JAXA Earth observation satellites.

This call for proposals is intended to promote the utilization of JAXA's Earth observation satellite data in various fields of society, to develop newer approaches for utilization, and to promote earth science research through the cooperation of researchers and engineers from Japan and overseas. In addition, we aim to maximize research results by developing highly accurate and valuable data products and promoting advanced research through data application and utilization to ensure the success of satellite missions.

For satellite earth observation to elucidate the complex earth system, it is necessary to organize and integrate the individual Earth observation mission and view them as a comprehensive system (such as "System of systems") to solve important issues. The fourth Earth Observation Research Announcement has reorganized the research categories into the "Earth Observation Research Program" and is calling for research proposals that contribute to a comprehensive understanding of the Earth system and to solving problems faced in the process of social implementation, as well as the research proposals for "Satellite Project Research" that meet the mission objectives of JAXA's earth observation satellites. The Program is also open to the Satellite Project Research themes that meet the mission objectives of JAXA's Earth observation satellites.

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

### 1.2.1 Target Satellite Missions and Data

The target JAXA satellite missions and data of the EO-RA4 are the Advanced Microwave Scanning Radiometer 3 (AMSR3) on board the Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW) & Global Change Observation Mission – Water (GCOM-W), the Global Change Observation Mission – Climate (GCOM-C), the Global Precipitation Measurement (GPM) & Precipitation Measuring Mission (PMM), the Advanced Land Observing Satellite-2 (ALOS-2) & Advanced Land Observing Satellite-4 (ALOS-4), the Multi-sensor Observation Lidar and Imager (MOLI) and the Earth Cloud Aerosol and Radiation Explorer (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-RA4 will be set aligned with the data policy of each satellite mission.

Considering the situation that the Ministry of the Environment and the National Institute for Environmental Studies are jointly conducting a public call for research on the Greenhouse Gases Observing Satellite (GOSAT), GOSAT-2 and TANSO series carried by the GOSAT-GW, which will become No.3 of GOSAT, research on algorithm development and calibration validation using only the TANSO series is not eligible for this EO-RA4, while applied research that combine the TANSO series with other data may be submitted.

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-RA4, even though "Himawari" data can be used together with the JAXA satellite data above.

The objectives and overview of each satellite mission are described in the APPENDIX 1~7.

### 1.2.2 Research Categories

In the EO-RA4, EORC invites the following research categories, as described in the figure 1.2.2-1.

I. Earth Observation Research Program (see Section 2.1 for details)
 (1) Disaster Prevention, Mitigation and Resilience
 (2) Contribution to climate change solutions (Atmosphere, Land, and Ocean)
 (3) Contribution to social economic assignment

II. Satellite Project Research (see Section 2.2 for details)
 (1) Algorithm development
 (2) Calibration/validation (Cal/Val) of the standard products and development of the reference data for the Cal/Val
 (3) Applied research that falls under the "Earth Observation Research Program" and that leads to achieve the objectives/goals and create new outcomes of each satellite mission


**Satellite Project Research**

| | | |
|---|---|---|
| (A) AMSR3 & GCOM-W | ①Algorithm Development ②Calibration/Validation | ③Earth Observation Research Program (Applied Research) |
| (B) GCOM-C | ①Algorithm Development ②Calibration/Validation | ③Earth Observation Research Program (Applied Research) |
| (C) GPM & PMM | ①Algorithm Development ②Calibration/Validation | ③Earth Observation Research Program (Applied Research) |
| (D) EarthCARE | ①Algorithm Development ②Calibration/Validation | ③Earth Observation Research Program (Applied Research) |
| (E) ALOS-2/ ALOS-4 | ①Algorithm Development ②Calibration/Validation | ③Earth Observation Research Program (Applied Research) |
| (F) MOLI | ①Algorithm Development ②Calibration/Validation | N/A |
| (G) Multi-satellite utilization | N/A | ③Earth Observation Research Program (Applied Research) |

**Earth Observation Research Programs**

| | | |
|---|---|---|
| (1) Disaster Prevention, Mitigation and National Resilience | | ①Preparing for and responding to water-related disasters, earthquakes, volcanic eruptions, etc.<br>②Fundamental information and digital national land for national resilience<br>③Improving forecast of extreme events that cause meteorological and water-related disasters |
| (2) Contribution to Climate Change Solutions | (2-a) Atmosphere | ①Observation of GHG concentration distribution in the earth's atmosphere and estimation of $CO_2$ absorption, $CO_2$ and $CH_4$ emissions by source, and contribution toward GST<br>②Clarifying true state of past and present global warming and improving future projections and understanding radiative forcing<br>③Monitoring and predicting water cycle variations<br>④Adaptation to variation of water resources |
| | (2-b) Land | ①Management of forests as $CO_2$ sinks, and carbon budget<br>②Understanding and predicting biodiversity and its environment<br>③Understanding and predicting of terrestrial hydrology and cryosphere |
| | (2-c) Ocean | ①Ocean carbon budget and cycle<br>②Monitoring/prediction and conservation of the ocean environments<br>③Marine bioresource management<br>④Understanding and predicting environment changes in the polar oceans |
| (3) Contribution to socio-economic issues | | ①Contribution to socio-economic benefits related to carbon neutrality<br>②Strengthening food security<br>③Smart agriculture, forestry and fishery<br>④Acquisition and use of environmental information related to public health<br>⑤Creation of environmental information related to atmospheric environment<br>⑥Creation of information for decision-making through combined use of satellite and socio-economic data<br>⑦Providing information to secure natural resources and energy<br>⑧Contributing to climate change solutions through ESG Investments<br>⑨Education in remote sensing |

Figure 1.2.2-1 Research Categories of the EO-RA4
"Applied research" was set in the Satellite Project Research in the previous EO-RA3

The Earth Observation Research Program targets “research that contributes to a comprehensive understanding of the Earth system and to solving problems faced in the process of social implementation," mainly using satellite data provided by JAXA.

Satellite Project Research covers research related to the development of satellite-specific algorithms and the Cal/Val of standard products. “Applied Research” that was set up in each Satellite Project Research in the 3rd Earth Observation Research Announcement (EO-RA3) is integrated into the "Earth Observation Research Program". Please also refer to the "JAXA Satellite Project Research" (Section 2.2) for applied research that falls under the Earth Observation Research Program and that will lead to achieve the mission objectives/goals and create new outcomes of each satellite project. Proposals that use data from multiple satellites and that are not tied to a specific satellite project are eligible for "Multi-satellite utilization".

### 1.2.3 Evaluation criterion and guidance for research announcement

For research proposals that fall under Satellite Project Research, evaluation and selection will be conducted from the perspective of the target satellite mission. Proposals that fall under the Earth Observation Research Program will be evaluated and selected not only from the perspective of using Earth observation data to address social issues, but also from the perspective of the mission of the target satellite (or satellites to be used primarily when data from multiple satellites is to be used). For this reason, we ask the applicants to clarify which satellite mission will be the main target of their research and which satellite data will be used in it when they submit proposals.

Proposals will be selected based on peer review by experts and discussion by the Science and Project Evaluation Committee, with the final decision made by JAXA. Relevance to the objectives, intrinsic validity of the research, and cost are the main points in selecting proposals (see Section 3.6).

The RA accepts applications from any domestic or foreign institution (except students) as long as the research is for non-profit and peaceful purposes; however, the conditions for research funding will vary depending on the nature of the research and the applicant. JAXA will select non-funded and funded PIs and allocate expenses, taking into consideration the novelty of the research and its contribution to the JAXA mission. In principle, JAXA's research funding is limited to PIs in Japan. Funding will not be applicable, basically, for this EO-RA4 Late Proposal. A

When applying, please keep in mind that the proposed research is not being conducted within the framework of general funding for the science community. The EO-RA4 seeks to achieve the objectives of the Earth observation mission and to identify new potential uses for Earth observation data. Therefore, research proposals must fully describe plans for the use of Earth observation satellite data.

### 1.2.4 Research Period

From October or later 2025 (after conclusion of the research agreement) to March 2028, in Japanese Fiscal Year. A

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).

### 1.2.5 How to apply and documents to be submitted

Applications must be submitted via the application website (see Section 3.11), and in addition to entering the required information on the website, applicants will need to upload the following documents (PDF files) to be submitted, including the proposal form. Please read Chapter 4 "Proposal Preparation Instructions" and Chapter 5 "Description of research agreement" before preparing and submitting the required documents.

Documents to be submitted:

- Application Form A (Research proposal title, proposer, and institutional affiliation information) (*1)
- Application Form B (Research plan)
- Application Form C (Satellite data and research funds necessary to conduct the research) (*2)
- Research proposal
- A set of appendices such as reprints of articles, etc. (if necessary)

(*1) The information of the responsible person in the proposer's organization or the representative authorized to enter into the research contract is required as the approving party.

(*2) The format of Application Form C is different for funded proposals and non-funded proposals; funded proposals that only use ALOS-2/ALOS-4 are not eligible (only non-funded proposals based on the provision of a limited number of funded data are eligible).

### 1.2.6 Submission due date

**June 18th, 2025 (Wed) 12:00 JST (03:00 UTC)**

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### 1.2.7 Measures against misconduct in research

In accordance with the "Guidelines for Responding to Misconduct in Research" (issued on August 26, 2014, Special Committee on Research Activities, Council for Science and Technology, Japan), etc., if misconduct in research activities (fabrication, falsification, plagiarism, etc.) is found in connection with the research proposals in this call, the research will be discontinued, all or part of the research funds, etc. will be returned. In addition, we may take measures to publicize the fact. Please refer to the following website for the "Guidelines on Responding to Misconduct in Research.

https://www.mext.go.jp/a_menu/jinzai/fusei/__icsFiles/afieldfile/2015/07/13/1359618_01.pdf

## 2. Research Category

### 2.1. The Earth Observation Research Program

#### 2.1.1 Target of the Earth Observation Research Program

The "Earth Observation Research Program" as defined in this RA is a program that aims to have satellite observations as an essential function in addressing the "climate crisis," an urgent issue facing humanity, as well as in Japan's disaster prevention and national resilience and economic security, and to play a fundamental role in social systems. The Program focuses on three fields from a research perspective: 1) disaster prevention, mitigation and national resilience, 2) contribution to climate change countermeasures, and 3) contribution to socio-economic issues. These fields are selected to addressing climate change as a priority issue for humanity, and scientific issues and strengthening social infrastructure that Japan must address from the view point of research.

Based on satellite data provided by JAXA, the Program covers research that uses a wide range of data in a cross-sectional and integrated way, including satellite data provided by other organizations; research that uses and integrates Earth system models and numerical models; and research that uses other big data in an integrated way. The Program targets research that "deepens and develops existing results or finds new value, thereby increasing the scientific and social significance of satellite data and contributing to the resolution of issues faced in the process of achieving a comprehensive understanding of the Earth system and social implementation."

We look forward to research proposals that aim to contribute to solving social issues through understanding the current situation and making predictions, such as contributing to solving global issues through medium-to-long-term predictions like measures against climate change, understanding the state of land and oceans, disaster prevention, socio-economic benefits related to carbon neutrality, food security, industrial use in agriculture, forestry and fisheries, obtaining environmental information related to public health including infectious diseases and using it for measures, creating information for decision-making through the combined use of atmospheric environment, satellite and socio-economic data, providing information to secure natural resources and energy, contributing to measures against climate change through ESG investment, and use in the education field.

This also includes research that will lead to the achievement of individual JAXA satellite mission objectives. For research using a single JAXA satellite, please also check the details of the research content being solicited for each satellite project (Section 2.2).

The research categories of the Earth Observation Research Program are shown in Table 2.1.1-1. An overview of each research category is provided in Section 2.1.3.

Table 2.1.1-1 Earth Observation Research Program - research categories

| | | |
|---|---|---|
| (1) | Disaster Prevention, Mitigation and National Resilience | |
| (2) | Contribution to Climate Change Solutions | (2-a) Atmosphere |
| | | (2-b) Land |
| | | (2-c) Ocean |
| (3) | Contribution to socio-economic issues | |

### 2.1.2 Evaluation criterion and guidance for the Earth Observation Research Program

This Program will focus on problem-solving research that utilizes the unique features of JAXA's Earth observation satellites, utilizing information obtained by combining satellite data provided by other organizations, data obtained by combining various numerical models, and other big data including those from the humanities and social science field. For research that primarily uses JAXA's single satellites, selection will be based on the evaluation criteria for the relevant Satellite Project Research.

The Principal Investigator (PI) of each selected proposal will become a science team member of the Earth Observation Research Program or each satellite mission.

Depending on the budget status, we are planning to spend a total of 25 million yen per year for research proposals, as well as an applied research budget for each satellite project.

### 2.1.3 Details of research proposals called for as the Earth Observation Research Program

**(1)** Disaster Prevention, Mitigation and National Resilience

Countermeasures against increasingly frequent and severe meteorological and water disasters, as well as earthquakes and volcanic eruption disasters, are an important and urgent social issue in Japan. In response to meteorological and water-related disasters, Earth observation satellites monitor the extreme phenomena that cause disasters to grasp their actual conditions, and the data obtained is used to create initial values for weather forecasts, contributing to improving the accuracy of forecasts. In short-term weather forecast systems, in addition to understanding the horizontal distribution of temperature, water vapor, and wind in wide-area, it is important to understand the vertical profile (3-D) and the temporal variation (4-D) for evolution of future forecasts. Satellite observation data can also contribute to improving weather forecast models through validation and/or understanding of model process. For example, to understand the central pressure, maximum wind speed, and internal structure of a typhoon over the ocean, as well as to clarify the generation mechanism of line-shaped precipitation systems, it is necessary to observe the three-dimensional structure of water vapor, wind, etc., and here too, three-dimensional observations by satellites will make a significant contribution to future research and development in those fields.

Furthermore, information on rainfall and flooded areas obtained from earth observation satellites plays an important role in improving the accuracy of forecasts of inundation and flooding caused by heavy rainfall and/or typhoons. Improving those forecast accuracy will enable meteorological and water-related disasters to be predicted with a longer lead time, so better disaster preparedness and response can be implemented.

In addition, to grasp the damage situation after a disaster occurs, it is important not only to improve satellite observation data analysis technology, but also to compare data before and after the disaster based on the latest basic land information. For this reason, it is desirable to frequently update topographical information (3-D) including height information, as well as land use and its classification. Increasing the frequency of observations will enable real-time risk assessment and its updates, as well as understanding of the damage situation, which will contribute to appropriate evacuation of people and the maintenance of social infrastructure.

This research program aims to demonstrate the effectiveness and contribution of satellite observations and the information obtained from them in each phase of the so-called "disaster prevention cycle" for a wide variety of disaster events and calls for research proposals to further advance these capabilities.

**Expected research themes:**

① Preparing for and responding to water-related disasters, earthquakes, volcanic eruptions, etc.
② Fundamental information and digital national land for national resilience
③ Improving forecasts of extreme events that cause meteorological and water-related disasters

**(2) Contribution to Climate Change Solutions**

Climate change, including global warming, which has got a lot attention in recent years, and its measures are one of the most important social issues. Data of Earth observation satellites, which can observe the entire globe uniformly and frequently, plays an important role in monitoring and understanding global environmental changes. Furthermore, in recent years, Earth system models that combine various processes in the atmosphere, land, and ocean have been developed to understand the complex Earth system and predict future warming and its impacts. It is expected that satellite data will contribute to further improving the prediction accuracy of models, as diagnostic information for climate change countermeasures and measuring their effectiveness.

We call for research themes related to research aimed at solving these issues, such as monitoring and adaptation to various changes in the global environment related to climate change, analysis of climate change, and variation of water and carbon cycles to improve the accuracy of future projections, clarification of their mechanisms, and process research, etc.. This includes research on fusion of satellite observation data, primarily from JAXA satellites, with numerical models and/or in situ observation data, as well as research related to model improvement.

In this research program, the research fields are classified into the following three areas: Atmosphere (2-a), Land (2-b), and Ocean (2-c). If applicant's research spans multiple areas, it is asked to submit proposal applying to the most relevant area.

**(2-a) Atmosphere**

The IPCC Sixth Assessment Report clearly states that the rapid increase in anthropogenic greenhouse gases, including carbon dioxide in the atmosphere, is having a major impact on global warming. Understanding the distribution and quantitative analysis of greenhouse gases will also contribute to the Global Stocktake (GST), which aims to confirm progress toward achieving the global goals set out in the Paris Agreement. Countermeasures against climate change require further improvements in the accuracy of global warming predictions. In order to improve the impact of aerosols and clouds, which have a large uncertainty, on the radiation budget and the cloud-precipitation processes, it is important not only to implement research to understand the relevant physical quantities, but also to conduct research that clarifies the process based on satellite observations and contributes to improving the processes in climate models. It is also considered that the global water cycle (the flux and storage of water) will change according to the global warming, making it important to monitor and predict changes in the water cycle, as well as to understand the distribution and changes in global water resources more quantitatively and from a long-term perspective.

This research program calls for research proposals that address these issues by primarily utilizing satellite data provided by JAXA.

**Expected research themes:**

① Observation of GHG concentration distribution in the earth's atmosphere and estimation of $CO_2$ absorption, $CO_2$ and $CH_4$ emissions by source, and contribution toward GST
② Clarifying true state of past and present global warming and improving future projections and understanding radiative forcing
③ Monitoring and predicting water cycle variations
④ Adaptation to variation of water resources

**(2-b) Land**

One of the major uncertainties in climate change research and global warming projections is the quantitative understanding of AFOLU (Agriculture, Forest, and Other Land Uses). There are expectations for quantitative evaluation and sophistication of carbon and water cycles, particularly in the terrestrial field, and for input into Earth system models.

This research program calls for research proposals for quantitative understanding and evaluation of mainly carbon and water cycles using satellite data provided by JAXA, with the goal of understanding the material cycles that are essential for understanding atmosphere-land interactions and dynamics on land, which are boundary conditions with the ocean. For example, we call for research proposals regarding the following: quantitative estimation of forest biomass, which acts as a carbon sink, and its changes over time; estimation of carbon budget including the distribution and temporal changes of wetlands and paddy fields, which are sources of carbon emissions, and plant activity; measurement of soil moisture, snow cover, and hydrological parameters in the polar regions and cryosphere, understanding of the water cycle and its temporal changes; improving the accuracy of land use and land cover, including anthropogenic activities, and their temporal changes; and understanding the effectiveness of satellite observations on biodiversity related to these, including collaboration with Earth System Models.

**Expected research themes:**

① Management of forests as $CO_2$ sinks, and carbon budget
② Understanding and predicting biodiversity and its environment
③ Understanding and predicting of terrestrial hydrology and cryosphere

**(2-c) Ocean**

In recent years, the influences of climate change including global warming (changes in the physical and biological environment and fishery resources, sudden polar changes, rising sea levels, progressing coastal erosion, etc.) have become apparent, and the oceans are playing an increasingly important role in monitoring global environment, mitigating impacts of climate change, fishery resources, disaster prevention and mitigation, and securing energy and maritime transport. Furthermore, as economic security and the realization of a decarbonized society become more important, the need for active utilization and development of the oceans is increasing, and it is becoming more important than ever to build a sustainable ocean (sustainable use of marine resources, healthy marine environments, understanding and preserving material circulation at the land-sea interface), comprehensive maritime security (ensuring the safety of maritime transport, comprehensive management of coastal and remote island areas), and promote the international cooperation and consensus building necessary to implement these activities.

In order to provide scientific information and knowledge necessary for society to understand and respond to changes in the marine environment under the above circumstances, this research program aims to contribute to understanding changes in marine ecosystems, monitoring ocean conditions, and using these results to clarify material circulation processes and improve the accuracy of physical ocean and marine ecosystem models, as well as to converting the data obtained from these into basic information, etc.. For example, in addition to understanding surface changes in the global oceans as well as seasonal and secular changes through satellite data on sea surface temperature, ocean color, solar radiation, sea surface wind speed, precipitation, etc., it will also be necessary to respond to requests for more detailed physical and biological observation information for coastal areas, and additional information below the sea surface through models as well as information on the sea surface. Through these activities, we will contribute to increasing public understanding of the ocean and ensuring its safety and security, while it is also important to foster and secure human resources with the skills to interpret and utilize it.

**Expected research themes:**

① Ocean carbon budget and cycle
② Monitoring/prediction and conservation of the ocean environments
③ Marine bioresource management
④ Understanding and predicting environment changes in the polar oceans

**(3) Contribution to socio-economic issues**

The need for scientific evidence is recognized in order to respond to increasingly complex global environmental issues, such as the climate crisis caused by global warming, the rapid decline of biological resources, the spread of new infectious diseases, and the effects of prolonged international conflicts. Earth observation satellites have strengths in terms of data characteristics, such as objectivity on a global scale, regular updates, and visualization of the spatial distribution of impacts. They have become an essential infrastructure for modern society, contributing to climate change countermeasures, biodiversity monitoring, and monitoring of social infrastructure such as roads and bridges. The vast amounts of data collected by global satellite observations are valuable assets in modern digital society, not only for their scientific value but also for their economic value. In recent years, as scientific understanding of the Earth system has deepened, satellite observation data has also been used in social and economic decision-making.

This research program aims to further promote the use of satellite observation data in social and economic decision-making, with the aim of contributing to solving social issues. Research areas in which Earth observation satellite data is likely to be particularly useful include carbon neutrality, food security, agriculture, forestry and fisheries, public health, atmospheric environment, and resources and energy. Through these research activities, we also place emphasis on expanding the use of satellite data by fostering human resources with the skills to utilize the Earth observation satellite data in social and economic fields.

**Expected research themes:**

① Contribution to socio-economic benefits related to carbon neutrality
② Strengthening food security
③ Smart agriculture, forestry and fishery
④ Acquisition and use of environmental information related to public health

⑤ Creation of environmental information related to atmospheric environment
⑥ Creation of information for decision-making through combined use of satellite and socio-economic data
⑦ Providing information to secure natural resources and energy
⑧ Contributing to climate change solutions through ESG Investments
⑨ Education in remote sensing

## 2.2. The JAXA Satellite Project Research

### 2.2.1 Objectives of the Satellite Project Research

The JAXA Satellite Project Research aims to maximize the outcome of the JAXA Earth Observation (EO) satellite projects, and the EO-RA4 calls for the research proposals in three research categories, algorithm development and improvement of standard and research products, which are needed for mission success, calibration/validation of standard products and provision of reference data, and applied research that corresponds to the "Earth Observation Research Program" but mainly uses single satellite data and/or product to contribute satellite mission objectives/goals and achievements.

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

Table 2.2.1-1 The research categories applied to each satellite mission

| | Algorithm Development | Standard Algorithm Calibration/Validation | Applied Research corresponding to the Earth Observation Research Program |
|---|---|---|---|
| AMSR3 & GCOM-W | ✔ | ✔ | ✔ |
| GCOM-C | ✔ | ✔ | ✔ |
| GPM & PMM | ✔ | ✔ | ✔ |
| ALOS-2/ALOS-4 | ✔ | ✔ | ✔ |
| MOLI | ✔ | ✔ | - |
| EarthCARE | ✔ | ✔ | ✔ |

✔: Applicable

- : Not Applicable

**Research Category**

**(1) Algorithm Development**

This research theme calls for two categories, development of standard algorithm and research algorithm.

**I. Development and Maintenance of Standard Algorithm**

In this category, JAXA seeks research proposals on development, maintenance and improvement of the standard algorithms, which will be used for processing standard products after the launch. The research plan is required to consider achievement of the accuracy targets defined in each mission, as well as the processing performance such as global applicability and processing efficiency and stability for operational processing.

Selected Principal Investigator (PI) and JAXA will work together to develop the algorithm, evaluate the algorithm, implement it in the computer system, validate it, and maintain the Algorithm Theoretical Basis Document (ATBD).

## II. Development of Research Algorithm

Research algorithms will include a new algorithm to produce geophysical parameters defined as 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 standard 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 Product 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 expected that information will be fed back to the calibration of satellite onboard sensors through these validation activities. Regarding the field campaigns and experiments, obtaining both effective validation results and scientific outputs by collaborating with other research programs is expected. In particular, 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) Applied Research that corresponds to the "Earth Observation Research Program" and leads to achieve each satellite mission objectives/goals and create new outcomes

In this category, JAXA seeks research proposals for applications to match or enhance mission objectives/goals by using products from the following satellite missions; AMSR3 & GCOM-W, GCOM-C, GPM & PMM, ALOS-2/ALOS-4, MOLI, and EarthCARE. The AMSR3 and GCOM-W missions, the GPM and PMM missions, and the ALOS-2 and its follow-on, ALOS-4, missions jointly call for proposals, respectively. Please check the contents of each Satellite Project Research for a detailed description.

Please note that this category coordinates with the Earth Observation Research Program and proposals applied to this category will be tied up with the research themes of the Program. Therefore, the applicants are asked to select the most related research theme in the Earth Observation Research Program. The research themes of the Program are described in Tables 2.1.1-1 and Chapter 2.1.3.

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

#### 2.2.2.1 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 to be launched in Japanese Fiscal Year (JFY) 2025, we call for research targeting both AMSR3 and GCOM-W in this RA. A

The GCOM-W satellite, which has been in post-mission period, is one of satellite systems that consist of the Global Change Observation Mission (GCOM) along with the GCOM-C satellite (see section 2.2.3). GCOM seeks to establish and demonstrate a global, long-term satellite observing system to measure essential geophysical parameters for understanding global climate change and the water cycle mechanism, and eventually contribute to improving future climate projections through a collaborative framework with climate model institutions. Demonstrating capabilities of operational applications through the provision of continuous data to operational agencies is another important objective. GCOM will take over the Advanced Earth Observing Satellite-II (ADEOS-II) mission and transition into long-term monitoring of the Earth.

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 JFY 2025. 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 enable solid precipitation retrievals and improvement of water vapor analysis in numerical weather prediction system. A

Table 2.2.2-1 shows mission objectives of AMSR3, Table 2.2.2-2 is success criteria of AMSR3 mission, and Table 2.2.2-3 shows mission targets of the GCOM-W satellite. Details of the AMSR3 and GCOM-W satellite and sensor are presented in APPENDIX 1 for GCOM including GCOM-W, and APPENDIX 7 for AMSR3, respectively.

This RA calls for research proposals that contribute to mission success of the AMSR series, including 1) Algorithm Development, 2) Calibration/Validation, and 3) Applied Research that corresponds to the "Earth Observation Research Program" and contributing to achieve mission targets/goals of the AMST series and creation of outcomes.

Table 2.2.2-1 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 2.2.2-2 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 2.2.2-3 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 applied 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. |

### 2.2.2.2 Details of research targets of the AMSR3 & GCOM-W

JAXA seeks proposals on research to contribute to achievements of AMSR series' mission objectives, which are contribution to water cycle and climate change research and operational applications, and creation of new outcomes. Research themes are 1) Algorithm Development of the AMSR series that develop/improve standard and research products as the basis of whole research, 2) Calibration and Validation of the AMSR series to contribute evaluation of accuracy and enhancement of the products, and 3) Applied Research that corresponds to the "Earth Observation Research Program" and contributes to achievement of the AMSR series' mission targets/goals and creation of new outcomes.

Please note that applied research that aims to create outcomes by multiple use of data from the AMSR series and other JAXA satellite data will be also categorized to the "Earth Observation Research Program" (see Section 2.1). Therefore, the applicants are asked to clarify to which category ((1), (2-a), (2-b), (2-c), and (3)) in the Program their proposals mainly contribute.

#### (1) Algorithm Development of the AMSR series

In this category, JAXA seeks proposals on algorithms to develop, maintain, and/or improve the following AMSR3 & GCOM-W standard and research products, which are contribute to the mission objectives of the AMSR series; contribution to water cycle and climate change research; and operational applications.

Please refer APPENDIX 1 for GCOM-W and APPENDIX 7 for AMSR3 for required accuracy of each product and its details. Proposals on development of other research algorithms that are not defined in AMSR3 nor GCOM-W should be applied to the category of Applied Research of the AMSR series in Section 2.2.2.2(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:** thin ice thickness (TIT), sea ice thickness (thicker than 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 developing, maintaining, evaluating, implementing, and validating the algorithms, as well as revision of the algorithm theoretical basis document (ATBD). 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 2.2.2-2, 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 the proposed products are selected as research products, those research products will have the potential to be candidates for 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 the total of this research category (Algorithm Development of the AMSR series).

Please note that 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.

### (2) Calibration & Validation of the AMSR series

In this category, 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 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) Calibration and validation targeting after the launch of AMSR3, and intercomparison, cross-calibration, cross-validation between AMSR3 and GCOM-W;

(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) Research 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 research on quantitative validation by comparing with other satellite observations are expected.

IV. Cryosphere

JAXA expected proposals for operational validation site for obtaining in situ snow depth observation, and for cooperation with other research projects, in which snow pit

observations are being conducted under a variety of snow conditions. 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 2.2.2-4; 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 35 million yen per year for the total of this research category (Calibration & Validation of the AMSR series).

Table 2.2.2-4 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 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 missions 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 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 raw data is prohibited. |

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

### (3) Applied Research that leads to achieve AMSR series' mission targets/goals and creation of new outcomes

In this category, JAXA seeks applied research, which will contribute to achievements of the AMSR series' mission targets/goals, which are contribution to water cycle and climate change research and operational applications, and creation of new outcomes, mainly using AMSR series data. Please note that proposal that aims to create outcomes by multiple use of data from the AMSR series and other JAXA satellite data will be also categorized to the "Earth Observation Research Program" (see Section 2.1). The applicants are asked to clarify to which category ((1), (2-a), (2-b), (2-c), and (3)) in the Program their proposals mainly contribute.

Especially, JAXA will be intensely focused on following research themes that will emphasize scientific and/or social values of the AMSR series. Research that enhances synergies by combined use of the AMSR series and other satellite missions, such as GCOM-C and GPM, and integrational use with numerical models and/or in situ observations are also appreciated;

(a) Research that corresponds 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

(b) Research that could contribute to data utilization of the AMSR series in areas of operational applications, such as weather forecast, safety navigation, fisheries, etc.;

(c) Research that leads to solutions of societal issues and new applications to meet societal needs;

(d) Creation of new research product that leads to achieve mission targets/goals, adding new values and/or expand data utilization; and

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

Other than existing research products that will be solicited in Section 2.2.2.2(1) "Algorithm Development of AMSR series," JAXA seeks new research products that retrieve new geophysical parameters corresponding to above (d). Those new research products may include algorithms that are challenging and need further research efforts to develop. Each proposal regarding new research products is expected to target production or submission of new research products 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 24 million yen per year for the total of this category (Applied Research of AMSR series).

### 2.2.3 The Global Change Observation Mission - Climate (GCOM-C)

#### 2.2.3.1 Overview of the GCOM-C mission category

The GCOM-C mission seeks to establish and to demonstrate a global, long-term satellite observation system to measure essential geophysical parameters for understanding the earth system and the climate change mechanism in cooperation with GCOM-W and other sensors. Its ultimate objectives are to improve future climate projection through a collaborative framework with the earth system model studies and to demonstrate the capabilities of operational applications by providing continuous data to operational agencies. The GCOM-C satellite equipped with the Second-generation Global Imager (SGLI) observes the atmosphere and earth surface such as vegetation, clouds, aerosol, sea surface temperature, etc. by multiple wavelength channels from near-UV to thermal infrared aiming to elucidate the global carbon cycle and the radiation budget. (see APPENDIX 1).

After the launch in December 2017, GCOM-C has achieved the continuous in-orbit operation, dataset processing, data publication, and the utilization demonstration in the five-year planned operation period. After 2023, as an extension phase, the observation and research activities have been restarted to produce outcomes of tables 2.2.3-1 (science areas) and 2.2.3-2 (operational application areas) with continue and expand the original observation concept of contribution to the global agenda through the global, long-term and continuous observation.

EORA4 GCOM-C category focuses (A) studies to produce the science outcomes in the GCOM-C extension phase (and basis research contributing the operational application outcomes), and (B) studies of long-term continuous and high accuracy product development supporting the creation of the outcomes.

Table 2.2.3-1 GCOM-C science-area outcomes targeted in the extension phase

| Science areas | **outline** |
|---|---|
| Enhancement of knowledge and information on the Earth system related to climate change | Through the research results of GCOM-C observation data, to investigate the carbon cycle and radiation budget processes related to climate change and contribute to the construction of a 4-D global environmental change monitoring system, the sophistication and the reduction of uncertainties in future predictions of earth system models including physical, biological, and chemical processes on the earth, and to create and provide scientific-based evidence for the climate change countermeasures.<br>Through these activities, we aim to make GCOM-C a social infrastructure information for monitoring and understanding the mechanisms of climate change. |
| Understanding of the polar environmental change situation and processes, and input for the policy making | Through the research results of GCOM-C observation data, to understand the situation of polar environmental changes due to global warming, to pursue the transient processes, and to serve as a scientific basis for knowledge that will contribute to policy making.<br>Through these activities, we aim to make GCOM-C a social infrastructure information for monitoring and understanding the mechanisms of polar environmental change. |

Table 2.2.3-2 GCOM-C operational application-area outcomes targeted in the extension phase

| Application areas | outline |
|---|---|
| Fishery | Contribute to the sustainable use of marine resources and the sustainable growth of the fishery as an industry (to be the smart fishery) by utilizing GCOM-C/SGLI data (e.g., monitoring of the environment of offshore fishing grounds, aquaculture areas, red tides, etc.). |
| Volcano | Contribute to the volcanic disaster prevention by applying to judgment of the volcanic activity changes (terrestrial volcanoes, marine volcanoes, temperature changes, discolored water, etc.) and overall grasping of the situation through long-term and continuous information collection by GCOM-C. |
| Agriculture | Contribute to the analysis of food security risks by understanding the crops growth and agricultural weather in Japan and overseas by utilizing mostly GCOM-C data. |

* For the research proposals related to the operational application, it is expected to collaborate with JAXA's application promotion activities to effectively lead to operational use.

### 2.2.3.2 Details of GCOM-C EORA4 research targets

GCOM-C EORA4 are looking for studies to enable GCOM-C data to become social infrastructure information for climate change and environmental monitoring through mostly using various information obtained by GCOM-C, (A) applied research for the creation of the GCOM-C extension phase outcomes (see Table 2.2.3-1 and -2) or for proposing further outcomes, and (B) product development research (algorithm development and improvement, calibration, and verification) to support to realize the outcomes.

Research that aims to produce results by combining GCOM-C and other JAXA satellite data could be also defined as a "proposal for the Earth Observation Research Program in Section 2.1", so please specify which items ((1), (2-a), (2-b), (2-c), (3)) of the program you will contribute to in the proposal.

**(A) Applied Research for the GCOM-C Outcomes**

**(A-1) Improvement of knowledge and information on the Earth system related to climate change**

We are aiming to reduce uncertainty of the future prediction and create and provide scientific based evidence for climate change countermeasures (e.g., contributing to the IPCC reports) by strengthening cooperation with research activities outside of JAXA related to the climate change issues based on various observation variables and analysis results using global 250-meter and multi-wavelength observations which are the characteristics of SGLI.

Currently, JAXA is participating in MEXT-Program for the Advanced Studies of Climate Change Projection (SENTAN) and involved in research on improvement of wildfire processes in the Earth system model. Promising research is expected to enhance the further outcomes creation, such as improvement of climate models by studying cloud microphysical processes using simultaneous estimation of multiple cloud physical quantities related to the cloud radiation effect, and research to improve processes in ecosystem models or discover unconsidered processes by comparing satellite observations of changes in terrestrial and marine ecosystems with model outputs.

In addition, through real-observation input and the numerical model improvement by GCOM-C data, studies for construction of a 4-D global environmental monitoring system (e.g., Earth Digital Twin) that will serve as basic information for solving the global agenda including the climate change are expected.

**(A-2) Monitoring of the coming polar environmental changes, understanding of the processes, and input for policy make**

We aim to create and provide scientific evidence of the changing polar environment, where rapid global warming is becoming apparent, based on GCOM-C observation results: monitoring the change, understanding the processes, modeling, evaluation the process based on the accumulation of the long-term satellite observation data, improving the accuracy of polar climate and earth system models, and improving the accuracy of climate change predictions from the point of view the polar region.

Currently, JAXA is conducting research on polar environmental changes such as ice albedo feedback through the development of long-term datasets that contribute to polar research with participation in Arctic Challenge for Sustainability II (ArCS II). We are looking for studies that are effective in promoting the creation of further outcomes, such as high-precision spatiotemporal variation analysis of snow grain size and albedo, and research related to the detection in physical, biological, and chemical field changes in the polar regions associated with the polar environmental changes.

**(A-3) Basic research that leads to the creation of outcomes in various fields of operational applications**

The JAXA application promotion group leads to create outcomes in the field of operational use basically, however, we are looking for fundamental studies or studies to support and bridge to the practical utilization.

In addition, in order to develop new operational applications, we are also looking for research proposals that will lead to the use of GCOM-C data in the fields of fisheries, agriculture, meteorology, public health, environmental disaster monitoring, etc., as well as research related to nowcast and short-term (from several days to seasonal) forecasts of the environment (atmospheric environment, the marine environment, snow cover, sea ice, vegetation and agricultural environment) through analysis and model assimilation of GCOM-C data.

**(B) GCOM-C Product Development supporting the Outcome Creation**

As foundation research for the creation of the above outcomes, we are looking for the following (B-1-4) GCOM-C product development and improvement research (including algorithm development, improvement, validation observation and evaluation). In the GCOM-C extension phase, due to particular emphasis on the creation of the outcomes, it is important to be aware of the priority of the products and their characteristics considering the usage of the products, as well as to collaborate with related applied research activities and provide feedback between the product development and the applied studies.

Particularly, we will promote product development that takes advantage of GCOM-C/SGLI's strengths such as 250m resolution, multiple wavelengths, polarization, and multi-directional observation, assimilation product development in collaboration with models, and one by new concept or new technologies such as machine learning. We aim to development long-term time series datasets as basic information for understanding the global environmental change with strengthen collaboration with external climate change research (e.g., SENTAN, ArCS II, etc.) through data analysis and process studies.

**(B-1) Maintain long-term accuracy and improvement of the Standard Product**

We focus on studies maintaining and improving the standard products being the basis of climate change research and long-term time series, especially products that contribute to the climate change research, such as Essential Climate Variables (ECVs) (e.g., leaf area index, biomass, ground surface temperature, sea surface temperature, sea color, cloud characteristics, aerosol properties, snow grain size, Snow and ice distribution, etc.) (see

Section 2.2.3.3 for points to note in product development research). It is also necessary to develop a quantitative error estimation for each pixel, which is necessary for the data assimilation for environmental prediction such as oceans and aerosols.

**(B-2) Research Product Development**

We will improve accuracy or newly develop research products that contribute to the understanding of the radiation budget and carbon cycle, which are key to the climate change research (A-1 and A-2), as well as products that are expected to be used in practical applications such as environmental monitoring and biodiversity monitoring by operational organizations (A-3). R&D that is not bound by the framework of conventional satellite products, such as one by integrated analysis of SGLI multi-wavelength observations from near-ultraviolet to thermal infrared, assimilation products in cooperation with models, and utilization of machine learning, and products that take advantage of the strengths of SGLI (e.g., 250-m resolution and polarimetry) are expected to be conducted (points to note in product research are described in Section 2.2.3.3).

**(B-3) Construction of Long-term Satellite Datasets for Climate Change Research**

GCOM-C mission aims to play a role in providing data for international consensus on climate change and is developing consistent observation data for more than 20-30 years by connecting it with existing other satellite data. In the future, we aim to create SGLI's own long-term datasets and information that take advantage of the features of GCOM-C. We are looking for studies for the construction of these datasets and information.

**(B-4) Maintenance of Validation Flow and Expansion of In-situ Observation Data**

We are looking for research related to the acquisition of in-situ observation data and its analysis methods, which are necessary for improving the accuracy of GCOM-C products, improving spatio-temporal consistency, improving consistency with other satellites, and quantifying errors, which are necessary for the creation of outcomes.

In the acquisition of in-situ observation data for GCOM-C validation, we are looking for research related to the maintenance and expansion of the network of in-situ validation observation sites, the continuous implementation of campaign observations, the continuous data collection based on international cooperation, and the reduction of the cost of in-situ measurement equipment to enhance observation opportunities. In addition, we are looking for studies of advanced validation methods for GCOM-C products using in-situ observation data, such as scaling up in-situ measurements using higher-resolution images and developing effective evaluation methods using new equipment such as UAV.

Table C1 in APPENDIX 1 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) which has been established by previous RAs. Please refer to them when drafting your research plan in this category.

Special emphasis will be placed on research 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.

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 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.

#### 2.2.3.3 Notes of GCOM-C Product Development

Table 2.2.3-3 lists the points to note for each product development. For more information on the current standard and research product and the PI in charge, please refer to the GCOM-C product homepage.

JAXA defines objectives of the GCOM-C algorithm development as the following. Proposals are expected to conform to these objectives, especially regarding the standard products which are operated in the routine processing system.

- Develop algorithms robustly and 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, highly accurate, stable and consistent datasets for the use of the earth environmental change research
- Develop effective and stable algorithm software considering the data usage including the operational use
- Developing new data analysis and application schemes to enhance future possibility of remote sensing in the Earth environment observation
- Improve the product accuracy 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

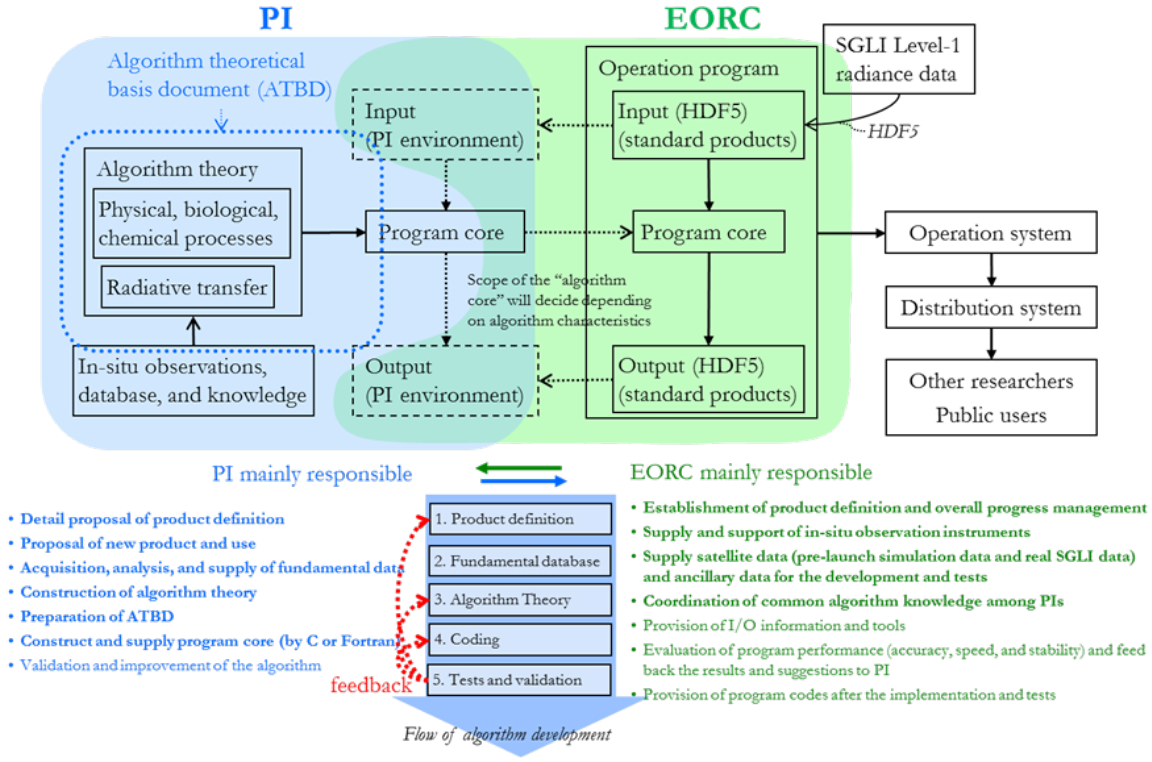


Fig. 2.2.3-1 Example of collaboration and sharing between PI and JAXA in algorithm development. The map should be modified according to algorithm characteristics and volume of the code (C or Fortran code).

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 ATBD. Plan of the work sharing must be described in the proposal and can be optimized according to the progress of the research.

Details on currently defined standard products and research products and expected focus points are listed in the following part of this section (Table 2.2.3-3). The algorithm development research should cooperate with the related validation research deeply to improve the accuracy of the products.

It is possible to 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. In that case, performance of the algorithm codes (processing speed, stability etc.) are also required to be better than existing standard ones. The research products could become new candidates for the standard products after completion of a specific evaluation process.

Directions and Considerations of about development of each product are listed in Table 2.2.3-3. Please refer GCOM-C product homepage about the current products and PIs responsible for each product.

Table 2.2.3-3 Direction and Considerations of GCOM-C Product Development

| Area | Product | Direction and Considerations |
|---|---|---|
| Level-1 | Satellite observed radiance | JAXA leads the development, validation and improvement |
| Land | Precise Geometrically Corrected Image (PGCI) | JAXA leads the development, validation and improvement |
| | Atmospherically Corrected Land Surface Reflectance<br>Land Surface Albedo [research product]<br>Vegetation Index (NDVI, EVI, SDI) | **L-1 Land Atmospheric Correction Group**<br>• JAXA will take initiatives in the development of the products.<br>• We are looking for validation and characterization studies to improve accuracy and stability of spectral and multidirectional surface reflectance, atmospheric radiance including aerosol scattering and absorption. |
| | Above-Ground Biomass<br>Vegetation Roughness Index | **L-2 Above-Ground Biomass Group**<br>• To improve modeling and application to the satellite estimate about three-dimensional structures and directional reflectance of the various shapes of canopies.<br>• Integrated analysis of GCOM-C AGB with other satellite measurements (canopy height LIDAR and SAR) and ecosystem models<br>• Further AGB validation by ground observation networks that continuously measures biomass such as the diameter at breast-height, Laser scanner, and UAV with canopy radiative transfer.<br>• Comparison and evaluation between the temporal change of the AGB and NPP (L-3).<br>• Collaboration with activities of the land cover group (L-5) to improve global applicability. |
| | Leaf Area Index (LAI)<br>fraction of Absorbed Photosynthetically Active Radiation (fAPAR)<br>Evapotranspiration [research product]<br>Land Net Primary Production [research product] | **L-3 Land Net Primary Production Group**<br>• Development and improvement of stable time series of LAI and fAPAR by effectively using SGLI channels, multi-angle observation, and the canopy radiative transfer<br>• Modeling and scale-up of relationship between the satellite observed reflectance and the products by considering the radiative transfer, physiological and ecological processes.<br>• Validation data acquisition for algorithm development and cooperation with ground observation programs such as flux tower observation networks.<br>• Collaboration with carbon cycle studies and ecosystem models (C-4) to estimate land CO2 fixation.<br>• Collaboration with relative activities of L-1, L-2, L-5, and A-3.<br>• The Evapotranspiration should cooperate with studies about water/energy cycle budget, vegetation water stress, and agriculture. |
| | Land Surface Temperature<br>Fire Detection (FD) [research product] | **L-4 Land Surface Temperature Group**<br>• LST product development using SGLI thermal infrared channels by quantitatively considering the atmospheric influence and the land surface emissivity<br>• Collaboration of the heat/water-budget process and model research are expected for improvement of the accuracy and enhancement of product usage.<br>• FD has been developed and improved by JAXA; and looking for wide-area, long-term, and high accuracy training and validation data. |
| | Land Cover Type [research product] | **L-5 Land Cover Group**<br>• Effective product development considering each usage, utilization of SGLI multiangle and wide swath frequent observations, and validation dataset construction, in collaboration with the research activity of JAXA/EORC high resolution land cover classification and its validation |
| Atmosphere | Cloud Flag<br>Classified Cloud Fraction<br>Cloud-Top Temperature and Height<br>Water Cloud Optical Thickness and Particle Effective Radius<br>Ice Cloud Optical Thickness<br>Water Cloud Geometrical Thickness [research product] | **A-1 Cloud Property Group**<br>• Stable accuracy of the standard cloud retrieval algorithms applicable to the long-term environmental change analysis<br>• Effective use of SGLI polarization, multi-angle, near-UV, and O2A band<br>• Collaboration with common subject C-1.<br>• Validation study of cloud coverage using the all-sky camera system which has been developed by JAXA.<br>• Cooperation with other JAXA satellite missions incl. EarthCARE (e.g., research collaboration, work sharing, and participation in workshops) for investigating the cloud radiative forcing by integrated analysis of the multiple satellite data.<br>• Combined analysis with the numerical models considering a radiative transfer and extension to model assimilation. |

| | | |
|---|---|---|
| | Aerosol properties over land and ocean (using NUV-SWIR and polarization) | **A-2 Aerosol Property Group**<br>• JAXA will take initiatives in development of the standard algorithm<br>• synthetic analysis with numerical models and collaboration with assimilation research<br>• Contribution to improving and validating the radiative transfer process (including polarization)<br>• Cooperation with AHI and EarthCARE for investigating cloud-aerosol interaction. |
| | Surface Short-Wave Radiation Flux [research product] | **A-3 Surface Radiation Flux Group**<br>• JAXA will take initiatives in developing algorithms for the satellite-basis downward shortwave radiation.<br>• estimation from products of A-1 (including Cloud Geometrical Thickness) or simultaneous estimation.<br>• consideration of BRDF for the upward short- and long-wave radiation<br>• Combined analysis with numerical models through radiative transfer models, its extension to the model assimilation, and synthetic analysis with other sensors (e.g., EarthCARE). |
| | Surface Long-Wave Radiation Flux [research product] | |
| Ocean | Normalized Water-Leaving Radiance<br>Atmospheric Correction Parameters<br>Photosynthetically Available Radiation | **O-1 Ocean Atmospheric Correction Group**<br>• Algorithm improvement using SGLI features, such as 250-m resolution.<br>• Improvement and validation of the radiative transfer using in the atmospheric correction<br>• Inter-comparison of international products and algorithms for contribution to the ECVs. |
| | Chlorophyll-a Concentration<br>Total Suspended Matter Concentration<br>Colored Dissolved Organic Matter | **O-2 Ocean Color Group**<br>• JAXA will take initiatives in development of the standard algorithms of global CHLA<br>• Inter-comparison of international products and algorithms for contribution to the ECVs.<br>• Coastal SGLI algorithms (detection and quantification) based on characterization of IOP spectra in each coastal region with a systematic measurement and analysis of AOP, IOP, plankton type and spectral property modeling.<br>• Red tide product (or information) should consider operational use in fishery and coastal environmental monitoring<br>• Combined analysis with numerical models through in-water bio-optical models and its extension to model assimilation. |
| | Inherent Optical Properties [research product] | |
| | Euphotic Zone Depth [research product] | |
| | Phytoplankton Functional Type [research product] | |
| | Red Tide [research product] | |
| | Sea-Surface Temperature | **O-3 Temperature Group**<br>• JAXA will take initiatives in developing the standard SST algorithm.<br>• Improvement of accuracy and error estimation to expand use for the polar areas and in-land water |
| | Ocean Net Primary Productivity [research product] | **O-4 Primary Productivity Group**<br>• Estimation of the carbon-cycle related variables including primary productivity through combined analysis with numerical models or data assimilation mainly using GCOM-C data.<br>• Research about accurate in situ data measurement and collection.<br>• 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) to contribute to CO2 absorption estimation |
| | Multi-sensor Merged Ocean Color [research product], Multi-sensor Merged Sea-Surface Temperature [research product] | **O-5 Multi-Sensor Merging Group**<br>• Combined products overcoming differences such as channel wavelengths, sensor characteristics, algorithms, and data formats and utilizes SGLI features such as 250-m resolution and time frequency.<br>• Effective use of GCOM-C data for bio-geo-chemical models.<br>• Development of model assimilation products by effectively use the SGLI 250 m spatial resolution |
| Cryosphere | Snow- and Ice-Covered Area (incl. cloud detection)<br>Okhotsk Sea-Ice Distribution | S-1 Snow Area Discrimination Group<br>• Development and improvement of the algorithm to make long-term accurate products using the SGLI features<br>• Contribution to other groups through C-1 activities such as discrimination between cloud and snow/ice areas.<br>• Acquisition of in situ data for effective validation and cooperation with in-situ monitoring by other groups.<br>• International comparison with other sensor products/algorithms to construct long-term datasets of ECVs, and contribution to aerosol models and weather models as a surface condition. |
| | Snow and Ice Classification [research product] | |
| | Snow-Covered Area in Forests and Mountains [research product] | |
| | Ice Sheet Boundary Monitoring [research product] | |

| | | |
|---|---|---|
| | Snow and Ice Surface Temperature | S-2 Snow-Surface Properties Group<br>• Development and improvement of the algorithm to make long-term accurate products using the SGLI features<br>• Product validation through effective in situ measurement in cooperation with domestic and foreign institutions, and theoretical evaluation of error budget considering limitation of in-situ measurements opportunities in the polar areas<br>• Cooperation with research on snow/ice physical processes and albedo (S-3) with numerical models (C-4) to contribute to the environment and climate prediction |
| | Snow Grain Size of Shallow Layer | |
| | Snow Grain Size of Subsurface Layer [research product] | |
| | Snow Grain Size of Top Layer [research product] | |
| | Snow Impurity [research product] | |
| | Snow and Ice Albedo [research product], Ice Sheet Surface Roughness [research product] | S-3 Snow Albedo Group<br>• Cooperation with the S-2 group, which measures snow grain size and impurities that significantly influence albedo<br>• Developments considering applications on numerical model research. |
| Common Issues | C-1 Cloud and Snow/Ice Discrimination | • Common issues that encourage collaboration among PI activities are coordinated by JAXA EORC.<br>• 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 encouraged PI teams to share their knowledge of spectral features of each observation target and discrimination schemes and to be implemented each algorithm effectively (the direction has been decided in the workshop in 2011).<br>• 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.<br>• The direction of the development of the atmospheric correction algorithms has been discussed in the workshops in 2012 and 2020, and we are developing the algorithm by cooperation with radiative transfer research in the earth surface and the atmosphere. EORA4 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 | • Addition to the aerosol estimation (A-2), the development of new products and applications, polarization radiation process in the atmosphere, land and ocean surface are encouraged through polarization observation which is a unique function of SGLI. |
| | C-4 Integrated Analysis | • Exchange of knowledge and new technologies such as integrated analysis using SGLI multi channels, model assimilation, machine learning, etc., among the PI research groups. |
| | C-5 Consideration of SGLI Calibration Performance | • It is necessary 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 sensor characteristics on the GCOM-C products are encouraged. |

### 2.2.3.4 Supplemental Notes for GCOM-C Category Proposals

The applied research is also placed in the category of Earth Observation Research Programs (Section 2.1 (1), (2-a), (2-b), (2-c), and (3)). In addition, research that combines multiple satellite sensors and ground observation data can be proposed if it is effective to obtain the outcomes as the GCOM-C product development research. However, the focus of the GCOM-C category is on creating and promoting GCOM-C outcomes mostly using GCOM-C data. Therefore, it is necessary to clearly plan and describe the use of GCOM-C data and its contribution to the outcomes in the research proposal.

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 applied studies. In addition, research particularly related to operational use can be linked with JAXA's application promotion activities (Table 2.2.3-2). PIs may have prioritized the opportunity to use tentative version of the GCOM-C data, shared in-situ measurements and instruments, attendance of the group meetings under the PI collaboration. The PI will be requested to attend and present yearly research status 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.

JAXA will only select non-funded PIs for this EO-RA4 late research proposals basically.

A

### 2.2.4 Global Precipitation Measurement (GPM)・Precipitation Measuring Mission（PMM）

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.

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.

The Precipitation Measuring Mission (PMM) Observatory will be equipped with a Ku-band Doppler precipitation radar, an advanced version of the scanning spaceborne precipitation radar observation technology installed on the TRMM and GPM Core Observatory, in which Japan has an advantage. Using advanced 3D precipitation information and the improved quality Global Satellite Mapping of Precipitation (GSMaP), the PMM Observatory will work in AOS constellations with NASA and other agencies for:

(1) Elucidation of global water cycle parameters and understanding of cloud-precipitation processes,

(2) Contribution to enhancement of weather and disaster management,

(3) Provision of long-term information on water resources infrastructure contributing to global-scale climate and water issues.

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

The GPM Core Observatory was launched in February 2014, completed the Prime mission phase in June 2017 and moved 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 applied studies.

The PMM Observatory is scheduled to be launched in JFY2028. This RA covers a 3-year research period beginning in JFY 2025, which corresponds to the pre-launch phase of the PMM. In this RA, JAXA will invite research proposals for algorithm developments and validation preparation for the PMM.

The Principal Investigator (PI) of selected proposals will be a member of the Japanese 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 100,000,000 yen as annual total budget in the GPM and the PMM. 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.

#### 2.2.4.1 GPM 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 2.2.4-1 lists JAXA standard products of the GPM mission, and Table 2.2.4-2 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.

Table 2.2.4-1 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 2.2.4-2 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 2.2.4-1.

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 2.2.4-1;

- 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 2.2.4-1.

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

#### 2.2.4.2 PMM Algorithm Development

We invite research proposals related to the developments of all or part of the PMM algorithms (KuDPR algorithm, GSMaP algorithm, latent heat algorithm) that produce Level 2 and Level 3 standard products of the Ku-band Doppler Precipitation Radar (KuDPR) onboard the PMM Observatory, as shown in Table 2.2.4-3 and Table 2.2.4-4.

Table 2.2.4-3. PMM Standard Products (L1 & L2)

| Level | Product (representative variable) | Major geophysical variables | Sensor | Unit | Swath |
|---|---|---|---|---|---|
| L1 | Received echo power | Received echo power | KuDPR | Orbital | 9km /255km |
| | Doppler velocity (primary correction) | Doppler velocity (primary correction), Pulse Pair Covariance, Spectrum Width | | Orbital | 5km |
| L2 | Precipitation rate | Radar reflectivity factor, Surface backscatter($\sigma_0$), Precip rate profile, DSD, Precip type, Non-uniform parameter etc. | | Orbital | 9km /255km |
| | Doppler velocity (final correction) | Doppler velocity (final correction), Vertical Air velocity etc. | | Orbital | 5km |
| | Spectral Latent Heating (SLH) | Latent heating profile, type, etc. | | Orbital | 255km |
| | Long-term dataset | Long-termK dataset of precipitation and SLH consistent with PMM/KuDPR | TRMM/PR, GPM/DPR | Orbital | 255km |

Table 2.2.4-4. PMM Standard Products (L3)

| Level | Product | Major geophysical variables | Sensor | Observation range | Time resolution | Grid resolution | |
|---|---|---|---|---|---|---|---|
| | | | | | | spatial | Vertical |
| L3 | Precipitation and Doppler velocity | Statistics of Precip rate profile, phase, DSD etc | KuDPR | Global | Daily /monthly | 0.05°x0.05° | 1 or 5 layer(s) |
| | | Statistics of Doppler velocity | | | | | |
| | Spectral latent heating | Statistics of SLH | | Global | Monthly | 0.5°x0.5° | 80 layers |
| | Long-term data record | Long-term precipitation dataset consistent with KuDPR | TRMM/PR, GPM/DPR*1 | Global | Daily /monthly | 0.05°x0.05° | 1 or 5 layer(s) |
| | | Long-term SLH dataset consistent with KuDPR | | Global | Monthly | 0.5°x0.5° | 80 layers |
| | Global Satellite Mapping of Precipitation (GSMaP) | Mean surface precipitation rate, observation pixel counts, precipitating pixel counts, phase infomation | KuDPR, Multi-passive microwave radiometers (PoR) | Global | Hourly /monthly | 0.1°x0.1° | N/A |

**(1) KuDPR precipitation and Doppler velocity algorithm**

The KuDPR precipitation estimation algorithm will be developed based on the TRMM/PR and GPM/DPR algorithms as much as possible. The Doppler velocity observation will be developed based on the EarthCARE/CPR algorithm. In addition, the algorithm will be developed as an algorithm that can be applied to PR, DPR, and KuDPR in order to produce long-term precipitation data.

This RA calls for enhancements to existing software. We invite research proposals to apply methods developed for existing precipitation radars such as TRMM/PR and GPM/DPR to KuDPR. We also invite research proposals of methods using observation data from EarthCARE/CPR, airborne Doppler radar, ground-based Doppler radar, etc.

**(2) KuDPR Latent Heating Algorithm**

The KuDPR latent heating algorithm will be developed based on the GPM/DPR latent heating algorithm as much as possible. In addition, the algorithm will be developed as an algorithm that can be applied to PR, DPR, and KuDPR in order to produce long-term latent heating data.

This RA calls for enhancements to existing software. We invite research proposals that will apply methods developed for existing precipitation radars such as TRMM/PR and GPM/DPR to KuDPR, as well as research and development of methods that combine other existing observation data such as EarthCARE/CPR.

**(3) GSMaP Algorithm**

For the microwave imager precipitation estimation algorithm (equivalent to level 2), which is the input for the GSMaP algorithm (level 3), GPM's standard algorithm will be adopted, and we will cooperate with GCOM-W/AMSR2 and GOSAT-GW/AMSR3 in algorithm development and calibration verification. For the CNES microwave radiometer precipitation estimation algorithm, we will develop an algorithm based upon the existing microwave sounder algorithm developed by GPM. We invite research proposals that contribute to the following development elements.

**(A) Development of forward calculation model**

The physical precipitation retrieval algorithm for microwave radiometer data requires a forward calculation model that calculates microwave radiometer brightness temperature from precipitation physical quantities, etc. In addition, when using KuDPR to improve this precipitation retrieval algorithm, it is possible to effectively utilize the features of KuDPR, 1) high sensitivity and 2) Doppler velocity observation. We invite research proposals for the development of a forward calculation model that utilizes these new observations.

**(B) Development of CNES radiometer algorithm with the same design concept as GSMaP algorithm**

GSMaP has developed an algorithm (GSMaP_MWS) to estimate precipitation from a microwave sounder based on the GSMaP microwave imager (GSMaP_MWI) algorithm.

In developing the precipitation estimation algorithm for the CNES radiometer, we will utilize our experience with MWS, but there is a development element in particular in the use of the 325 GHz channel. We seek for research that contributes to this.

**(C) Development of algorithms combined with ground observation data**

GSMaP creates products by integrating using not only satellite data, but also ground observation data, and it is possible to create products that are closer to the values observed by ground rain gauges. Currently, we use the ground rain gauge dataset from NOAA/CPC, but a new development element is the development of an algorithm to correct GSMaP using a new dataset, for example, ground rain gauge data from GPCC (Global Precipitation Climatology Center), etc.

**(D) Intercalibration of microwave sensors**

The International Working Group on Intercalibration of Radiometers (GSICS) is researching the L1 intercalibration product for the microwave sensor brightness temperature (Level 1) used as input to the precipitation estimation algorithm, and GPM

uses the microwave radiometer brightness temperature (L1C) calibrated against GMI by GPM Intercalibration (X-CAL) Working Group. However, the L1C provided by the GPM mission may not be available for the AOS Constellation, and it may be necessary for Japan to undertake the intercalibration of microwave sensors itself. Therefore, we invite research proposals that will contribute to the intercalibration of microwave sensors.

**(4) Research Algorithms**

We call for research proposals that contribute to the development of the following research algorithms.

**(A) GSMaP Research Algorithms**

PMM plans to develop algorithms to generate the following as GSMaP research algorithms.

- Real-time GSMaP products (GSMaP_NOW)

- High-resolution GSMaP products (GSMaP_HRES)

Based on the standard GSMaP algorithm, these products will be developed as research products because they have a significant research element to achieve immediate provision and high resolution. In particular, increasing the resolution of GSMaP using geostationary meteorological satellite data with high spatiotemporal resolution such as Himawari 8 and 9 is very attractive because it leads to use on a more regional scale. On the other hand, the accuracy of high-resolution GSMaP is one of the issues. For example, precipitation errors are expected due to the infrared-based estimation data input for high resolution, and it is also possible to consider improving the accuracy of precipitation estimation by machine learning using multi-channel data from geostationary meteorological satellites. Therefore, we call for research proposals to increase the resolution of GSMaP.

**(B) Model assimilation algorithm**

PMM plans to develop an algorithm to generate the following model assimilation algorithms.

・NEXRA (NICAM-LETKF JAXA Research Analysis) Global Atmospheric Model Assimilation Product

・Japan Region Mesoscale Model Assimilation Product

These are classified as Level 4 research products that assimilate satellite observation information obtained by the PMM Observatory and AOS constellations.

(B.1) NEXRA Global Atmospheric Model Assimilation Product

NEXRA is a system that combines satellite data and meteorological models, which JAXA has developed jointly with the University of Tokyo, the RIKEN and other universities. It is a meteorological data assimilation system that utilizes the large-scale

computing performance of JAXA's supercomputer, and products calculated using this system. We call for research proposals to improve the existing NEXRA by utilizing products developed within the framework of the PMM mission, AOS, etc.

(B.2) Japan Region Mesoscale Model Assimilation Product

GPM/DPR has been used for data assimilation in the Japan Meteorological Agency's mesoscale numerical forecast system since March 2016. Spaceborne precipitation radar can directly observe detailed 3-D distribution of precipitation over land and ocean, and contributes to improving the analysis and prediction accuracy of meso-models by reflecting water vapor spatial distribution based on the structure of precipitation over the ocean, where there are sparse observation data. During the AOS era, we plan to develop a research-oriented meso-model assimilation product for the Japan region based on the Japan Meteorological Agency's meso-scale numerical forecast system and by utilizing products developed within the framework of the PMM mission and AOS, and we call for research that will contribute to this.

(C) AOS synergy algorithm

This RA calls for the development of an AOS synergy algorithm, which is related to the synergy between KuDPR and the CNES radiometer. Synergy algorithms related to other sensors in the AOS constellations will be solicited after the 5th Earth Observation RA.

(D) Horizontal wind speed algorithm using data derived from off-nadir angles by the KuDPR experimental Doppler observation mode.

KuDPR will be designed to hold an experimental mode to conduct Doppler observation at off-nadir angles to measure horizontal wind speed. We will develop an algorithm to estimate horizontal wind speed. In this RA, we invite research that will contribute to confirming the feasibility of estimating horizontal wind speed using data derived from off-nadir angles Doppler observations.

#### 2.2.4.3 GPM 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 research related to validation of the algorithm to produce the DPR Level 2 standard product (DPR algorithm). In particular, research to compare and

evaluate models and parameters relating to 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, research to propose knowledge obtained by ground observation of snowfall to algorithm developers.

Applicants must 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 rent 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.

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 research 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 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 research 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.

## 2.2.4.4 PMM Validation

This RA covers the period before the launch of PMM Observatory. Thus, this RA invites research that contributes to the validation preliminary study and on the preparation of the implementation plan for the validation activity after the launch. Research that is expected to conduct validation efficiently by collaborating with other research plans is also taken into account.

The PMM mission aims to provide products with guaranteed quality and reliability through validation activities. Therefore, feasibility studies that quantitatively indicate how to link the observations to the evaluation of the PMM products are required. Furthermore, the validation plans are also recommended to be highly feasible (i.e. reliable observation instruments being utilizable, valid data being available, maintaining good cost performance, etc).

KuDPR precipitation and Doppler products will be validated by comparing rainfall and snowfall with high-sensitivity sensors (ground-based instruments, etc.) to evaluate the standard accuracy (past statistics will also be included if available). In particular, validation of Doppler products is an important new element, and we call for research that will contribute to the validation plan.

Regarding Doppler velocity, we are considering a comparative validation with the WINDAS (WInd profiler Network and Data Acquisition System) operated by the Japan Meteorological Agency. We are also considering the use of ground-based observation instruments with new technology. For example, we are considering the validation of the Doppler products using Phased Array Weather Radar (PAWR), atmospheric radars such as the MU radar operated by Kyoto University, small Doppler Ku-band radar, and micro rain radar, and so on. We call for research that will contribute to these.

#### 2.2.4.5 Applied Research that leads to achieve GPM and PMM mission targets/goals and creation of outcomes

In this category, JAXA seeks applied research, which will contribute to achievements of the GPM and PMM mission targets/goals, which are contribution to water cycle and climate change research and operational applications, and creation of new outcomes, mainly using TRMM and GPM data. Please note that proposal that aims to create outcomes by multiple use of data from the TRMM/GPM and other JAXA satellite data will be also categorized to the "Earth Observation Research Program" (see Section 2.1). The applicants are asked to clarify to which category ((1), (2-a), and (3)) in the Program their proposals mainly contribute.

Research themes related to applied 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."

### 2.2.5 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 five years of the post-operation phase, ALOS-2 is still in nominal operation. It is continuing to contribute its missions of monitoring disaster, forest, ecosystem, snow and ice, and ocean observations by utilizing its capabilities of high resolution, rapid response for disaster, precise measurement of land displacement, and long-term data archive in combination with upcoming satellites i.e., the 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 and was successfully launched on July 1st, 2024. It targets advancing weather-independent monitoring of disasters, 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 is 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 5.

This research announcement (EO-RA4) seeks a “non-funded Collaborative Research Agreement” on “ALOS-4 Cal/Val and algorithm development” and “ALOS-2/ALOS-4 Earth Observation Research Program”. Proposals may include new research topics through the simultaneous operation of ALOS-2 and ALOS-4 in a limited period, although the feasibility of the operation is still uncertain.

#### 2.2.5.1 ALOS-4 Calibration and Validation (Cal/Val), and Algorithm Development

EO-RA4 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 establish by JAXA, so that sufficient results will be obtained in the operational Cal/Val phase.

In addition, proposals for algorithm development for high-level research products are also invited for new processing methods and datasets that will maximize the potential of ALOS-4 data utilization and its results. “Algorithm development" is particularly aimed at social implementation and applied use, and research themes are expected to lead to "(2) ALOS-2/ALOS-4 Earth Observation Research Program".

Proposals that plan to share the information of your calibration and validation equipment, Cal/Val sites, products, or analysis tools will be preferentially accepted. We plan to accept approximately 50 proposals maximum for the research themes.

Expected research themes on “Cal/Val” and “Algorithm Development” 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 Algorithm development and sharing of high-level products and analysis tools for “Earth Observation Research Program”.

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.

In particular, research proposals to include the following are expected.
- ✓ Sharing the information about your calibration equipment and ground measurement data with JAXA.
- ✓ Development and sharing of high-level products and analysis tools.

**2.2.5.2 ALOS-2/ALOS-4 Earth Observation Research Program**

To create further achievement of ALOS-2 and ALOS-4, EO-RA4 seeks research proposals on "Earth Observation Research Program" as follows. Please select and indicate the number of the preferred "Research Categories" ((1), (2), and (3)) in your proposal. A maximum of approximately 150 applications are expected to be selected under this theme.

Expected research themes on ALOS-2/ALOS-4 "Earth Observation Research Program" are as follows;

(1) Natural disaster preventions, crustal and land surface deformations measurement, and their sophisticated method development.
(2-b) Forest management, forest, wetland and ecosystem related geophysical quantities measurement, and their sophisticated method development.
(2-c) Oceanography, sea-state condition, ship detection and environmental parameters measurement, and their sophisticated method development.
(3) Research for expanding the field of satellite data utilization.

The details are as follows;

(1) 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 among ALOS-2, ALOS-4 and other satellites.
- ALOS-2 and ALOS-4 mutual usage and time series analysis method.

(2-b) 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-ground 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 geophysical parameters estimation and its sophisticated method.
- Improvement of extraction of forest, wetland and ecosystem related information by combined use of among ALOS-2, ALOS-4 and other satellites.
- ALOS-2 and ALOS-4 mutual usage and time series analysis method.

(2-c) 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 among ALOS-2, ALOS-4 and other satellites.
- ALOS-2 and ALOS-4 mutual usage and time series analysis method.

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

In particular, research proposals to include the following are expected.
- ✓ Sharing the own reference data i.e. validation data on the ground with JAXA.
- ✓ Research proposal in group and share ALOS-2 and ALOS-4 data within the group to contribute streamlining of data provision from JAXA under the EO-RA4.
- ✓ Plan on publication of higher level- and research-product and analysis tool developed and verified by the PI.
- ✓ Publication plan of active achievements in Web sites, media, papers, academic societies, committees, etc.
- ✓ Combined use of ALOS-2 and ALOS-4 with other satellite data, products, numerical models etc., and proposal of new analysis method using artificial intelligence (AI) e.g. deep learning.
- ✓ Research proposals fully use the uniqueness of ALOS-2/ALOS-4 among other L-band SARs, e.g., fully-polarimetric data and 3-meter resolution data.

**2.2.5.3 Note on data provision requests of ALOS-2 and ALOS-4**

This research announcement of ALOS-2 and ALOS-4 will be implemented under the "non-funded Collaborative Research Agreement". The approved research themes will be

accessible to relevant ALOS-2 and ALOS-4 data (limited amount). At the time of this announcement, there is no commitment to ALOS-4 data provision. Please note that the research plan may have to be changed according to the satellite operation schedule.

In the past, data orders from PIs under the ALOS-2 Ras tended to concentrate at the end of the fiscal year, and it occasionally exceeded the capacity of processing systems and affected not only RA activities but also general users. From this reflection, please be aware that the ALOS-2 and ALOS-4 standard products will be provided under this policy as follows.

① Validity evaluation of the number of data requests

To validate the number of data requests of ALOS-2 and ALOS-4, please indicate your area of interests (AOIs) clearly i.e. name of location, region, latitude, and longitude), analysis method, a summary of the availability of ALOS-2 data for your research proposal and requested scene numbers in your proposal. For each research proposal, up to **30 scenes in a fiscal year** will be provided as a baseline with the following conditions. JAXA will evaluate your data requests. Note that due to the complexity of counting the number of scenes in ALOS-4, tentatively count the number of scenes as same scene size in ALOS-2.

Just for your reference, you can see the Basic Observation Scenario (BOS) as a future observation plan and the observation results as archived data of ALOS-2 on

https://www.eorc.jaxa.jp/ALOS/en/alos-2/a2_observation_e.htm

and the BOS of ALOS-4 on

https://www.eorc.jaxa.jp/ALOS/en/alos-4/a4_observation_e.htm

Future observation plan is not assured, as the BOS is subject to change and revision in coordination with the users.

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.). Details will be provided individually after adoption.

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 principal investigator (PI), and group members will be involved as Co-Investigators (CIs). The provided ALOS-2 and ALOS-4 data will be shared within the group.

### 2.2.6 Multi-sensor Observation Lidar and Imager (MOLI)

MOLI stands for Multi-sensor Observation LiDAR and Imager and 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 JFY2027. The operation period of MOLI will be basically one year, but an extended one-year operation will be considered, therefore 2 years of operation is planned in total. MOLI can observe highly precise forest parameters i.e. canopy heights and Above Ground Biomass (AGB) and ground height at the laser footprint from 51 degrees North to 51 degrees South, which depends on the ISS orbit. AGB is used as a measurement unit to understand the carbon stock of the forests because it is the dry weight of the tree above ground and approximately half the 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 a strong correlation between canopy heights and AGB. MOLI will provide accurate observation data of forest biomass on a 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 the measures against the climate change.

One of the unique features of MOLI is that it carries an imager in addition to the LIDAR. The imager is mainly used to determine forest conditions at the same time as the LIDAR observations. The footprint diameter of MOLI is 25 m, and laser beams are emitted at intervals of about 50 m along a line near the nadir of the ISS.

For more information on MOLI, please refer to Appendix 6.

#### (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 research to develop an algorithm to determine the presence or absence of cloud influence for each footprint using MOLI LDAR and imager data.

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

  This theme is 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 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 Japan (Muroto, Ise-Shima, Gero, Izu-Shimoda, and 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 these 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 research: (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 in large area 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 imager data (L3)

The MOLI imager will acquire image with an observation swath of over 1,000 m, a spatial resolution of 5 m, and 3 bands (green, red, and near infrared), simultaneously with LiDAR observation. This theme is 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 research to develop algorithms of mapping canopy height and AGB using the L2 products (estimated canopy height and AGB from LiDAR waveform data) and other satellite image data i.e. ALOS-2/PALSAR-2, ALOS-4/PALSAR-3, GCOM-C/SGLI, etc.

**(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)". During this 3-year EO-RA4 period (FY2025-FY2027), we plan to execute a budget of about 5 million each year for the entire MOLI PI. However, this is subject to change depending on the status of the project and the budget.

### 2.2.7 Earth Cloud Aerosol and Radiation Explorer (EarthCARE)

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

The objectives of the Earth Cloud Aerosol and Radiation Explorer (EarthCARE) mission, launched in May 2024, 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 are equipped with EarthCARE satellite. The active sensors are the Cloud Profiling Radar (CPR), developed by Japan, and the Atmospheric Lidar (ATLID), developed by ESA. The passive sensors are the Multispectral Imager (MSI) and the BroadBand Radiometer (BBR) developed by ESA. More details about the EarthCARE mission can be found in the Appendix.

In this research announcement, we will focus on algorithm development and validation researches of the products of EarthCARE, and applied 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 applied researches. The representative researchers of the selected the research topics (PIs) will belong to the Japanese EarthCARE science team and will conduct validation and applied 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 85 million yen in total for all research proposals (the total budget for algorithm development research proposals is planned to be approximately 57 million yen per year). 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 2.2.7-1 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 2.2.7-1 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

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

The JAXA EarthCARE seeks proposals to carry out algorithm development, validation and applied 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.

### 2.2.7.3 Algorithm development

We call for research on the development and improvement of JAXA's EarthCARE standard algorithms, as described in (1)-(9) below. In order to directly reflect the results of existing developments, we will select research that has been selected as the standard algorithm at launch in the research activities of previous RAs with an emphasis on continuity. The selected PI and JAXA will work together to maintain and revise the algorithms, evaluate them, implement them in JAXA's computer system, and develop algorithm descriptions.

(1) CPR One-Sensor Algorithm

This theme encompasses research to develop algorithms that produce the EarthCARE CPR Level 2 standard and research products shown in Table 2.2.7-1. The Level 2 CPR-only algorithm must have the following functions:

(i) Standard cloud product

- A function that detects clouds

- A function that estimates the phase and shape of cloud particles

- A function that retrieves cloud microphysics (liquid/ice water content, effective radius of liquid/ice cloud, optical thickness).

(ii) Research product

- A function that estimates rain/snow water content (where it is desirable to do the estimation both with and without using Doppler velocity information)

- A function that retrieves rain/snow rate

- A function that computes vertical air motion and sedimentation velocity.

(2) ATLID One-Sensor Algorithm

This theme encompasses research to develop algorithms that produce the EarthCARE Atmospheric LIDar (ATLID) Level 2 standard and research products shown in Table 2.2.7-1. The Level 2 ATLID-only algorithm must have the following functions:

(i) Standard product

- A function that detects aerosols and clouds

- A function that retrieves cloud phase and aerosol type (black carbon, dust, sea salt, etc.)

- A function that computes backscattering coefficient, depolarization ratio, lidar ratio, and extinction coefficient in cloud/aerosol regions

- A function that estimates planetary boundary layer height.

(ii) Research product

- A function that computes aerosol extinction with respect to its type (black carbon, dust, sea salt, etc.).

(3) MSI One-Sensor Algorithm

This theme encompasses research to develop algorithms that produce the EarthCARE Multi-Spectral Imager (MSI) Level 2 standard and research products shown in Table 2.2.7-1. The Level 2 MSI-only algorithm MSI must have the following functions:

(i) Standard product

- A function that detects clouds

- A function that retrieves cloud phase

- A function that retrieves the optical thickness of water clouds

- A function that retrieves the effective radius of water clouds (where it is desirable to retrieve using 1.6 $\mu$m and 2.1 $\mu$m bands)

- A function that computes the altitude, temperature, and pressure at the top of clouds.

(ii) Research product

- A function that retrieves the optical thickness of ice clouds

- A function that retrieves the effective radius of ice clouds (where it is desirable to retrieve using 1.6 $\mu$m and 2.1 $\mu$m bands)

- A function that calculates the altitude, temperature, and pressure at the top of ice clouds

- A function that computes the optical thickness of aerosols

- A function that computes the angstrom parameter of aerosols.

(4) CPR/ATLID Synergy Algorithm

This theme encompasses research to develop algorithms that produce the EarthCARE CPR/ATLID Synergy Level 2 standard and research products shown in Table 2.2.7-1. The Level 2 algorithm to be used synergistically by CPR and ATLID must have the following functions:

(i) Standard product

- A function that detects clouds

- A function that estimates the phase and shape of cloud particles

- A function that retrieves cloud microphysics (liquid/ice water content, effective radius of liquid/ice cloud, optical thickness).

(ii) Research product

- A function that computes the volume ratio of ice crystal plane within the liquid water content (where it is desirable to estimate both with and without using Doppler velocity information)

- A function that estimates rain/snow water content (where it is desirable to estimate both with and without using Doppler velocity information)

- A function that retrieves rain/snow rate

- A function that computes vertical air motion and sedimentation velocity.

(5) ATLID/MSI Synergy Algorithm

This theme encompasses research to develop algorithms that produce the EarthCARE ATLID/MSI Synergy Level 2 research products shown in Table 2.2.7-1. The Level 2 algorithm to be used synergistically by ATLID and MSI must have the following functions:

(i) Research product

- A function that computes the aerosol extinction with respect to its type (black carbon, dust, sea salt, etc.)

- A function that computes the size information (mode radius, etc.) of aerosols.

(6) CPR/ATLID/MSI Synergy Algorithm

This theme encompasses research to develop algorithms that produce the EarthCARE CPR/ATLID/MSI Synergy Level 2 standard and research products shown in Table 2.2.7-1. The Level 2 algorithm to be used synergistically by CPR, ATLID, and MSI must have the following functions:

(i) Standard product

- A function that detects clouds

- A function that estimates the phase and shape of cloud particles

- A function that retrieves cloud microphysics (liquid/ice water content, effective radius of liquid/ice cloud, optical thickness).

(ii) Research product

- A function that detects clouds, using Doppler velocity information

- A function that estimates the phase and shape of cloud particles, using Doppler velocity information

- A function that retrieves cloud microphysics (liquid/ice water content, effective radius of liquid/ice cloud, optical thickness), using Doppler velocity information

- A function that estimates rain/snow water content (where it is desirable to estimate both with and without using Doppler velocity information)

- A function that retrieves rain/snow rate

- A function that computes the vertical air motion and sedimentation velocity

- A function that estimates the effective radius and optical thickness of ice clouds using thermal channel.

(7) Four-Sensor Synergy Algorithm

This theme encompasses research to develop algorithms that produce the EarthCARE Four-sensor Synergy Level 2 standard and research products shown in Table 2.2.7-1. The Level 2 algorithm to be used synergistically by CRP, ATLID, MSI, and BBR must have the following functions:

(i) Standard product

- A function that computes shortwave and longwave radiation

- A function that computes the heating ratio of shortwave and longwave.

(8) EarthCARE Data Simulator

In order to assist with Level-2 algorithm development, as well as to promote the application of EarthCARE observation data, JAXA requires the development of an EarthCARE data simulator that can compute EarthCARE sensor data from the atmospheric data of numerical weather/climate models.

In order to support a wide range of weather and climate models, two types of simulators have been developed: a) a satellite data simulator based on the Joint-Simulator (Joint Simulator for Satellite Sensors), and b) a satellite data simulator based on the CFMIP Observation Simulator Package (COSP).

With regard to the development of these simulators, candidates need to take into account the following:

a) The data simulator based on the Joint-Simulator

This simulator has the function of inputting atmospheric data from a numerical weather and climate model and outputting simulated EarthCARE data.

The following points should be noted when developing this simulator.

- Based on the simulator shown in Hashino et al. (2016, JGR), it should be possible to perform forward calculations related to each sensor of EarthCARE.
- It should be usable with the global cloud-resolving atmospheric model Nonhydrostatic ICosahedral Atmospheric Model (NICAM) (Satoh et al., 2008, J.Comp. Physics). It is also desirable that it can be applied to other cloud-resolving atmospheric models.
- It is desirable to develop a technology to utilize EarthCARE data using a simulator applied to NICAM data, etc.

b) The data simulator based on the CFMIP Observation Simulator Package (COSP)

This simulator has the function of inputting atmospheric data from numerical climate models and outputting simulated EarthCARE/CPR data including Doppler velocity.

The following points should be kept in mind when developing this simulator.

- It should be possible to perform forward calculations related to the radar reflectivity factor and Doppler velocity of EarthCARE/CPR based on COSP2 as shown in Swales et al. (2018, GMD).
- It should be usable with atmospheric data from the climate model "MIROC (Model for Interdisciplinary Research on Climate)". It is also desirable that it should be applicable to other climate models participating in IPCC assessment reports.
- It is desirable to develop analysis technology to utilize EarthCARE data using a simulator applied to MIROC data, etc.

### 2.2.7.4 Validation

This RA covers a 3-year research period from JFY 2025 to JFY 2027. Since this RA period will correspond to the post-launch period of EarthCARE, JAXA invites proposals that directly contribute to the validation study of EarthCARE Standard and Research Products.

At the end of JFY2026, we will be required to submit product evaluation results for EarthCARE products upon completion of mission operation phase. Some validation activities (such as holding workshops) may be conducted considering the collaboration with the ESA.

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 volume 3 in 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). We invite

research proposals that are not currently listed in the VIP but that can directly contribute to EarthCARE validation. We also invite research proposals that are not listed in (i) to (iii), categorized as (iv) here, 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. Quantitative evaluations of the product accuracies will be performed by using data from observation sites and networks with ground instruments.

(ii) Campaign observation

JAXA will conduct campaign observations that aim to compare the EarthCARE products. JAXA has cooperated the validation activity with the National Institute of Information and Communications Technology (NICT), and the Headquarters (HQ) of the NICT (4-2-1, Nukui-Kitamachi, Koganei, Tokyo 184-8795, Japan) is a site for this, and instruments have been collocated in the NICT HQ. The instruments shown in Table 2.1.8-2 are expected to be collocated in the NICT HQ.

(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. 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. In addition, we invite statistical comparisons with the products from CPR onboard CloudSat satellite and CALIOP onboard CALIPSO satellite.

(iv) Other validation observations and data collection

We also accept research proposals for other validation activities and research topics related to the collection and organization of other observational data that are not included in (i)-(iii) above. Research topics must directly contribute to the validation of EarthCARE.

#### 2.2.7.5 Applied Research that leads to achieve EarthCARE mission targets/goals and creation of outcomes

In this category, JAXA seeks applied research, which will contribute to achievements of the EarthCARE mission targets/goals, which are contribution to weather/climate change research and operational applications, and creation of new outcomes, mainly using EarthCARE data. Please note that proposal that aims to create outcomes by multiple use of data from the EarthCARE and other JAXA satellite data will be also categorized to the “Earth Observation Research Program” (see Section 2.1). The applicants are asked to clarify to which category ((1), (2-a), and (3)) in the Program their proposals mainly contribute.

To achieve the mission objectives of EarthCARE, JAXA seeks a wide range of applied researches on evaluation and practical use of weather and climate models. applied 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 contribute 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 the Joint-Simulator and the COSP, 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 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.

## 3 Instructions for responding to this EO-RA4

### 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-RA4.

### 3.2 Research agreement conclusion

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

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

### 3.3 Research period

The maximum research duration of this EO-RA4 will be 3 years from JFY 2025 to JFY 2027. However, the progress will be evaluated based on the annual report submitted by the PI at the end of each JFY, in order to verify and decide whether the research is to be continued the following year.

### 3.4 Resources

(1) Funding

Funding will not be applicable, basically, for this EO-RA4 Late Proposal.

A

In the case of a newly open RA, JAXA will reserve funds to support selected proposals. Funding may differ for each research category and applicant. The basic policy for funding is as follows:

A) Based on the purpose of this EO-RA4, funding will be partially available for proposals applied to the Earth Observation Research Program and the JAXA Satellite Project Research on AMSR3 & GCOM-W [Algorithm development, Cal/Val, Earth Observation Research Program (Applied research)], GCOM-C [Algorithm development, Cal/Val, Earth Observation Research Program (Applied research)], GPM & PMM [Algorithm development, Cal/Val, Earth Observation Research Program (Applied research)], MOLI (Algorithm development, Cal/Val) and EarthCARE [Algorithm development, Cal/Val, Earth Observation Research Program (Applied research)], within JAXA's budget limitation and the status of approval. Proposals submitted to other areas than the 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/ALOS-4 standard products are necessary for conducting the proposed research, refer to the descriptions in "**2.2.5.3 Note on data provision requests of ALOS-2 and 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-RA4.

(2) Non-funded PIs shall also submit the annual 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

The proposals will be officially adopted upon approval of the next JAXA mid-term plan.

### 3.7 Late proposals

Proposals or modifications submitted after the due date specified in this EO-RA4, basically, will not be accepted. Proposals submitted after the due date as to offer JAXA a significant scientific and/or technical advantage or cost reductions can be exceptionally considered as late

proposals. However, late proposals must be submitted as non-funded research proposals and their evaluation and selection schedule will be different from the descriptions of "3.10 Important dates for selection of proposals" and considered later, possibly in summer, in JFY 2025.

### 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 terms and conditions of the research agreements.

### 3.9 Cancellation and postponement

JAXA reserves the right to cancel or postpone this EO-RA4 for reasons of JAXA's own. In addition, JAXA assumes no liability for canceling this EO-RA4 or for postponing this EO-RA4 schedule.

### 3.10 Important dates for selection of proposals (planned)

| | |
|---|---|
| Late May 2025 | Open call for the EO-RA4 Late Proposal |
| **June 18th, 2025 12:00 JST (03:00 UTC)** | **Proposal Due Date** |
| Late September 2025 | Notification of Selection Results |
| October or later 2025 (after conclusion of Research Agreement) | Start of Selected Research |

The updated schedule of this EO-RA4 Late Proposal will be announced in the JAXA EORC web site (https://earth.jaxa.jp/en/research/cooperation/ra4/index.html).

A

### 3.11 Proposal submission and contact point

Please access 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 further information on the Proposal Submission Web Site. Please do NOT use any free-mail address such as Gmail, Yahoo! Mail etc. to avoid any problems in 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 homepage.
(https://earth.jaxa.jp/en/research/cooperation/ra4/index.html)

* Note that this web site and the proposal submission web site, informed by e-mail after the registration, are located outside of JAXA 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

### 4.1 General

(1) Proposals received in response to this EO-RA4 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.

### 4.2 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, "EORA4_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, "EORA4_FormB_*name_ABC*.pdf".
(C) Form C (C-1 or C-2; depending on 'C-1: Funded' or 'C-2: Non-Funded' proposal) needs 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, "EORA4_FormC-1_*name_ABC*.pdf".
(D) Although no detailed formatting is specified for the research proposal, it should be prepared in accordance with the instructions given in Sections (2) and 4.3 below and converted to PDF format before uploading. In addition, a set of appendices such as reprints of the thesis should be uploaded in PDF format as well. Please submit the file name with the PI's name and the acronym of your affiliation, for example, "EORA4_Main_*name_ABC*.pdf" for the detailed proposal descriptions and "EORA4_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 (5) 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. In case you submit more than one proposal, it is necessary to make an individual ID for each proposal and set up each page on the proposal submission web site.

**4.3 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, address, email address, phone & fax number for the Research Agreement conclusion.

Please note that the descriptions on the above item from A) to C) are also required to put on 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) Research 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 (Form C-1: for Funded cases only)
Resource requirements, in the case of any research budget is preferred to provide for the proposed research activities, should be described in the form 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 of the proposed research are also included in APPENDIX A/B.

(5) Detailed descriptions of research proposal
A) Main body
The main text of this section should not exceed 20 pages and should include the following details: 1) objectives and importance; 2) relationship to existing knowledge, prior research, and ongoing related research; 3) overall research plan (outline of research items, schedule, structure, research materials to be used, etc.); 4) description of research methods and procedures including research techniques and data usage; 5) social or scientific/technological significance of the research results; 6) management procedures (see below); 7) personnel (see below), and other details. Please attach the necessary detailed information, such as reprints of the paper, as appendices. You should also be aware of addressing evaluation criteria and other items specified in this EO-RA4. 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.

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.

B) 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.

C) Personnel

- Biographical information, experience, papers in related fields

  A short biographical sketch, a list of publications, experiences related to this EO-RA4, and professional qualifications of the PI should be included. Also provide similar biographical information on each CI.
- 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) If JAXA determines that extension of a research project is qualified by the annual report at the end of the Japanese Fiscal Year, the research agreement will be extended for 1 year, and up to March 31, 2028. Funded organizations should submit the continuing agreement application form to JAXA at the beginning of every JFY.

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

(5) JAXA may coordinate to make an agreement with the Organization using JAXA's 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 "Applied Research";
- 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.

<u>The difference between a funded agreement and non-funded agreement:</u>

A) <u>Collaborative Research Agreement (Funded)</u>

- 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) <u>Collaborative Research Agreement (Non-funded)</u>

- 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 (https://earth.jaxa.jp/en/data/policy/); 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.

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