Global Change Observation Mission:

Sixth Research Announcement

Algorithm development, validation, application study, and multi-sensor research

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Earth Observation Research Center
Japan Aerospace Exploration Agency

Contents

1. Introduction

1.1. About the Sixth GCOM Research Announcement

In this sixth Global Change Observation Mission (GCOM) research announcement (RA), the Japan Aerospace Exploration Agency (JAXA) is announcing the opportunity for development of algorithms for geophysical products, validation, and application research using GCOM-C (Climate), as well as researches with multi-sensors such as GCOM-W and EarthCARE. The research period is three years from Japanese Fiscal Year (JFY) 2016 (April 2013) to 2018 (March 2019), and especially focuses on GCOM-C at-launch algorithm preparation, algorithm improvement, product validation, and development of new application schemes.

JAXA is conducting cross-cutting application researches in order to enhance synthetic use of multiple satellite data. The purposes of the cross-cutting application researches includes generation of valuable products integrated by multiple satellite data and satellite-model integrated use (data assimilation etc.), development of the prediction schemes using a model, and enhancement of operational and public use. The current subjects of the cross-cutting application researches are "water cycle and resources", "ecosystem monitoring", "climate system radiation process", "marine environment monitoring", "atmospheric environment monitoring", "infrastructure monitoring", "agriculture", and "public health." In this RA, proposals which contribute to these researches mainly using GCOM-C data are also recommended .

1.2. GCOM and GCOM-C

GCOM seeks to establish and to demonstrate a global, long-term satellite observation system to measure essential geophysical parameters for understanding global climate change, and the water cycle mechanism. Its ultimate objectives are to improve future climate projection through a collaborative framework with climate model researches and to demonstrate the capabilities of operational applications by providing continuous data to operational agencies. GCOM will assume the Advanced Earth Observing Satellite-II (ADEOS-II) mission and transition into long-term monitoring of the global environmental changes. To achieve global, comprehensive, long-term, and homogenous observation, GCOM will consist of two satellite series and three consecutive generations with a one-year overlap, resulting in a 13-year observation period. The two satellites series are GCOM-W and GCOM-C. The first generation satellite of GCOM for Water, GCOM-W satellite, will carry the Advanced Microwave Scanning Radiometer-2 (AMSR2) to provide a better understanding of the water and energy cycle. The GCOM-C satellite will be equipped with the Second-Generation Global Imager (SGLI) to observe the Earth's atmosphere and surface to elucidate the carbon cycle and radiation budget.

SGLI will be equipped with wide spectral coverage from 380 nm to 12 μm, a field of view exceeding 1000 km succeeding ADEOS-II/GLI. New additional features include 12 bands (14 bands including special mode of thermal infrared bands) of high spatial resolution of 250 m; two-direction simultaneous observation along the orbit (two bands); and polarization observation (two bands). The GCOM-C mission aims to improve our knowledge and prediction of the global carbon cycle and radiation budget through high-accuracy SGLI observation of global vegetation, ocean color, temperature, clouds, aerosols, and polar

regions.

The AMSR2 instrument on board GCOM-W is a multi-frequency, dual-polarized, passive microwave radiometer for observing water-related geophysical parameters. AMSR2 was designed and manufactured based on the experience of the AMSR aboard ADEOS-II and the AMSR for EOS (AMSR-E). The GCOM mission statement, the satellite and sensor system specification, and definition of the geophysical products are detailed in APPENDIX C.

1.3. Targets of GCOM and Mission Success Criteria

GCOM objectives, targets for the first generation, and mission success criteria are defined as Tables 1 and 2. This RA advertises research opportunities for achieving these targets and criteria with the ultimate goal of successful completion of this mission in collaboration with JAXA.

Table 1 GCOM Objectives and GCOM-C/W Targets

GCOM Objectives	GCOM-C Targets	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 radiance, nine land, eight atmosphere, seven ocean, and four cryosphere products as standard products	Produce and distribute satellite-observed brightness temperatures (Tbs), 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.	Process and provide satellite data to the Data Integration and Analysis System established by the University of Tokyo, JAMSTEC, and JAXA.
Establish an Earth-observation satellite system to obtain important physical parameters to assess the global environment and seek integrative use with other observation systems.	Improve the accuracy of climate change prediction by assimilating data and improving model parameters with the cooperation of application research organizations. Through the above activities, confirm the quality of GCOM data and demonstrate its ability to contribute to predicting long-term climate change. Contribute to predicting the global environment response to climate change by observing snow surface temperature, snow grain size, ocean chlorophyll-a concentration, and so on.	Improve short-term prediction accuracy by assimilating data, such as Tbs and water vapor, with the cooperation of application research organizations. Through the above activities, confirm the quality of GCOM data and demonstrate its ability to contribute to predicting long-term climate change. Contribute to predicting the global environment response to climate change by observing sea ice concentration, snow cover, sea surface temperature, and so on.
Contribute directly to operational fields, such as predicting intense weather that may bring disasters by distributing data to operational organizations that provide weather forecasts, fishery information service, sea-route information control, etc.	Improve fishery management by providing data to the Japan Fisheries Information Service Center within the required time frame.	Improve accuracy of weather forecast including typhoons, 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 five land, three atmosphere, seven ocean, and eight cryosphere research products by cooperating with research and application organizations.	Produce new research products by cooperating with research and application organizations.

Table 2 GCOM Success Criteria

GCOM-C

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

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

GCOM-W

Assessment condition \ Success level		*Minimum success*	*Full success*	*Extra success*
data production	***Standard product***[*1] *(Set release threshold/ standard/ target accuracies)*	Complete calibration and validation phase and start data distribution about 1 year after launch. Achieve release threshold accuracy[*2].	Achieve standard accuracies within 5 years after launch.	Achieve the target accuracy of one or more products within 5 years after launch.
	Research product[*1] *(Set only target accuracy)*	NA	NA	Add new important products for climate change research within 5 years after launch.
data distribution	*Real-time availability*	From the time of achieving the release threshold accuracy until 4 years after launch[*3], maintain ability to distribute the data within the required time.	From the time of achieving the release threshold accuracy until 5 years after launch, maintain ability to distribute the data within the required time.	NA
	Continuity	From the time of achieving the release threshold accuracy until 4 years after launch[*3], maintain ability to observe and distribute products.	From the time of achieving the release threshold accuracy until 5 years after launch, maintain ability to observe and distribute products.	NA

*1 Standard products are defined as products that are especially important for achieving the mission goal, sufficiently confirm the application reality from ADEOS-II results etc., and are suitable for operational data distribution. Research products are defined as products still in the research phase of development and application, or are unsuitable for operational data distribution.
*2 Release threshold accuracy: Minimum accuracy for release as available for climate research
*3 Set the period until the GCOM-W2 launch.

1.4. Standard and Research Products of GCOM-C

To achieve mission objectives effectively, standard and research products are determined by the GCOM Advisory Committee on the basis of three criteria: (1) centrality to the mission, (2) feasibility for algorithm development, and (3) effectiveness of data processing and distribution, which includes (A) data that are produced and distributed as they are acquired, (B) data that should be disclosed after accumulation and processing for a given period of time, and (C) data that will be presented as research findings (APPENDIX C, Table 7).

For example, standard products are defined as elements of particular importance for achieving the mission goal, such as cloud and aerosol properties, sea-surface temperature, ocean color, snow, and vegetation, that sufficiently confirm the application reality from ADEOS-II results and are suitable for operational data distribution (A). Research products are defined as elements still in the research phase of development and application or products that provide new important knowledge but are unsuitable for operational data processing, such as (C).

(1), (2), and (3) may be altered through changes in social requirements or progress in research and development. In such cases, the GCOM Advisory Committee may re-organize standard and research products or add new products by consultation with user communities.

1.5. RA Period and Development Phase

This RA period is JFY 2016–2018, which corresponds to ③ and ④ in Fig. 1. This period will include the satellite launch year; research will emphasize algorithm (processing code) development for post-launch operation, and validation observation for the algorithm improvement and product evaluation, and development of new application schemes to achieve the GCOM-C objectives (Table 1).

Research plans for this RA are required to fit to the development phase ③ and ④.

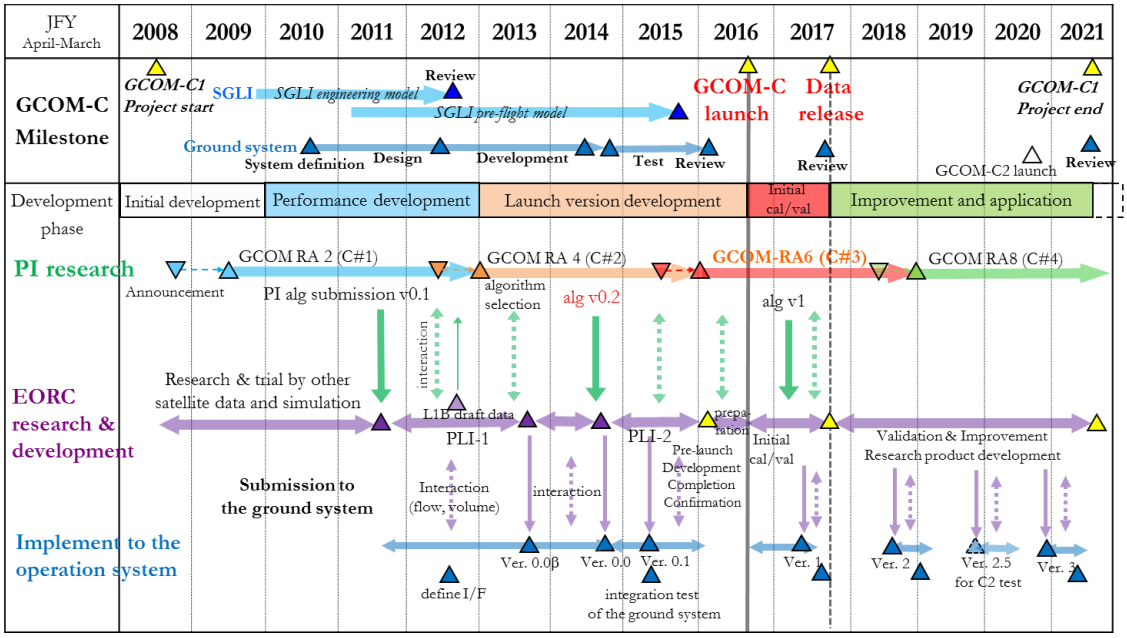

Fig. 1 GCOM-C algorithm development phase and the RA periods

① Initial development phase (JFY 2009)

- Select the candidates for algorithm and product development (Establishment & Implementation of Mission Requirements).
- Consider the feasibility of the new product, and resolve remaining issues.
- Validate and improve the algorithms by using satellite and in situ observation data.
- Consider algorithms that address the impact of GCOM-C satellite and SGLI sensor design evaluation.

② Performance development phase (JFY 2010–2012)

- Evaluate and propose improvements for the performance of candidate algorithms (theoretical validity, accuracy against test data, and processing stability) by using test inputs.
- Collect the necessary fundamental data, and evaluate development, validation, and application.
- Conduct pre-launch implementation test-1 (PLI-1) to evaluate algorithm fundamental performance and satellite data applicability on the basis of the previously stated points.
- Correspond to results of satellites and sensor development (e.g., evaluate the influence on the products and adjust the algorithms).
- Draft Algorithm Theoretical Basis Document (ATBD).
- Select at-launch algorithms on the basis of the PLI-1 results (the selection will be reflected in the next RA).

③ Launch preparation phase (JFY 2013–2016)

- Develop, evaluate, and improve the selected operational codes.
- Acquire fundamental data necessary for evaluation and improvement, and establish the post-launch product validation method.
- Conduct pre-launch implementation test-2 (PLI-2) to evaluate operational flow and performance (e.g., memory and time).
- Correspond to the performance of satellite and sensors.
- Modify the ATBD.

(JFY 2016 GCOM-C launch)

④ Post-launch development and improvement phase (JFY 2016–2021)

- Perform initial validation and product improvement (version upgrades) by using real SGLI data.
- Perform intensive validation and improvement of algorithms as initial calibration validation phase for the first product release one year after launch.
- Obtain fundamental and validation data for improvement.
- Develop, validate, and verify research products and new applications.
- Achieve GCOM-C success criteria.
- Adapt the new knowledge to the development of GCOM-C2 algorithms to achieve success and consistency with the second phase (GCOM-C2).

1.6. Role of PI and the RA Process

JAXA plans to select 30 to 40 proposals under this RA, including both funded and non-funded. The principal investigator (PI) of each selected proposal will become a science team member of GCOM-C and, in some cases, GCOM-W. The PI will conduct frequent discussions and collaborations with JAXA Earth Observation Research Center (EORC) staffs for the algorithm development, validation, and application studies. The PI must attend and present the research statuses at annual PI workshops. The science team leader will participate in the GCOM Advisory Committee and SGLI application working group to feed back our activities to the GCOM overall objectives and mission requirements.

PIs will be able to receive prioritized distribution of the new version of the GCOM data, as well as to use JAXA owned Earth observation satellite data and in-situ measurement data free of charge (priority of the research areas is stated in the next section). Depending on its budget status, JAXA plans to spend 130 million yen/year for total PI within the three years of this RA period. The budget for each PI may change for the following year depending on the results of PI research evaluation held at the annual GCOM workshop. JAXA may also select non-funded PIs for research without the requirement of additional costs for application study and research not directly related to the success criteria of GCOM.

With the exception of students, all categories of domestic and foreign nonprofit and peaceful organizations can apply under this RA. However, funding may differ for each

research category and applicant. Funding by JAXA is essentially restricted to domestic PIs, although some exceptions may be made for research necessary to achieve the GCOM mission success criteria. Proposals will be selected on the bases of a peer-review process and discussions in science/project evaluation boards. JAXA plans to announce the selection results in January 2016.

Collaboration with other RA such as GCOM-W, EarthCARE, and GPM etc. is encouraged. However, researchers or research groups applying for multiple RAs must clearly state on the proposal work distribution, budget (in case of a funded proposal), and effort ratio with respect to the other RA. Similarly, the allocation and ratio of effort of research related to other externally funded studies must be clearly stated (Refer to "**4.3 Proposal Contents"**).

2. Technical Descriptions

2.1. Purposes of this RA

GCOM aims to contribute to improvement of global change prediction accuracy and operational application. This RA seeks to conduct research necessary for global, long-term, and highly accurate and efficient GCOM-C product development/evaluation, as well as effective research on global change, by utilizing the achievements of previous GCOM-C RA (JFY2013–JFY2015) and by obtaining new knowledge and skills from domestic and foreign researches.

2.2. Research Areas

This RA seeks research proposals in the following areas: algorithm development, validation, application research, and multi-sensor application research basing GCOM-C data. Because the research period will cover the GCOM-C launch, this RA funding emphasizes algorithm development for post-launch regular processing, validation observation for product evaluation at the first data release, and new application scheme development such as synthetic use with models, agricultural application and so on. Details are listed below.

2.2.1 Development of GCOM-C Algorithms

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

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

- Develop algorithms effectively by applying broad knowledge obtained through RA.
- Develop algorithms efficiently by an in-house algorithm integration team following the ADEOS-II/GLI experience, GAIT (Fig. 2).
- Develop algorithms that consider construction of long-term, stable, and highly accurate datasets.
- Develop algorithms that consider research on the operational use of global environmental changes.
- By developing software to enable a stable process, perform data distribution and data analysis studies quickly and smoothly.
- By developing new data analysis and application schemes, enhance future possibility of remote sensing in Earth environment observation.
- By developing algorithm performance as a total observation system including satellite/sensor design and manufacturing, improve data product quality and accuracy, and feed the results to the next satellite and sensor development.

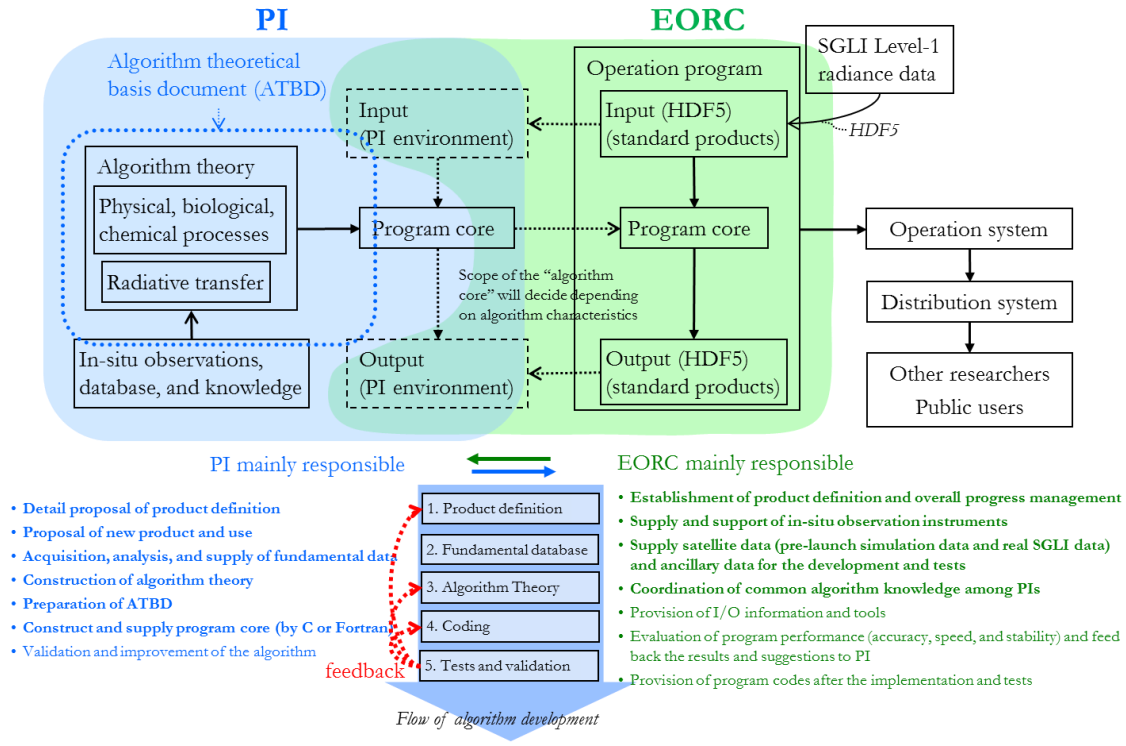

Fig. 2. Example of collaboration and sharing between PI and JAXA in algorithm development. The map should be modified according to algorithm characteristics and volume of the code (C or Fortran code).

Generally, GCOM-C algorithms will be developed through the following procedures, as shown in Figure 2: (1) definition of products; (2) construction of fundamental database; (3) development of algorithm theory; (4) coding of radiative transfer (algorithm theory); and (5) implementation, testing, and optimization of the JAXA operation system. This RA mainly covers procedures (2), (4), and (5) and may include (1) and (3) for research products and new product proposals. In particular, this RA seeks proposals for implementation and improvement of steady algorithm processing, expansion of the fundamental database from (2), and newly defined products and applications that contribute to the GCOM-C mission objectives.

To directly succeed the results of research and development from previous the RA (FY 2013–2015), past algorithm PIs are encouraged to continue their researches, and the yearly evaluation results will be considered in this RA selection as well as their submitted proposals; Table 3 shows the PI in charge for current RA.

As shown in Figure 2, selected PIs will collaborate with JAXA to develop algorithms, implement their codes, validate the output products, and update the algorithm and algorithm theoretical basis documents. Details on currently defined standard and research products and expected research themes are listed in section 2.3.

APPENDIX C, Table 7 lists geophysical parameters to be produced as standard and research products of the GCOM-C mission; their accuracy targets are defined as the mission success criteria. These accuracies were defined through consultation with users, including the GCOM advisory committee and the SGLI working group, on the basis of experiences of application of existing satellites. The "release threshold accuracy" is

defined as the minimum accuracy for the first data release; “standard accuracy” is defined as valuable and standard-level accuracy; and “target accuracy” includes numerous challenges in improving algorithm performance and calibration accuracy and is to be achieved on a research basis. Algorithms accepted in this research area will produce products that meet the requirements listed in APPENDIX C, Table 7 in the operational phase of the GCOM-C mission.

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

Applicants may propose a new algorithm, categorized as a type of research algorithm that produces a standard product at a higher quality than that of a standard algorithm developed in the previous RA. Through comparative validation of performance, the new algorithm may become the new standard algorithm at the point of product revision. Therefore, research should meet the requirements of target accuracy. Their performances (accuracy, processing speed etc.) are expected to be at the same level as existing standard algorithms.

Research algorithms will be evaluated by additional success criteria (target accuracy) for five years after the satellite launch, and their development must meet requirements. As noted in section 1.4, research products produced by these algorithms could become new candidates for the standard products after completion of a specific evaluation process.

To meet the GCOM objectives, algorithms require global applicability, robustness, and long-term stability. Algorithms that can be extended and applied for similar microwave radiometers and historical data records are preferable for integrated processing. Computationally efficient, fast-processing algorithms are important for operational applications of the products.

As described in chapter 5, research on standard algorithms is generally supported through a Commissioned Research Agreement, while research algorithms with many research factors are supported through a Collaborative Research Agreement.

2.2.2 Validation Observation and Product Validation

This research area seeks proposals of validation observation and effective product validation through cooperation with other ground and satellite observation researches. Table 4 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 8 and 9 in APPENDIX C) which has been established by previous RAs.

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

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

Proposals of in-situ data acquisition through collaboration with observation activities by other funds are also encouraged for enhancement of in-situ data coverage for the GCOM-C product validation. New observation plans, which include in-situ data acquisition and product evaluation methods, and will improve the GCOM-C product evaluation, can be proposed in addition to the APPENDIX C Tables 8 and 9.

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

Obtained in situ observation data and knowledge must be provided to JAXA and the PI in charge of algorithms for application of algorithm improvement and post-launch validation. Providers of in situ data can define the disclosure levels specified in Table 5: for EORC members only, EORC and PIs for algorithm development, calibration and validation, registered users, and public open. The provider will define the disclosure level for data and provide this information to EORC, which will share the data via EORC/GCOM-C Web pages (The disclosure level is required to be open wider user levels as much as possible). It is asked to provide in-situ data which was not funded by JAXA, if the policy of the in-situ data is allowed with appropriate disclosure levels.

As described in chapter 5, this research theme is generally supported through a Collaborative Research Agreement. Application is possible under subsection 2.2.1, Development of GCOM-C algorithms, if the researcher is developing the algorithm in addition to validation research.

2.2.3 Application Research

This research category seeks proposals on monitoring environmental changes, improving future prediction, and research leading to the social benefits including practical applications such as fishery use, agricultural use, biological carbon fixation, environment and disaster monitoring, and so on. Contribution to the EORC cross-cutting application researches is highly recommended. Development of new research products on the basis of new concepts, social needs, and those combined with other in situ observations and numerical models is also solicited.

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

As described in chapter 5, this research theme is generally supported through a Collaborative Research Agreement.

2.2.4 Multi-Sensor Research basing GCOM-C data

JAXA seeks proposals for multi-sensor research that uses data from multiple satellites and sensors basing GCOM-C data. This includes algorithm development for new research products and application research via multi sensor data basing GCOM-C data. Examples of anticipated cases in this multi-sensor research field are detailed below:

- GCOM-C and GCOM-W
  Merged sensor research is strongly encouraged to utilize data from GCOM-C and

GCOM-W for research on climate, carbon cycle, and water cycle changes. If the research attempts to directly merge the data from both satellites, differences in orbit and observation local time for each satellite must be accounted for through the use of models and objective analysis.

- Long-term data analysis by combined use of other optical sensor and GCOM-C
  GCOM-C aims to observe climate changes over a period of more than 10 years through three generations of satellites (GCOM-C–C2-C3). A highly accountable form of research on climate change can be expected through the continuous and complementary usage of both historical and contemporary data (e.g., MODIS, SeaWiFS, AVHRR, VIIRS, OLCI, SLSTR, Himawari-8/AHI).

- GCOM-C and JAXA Earth Environment Monitoring Satellites
  EarthCARE, GPM, and GOSAT-2 will be operated simultaneously with GCOM-C; thus, research that effectively uses these satellite data simultaneously will be solicited.

As described in chapter 5, algorithm development is generally supported through either a funded or non-funded Collaborative Research Agreement, while application study is supported through a non-funded Collaborative Research Agreement.

2.3. Science areas, product groups, and research issues

The science areas, product groups, and research items deemed particularly important in this RA are described below. These categories do not require agreement with the research unit of the RA, and research proposals on several products across these areas and groups are accepted. Research proposals on single products or groups should include careful consideration of other products within the same group and between different groups.

Product definitions are described in Table 3. Definitions of new products not included in Table 3, as well as their development and validation schemes, will be refined in detail through discussion among the users, PIs, and JAXA after the proposal is selected by the PI in charge.

L. Land

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

- ✓ On the basis of results from previous RA, JAXA will take initiatives in developing algorithms for the GCP matching and their validations. Proposals of the orientation algorithm using the GCP results and ORTHO collection algorithm for the GCOM-C tile product (LTOA) are required.
- ✓ The algorithms have to show the interface condition to integrate to other geometric correction algorithms which have been developed by JAXA.

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

- ✓ On the basis of results from previous RA, JAXA will take initiatives in

atmospheric correction algorithm development for standard products through consolidation of the PI's knowledge of atmospheric correction.

- ✓ Research collaboration is desired that relates to appropriate identification of cloud and snow areas, surface radiance, and multi-directional reflectance by vegetation, atmospheric radiance including aerosol dispersion and absorption, and establishment consistent with downstream products that use atmospheric correction reflectance products.
- ✓ Effective acquisition of sufficient ground surface observation data for correction and evaluation of directional reflectance and aerosol dispersion constituents is needed.
- ✓ For the land surface albedo product, consideration of numerical model parameters, such as spectrum and directionality, is expected, as is validation by a model.
- ✓ Collaboration with activities of C-1 (cloud discrimination), C-2 (aerosol correction), and C-5 (calibration) are desired.

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

- ✓ Modeling of relationship between the satellite observed reflectance and the radiative transfer process of the vegetation in various conditions is needed.
- ✓ Data acquisition is needed for algorithm development and cooperation with ground observation programs such as flux tower observation networks.
- ✓ Collaboration with studies of carbon cycle and ecological models (C-4) is encouraged to estimate land CO_2 fixation.
- ✓ Collaboration with activities of L-2, L-4, L-6, and A-3 is desired.
- ✓ Water stress trend should be in cooperation with L-5 if it derived using the land surface temperature, and with evapotranspiration research if it has a relationship to the evapotranspiration. Collaboration with researches of biological processes and agriculture is encouraged through knowledge of vegetation water stress.

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

- ✓ Modeling of three-dimensional structures and directional reflectance of the various shapes of canopies is needed.
- ✓ Collaboration is needed with a ground observation networks that continuously measures of biomass such as the diameter at breast-height.
- ✓ Establishment of a method to estimate above-ground biomass from 3D laser scanner measurements which have been conducted by JAXA and other groups is needed.
- ✓ Comparison and validation between the temporal change of the biomass and NPP (L-3) are desired.
- ✓ Collaboration with activities of the land cover group (L-6) is desired for global applicability; VRI is expected to improve land cover classification.

L-5 Land Surface Temperature Group: Land Surface Temperature [standard product],

Fire Detection Index [research product]

- ✓ In order to estimate the thermal infrared emissivity from the land surface, collaboration with visible and shortwave-infrared reflectance and land cover product is necessary.
- ✓ Real-time processing is needed for fire detection. In addition, collaboration with visible and short-wave infrared reflectance and the land cover group (L-6) is encouraged for the detection of burned areas.
- ✓ Fire detection product is expected to be used as an information of aerosol source.

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

- ✓ Classification is needed that considers various applications such as NPP.
- ✓ Algorithms are desired that use 3D information (L-4) and time change analysis by SGLI high-frequency observation.
- ✓ Effective construction of validation dataset and collaboration with AVNIR-2 high-accuracy land cover classification conducted by the EORC traverse-area research activities are desired.

A. Atmosphere

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

- ✓ Collaboration with common subject C-1 is needed.
- ✓ Cloud Geometrical Thickness will be derived by O_2A band, and used for the estimation of the downward long-wave radiation (A-3).
- ✓ Effective preparation of validation data and analysis methods is needed with respect to time-space differences of satellite and in situ data.
- ✓ Validation study of cloud coverage using the all-sky camera system which has been developed by JAXA is encouraged.
- ✓ Validation planning in collaboration with EarthCARE PI team which has similar products is encouraged.
- ✓ Cooperation such as research partnerships, work sharing, and participation in workshops with EarthCARE, GPM, and GCOM-W is desired for investigating the cloud radiative forcing by integrated analysis of the multiple satellite data.
- ✓ Development using the SGLI polarization observation is encouraged.
- ✓ Combined analysis with the numerical model through a radiative transfer model and extension to model assimilation is desired.

A-2 Aerosol Product Group: Aerosol over the Ocean [standard product], Land Aerosol by Near Ultra Violet [standard product], Aerosol by Polarization [standard product]

- ✓ Algorithm development is needed with global applicability and considerations for aerosol locality, as well as the global applicability.
- ✓ Contribution is needed in defining an aerosol candidate model and improving and validating the radiative transfer process for aerosol correction over the land

and the ocean.

- ✓ Effective algorithms for unifying the ocean and land algorithms and for estimating parameters such as aerosol size distribution and component ratio are desired.
- ✓ For aerosol by polarization, including land aerosol estimation through SGLI polarization observation, collaboration with POLDER research and polarized radiative transfer research is desired.
- ✓ The algorithm should be optimized to SGLI sensor performance and sensor operation characteristics, and it is encouraged to consider correction of the sensor-oriented errors such as spectral response and polarization sensitivity and so on.
- ✓ Cooperation with EarthCARE such as research partnerships, work sharing, and participation in workshops is desired for investigating cloud-aerosol interaction.
- ✓ Synthetic analysis of SGLI and the geostationary satellite sensor, Himawari-8/AHI, is encouraged to enhance the merit of the SGLI sensor characteristics.
- ✓ Combined analysis with a numerical model through a radiative transfer model and its extension to model assimilation are desired.
- ✓ Cooperation with calibration activities such as vicarious calibration (C-3) is necessary.

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

- ✓ On the basis of results from previous RA, JAXA will take initiatives in developing algorithms for the satellite-basis downward shortwave radiation.
- ✓ Downward long-wave radiation will be estimated by using Cloud Geometrical Thickness.
- ✓ Combined analysis with a numerical model through a radiative transfer model and its extension to model assimilation are desired.
- ✓ Cooperation with products of cloud detection, cloud properties, aerosol properties, surface reflectance, and surface estimation by other sensors (e.g., AMSR-2) is needed.
- ✓ Collaboration with a land flux site and in situ observation network such as an oceanic observation buoy is needed for validation.

O. Ocean

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

- ✓ Improvement in the treatment of aerosols and sea-surface reflection (sharing of knowledge from C-2) corresponding to in-water algorithms is necessary.
- ✓ Improvement is needed in processing speed and stability for near real-time processing
- ✓ Because ocean color requires particularly high calibration accuracy, algorithm adaptation to SGLI sensor features and collaboration with calibration activities including in situ observations for vicarious calibration and NWLR, C-5, are

needed.

- ✓ Effective use of SGLI characteristics, such as the 380nm band, multi-angle, and polarimetry, is encouraged.
- ✓ Acquisition and standardization of in situ optical measurements along with an ocean color group parameter (O-2) is desired.
- ✓ Inter-comparison of international products and algorithms are encouraged to contribute the ocean color ECV.

O-2 Ocean Color Group: Chlorophyll-a Concentration [standard product], Total Suspended Matter Concentration [standard product], Colored Dissolved Organic Matter [standard product], Inherent Optical Properties [research product], Phytoplankton Functional Type [research product], Red Tide [research product]

- ✓ Coastal algorithm development is planned to be based on characterization of IOP spectra observed in each coastal region. Therefore, a systematic measurement of IOP is needed.
- ✓ Improvement in algorithms is desired that considers application to ONPP estimation, redtide and in-land water, operational stability, and inter-sensor consistency through construction of fundamental datasets, in-water optical model development, and comparison of accuracy and methods in collaboration with VIIRS and OLCI.
- ✓ Combined analysis with a numerical model through in-water bio-optical models and its extension to model assimilation is encouraged.

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

- ✓ Stable and highly accurate algorithms are needed that consider operational purpose and model research combined with other sensors such as AMSR-2.
- ✓ Algorithms and products that effectively use coastal 250 m and 500 m spatial resolution of SGLI and numerical modeling research are desired.
- ✓ The combination of historical satellite sea-surface temperature data and the production and analysis of a long-term time series with improved atmosphere correction is promoted.

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

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

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

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

S. Cryosphere

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

- ✓ Contribution to other groups through C-1 activities such as discrimination between cloud and snow/ice areas is needed.
- ✓ Acquisition of in situ data for effective validation and cooperation with in situ monitoring by other groups is needed.
  - ✓ Contribution to aerosol models and weather models (as a boundary condition) is encouraged.

S-2 Snow-Surface Properties Group: Snow and Ice Surface Temperature [standard product], Snow Grain Size of Shallow Layer [standard product], Snow Grain Size of Subsurface Layer [research product], Snow Grain Size of Top Layer [research product], Snow Impurity [research product]

- ✓ Establishment of a highly accurate estimation method is needed for radiative transfer from snow/ice surfaces.
- ✓ Because opportunities for in situ measurements are generally limited, product validation must be conducted through effective in situ measurement in cooperation with domestic and foreign institutions, and theoretical evaluation of error budget.
- ✓ In order to contribute to research on Earth environment changes and climate prediction, cooperation with research on snow/ice physical processes and albedo (S-3) with numerical models (C-4) is desired.

S-3 Snow Albedo Group: Snow and Ice Albedo [research product], Ice Sheet Surface Roughness [research product]

- ✓ Cooperation with the S-2 group, which measures snow grain size and impurities that significantly influence albedo, is desired.
- ✓ Developments that consider application by numerical modeling are needed.

C. Common Issues

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

C-1 Cloud and Snow/Ice Discrimination

- A common task in most products and algorithms is to distinguish clear-sky, cloud, and snow/ice areas from SGLI TOA radiance data. However, the development of an appropriate discrimination scheme specific to each application is necessary. JAXA will encourage PI teams to share their knowledge of spectral features of each observation target and discrimination schemes and to effectively implement the individual algorithms.
- A mini workshop in 2011 was the basis for consolidation of the knowledge of each

area for cloud discrimination algorithms and for evaluating the validation scheme by using whole-sky camera systems. The cloud amount was estimated with a high degree of accuracy from whole-sky camera data; research that effectively integrates such data into algorithm improvement and validation is encouraged.

C-2 Aerosol Correction

- The light reflected from observation targets from atmospherically scattered light must be separated and corrected to estimate land, ocean, and snow surface reflectance from satellite-observed radiances, particularly those related to aerosol properties A-2. For this purpose, JAXA promotes sharing and exchange of knowledge and processing techniques for the radiative transfer process of the atmosphere–surface system.
- Direction of the development of an atmospheric correction algorithm has been discussed in the mini-workshop in 2012 and we are developing the algorithm by cooperation among researches on the land surface and the atmosphere. This RA will continue to promote activities for sharing knowledge of surface and aerosol products from each area among JAXA and PI groups.

C-3 Polarization Study

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

C-4 Integrated Analysis of Global Environmental Change

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

C-5 Consideration of SGLI Calibration Performance

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

Table 3 Persons responsible for the products in the FY2009-2012 research period

Category		*Product*	*PI in charge*
Land	Standard	Precise geometric corrected radiance	**JAXA & Tokai-U**
	Standard	Land atmospheric corrected reflectance	**JAXA (PI team collaboration)**; Val: Honda (Chiba-U)
	Standard	Vegetation index	**JAXA (PI team collaboration)**
	Standard	Above-ground biomass	**Kajiwara** (Chiba-U); Val, model: Nasahara (Tsukuba-U)
	Standard	Vegetation roughness index	**Kajiwara** (Chiba-U)
	Standard	Shadow index	**Moriyama** (Nagasaki-U)
	Standard	Fraction of absorbed PAR	**Y. Ono** (JAXA); Specific-area: Suzuki (JAMSTEC); Val : Nasahara (Tsukuba-U) , Honda (Chiba-U)
	Standard	Leaf area index	
	Standard	Land surface temperature	**Moriyama** (Nagasaki-U)
	Research	Land net primary production	Nasahara (Tsukuba-U) , Muramatsu (Nara Women's-U), Ichii (JAMSTEC), Mabuchi (Chiba-U)
	Research	Fire detection index	Moriyama (Nagasaki-U) | Nakau (Hokkaido-U)
	Research	Land cover type	Fukue (Tokai-U) | Soyama(Tenri-U) ; Takagi (Kochi-U)
	Research	Land surface albedo	JAXA (TBD); Val: Honda (Chiba-U), Nasahara (Tsukuba-U)
	Research	Water stress trend	Kajiwara (Chiba-U)
	New	Evapotranspiration Index (Crop Coefficient)	Tasumi (Miyazaki-U) ; Val: Nasahara (Tsukuba-U)
	New	Phenology	Nasahara (Tsukuba-U)
	New	Volcano monitoring	Kaneko (Tokyo-U)
	New	Land PAR	JAXA & Frouin (SIO)
	New	Land biological model	Nasahara (Tsukuba-U), Ichii (JAMSTEC), Mabuchi (Chiba-U)
Atmosphere	Standard	Cloud flag	**Nakajima** (Tokai-U)
	Standard	Classified cloud fraction,	**Nakajima** (Tokai-U); Ishimoto (particle scattering model) (MRI), Riedi (LOA); Val: Irie (Chiba-U), Yamazaki (MRI)
		Cloud top temp/height,	
		Water-cloud COT & CER,	
		Ice-cloud COT	
	Research	Water cloud geometrical thickness	Kuji (Nara Women's-U)
	Standard	Aerosol over the ocean,	**Inoue** (AORI); Val: Aoki (Toyama-U), Irie (Chiba-U)
		Land aerosol by near-UV	
	Standard	Aerosol by Polarization	**Sano** (Kinki-U); Support: Riedi (LOA); Val: Aoki (Toyama-U)
	Research	Long-wave & Short-wave radiation flux	JAXA (satellite base SW) | Inoue (AORI) (model assimilation); Val: Nasahara (Tsukuba-U) , Hayasaka (Tohoku-U)
	New	Cloud phase by polarization	Riedi (LOA)
Ocean	Standard	Normalized water leaving radiance	**Toratani** (Tokai-U); Support: Frouin (SIO)
		Atmospheric correction param.	
	Standard	Ocean PAR	**JAXA & Frouin** (SIO)
	Standard	Chlorophyll-a conc.	**JAXA**; Val: Ishizaka (Nagoya-U), Hirawake (Hokkaido-U)
	Standard	Total suspended matter conc.	**Toratani** (Tokai-U); Val: Ishizaka (Nagoya-U), Hirawake (Hokkaido-U) , Suzuki (Hokkaido-U)
	Standard	Colored dissolved organic matter	**Hirata** (PML, Hokkaido-U) ; Val: Ishizaka (Nagoya-U), Hirawake (Hokkaido-U) , Suzuki (Hokkaido-U)
	Research	Inherent optical properties	
	Research	Euphotic zone depth	
	Standard	Sea surface temperature	**Kurihara** (JAXA)
	Research	Ocean net primary productivity	Hirawake (Hokkaido-U) | Ishizaka (Nagoya-U)
	Research	Phytoplankton functional type	Hirawake (Hokkaido-U) | Hirata (Hokkaido-U)
	Research	Redtide	Ishizaka(Nagoya-U)
	New	Absorption of PAR	Frouin (SIO)
	New	Multiple sensor products	Franz (NASA), Wang (NOAA), JAXA
sp	Standard	Snow and Ice covered area	**Stamnes** (Stevens Institute of Technology); Val: JAXA
		Okhotsk sea-ice distribution	

	Research	Snow and ice classification	
	Research	Snow area in forest and mountain	JAXA
	Standard	Snow and ice surface Temperature	**Stamnes** (Stevens Institute of Technology); Val: Aoki (MRI)
	Standard	Snow grain size of shallow layer	**Stamnes** (Stevens Institute of Technology); Val: Aoki (MRI)
	New	Bare ice area in the ice ceet	Aoki (MRI)
	Research	Snow grain size of subsurface & top layer	Stamnes (Stevens Institute of Technology) & Aoki (MRI)
		Snow impurity	
	Research	Snow and ice albedo	Stamnes (Stevens Institute of Technology)
	Research	Ice sheet surface roughness	Aoki (MRI)
	Research	Ice sheet boundary monitoring	JAXA
	New	Micro-algae concentration in the bare ice	Aoki (MRI)
	New	Aerosol over snow area	Stamnes (Stevens Institute of Technology)

Bold characters *show main developers for the standard products*

Table 4　GCOM-C L1B and L2 product definitions and validation methods

Cate-gory	Product [Definition・Unit]	Accuracy[*16]		Cal/Val Method
Common	Satellite-observed radiance (Level-1B) Def.: Satellite-observaed radiances which are radiometrically and geometrically corrected with inter-band registration. Calibration information is added. Unit: W/m^2/str/μm	Release (Data release thresh-old)	5% (absolute[*11]) geometric accr.<1pixel	Accuracy of radiance is evaluated as RMS error based on vicarious calibration, on-board calibrations with solar diffuser and blackbody and so on. Geometrical accuracy is evaluated using GCP as RMS error of pixel position after systematic geometric correction.
		Stan-dard	except TIR: 5%(abs.[*11]), 1% (relative) TIR: 0.5K (@300K) geometric accr.<0.5pixel	Accuracy of radiance is evaluated as RMS error based on vicarious calibration, on-board calibrations with solar diffuser and blackbody, and maneuver operations for moon calibration and inter-band calibration (yaw-direction maneuver). Geometrical accuracy is evaluated using GCP as RMS error of pixel position after systematic geometric correction.
		Goal	Except TIR: 3%(abs.[*11]), 0.5% (relative) TIR: 0.5K (@300K) geometric accr.<0.3pixel	
Land	Precise geometric corrected radiance (LTOA) Def.: This product contains 1) PGCP parameters which indicate geometric biases estimated using GCP, and 2) radiance images which are projected to sinusoidal projection plane with the center longitude of 0 degree after the correction of the geometric biases using the PGCP. Unit: W/m2/str/μm	Release	<1pixel	Accuracy of precise geometric correction is evaluated as RMS error of pixel position using GCPs.
		Stan-dard	<0.5pixel	
		Goal	<0.25pixel	
	Land atmospheric corrected reflectance (LSRF) Def.: Land surface reflectance corrected for the effects of atmospheric scattering and absorption. Correction of directional anisotropic effects are also made for 8-day and monthly composite products. Unit: none	Release	0.3 (<=443nm), 0.2 (>443nm) (scene)[*8]	RMS error between satellite-derived reflectances and ground truth measurements is estimated at a region where aerosol optical thickness at 500nm is less than 0.25.
		Stan-dard	0.1 (<=443nm), 0.05 (>443nm) (scene)[*8]	RMS error between satellite-derived reflectances and ground truth measurements is estimated.
		Goal	0.05 (<=443nm), 0.025 (>443nm) (scene)[*8]	
	Vegetation index (VGI) Def.: Indices indicating vegetation cover and activity such as NDVI and EVI	Release	Grass land: 25% (scene), Forest: 20% (scene)	RMS error is evaluated comparing SGLI-derived VI with in-situ measured VI derived from spectroradiometer data at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc. and also with other

	Unit: none			satellite VI products.
		Stan-dard	Grass land: 20% (scene), Forest: 15% (scene)	RMS error is evaluated comparing SGLI-derived VI with in-situ measured VI derived from spectroradiometer data at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc.
		Goal	Grass land: 10% (scene), Forest: 10% (scene)	
	Above-ground biomass (AGB) Def.: Dry weight of above-ground vegetation Unit: t/ha	Release	Grass land: 50%, Forest: 100%	RMS error is evaluated comparing SGLI-derived AGBIO with in-situ measured AGBIO at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc. (derived from direct measurements of dry weight of grass at grass land, indirect estimation with allometry equation as functions of tree diameter at brest height (DBH) and tree height, or 3-D laser scanner measurements at forest), and also with AGBIO derived from other satellites and numerical ecosystem models.
		Stan-dard	Grass land: 30%, Forest: 50%	RMS error is evaluated comparing SGLI-derived AGBIO with in-situ measured AGBIO at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc.
		Goal	Grass land: 10%, Forest: 20%	
	Vegetation roughness index (VRI) Def.: An index indicating plant vertical structure observed from multi-angle directions. Unit: none	Release	Grass land・Forest: 40% (scene)	RMS error is evaluated comparing SGLI-derived VRI with in-situ measured VRI at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc. (derived from spectoral reflectance data acquired using tower and RC helicopter and so on).
		Stan-dard	Grass land・Forest: 20% (scene)	
		Goal	Grass land・Forest: 10% (scene)	
	Shadow index (SI) Def.: An index indicating shadow fraction of vegetation area inferred from spectral reflectance. Unit: none	Release	Grass land・Forest: 30% (scene)	RMS error is evaluated comparing SGLI-derived VRI with in-situ measured SI at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc. (derived from spectoral reflectance data acquired using tower and RC helicopter and so on), or comparing with SI inferred from data of high spatial resolution optical sensor.
		Stan-dard	Grass land・Forest: 20% (scene)	
		Goal	Grass land・Forest: 10% (scene)	
	Fraction of absorbed PAR (FAPAR) Def.: Fraction of photosynthetically active radiation absorbed by vegetation Unit: none	Release	Grass land: 50%, Forest: 50%	RMS error is evaluated comparing SGLI-derived FAPAR with in-situ measured FAPAR at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc. (derived from data of PAR meter or spectroradiometer data measuring upward and downward PAR at forest canopy and floor.), and with other satellite FAPAR products.
		Stan-dard	Grass land: 30%, Forest: 20%	RMS error is evaluated comparing SGLI-derived FAPAR with in-situ measured FAPAR at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc. (derived from data of PAR meter or spectroradiometer data measuring upward and downward PAR at forest canopy and floor.).
		Goal	Grass land: 20%, Forest: 10%	
Land	Leaf area index (LAI) Def.: The sum of the one sided green leaf area per unit ground area. Unit: none	Release	Grass land: 50%, Forest: 50%	RMS error is evaluated comparing SGLI-derived LAI with in-situ measured LAI at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc. (derived from data of litter trap or LAI-2000 and spectroradiometer data measuring downward radiant flux etc. at forest floor.), and with other satellite LAI products.
		Stan- dard	Grass land: 30%, Forest: 30%	RMS error is evaluated comparing SGLI-derived LAI with in-situ measured LAI at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc. (derived from data of litter trap or LAI-2000 and spectroradiometer data measuring downward radiant flux etc. at forest floor.).
		Goal	Grass land: 20%, Forest: 20%	
	Land surface temperature (LST) Def.: Temperature of terrestrical land surface. Unit: Kelvin	Release	Less than 3.0K (scene)	RMS error is evaluated comparing SGLI-derived LST with in-situ measured LST at the ground surface with uniform land cover and also comparing with other satellite LST products.
		Stan- dard	Less than 2.5K (scene)	RMS error is evaluated comparing SGLI-derived LST with in-situ measured LST at the ground surface with uniform land cover (TBD).
		Goal	Less than 1.5K (scene)	
	Land net primary production	Release	N/A	N/A

	(LNPP) Def.: Net primary productivity which is how much carbon dioxide vegetation takes in during photosynthesis (GPP) minus how much carbon dioxide the plants release during respiration or decay. Unit: gC/m^2/year	Stan- dard	N/A	N/A
		Goal	30%(annual ave.)	RMS error is evaluated comparing SGLI-derived LNPP with in-situ measured LNPP at JaLTER, JapanFlux, PEN sites and also comparing with other satellite LNPP products.
	Water stress trend (WST) Def.: An index to understand the droughty state of vegetation. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	10%(as classification error)[*13]	Classification error is evaluated comparing SGLI derived WST with in-situ measured latent heat transport at flux sites (TBD).
	Fire detection index (FDI) Def.: Location of fire hot spots detected using thermal and shortwave infrared bands. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	20% (as classification error)[*14]	Classification error is evaluated comparing SGLI derived FDI with that derived from high spatial resolution optical sensors which has shortwave and thermal infrared bands.
	Land cover type (LCT) Def.: Land cover type classified using vegetation indices and land reflectance. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	30% (as classification error)	Classification error is evaluated comparing SGLI derived LCT with the ground truth derived from Degree Confluence Project data on a global scale, and also comparing with regional LCT (such as Japan area) derived from high spatial resolution sensors.
	Land surface albedo (LALB) Def.: Ratio of upward reflected energy to downward solar radiation energy. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	10%	RMS error is evaluated comparing SGLI-derived LALB with in-situ measured LALB derived from spectroradiometer data at JaLTER, JapanFlux, PEN, Yatsuga-take tower site etc. (derived from spectoral reflectance data acquired using tower and RC helicopter and so on) and also with other satellite LALB products.
Atmosphere	Cloud flag (CLFG) Def.: Cloud discrimination flag including the classification of cloud type and phase (liquid/solid). Unit: none	Release	10% (comparison with sky-camera binary image)	Overall classification error is evaluated comparing SGLI derived CLFG with those derived from other satellite sensors, cloud amounts collected through GTS (The Global Telecommunication System), and skycamera images.
		Stan- dard	Evaluated as the cloud fraction products.	Same as the classified cloud fraction.
		Goal	Evaluated as the cloud fraction products.	Same as the classified cloud fraction.
	Classified cloud fraction(CLFR) Def.: Cloud fractions for 9 cloud types which are classified based on the ISCCP classification rule. Unit: percent	Release	20% (as solar radiation)[*6]	Overall classification error is evaluated comparing SGLI derived solar radiation which is monthly average for every 0.1 degree global grid with in-situ measured solar radiation, skycamera images, and existing cloud fraction climatology datasets such as ISCCP(the International Satellite Cloud Climatology Project).
		Stan- dard	15%(as solar radiation)[*6]	
		Goal	10%（as solar radiation)[*6]	
	Cloud top temp/height (CLTTH) Def.: Temperature and height of cloud top layer. Unit: Kelvin for temperature, km for height	Release	1K [*1]	The release criterion shown in the left column indicates a threshold for SGLI TIR band brightness temperature by which the ability to sense cloud top temperature is evaluated indirectly. The accuracy of TIR band is assessed through the product evaluation process of sea surface temperature etc. Also confirmed is the consistency of SGLI derived cloud top temperature with object analysis data of air temperature profile over ocean in daytime.
		Stan- dard	3K [*2] /2km [*2]	RMS error is evaluated comparing SGLI derived CLTTH with those derived from airbone and satellite borne lidar and radiometer etc. for uniform liquid clouds with moderate optical thickness.
		Goal	1.5K [*2] /1km [*2]	

	Water-cloud optical thickness & effective radius (CLOTER_W) Def.: Optical thickness and effective radius of water cloud droplets Unit: none for thickness, μm for radius	Release	10%/30% (optial thickess/radius) [*3]	RMS error is evaluated comparing SGLI derived CLOTER_W with those from other satellite sensors for clouds of mid- to low latitude regions (monthly average).
		Stan- dard	100% (as cloud liquid water [*4])	RMS error is evaluated comparing cloud liquid water converted from SGLI derived CLOTER_W with those measured with microwave radiometer on the ground.
		Goal	50% [*4] /20% [*5]	Overall RMS error is evaluated comparing SGLI derived CLOTER_W with those derived from microwave radiometer and skyradiometer (for optical thickness) and other satellite sensors (both param.).
Atmosphere	Ice-cloud optical thickness (CLOT_I) Def.: Optical thickness of ice cloud. Unit: none	Release	30% [*3]	RMS error is evaluated comparing SGLI derived CLOT_I with those from other satellite sensors for clouds of mid- to low latitude regions (monthly average). .
		Stan- dard	70% [*5]	RMS error is evaluated comparing SGLI derived CLOT_I with those from skyradiometers at ground observation network and other satellite sensors.
		Goal	20 % [*5]	
	Aerosol over the ocean (ARNP) Def.: Optical thickness, Ångström exponent, and classification of aerosol over ocean estimated using visible and near infrared band. Unit: none	Release	0.1(monthly ave. of τa_670, 865)	Overall RMS error is evaluated comparing SGLI derived ARV with those from other satellite sensors and climatology based on the past satellite observations (monthly average).
		Stan- dard	0.1(scene's τa_670, 865) [*7]	RMS error is evaluated comparing SGLI derived ARV with those from other satellite sensors and shipborne in-situ observations (AERONET/Maritime Aerosol Network).
		Goal	0.05(scene's τa_670, 865)	
	Land aerosol by near-UV (ARNP) Def.: Optical thickness and light absorption coefficient of aerosol over land estimated using near-ultraviolet band. Unit: none	Release	0.15(monthly ave. ofτa_380)	RMS error is evaluated comparing SGLI derived ARU with those from skyradiometers at ground observation network (Skynet, Aeronet) and other satellite sensors.
		Stan- dard	0.15(scene's τa_380) [*7]	
		Goal	0.1(scene's τa_380)	
	Aerosol by Polarization (ARPL) Def.: Optical thickness, Ångström exponent, and classification of aerosol estimated using polarization bands. Unit: none	Release	0.15(monthly ave. of τa_670, 865)	RMS error is evaluated comparing SGLI derived ARP with those from skyradiometers at ground observation network (Skynet, Aeronet) and other satellite sensors for fine mode particles.
		Stan- dard	0.15(scene's τa_670, 865) [*7]	
		Goal	0.1(scene's τa_670, 865)	
	Water cloud geometrical thickness (CLGT_W) Def.: Geometrical thickness of water cloud. Unit: m	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	300m	RMS error is evaluated comparing SGLI derived CLGT_W with those measured at the ground and from space (satellite) with cloud radar and lidar instruments.
	Long-wave radiation flux (LWRF) Def.: Longwave radiation flux at the ground including downward longwave radiation flux and upward longwave radiation flux. Unit: W/m^2	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	Downward flux: 10W/m^2, Upward flux: 15W/m^2 (0.1 deg., monthly ave.)	RMS error is evaluated comparing SGLI derived monthly averaged LWRF with those from ground radiation observation network (ARM, BSRN), ground observation network (JaLTER, JapanFLux, PEN, Fluxnet etc.), and other satellite sensors.
	Short-wave radiation flux (SWRF) Def.: Shortwave radiation flux at the ground including downward shortwave radiation flux and upward shortwave radiation flux. Unit: W/m^2	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	Downward: 13W/m^2, Upward: 10W/m^2 (0.1deg. , monthly ave.)	RMS error is evaluated comparing SGLI derived monthly averaged SWRF with those from ground radiation observation network (ARM, BSRN), ground observation network (JaLTER, JapanFLux, PEN, Fluxnet etc.), and other satellite sensors.
Ocean	Normalized water leaving radiance (NWLR) Def.: The upwelling radiance just above the sea surface.	Release	60% (443~565nm)	RMS error is evaluated comparing SGLI derived NWLR with in-situ optical measurements conducted during simultaneous ship observations campaign and also comparing with other satellite products.

	Unit: W/m^2/str/um or 1/sr	Stan- dard	50% (<600nm) 0.5W/m2/str/um (>600nm)	RMS error is evaluated comparing SGLI derived NWLR with in-situ optical measurements conducted during simultaneous ship observations campaign.
		Goal	30% (<600nm) 0.25W/m2/str/um (>600nm)	
	Atmospheric correction param.(ACP) Def.: Aerosol optical properties for the atmospheric correction over ocean. Unit: none	Release	80% (τa_865)	RMS error is evaluated comparing SGLI derived aerosol optical thickness with those from in-situ measurements using radiometers during simultaneous ship observations campaign and also comparing with other satellite sensors.
		Stan- dard	50% (τa_865)	RMS error is evaluated comparing SGLI derived aerosol optical thickness with those from in-situ measurements using radiometers during simultaneous ship observations campaign.
		Goal	30%	
	Photosynthetically Available Radiation (PAR) Def.: Photon flux density within the visible wavelength range (400 to 700 nm) over ocean which is potencially available to plant for photosynthesis. Unit: Ein/m^2/day or mol photons/m$^{2/}$day	Release	20% (10km/month)	RMS error is evaluated comparing SGLI derived monthly averaged PAR with those derived from mooring buoy such as NDBC, TAO/TRITON etc. as solar radiation or PAR.
		Stan- dard	15% (10km/month)	
		Goal	10% (10km/month)	
	Chlorophyll-a concentration (CHLA) Def.: Concentration of the green pigment in phytoplankton in sea surface layer. Unit: mg/m^3	Release	-60~+150% (open sea)	RMS error is evaluated comparing SGLI derived CHLA with those derived from sea water samples by fluorescence method or HPLC analysis and also with other satellite products.
		Stan- dard	-60~+150%	RMS error is evaluated comparing SGLI derived CHLA with those derived from sea water samples by fluorescence method or HPLC analysis.
		Goal	-35~+50% (open sea), -50~+100% (coastal)	
Ocean	Total Suspended Matter concentration (TSM) Def.: Dry weight of suspended matter in a unit volume of surface water which is the sum of organics such as phytoplankton and inorganics such as soil. Unit: g/m^3	Release	-60~+150% (open sea)	RMS error is evaluated comparing SGLI derived SS with those derived from sea water samples by filtration method and also with other satellite products.
		Stan- dard	-60~+150%	RMS error is evaluated comparing SGLI derived SS with those derived from sea water samples by filtration method.
		Goal	-50~+100%	
	Colored dissolved organic matter (CDOM) Def.: Light absoption coefficient of organics dissolved in surface water. Unit: 1/m	Release	-60~+150% (open sea)	RMS error is evaluated comparing SGLI derived CDOM with those derived from sea water samples by optical measurements and also with other satellite products.
		Stan- dard	-60~+150%	RMS error is evaluated comparing SGLI derived CDOM with those derived from sea water samples by optical measurements.
		Goal	-50~+100%	
	Sea surface temperature (SST) Def.: Temperature of sea surface. Unit: °C	Release	0.8K (daytime only)	Overall RMS error is evaluated comparing SGLI derived SST with those derived from other satellite sensors and also comparing with those from buoy measurements (daytime only) obtained through GTS and internet.
		Stan- dard	0.8K	Overall RMS error is evaluated comparing SGLI derived SST with those derived from other satellite sensors and also comparing with those from buoy measurements obtained through GTS and internet.
		Goal	0.6K	
	Euphotic zone depth (EZD) Def.: The sea depth where photosynthetic available radiation (PAR) is 1% of its surface value. Unit: m	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	30% (inferred from extinction coefficient)	RMS error is evaluated comparing SGLI derived EZD with those derived from simultaneous measurements of in-water downward irradiance (in-situ EZD is determined from the slope of measured irradiance).
	Inherent optical properties	Release	N/A	N/A

	(IOP) Def.: Optical properties of sea water such as spectral absorption, scattering, and backscattering coefficients for characterizing the marine optical environment and remote-sensing applications. Unit: 1/m	Stan- dard	N/A	N/A
		Goal	Absorption coefficient @440nm: RMSE<0.25 and backscattering coefficient of phytoplankton@550nm : RMSE<0.25	RMS error is evaluated comparing SGLI derived IOP with those derived from simultaneous optical measurements.
	Ocean net primary productivity (ONPP) Def.: Net primary productivity which is gross photosynthetic carbon fixation minus the carbon respired to support maintenance requirements of the whole plant. Unit: $mgC/m^2/day$	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	70% (monthly ave.)	RMS error is evaluated comparing SGLI derived monthly averaged ONPP with those derived from simultaneous in-situ measurements.
	Phytoplankton functional type (PHFT) Def.: Conceptual groupings of phytoplankton species, which have a ecological functionality in common such as nitrogen fixation, calcification, silicification, DMS production and so on. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	Classification error of dominant/non-dominant spesies of large/small phytoplankton: 20%, or classification error of dominant functional type in a phytoplankton group: 40%	Classification error is evaluated comparing with SGLI derived PHFT with the dominant type of phytoplankton group (such as Bacillariophyceae, Chlorophyceae, and Haptophyta etc.) determined from the plant pigment analysis of sea water samples using HPLC.
	Redtide (RTD) Def.: Detection of a red tide phenomenon known as an algal bloom. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	20% (as classification error)	Classification error is evaluated comparing SGLI derived RTD with the occurrence of red tide events determined by eye during simultaneous ship observations campaign.
	Multi sensor merged ocean color parameters (MOC) Def.: Multi-sensor merged chrollophyl-a concentration product with higher temporal resolution than that of SGLI original product. Unit: mg/m^3	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	-35~+50% (Open sea), -50~+100% (Coastal)	Same as the SGLI original product (CHLA).
	Multi sensor merged sea surface temperature (MSST) Def.: Multi-sensor merged seasurface temperature product with higher temporal resolution than that of SGLI original products. Unit: °C	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	0.8K	Same as the SGLI original product (SST).
Cryosphere	Snow and Ice covered area (SICA) Def.: The extent of global snow and ice cover. Unit: none	Release	10% (comparison with other satellite products)	Overall classification error is evaluated comparing SGLI derived SICA with other satellites' same products and climatology of related geophysical parameters derived from the past observations.
		Stan- dard	7%	Overall classification error is evaluated comparing SGLI derived SICA with those derived from moderate and high spatial resolution satellite sensors and also with snow and ice information obtained at ground stations etc.
		Goal	5%	
	Okhotsk sea-ice distribution (OKID) Def.: The extent of sea ice in Okhotsk Sea. Unit: none	Release	10% (comparison with other satellite products)	Overall classification error is evaluated comparing SGLI derived OKID with other satellites' same products and climatology of related geophysical parameters derived from the past observations.
		Stan- dard	5%	Overall classification error is evaluated comparing SGLI derived OKID with those derived from moderate

		Goal	3%	and high spatial resolution satellite sensors and also with ice information obtained at ship etc.
	Snow and ice surface Temperature (SIST) Def.: Temperature of snow and ice surface. Unit: Kelvin	Release	5K (comparison with other satellite products and meteorological measurements)	Overall RMS error is evaluated comparing SGLI derived SIST with those from other satellite sensors, air temperatures from GTS and ice buoys, and climatology derived from the past observations.
		Stan- dard	2K	RMS error is evaluated comparing SGLI SIST with those from in-situ radiometer measurements and snow pit works, air temperatures from GTS and ice buoys.
		Goal	1K	
	Snow grain size of shallow layer (SNGSL) Def.: Grain size of snow ice particle in shallow layer derived mainly from SGLI 865nm band reflectance. Unit: μm	Release	100%(evaluated with climatology of temperature-snow grain size relationship)	Overall error is evaluated comparing SGLI derived SNGSL with other satellites' products and climatology derived from the past observations.
		Stan- dard	50%	RMS error is evaluated comparing SGLI SNGSL with those from in-situ radiometer measurements and snow pit works.
		Goal	30%	
	Snow and ice classification (SIC) Def.: Classification of snow and ice cover types derived using spectral reflectance and temperature. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	10%	Classification error is evaluated comparing SGLI derived SIC with those derived from other moderate and high spatial resolution satellite sensors and also with snow and ice information obtained at ground station etc.
	Snow area in forest and mountain (SCAFM) Def.: The extent of snow cover in forest and mountaneous region. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	30%	Classification error is evaluated comparing SGLI derived SCAFM with those derived from other moderate and high spatial resolution satellite sensors and also with snow information obtained at ground station etc.
	Snow grain size of subsurface layer (SNGSS) Def.: Grain size of snow ice particle in sub-surface layer derived mainly from SGLI 1050nm band reflectance. Unit: μm	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	50%	RMS error is evaluated comparing SGLI SNGSS with those from in-situ radiometer measurements and snow pit works.
	Snow grain size of top layer (SNGST) Def.: Grain size of snow ice particle in top-surface layer derived mainly from SGLI 1640nm band reflectance. Unit: μm	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	50%	RMS error is evaluated comparing SGLI SNGST with those from in-situ radiometer measurements and snow pit works.
	Snow and ice albedo (SIALB) Def.: Spectrally integrated albedo of snow surface. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	7%	RMS error is evaluated comparing SGLI SIALB with those from in-situ radiometer measurements and snow pit works.
	Snow impurity (SNIP) Def.: Mass fraction of snow impurity mixed in snow layer which is optically equivalent to soot. Unit: ppmw	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	50%	RMS error is evaluated comparing SGLI SNIP with those from in-situ radiometer measurements and snow pit works.
	Ice sheet surface roughness (ISRGH) Def.: Surface roughness of ice sheets defined as the ratio of height to width of a roughness pattern. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	0.05 *15	RMS error is evaluated comparing SGLI derived ISRGH with those derived from other moderate and high spatial resolution satellite sensors and with numerical simulation results.

Cryosphere	Ice sheet boundary monitoring (ISBM) Def.: Boundary line between ice sheets and sea surface. Unit: none	Release	N/A	N/A
		Stan- dard	N/A	N/A
		Goal	500m 以下	Overall bias of ice sheet boundary line is evaluated comparing SGLI derived ISBM with those derived from other moderate and high spatial resolution satellite sensors.

*Notes in this table are the same as those shown in Table 7 of the APPENDIX C.

Table 5 Definition of the disclosure level (DL)

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

*1 follow the JAXA's policy on data use

3. Instructions for responding to this RA

3.1. Qualifications

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

3.2. Research agreement conclusion

After the proposals are selected, a research agreement should be made between JAXA and the organization to which the PI belongs, using associated terms and conditions to be prepared by JAXA. In principle, the associated terms and conditions of research agreements attached in APPENDIX D will be used.

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 D.

3.3. Research period

The research period for this RA is three years, beginning in JFY 2016. The contractual period for funded contracts is one year. Contract renewal for the following years will be dependent on performance evaluation described in the interim report released at the end of each JFY, which decides whether the research will continue.

The contractual period for non-funded contracts is three years. However, JAXA reserves the right to cancel contracts in the event of research cancellation, which is determined on the basis of the interim report released at the end of each JFY.

3.4. Resources

(1) Funding

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

A) Based on the purpose of this RA, funding will be mainly available for GCOM-C algorithm development and validation, within JAXA's budget limitation. Proposals submitted to other areas may be funded if they provide a substantial contribution to the GCOM mission.

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

C) JAXA funding is restricted to the direct cost of research ("Direct Cost") and does not bear any overhead costs, indirect costs, general costs, or whatsoever ("Overhead Cost") of the organization to which an applicant belongs, provided however that, if this is not acceptable to the research organization due to its regulation, it may not be applied when an applicant fills in the prescribed remarks column of the Resource Requirement (Appendix B) as such and presents an evidential document, such as a copy of the regulation, for

justification. In addition, JAXA does not approve the research organization to provide JAXA funding for other PI ("Other PI") selected through JAXA's RA, with exception that such Other PI acts as a CI under a research project of the research organization.

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 by JAXA

Earth observation satellite data necessary for conducting research and owned by JAXA will be provided free of charge within the limitations of the distribution capability of JAXA. Available data are listed in APPENDIX B. Those who receive Earth observation satellite data shall comply with the 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 a yearly report on the results at the end of each JFY and a 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 a status report. PIs must cover necessary travel expenses to participate in the workshop within the funds provided by this RA.
(2) Non-funded PIs shall also submit a yearly report and a 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 will be decided 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 and technical merit of the proposal or unique and innovative methods, approaches, or concepts demonstrated by the proposal

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

(3) Qualifications, capabilities, and experience of the proposed PI and CI

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

3.7. Late proposals

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

3.8. Withdrawal of proposal

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

3.9. Cancellation and postponement

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

3.10. Important dates

August 31, 2015	Fourth Research Announcement Issued
November 1, 2015	**Proposal Due Date**
January 2016	Notification of Selection Results (TBD)

3.11. Proposal submission and contact point

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

GCOM RA Office E-mail address: GCOM_RA@ml.jaxa.jp

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

GCOM RA Office
Earth Observation Research Center (EORC)
Tsukuba Space Center
Japan Aerospace Exploration Agency
2-1-1 Sengen, Tsukuba, Ibaraki, 305-8505, Japan

The point of contact is:

GCOM RA Office
Earth Observation Research Center
Tel: +81-50-3362-6529
Fax: +81-29-868-2961
E-mail address: GCOM_RA@ml.jaxa.jp

4. Instructions for proposal contents

4.1. General

(1) Proposals received in response to this RA will be used only for evaluation purposes.
(2) The following types of proposals are not acceptable:
   A) Proposals that include restrictions 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) It is highly recommended that applicants send their proposals and complete sets of all attachments, such as reprints of papers, in **PDF via E-mail**.
(2) Forms for the cover sheet, work plan, effort allocation, and resource requirements can be found in 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 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 should not exceed 20 pages. Necessary detailed information, such as reprints, should be included as attachments. A complete set of attachments must accompany each copy of a proposal when submitting via postal mail.

4.3. Proposal contents

(1) Cover sheet
   A) Research title
      State your research title precisely and clearly. The title should be brief, reflecting an especially valid project intelligible to a science-literate reader and suitable for use in the public process.
   B) Research category
      Choose a relevant category to which the proposal belongs.
   C) Information of applicants
      - Identifying information of the 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
        State the name, organization, telephone number, and E-mail address of each Co-investigator (CI). JAXA doesn't use provided personal information except for purposes relating to this research announcement.
        One research team should consist of only one PI, or one PI and several CIs.
   D) Budget
      Provide a budget broken down by year and the total amount in Japanese yen.

E) Endorsement
Provide a signature of a responsible official or authorized representative of the proposing organization.

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

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

(4) Work plan (Research schedule)
The research schedule should be outlined in the form indicated in APPENDIX A.

(5) Effort allocation
Provide effort allocation for currently proposed and/or ongoing research funding including those of other JAXA satellite projects. Include the name of research funding, period, research title, role, budget, and difference from the present proposal in the form in APPENDIX A. The effort allocation should be provided with a percentage of time allocation (%) necessary for implementing each research activity (assuming the entire yearly working time as 100%) for the research period of this RA.

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

(7) Personnel
A) Biographical information, experience, papers in related fields
A short biographical sketch, a list of publications, experiences related to this RA, and professional qualifications of the PI should be included. Also provide similar biographical information on each CI.
B) Role of CI
The PI is responsible for supervising the work and the CIs in the research. State each CI's role in the proposed research.

(8) Resource requirements

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

5. Description of research agreement

5.1. Contractual procedure

(1) After selecting the proposal and the PI, JAXA will send the PI guidelines and an application form for making an agreement. Please note that JAXA will make an agreement with the organization to which the PI belongs ("the Organization"), not to the PI or CI.
(2) A research agreement will be made using associated terms and conditions, such as those in APPENDIX D. 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 D, 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 interim report at the end of the JFY, the research agreement will be extended for 1 year, and up to March 31, 2019. 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) A special agreement will be contracted separately for cases in which certain articles cannot be applied to foreign organizations and institutions owing to restrictions of the respective countries.

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 "GCOM-C algorithm development (standard algorithm)" 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.

- 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 a category "other than" GCOM-C algorithm development (standard algorithm).
- 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.
- JAXA will retain the right to use all results including results belonging to the Organization (if any), and the Organization will retain the right to use jointly-owned research results only for its own research and development purposes, without prior consent by the other party.

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

- Collaborative Research Agreement (Funded)
  JAXA provides part of the research funds and the Earth observation satellite data. JAXA adjusts the amount of the research funds based on a fiscal financial statement at the end of a year-on-year contract. The Organization shall submit an interim report and a final report to JAXA, and shall participate in the workshops to report research progress. If this agreement is canceled, the Organization shall refund to JAXA any unexpended funds that have already been paid by JAXA.
- Collaborative Research Agreement (Non-funded)
  JAXA provides the Earth observation satellite data. The Organization shall submit an interim report and a final report to JAXA. However, such reports can be substituted with papers published during the research term. Participation in the workshops is highly recommended.

(3) Publication of results

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

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

APPENDIX A
PROPOSAL COVER SHEET AND SCHEDULE

Proposal Cover Sheet
JAXA GCOM Research Announcement

Proposal No.	_____ (Leave Blank for JAXA Use)
Title	
Research category (check one) **GCOM-C: ☐Algorithm (Standard) ☐Algorithm (Research) ☐Validation ☐Application** **Multi-Sensor: ☐Algorithm ☐Application**	

Principal Investigator

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

Co - Investigator

Name	Institution	Telephone	E-mail

Budget (yen in thousands) (Direct Cost only)

JFY2016	JFY2017	JFY2018	TOTAL

(Leave Blank for JAXA Use)

Authorizing Official: _____ _____

(Name and Title) (Institution)

空へ挑み、宇宙を拓く
JAXA
宇宙航空研究開発機構

Research Schedule

JFY	2016				2017				2018			
Month	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3
Milestone												
Activities												

Application for Research Funding, the Current State of Funding and Effort

(1) Research Funding Applied for					
Funding System e.g., JAXA, JSPS etc.	**Research Title (PI name)**	**Role** e.g.,PI or CI	**Budget** (throughout the period) (thousands of yen)	**Effort (%)**	**Differences in Research and Reasons for Additional Application for This Research**
(About this research) GCOM 6th RA (JFY2016-18)					
(2) Research Funding to Be Provided					
(3) Other activities					
Total (Total of the effort in (1), (2) and (3) above)				100 (%)	

APPENDIX B
RESOURCE REQUIREMENTS

BUDGET SUMMARY

Direct Cost only

1. Personnel Expenses (unit: yen in thousands)

	2016	2017	2018	Total

2. Purchases

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

ITEM	2016	2017	2018	Total

2.2 Software (unit: yen in thousands)

ITEM	2016	2017	2018	Total

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

ITEM	2016	2017	2018	Total

3. Subcontracts (unit: yen in thousands)

ITEM	2016	2017	2018	Total

4. Travel Expenses (unit: yen in thousand)

Departure Point – Destination (number of travelers)	2016	2017	2018	Total

5. Observation Equipment (unit: yen in thousands)

ITEM	2016	2017	2018	Total

6. Satellite Data (unit: yen in thousands)

Name of Satellite / Sensors	Distributor	Purpose	Cost			
			2016	2017	2018	Total

7. Other Data (unit: yen in thousands)

Name of Data Sets	Distributor	Purpose	Cost			
			2016	2017	2018	Total

8. Others (unit: yen in thousands)

ITEM	2016	2017	2018	Total

TOTAL (unit: yen in thousands)				

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

Please check either of the following boxes:

☐ **Unnecessary**

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

☐ **Indispensable (Reason(s):**)

BUDGET SUMMARY (EXAMPLE)

1. Personnel Expenses (unit: yen in thousands)

	2016	2017	2018	Total
Part-time job for DSD data analysis	*320 (40x8)*	*160 (20x8)*	*800 (100x8)*	*1280*

2. Purchases

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

ITEM	2016	2017	2018	Total

2.2 Software (unit: yen in thousands)

ITEM	2016	2017	2018	Total

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

ITEM	2016	2017	2018	Total
8mm tape (112m)	*50*	*50*	*50*	*150*
CD-R	*100*	*120*	*120*	*340*
MO (640MB)	*15*	*10*	*10*	*35*
A4 Paper (package of 500 sheets)	*2*	*1*	*1*	*4*
CD-RW Drive	*50*			*50*

3. Subcontracts (unit: yen in thousands)

ITEM	2016	2017	2018	Total
Software development for DSD data analysis	*1,500*	*600*	*600*	*2,700*

4. Travel Expenses (unit: yen in thousand)

Departure Point – Destination (number of travelers)	2016	2017	2018	Total
Tokyo – Washington, D.C. (1 person)	*600*			*600*
Tokyo – Paris (1 person)	*650*	*650*		*1,300*
Tokyo – Paris (1 person)		*650*	*650*	*1,300*
Tokyo – Osaka (1 person)			*35*	*35*

5. Observation Equipment (unit: yen in thousands)

ITEM	2016	2017	2018	Total
Micro Rain Radar	*1,500*			*1,500*

6. Satellite Data (unit: yen in thousands)

Name of Satellite / Sensors	Distributor	Purpose	Cost			
			2016	2017	2018	Total

7. Other Data (unit: yen in thousands)

Name of Data Sets	Distributor	Purpose	Cost			
			2016	2017	2018	Total

8. Others (unit: yen in thousands)

ITEM	2016	2017	2018	Total

TOTAL (unit: yen in thousands)	*4,787*	*2,241*	*2,266*	*9,294*

JAXA DATA REQUIREMENTS

1. JAXA-Archived Satellite Datasets

(JERS-1, ADEOS, TRMM, GPM, Aqua, ADEOS-II, GOSAT, GCOM-W, GCOM-C, ALOS, ALOS-2)

Name of Satellite / Sensor	Quantity (scenes)	Purpose

B.1 Instructions for budget summary

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

(1) Personnel expenses
Enter expenses for part-time workers here as the total cost calculated by multiplying the unit cost per day by the number of days. For part-time workers, use your own cost estimates.
(2) Computers/peripheral equipment/software
Enter the lease and rental cost of computers and/or peripheral equipment. Note that JAXA has the right to change specifications of all equipment. Also enter the cost of software here.
(3) Expendable materials and supplies
Enter the quantity of each item, following the example.
(4) Subcontracts
Provide the cost of subcontracts to outside companies or organizations here.
(5) Travel expenses
Describe the proposed domestic and/or international travel including information on destination and number of days/number of times (or travelers).
(6) Observation equipment
Enter costs of observation equipment including installation cost.
(7) Satellite data
Investigators requesting satellite data other than JAXA-owned or archived data (listed in the next section) should provide cost information here.
(8) Other data
Enter costs for data other than satellite data.
(9) Others
Enter costs for publication and others here.

B.2 Instructions for data requirements

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

- Japanese Earth Resources Satellite (JERS) (global)
- Advanced Earth Observing Satellite (ADEOS)
- Tropical Rainfall Measuring Mission (TRMM)
- Global Precipitation Measurement (GPM)
- Advanced Microwave Scanning Radiometer for EOS (AMSR-E) aboard EOS-Aqua Satellite
- Advanced Earth Observing Satellite-II (ADEOS-II)
- Greenhouse Gases Observing Satellite (GOSAT)
- Global Change Observation Mission - Water (GCOM-W)
- Global Change Observation Mission - Climate (GCOM-C)
- Advanced Land Observing Satellite (ALOS) (50 scenes per year from JAXA archives)
- Advanced Land Observing Satellite-2 (ALOS-2) (50 scenes per year from JAXA archives)

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

APPENDIX C

OVERVIEW OF THE GLOBAL CHANGE OBSERVATION MISSION (GCOM)

1. Introduction

Comprehensive observation, understanding, assessment, and prediction of global climate change are common and important issues for all mankind. This is also identified as one of the important socio-economic benefits by the 10-year implementation plan for Earth Observation that was adopted by the Third Earth Observation Summit to achieve the Global Earth Observation System of Systems (GEOSS). International efforts to comprehensively monitor the Earth by integrating various satellites, in-situ measurements, and models are gaining importance. As a contribution to this activity, the Japan Aerospace Exploration Agency (JAXA) plans to develop the Global Change Observation Mission (GCOM). GCOM will take over the mission of the Advanced Earth Observing Satellite-II (ADEOS-II) and develop into long-term monitoring of the Earth.

As mentioned in the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC), warming of the climate system is unequivocal as is now evident from observations of increases in global average air and ocean temperatures and widespread melting of snow and ice. However, climate change signals are generally small and modulated by natural variability, and are not necessarily uniform over the Earth. Therefore, the observing system of the climate variability should be stable, and should cover a long term over the entire Earth.

To satisfy these needs, GCOM consists of two medium-size, polar-orbiting satellite series and multiple generations (e.g., three generations) with one-year overlaps between consecutive generations for inter-calibration. The two satellite series are GCOM-W (Water) and GCOM-C (Climate). Two instruments were selected to cover a wide range of geophysical parameters: the Advanced Microwave Scanning Radiometer-2 (AMSR2) on GCOM-W and the Second-generation Global Imager (SGLI) on GCOM-C. The AMSR2 instrument will perform observations related to the global water and energy cycle, while the SGLI will conduct surface and atmospheric measurements related to the carbon cycle and radiation budget. This chapter presents an overview of the mission objectives, observing systems, and data products of GCOM.

2. Mission Objectives

The major objectives of GCOM can be summarized as follows.

- Establish and demonstrate a global, long-term Earth-observing system for understanding climate variability and the water-energy cycle.
- Enhance the capability of climate prediction and provide information to policy makers through process studies and model improvements in concert with climate model research institutions.
- Construct a comprehensive data system integrating GCOM products, other satellite data, and in-situ measurements.
- Contribute to operational users including weather forecasting, fishery, and maritime agencies by providing near-real-time data.
- Investigate and develop advanced products valuable for understanding of climate change and water cycle studies.

Detailed explanations of the objectives are as follows.

(1) Understanding global environment changes

A) Establish and demonstrate a global, long-term Earth-observing system that is able to observe valuable geophysical parameters for understanding global climate variability and

water cycle mechanisms.

B) Contribute to improving climate prediction models by providing accurate values of model parameters.
C) Clarify sinks and sources of greenhouse gases.
D) Contribute to validating and improving climate prediction models by forming a collaborative framework with climate model institutions and providing long-term geophysical datasets to them.
E) Detect trends of global environment changes (e.g., global warming, vegetation changes, desertification, variation of atmospheric constituents, wide area air pollution, and depletion of ozone layers) from long-term variability of geophysical parameters by extracting short-term (three- to six-year) natural variability.
F) Advance process studies of Earth environmental changes using observation data.
G) Estimate radiative forcing, energy and carbon fluxes, and albedo by combining satellite geophysical parameters, ground in-situ measurements, and models.
H) Advance the understanding of the Earth's system through the activities above.
I) Contribute to an international environmental strategy utilizing the results above.

(2) Direct contribution to improving people's lives

A) Improvement of weather forecast accuracy (particularly typhoon track prediction, localized severe rain, etc.).
B) Improvement of forecast accuracy for unusual weather and climate.
C) Improvement of water-route and maritime information.
D) Provision of fishery information.
E) Efficient coastal monitoring.
F) Improved yield prediction of agricultural products.
G) Monitoring and forecasting air pollution including yellow dust.
H) Observation of volcanic smoke and prediction of the extent of the impact.
I) Detection of forest fires.

3. Observing Systems

3.1. Overall concept

As mentioned in the previous section, the entire GCOM will consist of two satellite series spanning three generations. However, a budget will be approved for each satellite. Currently, only the GCOM-W satellite has been launched as the first satellite in the GCOM series. Both GCOM-W and GCOM-C satellites will be medium-size platforms that are smaller than the ADEOS-II satellite. This is to reduce the risk associated with large platforms having valuable and multiple observing instruments. Also, since the ADEOS-II problem was related to the solar paddle, a dual solar-paddle design was adopted for both satellites. To assure data continuity and consistent calibration, follow-on satellites will be launched so as to overlap the preceding satellite by one year. The concept is summarized in Fig. 1.

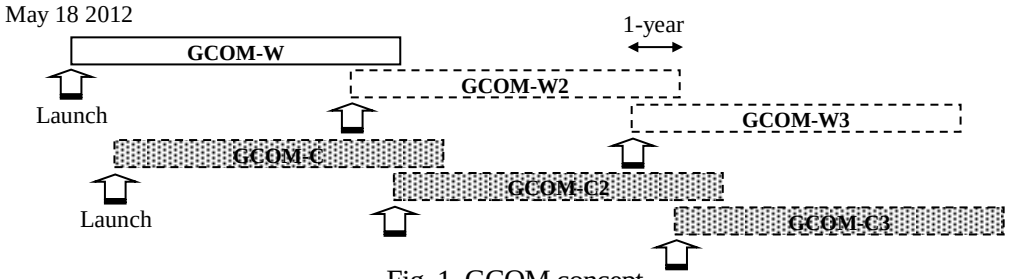

Fig. 1. GCOM concept

3.2. GCOM-W and AMSR2 instrument

Figure 2 presents an overview of the GCOM-W satellite; its major characteristics are listed in Table 1. GCOM-W will carry AMSR2 as the sole onboard mission instrument. The satellite will orbit at an altitude of about 700km and will have an ascending node local time of 13:30, to maintain consistency with Aqua/AMSR-E observations.

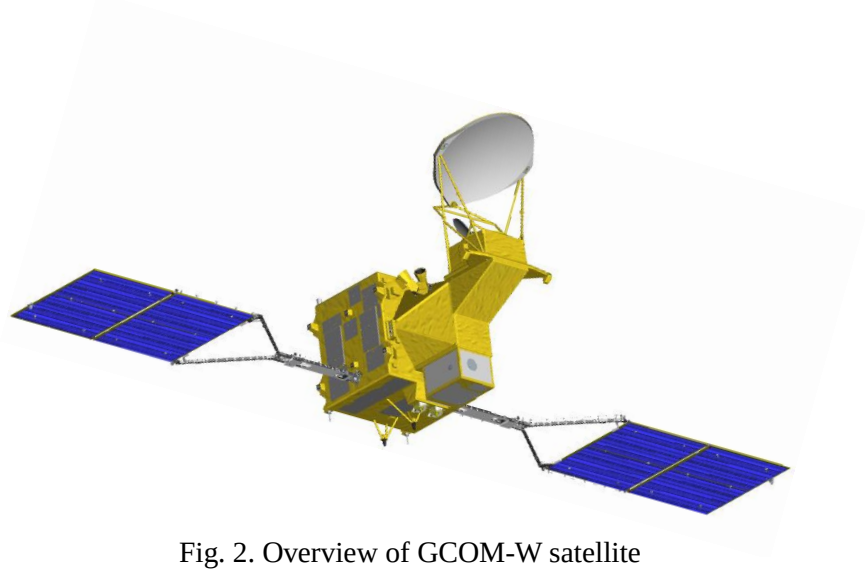

Fig. 2. Overview of GCOM-W satellite

TABLE 1
MAJOR CHARACTERISTICS OF GCOM-W SATELLITE

Instrument	Advanced Microwave Scanning Radiometer-2 (AMSR2)
Orbit	Sun-synchronous orbit Altitude: 700km (over the equator)
Size	5.1m (X) * 17.5m (Y) * 3.4m (Z) (on-orbit)
Mass	1991kg
Power	More than 3880W (EOL)
Launch	May 18, 2012 by H-IIA Rocket
Design Life	5 years
Status	Phase-D

Figure 1 presents an overview of the AMSR2 instrument in two different conditions. Also, basic characteristics including center frequency, bandwidth, polarization, instantaneous field of view (FOV), and sampling interval are indicated in Table 2. The basic concept is almost identical to that of AMSR-E: a conical scanning system with a large offset parabolic antenna, feed horn cluster to realize multi-frequency observation, external calibration with two temperature standards, and total-power radiometer systems. The 2.0m diameter antenna, which is larger than that of AMSR-E, provides better spatial resolution at the same orbit altitude of around 700km. The antenna will be developed based on the experience gained from the 2.0m diameter antenna for ADEOS-II AMSR except the deployment mechanism. For the C-band receiver, we adopted additional 7.3GHz channels for possible mitigation of radio-frequency interference. An incidence angle of 55 degrees (over the equator) was selected to maintain consistency with AMSR-E. The swath width of 1450km and the selected satellite orbit will provide almost complete coverage of the entire Earth's surface

within two days independently for ascending and descending observations.

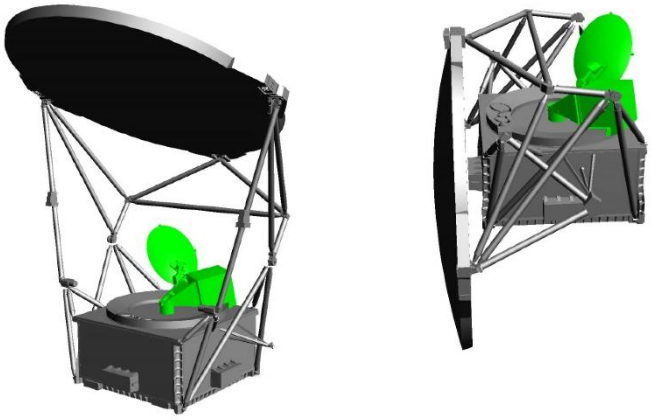

Fig. 3. Sensor unit of AMSR2 instrument in deployed (left) and stowed (right) conditions.

TABLE 2
MAJOR CHARACTERISTICS OF AMSR2 INSTRUMENT

Parameter	Performance and characteristics					
Center Frequency (GHz)	6.925/7.3	10.65	18.7	23.8	36.5	89.0
Bandwidth (MHz)	350	100	200	400	1000	3000
Polarization	Vertical and Horizontal polarization					
NEΔT (K) [1]	< 0.34/0.43	< 0.70	< 0.70	< 0.60	< 0.70	< 1.20/1.40 [2]
Dynamic range (K)	2.7 to 340					
Nominal incidence angle (deg.)	55.0					55.0/54.5 [2]
Beam width (deg.)	1.8	1.2	0.65	0.75	0.35	0.15
IFOV (km) Cross-track x along-track	35x62	24x42	14x22	15x26	7x12	3x5
Approximate sampling interval (km)	10					5
Swath width (km)	> 1450					
Digital quantization (bits)	12					
Scan rate (rpm)	40					

3.3. GCOM-C and SGLI instrument

Figure 4 gives an overview of the GCOM-C satellite; its major characteristics are listed in Table 3. GCOM-C will carry SGLI as the sole mission onboard instrument. The satellite will orbit at an altitude of about 800km; the descending node local time will be 10:30, to maintain a wide observation swath and reduce cloud interference over land.

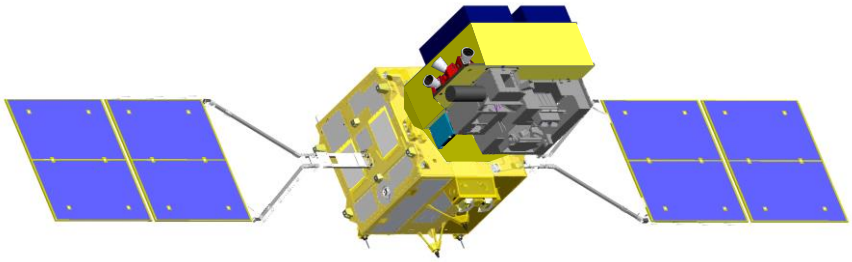

Fig. 4. Overview of GCOM-C satellite

TABLE 3
MAJOR CHARACTERISTICS OF GCOM-C SATELLITE

Instrument	Second-generation Global Imager (SGLI)
Orbit	Sun-synchronous orbit Altitude: 798km (over the equator)
Size	4.6m (X) * 16.3m (Y) * 2.8m (Z) (on orbit)
Mass	2093kg
Power	More than 4000W (EOL)
Launch	JFY2016 by H-IIA Rocket
Design Life	5 years
Status	Phase-C

The SGLI instrument has two major new features: 250m spatial resolution for most of the visible channels and polarization/multidirectional observation capabilities. The 250m resolution will provide enhanced observation capability over land and coastal areas where the influences of human activity are most obvious. The polarization and multidirectional observations will enable us to retrieve aerosol information over land. Precise observation of global aerosol distribution is a key for improving climate prediction models.

SGLI consists of two major components: the Infrared Scanner (IRS) and the Visible and Near-infrared Radiometer (VNR). An overview of the SGLI instrument is shown in Fig. 5 for the entire radiometer layout, IRS, and VNR components. Also, requirements for sensor performance are listed in Tables 4 and 5. VNR can be further divided into two components: VNR-Non Polarized (VNR-NP) and VNR-Polarized (VNR-P). VNR-NP and VNR-P are the 11-channel multi-band radiometer and the polarimeter with three polarization angles (0, 60, and 120 degrees). VNR-P has a tilting function to meet the scatter angle requirement from aerosol observation. The IRS is an infrared radiometer covering wavelengths from 1μm to 12μm. It consists of short infrared (SWI; 1.05 to 2.21μm) and thermal infrared (TIR 10.8 and 12.0μm) sensors. It employs a scanning mirror system with a 45-degree tilted flat mirror rotating continuously to realize an 80-degree observation swath and calibration measurement in every scan.

Through intensive discussions and optimizing studies, the number of SGLI channels was decreased from the 36 channels of GLI aboard ADEOS-II to 19 channels, while the number of SGLI standard products will increase compared to those of GLI.

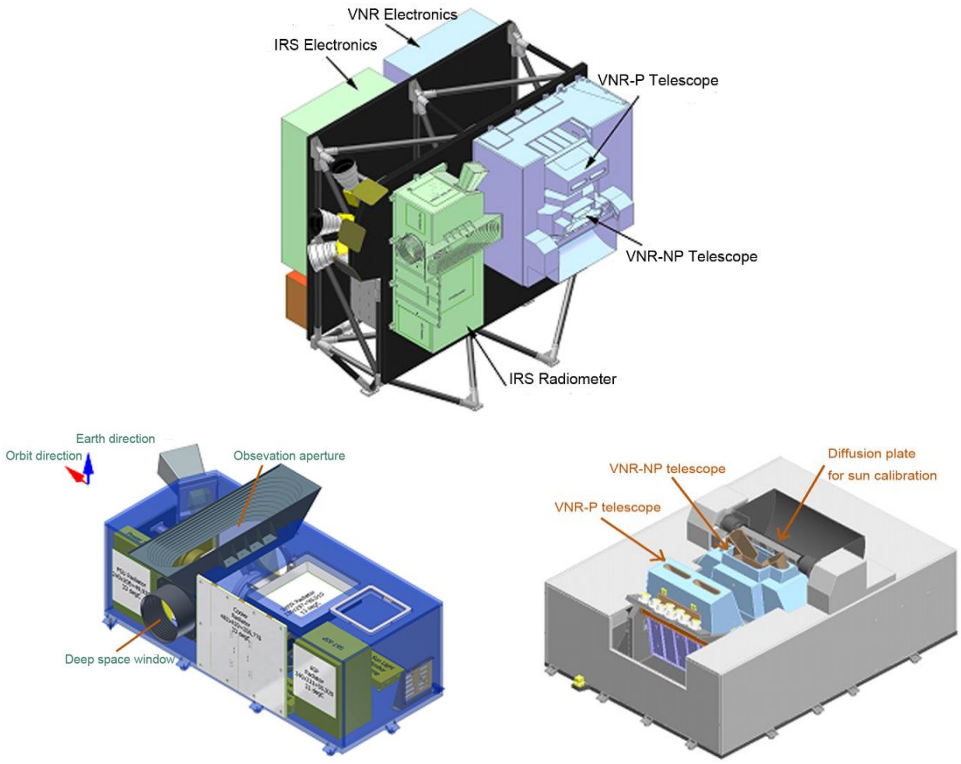

Fig. 5. Overview of SGLI radiometer layout (upper), IRS instrument (lower-left), and VNR radiometers (lower-right).

TABLE 4

SGLI MAJOR PERFORMANCE REQUIREMENTS

Item	Requirement
Spectral Bands	VNR-NP : 11CH 380-865nm VNR-P : 2CH 673.5, 868.5nm / 0, 60, 120deg Polarization IRS SWI : 4CH 1.05-2.21μm IRS TIR : 2CH 10.8, 12.0μm
Scan Angle	VNR-NP : 70deg (Push broom scanning) VNR-P : 55deg (Push broom scanning) IRS SWI/TIR : 80deg (45deg rotation mirror scanning)
Swath width	1150km for VNR-NP/P 1400km for IRS SWI/TIR
Instantaneous field of view (IFOV) at nadir	VNR-NP : 250m VNR-P : 1000m IRS SWI : 250m(SW3CH), 1000m(SW1,2,4CH) IRS TIR : 500m (250m: option)
Observing direction	±45 degrees in along track direction for VNR-P Nadir for VNR-NP, IRS SWI, and IRS TIR
Quantization	12bit
Absolute Calibration Accuracy	VNR : ≤3% IRS : ≤5% TIR : ≤0.5K
Lifetime	5 Years

TABLE 5
SGLI OBSERVATION REQUIREMENT DETAILS

	CH	λ	Δλ	IFOV	SNR	L (for SNR)
		nm: VNR, IRS SWI μm: IRS TIR		m	SNR: VNR, IRS SWI NEΔT(K): IRS TIR	$W/m^2/sr/\mu m$
VNR-NP	VN1	380	10	250	250	60
	VN2	412	10	250	400	75
	VN3	443	10	250	300	64
	VN4	490	10	250	400	53
	VN5	530	20	250	250	41
	VN6	565	20	250	400	33
	VN7	673.5	20	250	400	23
	VN8	673.5	20	250	250	25
	VN9	763	12	250	1200 (@1kmIFOV)	40
	VN10	868.5	20	250	400	8
	VN11	868.5	20	250	200	30
VNR-P	P1	673.5	20	1000	250	25
	P2	868.5	20	1000	250	30
IRS SWI	SW1	1050	20	1000	500	57
	SW2	1380	20	1000	150	8
	SW3	1630	200	250	57	3
	SW4	2210	50	1000	211	1.9
IRS TIR	T1	10.8	0.74	500/250	0.2	300 (K)
	T2	12.0	0.74	500/250	0.2	300 (K)

4. Products

Geophysical products made available by GCOM-W and GCOM-C are listed in Tables 6 and 7. There are two categories of data products: standard product and research product. A “standard” product is defined as a product with proven accuracy that is to be operationally processed and distributed. In contrast, a “research” product is a prototype for a standard product and is processed on a research basis. Both tables indicate standard products with shading.

TABLE 6
GEOPHYSICAL PRODUCTS OF GCOM-W

Product	Areas	Grid (km)	Accuracy [1]			Range	
			Release threshold	Standard	Goal		
Integrated water vapor	Global, over ocean	15	±3.5 kg/m^2	±3.5 kg/m^2	±2.0 kg/m^2	0-70 kg/m^2	Vertically integrated (columnar) water vapor amount. Except sea ice and precipitating areas.
Integrated cloud liquid water	Global, over ocean	15	±0.10 kg/m^2	±0.05 kg/m^2	±0.02 kg/m^2	0-1.0 kg/m^2	Vertically integrated (columnar) cloud liquid water. Except sea ice and precipitating areas.
Precipitation	Global, except cold latitudes	15	Ocean ±50 % Land ±120 %	Ocean ±50% Land ±120 %	Ocean ±20% Land ±80 %	0-20 mm/h	Surface precipitation rate. Accuracy is defined as relative error (ratio of root-mean-square error to average precipitation rate) in 50km grid average.
Sea surface temperature	Global, over ocean	50	±0.5 ℃	±0.5 ℃	±0.2 ℃	-2-35 ℃	Except sea ice and precipitating areas. Goal accuracy is defined as monthly mean bias error in 10 degrees latitudes.
Sea surface wind speed	Global, over ocean	15	±1.5 m/s	±1.0 m/s	±1.0 m/s	0-30 m/s	Except sea ice and precipitating areas.
Sea ice concentration	Polar region, over ocean	15	±10 %	±10 %	±5 %	0-100 %	Accuracy is expressed in absolute value of sea ice concentration (%).
Snow depth	Land	30	±20 cm	±20 cm	±10 cm	0-100 cm	Except ice sheets and dense forest areas. Accuracy is expressed in snow depth and defined as mean absolute error of instantaneous observations.
Soil moisture	Land	50	±10 %	±10 %	±5 %	0-40 %	Volumetric water content over global land areas including arid and cold regions, except areas covered by vegetation with 2kg/m^2 water equivalent. Accuracy is defined as mean absolute error of instantaneous observations.

1 Accuracy is defined as root-mean-square error of instantaneous values unless otherwise stated. Assumed validation methodologies are not explained here.

TABLE 7
GEOPHYSICAL PRODUCTS OF GCOM-C (1/3)

Area	*Group*	*Product*	*Category*	*Developer*	*Day/night*	*Production unit*	*Grid size*	*Release threshold*[*2]	*Standard accuracy*[*2]	*Target accuracy*[*2]
common	Radiance	TOA radiance (including system geometric correction)	Standard	JAXA	TIR and land 2.2μm: both, Other VNR, SWI: daytime (+special operation)	Scene	VNR,SWI Land/coast: 250m, offshore: 1km, polarimetory:1km TIR Land/coast: 500m, offshore: 1km	Radiometric 5% (absolute)[*3] Geometric<1 pixel	VNR,SWI: 5% (absolute), 1% (relative) [*3] TIR: 0.5K (@300K) Geometric<0.5 pixel	VNR,SWI: 3% (absolute), 0.5% (relative) [*3] TIR: 0.5K (@300K) Geometric<0.3 pixel
Land	Surface reflectance	Precise geometric correction	Standard	JAXA	Both	Tile, Global (mosaic 1, 8 days, month)	250m	<1pixel	<0.5pixel	<0.25pixel
		Atmospheric corrected reflectance (incl. cloud detection)	Standard	JAXA	Daytime	Tile , Global (1, 8 days, month)	250m	0.3 (<=443nm), 0.2 (>443nm) (scene) [*7]	0.1 (<=443nm), 0.05 (>443nm) (scene) [*7]	0.05 (<=443nm), 0.025 (>443nm) (scene)[*7]
	Vegetation and carbon cycle	Vegetation index	Standard	PI/JAXA	Daytime	Tile , Global (1, 8 days, month)	250m	Grass: 25%, forest: 20% (scene)	Grass: 20%, forest: 15% (scene)	Grass: 10%, forest: 10% (scene)
		fAPAR	Standard	JAXA/PI				Grass: 50%, forest: 50%	Grass: 30%, forest:20%	Grass: 20%, forest: 10%
		Leaf area index	Standard	JAXA/PI				Grass: 50%, forest: 50%	Grass: 30%, forest:30%	Grass: 20%, forest: 20%
		Above-ground biomass	Standard	Kajiwara	Daytime	Tile , Global (1, 8 days, month)	1km	Grass: 50%, forest: 100%	Grass: 30%, forest: 50%	Grass: 10%, forest: 20%
		Vegetation roughness index	Standard				1km	Grass and forest: 40% (scene)	Grass and forest: 20% (scene)	Grass and forest: 10% (scene)
		Shadow index	Standard				250m, 1km	Grass and forest: 30% (scene)	Grass and forest: 20% (scene)	Grass and forest: 10% (scene)
	Temperature	Surface temperature	Standard	Moriyama	Both	Tile , Global (1, 8 days, month)	500m	<3.0K (scene)	<2.5K (scene)	<1.5K (scene)
	Application	Land net primary production	Research	Nasahara/ Muramatsu	Daytime	Global (month, year)	1km	N/A	N/A	30% (yearly)
		Water stress trend	Research	Moriyama	N/A	Tile , Global (1, 8 days, month)	500m	N/A	N/A	10% [*13] (error judgment rate)
		Fire detection index	Research	Moriyama | Nakau	Both*12	Scene or Tile	500m	N/A	N/A	20% [*14] (error judgment rate)
		Land cover type	Research	Fukue | Soyama /Takagi	Daytime	Global (month, season)	250m	N/A	N/A	30% (error judgment rate)
		Land surface albedo	Research	JAXA/PI	N/A	Tile , Global (1, 8 days, month)	1km	N/A	N/A	10%
Atmosphere	Cloud	Cloud flag/Classification	Standard	Nakajima /Ishimoto/Riedi	Both	Tile , Global（1, 8 day, month）	1km	10% (with whole-sky camera)	Incl. below cloud amount	Incl. below cloud amount
		Classified cloud fraction	Standard		Daytime	Global（1, 8 day, month）	1km (Tile), 0.1deg (global)	20% (on solar irradiance)[*9]	15% (on solar irradiance)[*9]	10% (on solar irradiance)[*9]
		Cloud top temp/height	Standard		Both	Tile , Global（1, 8 day, month）		1K[*4]	3K/2km (top temp/height)[*5]	1.5K/1km (temp/height)[*5]
		Water cloud OT/effective radius	Standard		Daytime	Tile , Global（1, 8 day, month）		10%/30% (Cloud OT/radius)[*6]	100% as CLW[*7]	50%[*7] / 20%[*8]
		Ice cloud optical thickness	Standard		Daytime	Tile , Global（1, 8 day, month）		30%[*6]	70%[*8]	20%[*8]
		Water cloud geometrical thickness	Research	Kuji	Daytime	Tile , Global（1, 8 day, month）		N/A	N/A	300m
	Aerosol	Aerosol over the ocean	Standard	Inoue	Daytime	Tile , Global（1, 8 day, month）		0.1 (Monthly τa_670,865)[*10]	0.1(scene τa_670,865)[*10]	0.05 (scene τa_670,865)
		Land aerosol by near UV	Standard		Daytime	Tile , Global（1, 8 day, month）		0.15 (Monthly τa_380)[*10]	0.15 (scene τa_380)[*10]	0. 1(scene τa_380)
		Aerosol by Polarization	Standard	Sano	Daytime	Tile , Global（1, 8 day, month）		0.15 (Monthly τa_670,865)[*10]	0.15 (scene τa_670,865)[*10]	0.1 (scene τa_670,865)

	Radiation budget	Long-wave radiation flux	Research	TBD	Daytime	Tile , Global（1, 8 day, month）		N/A	N/A	Downward 10W/m2, upward 15W/m2 (monthly)
		Short-wave radiation flux	Research	JAXA | Inoue	Daytime	Tile , Global（1, 8 day, month）		N/A	N/A	Downward 13W/m2, upward 10W/m2

TABLE 7

GEOPHYSICAL PRODUCTS OF GCOM-C (2/3)

Area	*Group*	*Product*	*Category*	*Developer*	*Day/night*	*Production unit*	*Grid size*	*Release threshold*[*2]	*Standard accuracy*[*2]	*Target accuracy*[*2]
Ocean	Ocean color	Normalized water-leaving radiance (incl. cloud detection)	Standard	Toratani / Frouin	Daytime	Scene, Global (1, 8 days, month)	Coast: 250m Offshore: 1km Global: 4-9km	60% (443~565nm)	50% (<600nm) 0.5W/m2/str/um (>600nm)	30% (<600nm) 0.25W/m2/str/um (>600nm)
		Atmospheric correction parameter	Standard					80% (AOT@865nm)	50% (AOT@865nm)	30% (AOT@865nm)
		Photosynthetically available radiation	Standard	JAXA/ Frouin	Daytime	Scene, Global (1, 8 days, month)		20% (10km/month)	15% (10km/month)	10% (10km/month)
		Euphotic zone depth	Research	Hirata	Daytime	Scene, Global (1, 8 days, month)		N/A	N/A	30%
	In-water	Chlorophyll-a concentration	Standard	JAXA/PI	Daytime	Scene, Global (1, 8 days, month)		–60 to +150% (offshore)	–60 to +150%	–35 to +50% (offshore), –50 to +100% (coast)
		Total suspended matter concentration	Standard	Toratani				–60 to +150% (offshore)	–60 to +150%	–50 to +100%
		Colored dissolved organic matter	Standard	Hirata				–60 to +150% (offshore)	–60 to +150%	–50 to +100%
		Inherent optical properties	Research	Hirata	Daytime	Scene, Global (1, 8 days, month)		N/A	N/A	a (440): RMSE<0.25, bbp (550): RMSE<0.25
	Temperature	Sea-surface temperature	Standard	JAXA	Both	Scene, Global (1, 8 days, month)	Coast: 500m Others: Same as above	0.8K (daytime)	0.8K (day & night time)	0.6K (day and night time)
	Application	Ocean net primary productivity	Research	Ishizaka | Hirawake	Daytime	Scene, Global (1, 8 days, month)	Coast: 500m Others: Same as above	N/A	N/A	70% (monthly)
		Phytoplankton functional type	Research	Hirawake | | Hirata	Daytime	Scene, Global (1, 8 days, month)	Coast: 250m Others: Same as above	N/A	N/A	error judgment rate of large/ small phytoplankton dominance<20%; or error judgment rate of the dominant phytoplankton functional group <40%
		Red tide	Research	Ishizaka	Daytime	Scene, Global (1, 8 days, month)		N/A	N/A	error judgment rate <20%
		multi sensor merged ocean color	Research	JAXA, Franz, Wang	Daytime	Area, Global (1, 8 days, month)	Coast: 250m Offshore: 1km	N/A	N/A	–35 to +50% (offshore), –50 to +100% (coast)
		multi sensor merged SST	Research	TBD	Both			N/A	N/A	0.8K (day & night time)
Cryosphere	Area/ distribution	Snow and Ice covered area (incl. cloud detection)	Standard	Stamnes / JAXA	Daytime	Tile, Global (1, 8 days, month)	250m (Tile), 1km (global)	10% (vicarious val with other sat. data)	7%	5%
		Okhotsk sea-ice distribution	Standard		Daytime	Area (1day)	250m	10%	5%	3%
		Snow and ice classification	Research		Daytime	Global (8 days, month)	1km	N/A	N/A	10%
		Snow covered area in forests and mountains	Research	JAXA	Daytime	Area (1, 8 days)	250m	N/A	N/A	30%
	Surface properties	Snow and ice surface Temperature	Standard	Stamnes / Aoki	Daytime	Tile, Global (1, 8 days, month)	500m (Tile), 1km (global)	5K (vicarious val with other sat. data and climatology)	2K	1K
		Snow grain size of shallow layer	Standard		Daytime	Tile, Global (1, 8 days, month)	250m (Tile), 1km (global)	100% (vicarious val. with climatology between temp-size)	50%	30%
		Snow grain size of subsurface layer	Research		Daytime	Tile, Global (1, 8 days, month)	1km	N/A	N/A	50%
		Snow grain size of top layer	Research		Daytime	Tile, Global (1, 8 days, month)	250m (Tile), 1km (global)	N/A	N/A	50%
		Snow and ice albedo	Research	Stamnes	Daytime	Global (1, 8 days, month)	1km	N/A	N/A	7%

TABLE 7

GEOPHYSICAL PRODUCTS OF GCOM-C (3/3)

Area	*Group*	*Product*	*Category*	*Developer*	*Day/night*	*Production unit*	*Grid size*	*Release threshold*[*2]	*Standard accuracy*[*2]	*Target accuracy*[*2]
Cryosphere	Surface properties	Snow impurity	Research	Stamnes / Aoki	Daytime	Tile, Global (1, 8 days, month)	250m (Tile), 1km (global)	N/A	N/A	50%
		Ice sheet surface roughness	Research	Aoki	Daytime	Area (Season)	1km	N/A	N/A	0.05 *15
	Boundary	Ice sheet boundary monitoring	Research	JAXA	Daytime	Area (Season)	250m	N/A	N/A	<500m

Common notes:
*1. Heritage levels from ADEOS-II/GLI study are shown by A-C; A: high heritage, B: Remaining issues, C: new or many issues remaining to be resolved
*2. The “release threshold” is minimum levels for the first data release at one year from launch. The "standard" and "research" accuracies correspond to full and extra success criteria of the mission. Accuracies are basically shown by RMSE.

Radiance data notes:
*3. Absolute error is defined as offset + noise; relative error is defined as relative errors among channels, FOV, and so on. Release threshold of radiance is defined as estimated errors from vicarious, onboard solar diffuser, and onboard blackbody calibration because of lack of long-term moon samples

Atmosphere notes:
*4. Vicarious val. on sea-surface temperature and comparison with objective analysis data
*5. Inter comparison with airplane remote sensing on water clouds of middle optical thickness
*6. Release threshold is defined by vicarious val. with other satellite data (e.g., global monthly statistics in the mid-low latitudes)
*7. Comparison with cloud liquid water by in-situ microwave radiometer
*8. Comparison with optical thickness by sky-radiometer (the difference can be large due to time-space inconsistence and large error of the ground measurements)
*9. Comparison with in-situ observation on monthly 0.1-degree
*10. Estimated by experience of aerosol products by GLI and POLDER

Land data notes:
*11. Defined with land reflectance~0.2, solar zenith<30deg, and flat surface. Release threshold is defined with AOT@500nm<0.25
*12. Night time 250m product can be produced by special observation requests of 1.6μm channel
*13. Evaluate in semiarid regions (steppe climate, etc.)
*14. Fires >1000K occupying >1/1000 on 1km pixel at night (using 2.2um of 1 km and thermal infrared channels)

Cryosphere notes:
*15. Defined as height/width of the surface structures

TABLE 8 Reference data for the validation of GCOM-C/SGLI standard products

Category	Product [Unit]	Accuracy Targets	Val. Data Type (Main/Auxiliary)	Algorithm PIs	Validation PIs	In-situ Data	Instruments	Observation Sites	Period, Frquency, Obs. Cycles
Common	**Satellite-observed radiance (Level-1B) [W/m^2/str/μm]**	Release: 5% (Abs. *11) Geometric: <1pixel	**In-situ & various cal.data (Main)**	**JAXA (NEC)**	**JAXA**	Ground reflectance data, MOBY data etc. (cooperation with NOAA) Onboard calibration data Other satellite data (TBD)	Spectrometer SGLI MODIS(MOD02,MYD02) CAI(L1,L1B) ASTER(L1B)	CEOS cal sites Global	Year-round Year-round
		Standard: VIS-SWIR: 5% (Abs.*11), 1% (Relative) TIR: 0.5K (@300K) Geometric: <0.5pixel Goal: VIS-SWIR : 3% (Abs.*11), 0.5% (Relative) TIR: 0.5K (@300K) Geometric: <0.3pixel	**In-situ & various cal.data (Main)**			Ground reflectance data, MOBY data etc. (cooperation with NOAA) Onboard calibration data Other satellite data (TBD)	Spectrometer SGLI MODIS(MOD02,MYD02) CAI(L1,L1B) ASTER(L1B)	CEOS cal sites Global	Year-round Year-round
Land	**Precise geometric corrected radiance [W/m2/str/μm]**	Release: <1pixel	**Other satellites (Main)**	**JAXA (RESTEC, Tokai U.)**	**JAXA**	GCP database derived from AVNIR-2 etc.	MODIS（MCD43C4) CAI AVNIR-2	(Defined in GCP library)	Year-round
		Standard: <0.5pixel Goal: <0.25pixel	**Other satellites (Main)**			GCP database derived from AVNIR-2 etc.	MODIS（MCD43C4)		
							CAI		

	Land atmospheric corrected reflectance [—]	Release : 0.3 (<=443nm), 0.2 (>443nm) (scene)(*8)	**In-situ (Main)**	**JAXA (Sano)**	**Honda-Kajiwara** **Nasahara**	Spectral reflectance (incl. BRDF) data measured from UAV Spectral data measured from Tower Spectral data measured from UAV (combined with BiRS simulations for uniform surfaces)	FieldSpec, MS-720 Hyperspectral Camera MS-700 MS-720	Yatsugatake JaLTER, JapanFlux, PEN sites	Campaign (Period/Freq: TBD) Year-round
			Other satellites (Auxiliary)		**(JAXA)**	L2 atmospheric crrected reflectance product (MOD09, MYD09)	MODIS of Terra & Aqua	Global but every typical LCC (TBD)	Year-round or Seasonally
		Standard: 0.1 (<=443nm), 0.05 (>443nm) (scene)(*8) Goal: 0.05 (<=443nm), 0.025 (>443nm) (scene)(*8)	**In-situ (Main)**		**Honda-Kajiwara** **Nasahara**	Spectral data measured from UAV Spectral data measured from Tower Spectral data measured from UAV	FieldSpec, MS-720 Hyperspectral Camera MS-700 MS-720	Yatsugatake JaLTER, JapanFlux, PEN sites	Campaign (Period/Freq: TBD) Year-round
	Vegetation index [—]	Release: grass：25% (scene), forest：20% (scene)	**In-situ (Main)**	**JAXA (Huete, Miura, Furumi)**	**Honda-Kajiwara** **Nasahara**	Spectral data measured from UAV Spectral data measured from Tower Spectral data measured from UAV	FieldSpec, MS-720 Hyperspectral Camera MS-700 MS-720	forest：Yatsugatake grass・forest：JaLTER, JapanFlux, PEN sites	Campaign (Period/Freq: TBD) Year-round
			Other satellites (Main)		**(JAXA)**	L2 VI products (MOD13,MYD13)	MODIS of Terra & Aqua JASMES CAI	Global	Year-round
		Standard: grass：20% (scene), forest：15% (scene) Goal: grass：10% (scene), forest：10% (scene)	**In-situ (Main)**		**Honda-Kajiwara** **Nasahara**	Spectral data measured from UAV Spectral data measured from Tower Spectral data measured from UAV	FieldSpec, MS-720 Hyperspectral Camera MS-700 MS-720	forest：Yatsugatake grass, forest：JaLTER, JapanFlux, PEN sites	Campaign (Period/Freq: TBD) Year-round

	Above-ground biomass [t/ha]	Release: grass： 50%, forest： 100%	**In-situ (Main)**	**Kajiwara**	**Honda-Kajiwara-Nasahara**	AGBIO estimated from Every Tree Measurements (DBH, Tree Hight, Tree Density etc.)	Tree (direct) measurements	forest：Yatsugatake, grass・forest： JaLTER, JapanFlux, PEN sites Mine site (GOSAT2) of Australia、Fuji-hokuroku, Tomakomai, Uryuu, Mase, Alaska (boreal, 200m sq scale), Pasoh/ Malaysia (Tropical-rain)	Campaign (Period/Freq: TBD)
					Honda-Kajiwara-JAXA	AGBIO estimated from 3D-Laser Scanner data measured at ground	3D-Laser Scanner	forest：Yatsugatake, grass・forest： JaLTER, JapanFlux, PEN sites	Campaign (Period/Freq: TBD)
			Other satellites (Main)		**Honda-Kajiwara**	L2-L3 AGBIO products derived from satellite borne lider and SAR	PALSAR-2, ISS/MOLI (L+5yr), ISS/GEDI (L+5yr)		Year-round
			model (Main)		**Sasai**	Output of eco-system model	BEAMS (Sasai)	Global but every typical LCC (TBD)	Year-round
		Standard: grass：30%, forest：50% Goal: grass：10%, forest：20%	**In-situ (Main)**		**Honda-Kajiwara-Nasahara**	AGBIO estimated from Every Tree Measurements (DBH, Tree Hight, Tree Density)	Tree (direct) measurements	forest：Yatsugatake, grass・forest： JaLTER, JapanFlux, PEN sites Mine site (GOSAT2) of Australia、Fuji-hokuroku, Tomakomai, Uryuu, Mase, Alaska (boreal, 200m sq scale), Pasoh/ Malaysia (Tropical-rain)	Campaign (Period/Freq: TBD)
					Honda-Kajiwara-JAXA	AGBIO estimated from 3D-Laser Scanner data measured at grou	3D-Laser Scanner	forest：Yatsugatake, grass・forest： JaLTER, JapanFlux, PEN sites	Campaign (Period/Freq: TBD)
	Vegetation roughness index [—]	Release: grass・forest： 40% (scene)	**In-situ (Main)**	**Kajiwara**	**Honda-Kajiwara**	VRI derived from 3D-Laser Scanner data measured from UAV or near surface (Tower)	3D-Laser Scanner	forest：Yatsugatake, grass・forest： JaLTER, JapanFlux, PEN sites	Campaign (Period/Freq: TBD)

		Standard: grass・forest： 20% (scene) Goal: grass・forest： 10% (scene)	**In-situ (Main)**		**Honda-Kajiwara**	VRI derived from 3D-Laser Scanner data measured from UAV or near surface (Tower)	3D-Laser Scanner	forest：Yatsugatake, grass・forest： JaLTER, JapanFlux, PEN sites	Campaign (Period/Freq: TBD)
	Shadow index [—]	Release: grass・forest： 30% (scene)	**In-situ (Main)**	**Moriyama**	**Honda-Kajiwara** **Nasahara**	Spectral reflectance from UAV 3D-Laser Scanner data & images from UAV Spectral reflectance from Tower Spectral data measured from UAV	FieldSpec, MS-720 3D-Laser Scanner Digital camera etc. MS-700 MS-720	forest：Yatsugatake, Goto grass・forest： JaLTER, JapanFlux, PEN sites forest：Yatsugatake, Goto grass・forest： JaLTER, JapanFlux, PEN sites	Campaign (Period/Freq: TBD) Campaign (Period/Freq: TBD)
			Other satellites (Auxiliary)		**Moriyama**	L1 radiance of high-rsol. satellite imagers	Landsat8	grass： forest：Goto Is.	Year-round
		Standard: grass・forest： 20% (scene) Goal: grass・forest： 10% (scene)	**In-situ (Main)**		**Honda-Kajiwara** **Nasahara**	Spectral reflectance from UAV 3D-Laser Scanner data & images from UAV Spectral reflectance from Tower Spectral data measured from UAV	FieldSpec, MS-720 3D-Laser Scanner Digital camera etc. MS-700 MS-720	forest：Yatsugatake, Goto grass・forest： JaLTER, JapanFlux, PEN sites forest：Yatsugatake, Goto grass・forest： JaLTER, JapanFlux, PEN sites	Campaign (Period/Freq: TBD) Campaign (Period/Freq: TBD)
			Other satellites (Auxiliary)		**Moriyama**	L1 radiance of high-rsol. satellite imagers	Landsat8	grass： forest：Goto Is.	Year-round
	Fraction of absorbed photosynthetically active radiation (PAR) [—]	Release: grass： 50%, forest： 50%	**In-situ (Main)**	**Nasahara (Ono)**	**Honda-Kajiwara-Nasahara**	PAR derived with PAR meter or spectrometer (incident, reflercted, transmitted PAR) measured from Towers Combine canopy model. <= Ground LIDER+ Heli DSM	PAR meters MS700 Spectrometer 3D-Laser Scanner Digital camera etc.	forest：Yatsugatake, grass・forest： JaLTER, JapanFlux, PEN sites, Australia, Fuji-hokuroku, Tomakomai, Uryuu, Mase 500m square sites	Year-round

			Other satellites (Main)		**(JAXA)**	L2 FPAR products (MOD15, MYD15)	MODIS of Terra & Aqua	Global	Year-round
		Standard: grass：30%、 forest：20% Goal: grass：20%, forest：10%	**In-situ (Main)**		**Honda-Kajiwara-Nasahara**	PAR derived with PAR meter or spectrometer (incident, reflercted, transmitted PAR) measured from Towers Combine canopy model. <= Ground LIDER+ Heli DSM	PAR meters MS700 Spectrometer 3D-Laser Scanner Digital camera etc.	forest：Yatsugatake, grass・forest： JaLTER, JapanFlux, PEN sites Australia, Fuji-hokuroku, Tomakomai, Uryuu, Mase 500m square sites	Year-round
	Leaf area index [—]	Release: grass： 50%, forest： 50%	**In-situ (Main)**	**JAXA (Ono)**	**Honda-Kajiwara-Nasahara**	In-situ measured LAI (from instrument (indirect) or grass cutting (direct) method)	LAI-2000 Litter trap etc.	forest：Yatsugatake, grass・forest： JaLTER, JapanFlux, PEN sites Australia, Fuji-hokuroku, Tomakomai, Uryuu, Mase Alaska (boreal, 200m sq scale), Pasoh/ Malaysia (Tropical-rain) (500m square sites)	Campaign (Period/Freq: TBD)
			Other satellites (Main)		**(JAXA)**	L2 LAI products (MODIS)	MODIS of Terra & Aqua	Global but every typical LCC (TBD)	Year-round
		Standard: grass：30%、 forest：30% Goal: grass：20%, forest：20%	**In-situ (Main)**		**Honda-Kajiwara-Nasahara**	In-situ measured LAI (from instrument (indirect) or grass cutting (direct) method)	LAI-2000 Litter trap etc.	forest：Yatsugatake, grass・forest： JaLTER, JapanFlux, PEN sites Australia, Fuji-hokuroku, Tomakomai, Uryuu, Mase Alaska (boreal, 200m sq scale), Pasoh/ Malaysia (Tropical-rain) (500m square sites)	Campaign (Period/Freq: TBD)

	Land surface temperature [K]	Release: 3.0K 以下 (scene)	**In-situ (Main)**	**Moriyama**	**Moriyama** **Honda-Kajiwara** **Nasahara** **JAXA**	in situ BT measured from ground In-situ BT measured from UAV In-situ BT measured from Tower LST converted from Tair obtained at Fluxsite, GTS, GSOD or other sites	IR thermometer IR thermometer IR thermometer Thermometer	Railroad Valley, ND & Ivanpah playa, CA Yatsugatake JaLTER, JapanFlux, PEN sites Fluxnet, GTS sites	Campaign (Period/Freq: TBD) Campaign (Period/Freq: TBD) Year-round Year-round
			Other satellites (Main)		**(JAXA)**	L2 LST products (MOD11, MYD11) L2 LST products from Sentinel-3	MODIS of Terra & Aqua Sentinel-3	Global but every typical LCC (TBD)	Year-round
		Standard: 2.5K 以下 (scene) Goal: 1.5K 以下 (scene)	**In-situ (Main)**		**Moriyama** **Honda-Kajiwara** **Nasahara** **JAXA**	in situ BT measured from ground In-situ BT measured from UAV In-situ BT measured from Tower Tair obtained from Fluxsite, GTS, GSOD or other sites	IR thermometer IR thermometer IR thermometer Thermometer	Railroad Valley, ND & Ivanpah playa, CA Yatsugatake JaLTER, JapanFlux, PEN sites GTS sites	Campaign (Period/Freq: TBD) Campaign (Period/Freq: TBD) Year-round Year-round
Atmosphere	**Cloud flag [—]**	Release: 10% (comparisonwith sky-camera binary image)	**In-situ (Main)**	**Nakajima (main), Ishimoto, Riedi**	**Irie Nakajima Kuji**	Cloud amount derived from skycamera GTS cloudiness	Sky-Camera Human-eye	Kumamoto, Greenland, Abashiri, Tsukuba, Shirase, Noto, Yoyogi, Iriomote, Osaka, Polar region (Sbalvard, Syowa St.)	Year-round
			Other satellites (Main)			L2 cloud flag product (MOD35, MYD35)	MODIS VIIRS etc.	Global	Year-round
		Standard&Goal: Eavaluated as the cloud fraction products	**In-situ (Main)**			same as CLFR	same as CLFR		

	Classified cloud fraction [%]	Release: 20% (as solar radiation)(*6)	**In-situ (Main)**	**Nakajima (main), Ishimoto, Riedi**	**Hayasaka**	BSRN solar radiation data Whole sky image data	Solar radiation base Sky-Camera (supplemental)	BRSR etc. Kumamoto, Greenland, Abashiri, Tsukuba, Shirase, Noto, Yoyogi, Iriomote, Osaka, Polar region (Sbalvard, Syowa St.)	Year-round Year-round
			Climatology (Main)			ISCCP climatological dataset	Various satellites	Global	Year-round
		Standard: 15%(as solar radiation)(*6) Goal: 10%（ as solar radiation)(*6)	**In-situ (Main)**			BSRN solar radiation data Whole sky image data	Solar radiation base Sky-Camera (supplemental)	BRSR etc. Kumamoto, Greenland, Abashiri, Tsukuba, Shirase, Noto, Yoyogi, Iriomote, Osaka, Polar region (Sbalvard, Syowa St.)	Year-round Year-round
	Cloud top temp & height [K], [km]	Release: 1K(*1)	**Climatology (Main)**	**Nakajima (main), Ishimoto, Riedi**	**(JAXA)**	ISCCP climatological dataset	Various satellites	Global	Year-round
		Standard: 3K(*2)/2km(*2) Goal: 1.5K(*2)/1km(*2)	**In-situ (Main)**		**Irie (Takano)**	Data measured with ground-based radar *Data measured with airborne lidar*	FALCON(radar) *NASA Airborne lidar*	Chiba, etc., Nieolson (Contact to Shiobara-san (Irie)) *Flight courses (TBD, Shinozuka-san (CI of Sano PI) has info.)*	Year-round *Campaigns*
			Other satellites (Main)		**(JAXA)**	Data measured with satellite-borne lidar	Satellite borne lidar	Global	Year-round
	Water-cloud optical thickness & effective radius [—], [μm]	Release: 10%/30% (optial thickess/radius) (*3)	**Other satellites (Main)**	**Nakajima (main), Ishimoto, Riedi**	**Irie**	L2 Cloud effective radius prd. (MOD06, MYD06)	MODIS of Terra & Aqua	Mid- to Low latitude area	Year-round

		Standard: 100% (as cloud liquid water: *4)	**In-situ (Main)**			Cloud liquid water data from Ground based passive microwave radiometer (PMR)	Microwave radiometer	Fukue, Hedo, Chiba (Skynet supersites) PMR by NICT@ Okinawa (TBD)	Year-round
		Goal: 50% (*4) /20% (*5)	**In-situ (Main)**			Cloud liquid water data from ground based passive microwave radiometer (PMR) Cloud optical thickness data from skyradiometer	Microwave radiometer Skyradiometer	Fukue, Hedo, Chiba (Skynet supersites) Thai, Gouhi, Chiba, Fukue, Hedo	Year-round Year-round
			Other satellites (Main)			L2 Cloud effective radius prd. (MOD06, MYD06)	MODIS of Terra & Aqua	Global	Year-round
	Ice-cloud optical thickness [—]	Release: 30%(*3)	**Other satellites (Main)**	**Nakajima (main), Ishimoto, Riedi**	**Irie**	L2 Cloud optical thickness prd. (MOD06, MYD06)	MODIS of Terra & Aqua	Mid- to Low latitude area	Year-round
		Standard: 70%(*5) Goal: 20 %(*5)	**In-situ (Main)**			SKYNET data	Skyradiometer	Thai, Gouhi, Chiba, Fukue, Hedo (Skynet super sites)	Year-round
			Other satellites (Main)			L2 Cloud optical thickness prd. (MOD06, MYD06)	MODIS of Terra & Aqua	Global	Year-round
	Aerosol over the ocean [—]	Release: 0.1(monthly ave. of τa_670, 865)	**In-situ (Auxiliary)**	**Inoue (main), Ishimoto, Riedi**	**Aoki, K., Kobayashi, *NASA*** **Sano (Shinozuka)**	Skyradiometer data on Mirai, Shirase etc. Microtops data from Maritime Aerosol Network *Airborne Sunphoto data by NASA Ames*	Skyradiometer Microtops *Airbone Sunphoto*	Cruise route of Mirai, Shirase etc. Various sites *Flight courses (TBD, Shinozuka-san (CI of Sano PI) has info.)*	Campaign (Period/Freq: TBD) *Campaign* *Campaigns*
			Other satellites (Main)		**(JAXA)**	L2 Aersosol products (MOD04, MYD04)	MODIS of Terra & Aqua CAI VIIRS	Global	Year-round

		Standard: 0.1(scene's τa_670, 865)(*7) Goal: 0.05(scene's τa_670, 865)	**In-situ (Main)**		**Aoki, K., Kobayashi, *NASA*** **Sano (Shinozuka)**	Skyradiometer data on Mirai, Shirase etc. Microtops data from Maritime Aerosol Network Airborne Sunphoto data by NASA Ames	Skyradiometer Microtops Airbone Sunphoto	Cruise route of Mirai, Shirase etc. Various sites *Flight courses (TBD, Shinozuka-san (CI of Sano PI) has info.)*	Campaign (Period/Freq: TBD) *Campaign* *Campaigns*
			Other satellites (Main)		**(JAXA)**	L2 Aersosol products (MOD04, MYD04)	MODIS of Terra & Aqua CAI VIIRS	Global	Year-round
	Land aerosol by near-UV [—]	Release: 0.15(monthly ave. of τa_380)	**In-situ (Main)**	**Inoue (main), Ishimoto, Riedi**	**Aoki K.** **Sano** **Yamazaki** **Various PI/CI** **Sano (Shinozuka)**	SKYNET (Aoki), AERONET (Sano), Skyradiometer (Yamazaki, etc.) Microtops data Airborne Sunphoto data by NASA Ames	Skyradiometer Aeronet Skyradiometer Microtops Airbone Sunphoto	Many Skynet sites (<100) Many Aeronet sites (<100) MRI sites Various sites *Flight courses (TBD, Shinozuka-san (CI of Sano PI) has info.)*	Year-round Year-round Year-round *Campaigns* *Campaigns*
			Other satellites (Main)		**(JAXA)**	L2 Aersosol products (MOD04, MYD04)	MODIS of Terra & Aqua CAI VIIRS	Global	Year-round
		Standard: 0.15(scene's τa_380) (*7) Goal: 0.1(scene's τa_380)	**In-situ (Main)**		**Aoki K.** **Sano** **Yamazaki** **Various PI/CI** **Sano (Shinozuka)**	SKYNET (Aoki), AERONET (Sano), Skyradiometer (Yamazaki, etc.) Microtops data Airborne Sunphoto data by NASA Ames	Skyradiometer Aeronet Skyradiometer Microtops Airbone Sunphoto	Many Skynet sites (<100) Many Aeronet sites (<100) MRI sites Various sites *Flight courses (TBD, Shinozuka-san (CI of Sano PI) has info.)*	Year-round Year-round Year-round *Campaigns* *Campaigns*
			Other satellites (Main)		**(JAXA)**	L2 Aersosol products (MOD04, MYD04)	MODIS of Terra & Aqua CAI VIIRS	Global	Year-round

	Aerosol by Polarization [—]	Release: 0.15(monthly ave. of τa_670, 865)	**In-situ (Main)**	**Sano (main), Riedi**	**Aoki K. Sano Yamazaki Various PI/CI Sano (Shinozuka)**	SKYNET (Aoki), AERONET (Sano), Skyradiometer (Yamazaki, etc.) Microtops data *Airborne Sunphoto data by NASA Ames*	Skyradiometer Aeronet Skyradiometer Microtops *Airbone Sunphoto*	Many Skynet sites (<100) Many Aeronet sites (<100) MRI sites Various sites *Flight courses (TBD, Shinozuka-san (CI of Sano PI) has info.)*	Year-round Year-round Year-round *Campaigns* *Campaigns*
			Other satellites (Main)		**(JAXA)**	L2 aersosol products (MOD04, MYD04)	MODIS of Terra & Aqua CAI VIIRS	Global	Year-round
		Standard: 0.15(scene's τa_670, 865)(*7) Goal: 0.1(scene's τa_670, 865)	**In-situ (Main)**		**Aoki K. Sano Yamazaki Various PI/CI Sano (Shinozuka)**	SKYNET (Aoki), AERONET (Sano), Skyradiometer (Yamazaki, etc.) Microtops data *Airborne Sunphoto data by NASA Ames*	Skyradiometer Aeronet Skyradiometer Microtops *Airbone Sunphoto*	Many Skynet sites (<100) Many Aeronet sites (<100) MRI sites Various sites *Flight courses (TBD, Shinozuka-san (CI of Sano PI) has info.)*	Year-round Year-round Year-round *Campaigns* *Campaigns*
			Other satellites (Main)		**(JAXA)**	L2 aersosol products (MOD04, MYD04)	MODIS of Terra & Aqua CAI VIIRS	Global	Year-round
Ocean	**Normalized water leaving radiance [W/m2/str/µm or 1/sr]**	Release: 60% (443~565nm)	**In-situ (Main)**	**Toratani**	**Hirawake, Ishizaka, Suzuki, Kobayashi, Hirata, *Saikaiku, Tohoku, SEABASS***	In-situ measured optical data	PRR (Hirawake, etc.) TRIOS (Ishizaka, etc.) C-OPS (Suzuki)	ECS, A-line, O-line, Funka-bay, Tokyo-bay,Seto Inland sea, Chukchi Sea, Bering Sea, North Pacific, Ise-bay, Akkeshi-bay, Toyama-Bay	Campaign (Period/Freq: TBD)
			Other satellites (Main)		**(JAXA)**	MOD18	AQUA/MODIS, NPP/VIIRS	Global	Year-round

		Standard: 50% (<600nm) 0.5W/m2/str/um (>600nm) Goal: 30% (<600nm) 0.25W/m2/str/um (>600nm)	**In-situ (Main)**		**Hirawake, Ishizaka, Suzuki, Kobayashi, Hirata, Saikaiku, Tohoku, SEABASS**	In-situ measured optical data	PRR (Hirawake, etc.) TRIOS (Ishizaka, etc.) C-OPS (Suzuki) Aeronet-OC	ECS, A-line, O-line, Funka-bay, Tokyo-bay,Seto Inland sea, Chukchi Sea, Bering Sea, North Pacific, Ise-bay, Akkeshi-bay, Toyama-Bay	Campaign (Period/Freq: TBD)
	Atmospheric correction param. [—]	Release: 80% (τa_865)	**In-situ (Main)**	**Toratani, Frouin**	**Kobayashi Toratani *NASA***	Aerosol optical thickness data Aerosol optical thickness data	Skyradiometer AERONET/maritime(NASA)	Cruise track of Shirase etc. Many Aeronet sites (<100)	Campaign (Period/Freq: TBD)
			Other satellites (Main)		**(JAXA)**	Aerosol optical thickness data	AQUA/MODIS、NPP/VIIRS	Global	Year-round
		Standard: 50% (τa_865) Goal: 30%	**In-situ (Main)**		**Kobayashi, Toratani, etc. *NASA, Cooperation with Atmos. Gr.***	Aerosol optical thickness data	Skyradiometer AERONET/maritime(NASA), SKYNET	Cruise track of Shirase etc. Many Aeronet sites (<100)	Campaign (Period/Freq: TBD)
	Photosynthetically Available Radiation [Ein/m^2/day or mol photons/m^2/day]	Release: 20% (10km/month)	**In-situ (Main)**	**JAXA & Frouin**	**Hirawake, Ishizaka, Suzuki, Hirata, *Saikaiku, Tohoku, SEABASS***	Buoy: NDBC, TAO/TRITON etc. Ship: PRR data	PRR	Buoy sites ECS, A-line, O-line, Funka-bay, Tokyo-bay, Coast of Oita, Chukchi Sea, Bering Sea, North Pacific	Year-round Campaign (Period/Freq: TBD)
		Standard: 15% (10km/month) Goal: 10% (10km/month)	**In-situ (Main)**			Buoy: NDBC, TAO/TRITON etc. Ship: PRR data	PRR	Buoy sites ECS, A-line, O-line, Funka-bay, Tokyo-bay, Coast of Oita, Chukchi Sea, Bering Sea, North Pacific	Year-round Campaign (Period/Freq: TBD)

	Chlorophyll-a concentration [mg/m^3]	Release: -60~+150% (open sea)	**In-situ (Main)**	**JAXA, Toratani, Hirata**	**Hirawake, Ishizaka, Suzuki, Kobayashi, *Saikaiku, Tohoku, SEABASS***	Pigment concentration data measured with fluorescense method and HPLC at Ship	Fluorescense method, HPLC	ECS, A-line, O-line, Funka-bay, Tokyo-bay,Seto Inland sea, Chukchi Sea, Bering Sea, North Pacific, Ise-bay, Akkeshi-bay, Toyama-Bay	Campaign (Period/Freq: TBD)
			Other satellites (Main)		**(JAXA)**	MOD20, MOD21	AQUA/MODIS、NPP/VIIRS	Global	Year-round
		Standard: -60~+150% Goal: -35~+50% (open sea), -50~+100% (coastal)	**In-situ (Main)**		**Hirawake, Ishizaka, Suzuki, Kobayashi, *Saikaiku, Tohoku, SEABASS***	Pigment concentration data measured with fluorescense method and HPLC at Ship	Fluorescense method, HPLC	ECS, A-line, O-line, Funka-bay, Tokyo-bay,Seto Inland sea, Chukchi Sea, Bering Sea, North Pacific, Ise-bay, Akkeshi-bay, Toyama-Bay	Campaign (Period/Freq: TBD)
	Total suspended matter concentration [g/m^3]	Release: -60~+150% (open sea)	**In-situ (Main)**	**JAXA, Toratani, Hirata**	**Ishizaka, Kobayashi, SeaBASS**	Dry weight of filtered SS sampled at Ship	Sampling and filtering	ECS, Tokyo-bay	Campaign (Period/Freq: TBD)
			Other satellites (Main)		**(JAXA)**	MOD23	AQUA/MODIS、NPP/VIIRS	Global	Year-round
		Standard: -60~+150% Goal: -50~+100%	**In-situ (Main)**		**Ishizaka, Kobayashi, SeaBASS**	Dry weight of filtered SS sampled at Ship	Sampling and filtering	ECS, Ariake, Tokyo-bay	Campaign (Period/Freq: TBD)
	Colored dissolved organic matter [m^{-1}]	Release: -60~+150% (open sea)	**In-situ (Main)**	**JAXA, Toratani, Hirata**	**Hirawake, Ishizaka, Kobayashi, *Saikaiku, SeaBASS***	Ship: Absorption data of sampling water	Absorption meter	ECS, Ariake, Tokyo-bay, Ise-bay, Chukchi Sea, Bering Sea, Akkeshi-bay	Campaign (Period/Freq: TBD)
			Other satellites (Main)		**(JAXA)**	MOD24	AQUA/MODIS	Global	Year-round

		Standard: -60~+150% Goal: -50~+100%	**In-situ (Main)**		**Hirawake, Ishizaka, Kobayashi, *Saikaiku, SeaBASS***	Ship: Absorption data of sampling water	Absorption meter	ECS, Tokyo-bay, Ise-bay, Chukchi Sea, Bering Sea, Akkeshi-bay	Campaign (Period/Freq: TBD)
	Sea surface temperature [℃]	Release: 0.8K (daytime only)	**In-situ (Main)**	**Sakaida, (JAXA)**	**(JAXA)**	GTS iQuam (buoy data for AMSR2 val)		GTS sites	Year-round
					Hirawake, Ishizaka, Kobayashi, *Saikaiku, Tohoku, SEABASS*	In-situ measured SST Bucket SST, Nautical SST, Argo float SST, etc.	Bucket, thermometer	ECS, A-line, O-line, Funka-bay, Tokyo-bay,Seto Inland sea, Chukchi Sea, Bering Sea, North Pacific, Ise-bay, Akkeshi-bay, Toyama-Bay	Campaign (Period/Freq: TBD)
			Other satellites (Main)		**(JAXA)**	MOD28 SST of AMSR2	MODIS AMSR2	Global	Year-round
		Standard: 0.8K Goal: 0.6K	**In-situ (Main)**		**(JAXA)**	GTS iQuam (buoy data for AMSR2 val)	thermometer onboard buoy	GTS sites	Year-round
					Hirawake, Ishizaka, Kobayashi, *Saikaiku, Tohoku, SEABASS*	In-situ measured SST Bucket SST, Nautical SST, Argo float SST, etc.	Bucket, thermometer	ECS, A-line, O-line, Funka-bay, Tokyo-bay,Seto Inland sea, Chukchi Sea, Bering Sea, North Pacific, Ise-bay, Akkeshi-bay, Toyama-Bay	Campaign (Period/Freq: TBD)
			Other satellites (Main)		**(JAXA)**	MOD28 SST of AMSR2	MODIS AMSR2	Global	Year-round
Cryosphere	**Snow and Ice covered area [—]**	Release: 10% (comparison with other satellites products)	**In-situ (Auxiliary)**	**Stamnes**	**(JAXA)**	In-situ snow depth from WMO(GSOD), In-situ snow depth from NOAA(GHCND)	supersonic or laser supersonic or laser	GTS sites GTS sites	Year-round
			Other satellites Climatology (Main)		**(JAXA)**	L2 snow cover prd. (MOD10、MYD10) L2 snow cover product L1 radiance	MODIS VIIRS Landsat8 etc.	Global	Year-round

		Standard : 7% Goal : 5%	**In-situ (Auxiliary)**		**(JAXA)**	In-situ snow depth from WMO(GSOD), In-situ snow depth from NOAA(GHCND)	supersonic or laser supersonic or laser	GTS sites GTS sites	Year-round
			Other satellites Climatology (Main)		**(JAXA)**	L2 snow cover prd. (MOD10、MYD10) L2 snow cover product L1 radiance	MODIS VIIRS Landsat8 etc.	Global	Year-round
	Okhotsk sea-ice distribution [—]	Release: 10% (comparison with other satellite products)	**Other satellites (Main)**	**Stamnes**	**(JAXA)**	L2 sea-ice cover product (MOD10、MYD10) L2 sea-ice cover product L1 radiance	MODIS VIIRS Landsat8 etc.	Sea of Okhotsk	Dec.-May
		Standard : 5% Goal : 3%	**In-situ (Auxiliary)**		**TBD**	Sea ice conc. measured from ground, airplane etc.	Human-eye, Camera	Sea of Okhotsk	Dec.-May
			Other satellites Climatology (Main)		**(JAXA)**	L2 sea-ice cover product (MOD10、MYD10) L2 sea-ice cover product L1 radiance	MODIS VIIRS Landsat8 etc.	Sea of Okhotsk	Dec.-May
	Snow and ice surface Temperature [K]	Release: 5K (comparison with other satellite products and meteorological measurements)	**In-situ (Main)**	**Stamnes**	**(JAXA)**	In-situ Tair obtained from GTS, GSOD, GC-Net etc.	Thermometer at GTS and GC-Net sites or ocean bouys	GTS sites etc. GC-Net sites on Greenland	Year-round
			Other satellites (Main) **Climatology (Main)**		**(JAXA)**	GLI snow surface temp. (Climatology) MODIS snow surf. temp. (Climatology) VIIRS snow surface temp. Landsat8 snow surface temp. (High resol.) Climatology of Tair etc.	GLI MODIS VIIRS Landsat8 etc. Thermometer at GTS sites or ocean bouys	Global, Greenland, Antarctica etc. GTS sites etc.	Year-round Year-round
		Standard : 2K Goal : 1K	**In-situ (Main)**		**Aoki**	In-situ Tair obtained from GTS, GSOD, GC-Net etc. In-situ Tsnow and Tair data	Thermometer at GTS and GC-Net sites or ocean bouys IR thermoeter, FT-IR, Thermometer etc.	GTS sites etc. GC-Net sites on Greenland Hokkaido, Greenland, Antarctica etc.	Year-round Campaign (Period/Freq: TBD)

	Snow grain size of shallow layer [μm]	Release: 100% (evaluated with climatology of temperature-snow grain size relationship)	**Other satellites Climatology (Main)**	**Stamnes**	**(JAXA)**	GLI snow grain size (Climatology) MODIS snow grain size (Climatology) VIIRS snow grain size Landsat8 snow grain size (High resol.) SGLI SIST product In-situ Tair obtained from GTS etc	GLI MODIS VIIRS Landsat8 etc. SGLI Thermometer at GTS	Global, Greenland, Antarctica etc. GTS sites etc.	Year-round
		Standard : 50% Goal : 30%	**In-situ (Main)**		**Aoki**	Snow grain size derived from in-situ snow pit data and optical measurements (reflectance, SSA etc.)	Snow Pit Work Tools, FieldSpecFR, NIR Camera, IceCube etc.	Hokkaido, Greenland, Antarctica etc.	Campaign (Period/Freq: TBD)
			Other satellites Climatology (Auxiliary)		**(JAXA)**	GLI snow grain size (Climatology) MODIS snow grain size (Climatology) VIIRS snow grain size Landsat8 snow grain size (High resol.)	GLI MODIS VIIRS Landsat8 など	Global, Greenland, Antarctica etc.	Year-round

*Notes in this table are same as Table 7.

TABLE 9 Reference data for the validation of GCOM-C/SGLI research products

Category	Product [Unit]	Accuracy Targets	Val. Data Type (Main/Auxiliary)	Algorithm PIs	Validation PIs	In-situ Data	Instruments	Observation Sites	Period, Frquency, Obs. Cycles
Land	**Land net primary production [gC/m2/year]**	Goal: 30% (annual ave.)	**In-situ (Main)**	**Nasahara**	**Nasahara**	LNPP data derived from various variables measured at flux tower sites	Thermometer, spectrometer, pyranometer etc.	forest : Yatsugatake, grass・forest : JaLTER, JapanFlux, PEN sites	Year-round
			Other satellites (Main)			LNPP products derived from other satellites	MODIS VIIRS etc.	Global covering every typical LCT	Year-round
	Water stress trend [—]	Goal: 10% (as classification error)(*13)	**In-situ (Main)**	**Kajiwara**	**Nasahara**	Latent heat flux measured at flux tower sites	Eddy Correlation Flux Measurement System	forest : Yatsugatake, grass・forest : JaLTER, JapanFlux, PEN sites	Campaign /Year-round
	Fire detection index [—]	Goal: 20% (as classification error)(*14)	**Other satellites (Main)**	**Moriyama Nakau**	**Moriyama Nakau**	Hotspots data derived from other satellites	MODIS Landsat8	Global covering every typical vegetation type	Year-round
	Land cover type [—]	Goal: 30% (as classification error)	**In-situ (Main)**	**Fukue Soyama Takagi Nasahara**	**Sasai Soyama Nasahara**	Degree Confluence Project (DCP) data		Global covering every typical LCT	Every year (TBD)
			Other satellites (Main)		**Soyama Nasahara**	L1 radiance data of high resolution satellite Google Earth	Landsat8 AVNIR-2 etc.	Global covering every typical LCT	Seasonally (TBD)
	Land surface albedo [—]	Goal: 10%	**In-situ (Main)**	**JAXA**	**Honda-Kajiwara** **Nasahara**	Spectral reflectance data measured at flux tower, RC helocopter etc	Spectometer	forest : Yatsugatake, grass・forest : JaLTER, JapanFlux, PEN sites	Campaign /Year-round
			Other satellites (Main)		**(JAXA)**	LALB products derived from other satellites	MODIS VIIRS etc.	Global covering every typical LCT	Year-round
Atmosphere	**Water cloud geometrical thickness [m]**	Goal: 300m	**In-situ (Main)**	**Kuji**	**Irie, Kuji**	Cloud profile data Cloud bottom height obtained with ceilometer onboard Shirase	Falcon radar Ceilometer	Falcon sites Cruise course of Shirase between Japan and the Antarctica	Year-round Campaign

			Other satellites (Main)			Cloud top height data etc. measured from space	Calipso etc.	Global	Year-round
	Long-wave radiation flux [W/m2]	Goal: Downward flux: 10W/m^2, Upward: 15W/m^2 (0.1deg., monthly ave)	**In-situ (Main)**	**Hayasaka**	**Hayasaka**	Longwave radiation data from radiation network Longwave radiation data from from flux network	Net radiometer etc.	BSRN, Skynet, JMA etc sites JaLTER, JapanFLux, PEN, Fluxnet sites	Year-round
			Other satellites Climatology (Main)			Clouds and aerosol data Global radiative flux data (ISCCP-FD) Surface Radiation Budget (GEWEX-SRB)	MODIS ISCCP GEWEX	Global	Year-round
	Short-wave radiation flux [W/m2]	Goal: Downward: 13W/m^2, Upward: 10W/m^2 (0.1deg., monthly ave)	**In-situ (Main)**	**Hayasaka**	**Hayasaka**	Longwave radiation data from radiation network Longwave radiation data from from flux network	Net radiometer etc.	BSRN, Skynet, JMA etc sites JaLTER, JapanFLux, PEN, Fluxnet sites	Year-round
			Other satellites Climatology (Main)			Clouds and aerosol data Global radiative flux data (ISCCP-FD) Surface Radiation Budget (GEWEX-SRB)	MODIS ISCCP GEWEX	Global	Year-round
Ocean	**Euphotic zone depth [m]**	Goal: 30% (inferred from extinction coefficient)	**In-situ (Main)**	**Hirata**	**Hirawake, Ishizaka, Suzuki, Kobayashi, *Saikaiku, Tohoku, SeaBASS***	In-situ measured optical data	PRR (Hirawake, etc.) TRIOS (Ishizaka, etc.) C-OPS (Suzuki)	ECS, A-line, O-line, Funka-bay, Tokyo-bay,Seto Inland sea, Chukchi Sea, Bering Sea, North Pacific, Ise-bay, Akkeshi-bay, Toyama-Bay	Campaigns
	Inherent optical properties [1/m]	Goal: Absorption coefficient @440nm: RMSE<0.25 and backscattering coefficient of phytoplankton@ 550nm: RMSE<0.25	**In-situ (Main)**	**Hirata**	**Hirawake, Ishizaka, Suzuki, Frouin, SeaBASS**	Pigment concentration data measured with fluorescense method and HPLC at Ship	Fluorescense method, HPLC	ECS, A-line, O-line, Funka-bay, Tokyo-bay,Seto Inland sea, Chukchi Sea, Bering Sea, North Pacific, Ise-bay, Akkeshi-bay, Toyama-Bay	Campaigns

	Ocean net primary productivity [mgC/m2/day]	Goal: 70% (monthly ave.)	**In-situ (Main)**	**Hirawake, Ishizaka**	**Hirawake, Ishizaka, SeaBASS**	ONPP derived from in-situ measurements	FRRF	ECS, A-line, O-line, Funka-bay, Tokyo-bay, Coast of Oita, Chukchi Sea, Bering Sea, North Pacific	Campaigns
	Phytoplankton functional type [—]	Goal: Classification error of dominant/non-dominan t spesies of large/small phytoplankton: 20%, or classification error of dominant functional type in a phytoplankton group: 40%	**In-situ (Main)**	**Hirawake, Hirata**	**Hirawake, Ishizaka, Suzuki**	Pigment concentration data measured with fluorescense method and HPLC at Ship	Fluorescense method, HPLC	ECS, A-line, O-line, Funka-bay, Tokyo-bay, Coast of Oita, Chukchi Sea, Bering Sea, North Pacific, Okhotsk, East and west of tohoku, east setonai-kai, Ise-bay	Campaigns
	Redtide [—]	Goal: 20% (as classification Error)	**In-situ (Main)**	**Ishizaka**	**Ishizaka**	Existence of red tide observed by human eyes	Human eye	Funka-bay, Tokyo-bay, Coast of Oita, East and west of tohoku, east setonai-kai, Ise-bay	Campaigns
	Multi sensor merged ocean color parameters [mg/m3]	Goal:-35~+50% (open sea), -50~+100% (coastal)	**In-situ (Main)**	**JAXA**	**Hirawake, Ishizaka, Kobayashi, *Saikaiku etc.***	Pigment concentration data measured with fluorescense method and HPLC at Ship	Fluorescense method, HPLC	ECS, Ariake, A-line, O-line, Funka-bay, Tokyo-bay, Coast of Oita, Chukchi Sea, Bering Sea, North Pacific, Okhotsk, East and west of tohoku, east setonai-kai, Ise-bay	Campaigns
	Multi sensor merged sea surface temperature [℃]	Goal: 0.8K	**Other satellites (Main)**	**Sakaida**	**Sakaida**	L2 SST products	MODIS, VIIRS	Global	Year-round
			In-situ (Main)		**(JAXA)**	GTS iQuam (buoy data for AMSR2 val)	Thermometer	GTS sites	Year-round
Cryosphere	**Snow and ice classification [—]**	Goal：10%	**Other satellites (Main)**	**Stamnes**	**(JAXA)**	L2 snow cover prd. (MOD10、MYD10) L2 snow cover product L1 radiance	MODIS VIIRS Landsat8 etc.	Global	Year-round

			In-situ (Main)		**(JAXA)**	In-situ photograph taken at Buoy, Ship, etc. Photograph taken from Airplane	Web camera etc.	Buoys, Ships, etc.	Year-round
	Snow area in forest and mountain [—]	Goal : 30%	**Other satellites (Main)**	**JAXA (Stamnes)**	**(JAXA)**	L2 snow cover prd. (MOD10、MYD10) L2 snow cover product L1 radiance	MODIS VIIRS Landsat8 etc.	Global	Year-round
			In-situ (Auxiliary)		**(JAXA)**	In-situ photograph taken at ground sites etc. Photograph taken from Airplane	Web camera etc.	Mountain and forest sites, etc.	Year-round
	Snow grain size of subsurface layer [μm]	Goal : 50%	**In-situ (Main)**	**Stamnes, Aoki**	**Aoki**	Snow grain size derived from in-situ snow pit data and optical measurements	Snow Pit Work Tools, FieldSpecFR, NIR Camera, IceCube etc.	Hokkaido, Greenland, Antarctica etc.	Campaign
	Snow grain size of top layer [μm]	Goal : 50%	**In-situ (Main)**	**Stamnes, Aoki**	**Aoki**	Snow grain size derived from in-situ snow pit data and optical measurements	Snow Pit Work Tools, FieldSpecFR, NIR Camera, IceCube etc.	Hokkaido, Greenland, Antarctica etc.	Campaign
	Snow and ice albedo [—]	Goal : 7%	**In-situ (Main)**	**Stamnes, Aoki**	**Aoki**	Albedo calculated based on in-situ measured optical data and snow pit work data	Snow Pit Work Tools, FieldSpecFR, NIR Camera, IceCube etc.	Hokkaido, Greenland, Antarctica etc.	Campaign
	Snow impurity [ppmw]	Goal : 50%	**In-situ (Main)**	**Stamnes, Aoki**	**Aoki**	Snow impurity concentration estimated from in-situ measured optical data and also directly measured by filtering method	Spectrometer (FieldSpecFR etc.), Snow Pit Work Tools, Snow filteration system	Hokkaido, Greenland, Antarctica etc.	Campaign
	Ice sheet surface roughness [—]	Goal : 0.05 (*15)	**Other satellites (Main)**	**Aoki**	**Aoki**	Roughness estimated from other satellite data	MODIS, MISR, VIIRS Landsat8 etc.	Greenland, Antarctica	Annually
			Model (Main)			Roughness estimated through simulations of snow BRDF using radiative transfer code	Radiative transfer code (ARTMASS)	Greenland, Antarctica etc.	Annually

	Ice sheet boundary monitoring [—]	Goal : <500m	**Other satellites Climatology (Auxiliary)**	**JAXA**	**(JAXA)**	L1 radiance data	MODIS VIIRS Landsat8 etc.	Antarctica etc.	Monthly

*Notes in this table are same as TABLE 7.

APPENDIX D

ASSOCIATED TERMS AND CONDITIONS OF RESEARCH AGREEMENTS (FOR THE GCOM RESEACH ANNOUNCEMENT)

COMMISSIONED RESEARCH AGREEMENT
FOR THE GLOBAL CHANGE OBSERVATION MISSION
BETWEEN THE
JAPAN AEROSPACE EXPLORATION AGENCY (JAXA)
AND
THE RESEARCH ORGANIZATION
(FOR THE RESEARCH ANNOUNCEMENT)

JAPAN AEROSPACE EXPLORATION AGENCY

6th GCOM SCIENCE RESEARCH ANNOUNCEMENT
COMMISSIONED RESEARCH AGREEMENT

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

WITNESSETH

WHEREAS, the Global Change Observation Mission ("GCOM") aims to construct, use, and verify systems that enable continuous global-scale observations of effective geophysical parameters for clarifying global climate change and water circulation mechanisms;

WHEREAS, JAXA issued the Research Announcement ("RA") to engage in research activities directly related to retrieval algorithms for geophysical products, product validation, and data application of GCOM, and the Research Organization applied pursuant to such RA;

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

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

NOW, THEREFORE, in consideration of the mutual agreements hereinafter set forth, and for other good and reasonable consideration, the receipt and adequacy of which are hereby acknowledged, the Parties hereby agree as follows:

Article 1. Definition

1. The following capitalized terms in this Agreement shall have the following meanings.

(1) “Research Results” means the technical results and scientific knowledge derived from the implementation of the Research Projects pursuant to this Agreement, including all inventions, ideas, designs, literary works, algorithms (e.g. Technological development accompanied by Program/Data to embody such algorithms), and technical know-how.

(2) "Intellectual Property Rights" generated in the course of implementation of the Agreement means the following:

(i) Industrial Property Rights (as defined below);

(ii) Potential Industrial Property Rights (as defined below); and

(iii) Program/Data Copyrights (as defined below).

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

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

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

(3) “Commissioned Research Plan” means the plan described in Attachment 1 of the Application Form for the GCOM Research Announcement Commissioned Research Agreement (hereinafter “Application Form”).

(4) “Research Period” means the research period as described in the Commissioned Research Plan. In accordance with the provisions of this Agreement, in the event that the Agreement ended prior to the completion date of the research originally set, the date the Agreement ends shall be read as the research period.

(5) “Annual Evaluation” means JAXA’s annual review, which is carried out by JAXA before the end of the Japanese fiscal year during which the Agreement was concluded. At the end of each fiscal year, the review is conducted through the RO’s presentation at workshops and meetings as well as based on the Progress Report.

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

(7) “Meteorological Data” means the data provided by the Japanese Meteorological Agency.

2. In this Agreement, “Invention etc.” contains multiple meanings: When it is a subject of patent rights it refers to an invention; when it is a subject of a utility model it refers to an idea; when it is a subject of the rights for industrial design, literary work of program and database, it refers to a creation; when it is a subject of algorithm and technological know-how it refers to proposition.
3. In this Agreement, “utilization” of Intellectual Property Rights and Research Results refer to the acts specified in paragraph 3 of Article 2 of the Patent Act, paragraph 2 of Article 3 of the Utility Model Act, paragraph 3 of Article 2 of the Design Act, and Article 21 and 27 of the Copyright Act (including the use of the secondary publication created by JAXA), as well as the use of algorithm and technical know-how.
4. In this Agreement, “PI” (Principal Investigator) refers to the person who submitted the research proposal to this Research Announcement and who is also the RO employee selected to be responsible for the implementation of the accepted Research Project. “CI” means “Co-Investigator” who supports the research activities represented by the PI. Name of the PT and CI (hereinafter “Commissioned Researchers”) and their affiliated organization will be show in the “Commissioned Research Plan”.

Article 2. Purpose and Scope of Research Projects

The RO shall implement the following tasks.

(1) The RO shall conduct the research activities (“Research Projects”) in accordance with the Statement of Work issued by JAXA (“Statement of Work”) and the Commissioned Research Plan.
(2) The RO shall respond to requests from JAXA and attend required meetings hosted by JAXA such as the workshop at the end of each fiscal year.
(3) The RO shall report the Research Results and progress of the research at the annual workshops and meetings hosted by JAXA.
(4) Each year before the end of the Agreement Period, the RO shall deliver JAXA the Research Results acquired during the effective term of the Agreement in the form of a Progress Report in accordance with the Statement of Work. The Progress Report shall contain the deliverable Research Results specified in the Statement of Work. In addition, upon the completion of the research period, the RO shall deliver JAXA the Progress Report regarding the Research Results acquired during the whole of the commissioned research period. In such a case, the RO will not be required to deliver another Progress Report for the final year of the Agreement.

Article 3. Effective Term and Renewal

1. The Agreement shall be concluded upon the acceptance through the issuance of the Confirmation Sheet by JAXA for the application submitted by the RO using the application form, and the Agreement shall become effective as per the date prescribed on the Confirmation Sheet issued by JAXA and shall continue to be in effect until the end of the present Japanese fiscal year ("Agreement Term"). In case of a conflict between the Confirmation Sheet and this Agreement, the terms and conditions stipulated in the Confirmation Sheet will supersede this Agreement.
2. The Agreement Term shall be renewed for one Fiscal Year provided that JAXA approves an extension of the research period in the Annual Evaluation; provided, however, that the Parties mutually agree upon the amount to be paid by JAXA for the extended period; further provided, however, the RO shall submit a renewal Application Form to JAXA and JAXA shall approve by issuing a new Confirmation Sheet. Thereafter the procedure shall be the same as above.

Article 4. Annual Evaluation

1. JAXA shall conduct an Annual Evaluation regarding the contents of the Agreement fairly at the end of the Agreement Term.
2. In the event that the results of the evaluation was a fail in the Annual Evaluation, the provisions in Article 29 ("Incompleteness of Performance") shall be applied.

Article 5. Commissioned Researchers

1. The RO shall let the researchers listed in the Commissioned Research Plan engage in this commissioned research.
2. The RO shall undertake necessary measures to ensure that all the commissioned researchers comply with the contents of the Agreement.
3. In the event that the RO intends to add new CIs, the RO shall obtain prior written consent from JAXA and the RO shall undertake necessary measures to ensure that such personnel comply with the contents of the Agreement.
4. In the event that the PI dies, retires from the RO, takes a leave of absence from work, or can no longer engaged in the RO for any other reasons, JAXA may terminate this Agreement. Provided, however, if the RO designates a researcher who belongs to the RO as the PI's successor and JAXA approves the succession, the parties may amend this Agreement, with the succeeding researcher being a new PI.

The terms and conditions of the amendment to this Agreement shall be determined separately upon mutual consultation and consent.

Article 6. Prohibition of Re-commission

1. The RO shall not commission the whole Research Projects to a third party (hereinafter "Subcontract"). The RO may, however, subcontract part of it upon prior written application to JAXA and approval from JAXA. Should there be a case where subcontractors further re-commission the Research Projects to a third party, the company name, address and scope of business of such third party are required to be submitted to the RO in writing.
2. If the RO subcontracts the Research Projects in accordance with the preceding paragraph, any act of all the third parties involved in the subcontract, which includes a contractor and commissioned party of the RO, re-commissioned party, subcontractor and supplier at any tier, in connection with the subcontractor shall be deemed to be an act of the RO and the RO shall be responsible therefor.
3. In the event that the RO subcontract part of the Agreement, the RO shall enter an agreement with the subcontractor regarding the items necessary for the RO to comply with the contents of the Agreement as well as the items specified by JAXA.

Article 7. Research Funding

1. JAXA shall make advance payment of the "Research Funding" stated in the Confirmation Sheet or Continuous Confirmation Sheet, which is issued in accordance with Article 3, to the RO as a necessary research expense to carry out the Agreement.
2. JAXA shall, within thirty (30) days from the date when they receive an invoice duly issued by the RO, make payment for the Research Funding described in the previous paragraph.
3. If RO wishes to reallocate expenses between Expense Item Categories for more than 50% increase or decrease (3,000,000 Japanese yen, in case the amount of 50% is less than 3,000,000 Japanese yen), RO shall obtain a written approval from JAXA in advance.
4. Provided, however, that the RO shall not conduct the reallocation of budget between the general administrative expenses and the direct expenses.
5. In case that JAXA fails to pay the Research Funding within the above period, the RO may request JAXA to pay default interest of six (6) percent per annum on such unpaid amount for the period from the immediately succeeding day of due date for payment to the date of actual payment.

6. If the interest on late payment calculated following the preceding paragraph is less than 10,000 Japanese yen, JAXA shall be exempt from payment of such interest. Where there is a fraction of that amount and if it is less than 1,000 yen, such a fraction shall be omitted.

Article 8. Accounting

RO shall conduct accounting of the Research Funding stipulated in Article 7.1. RO shall maintain books to record expenses according to items and store documents to prove such expenses. In addition, RO shall keep all the accounting documents for seven (7) years after the end of the contract counting from next fiscal year. JAXA may request RO to submit a copy of such books and documents to clarify the expenses, and RO shall respond to such requests from JAXA.

Article 9. Submission of Completion Notice and Performance Report

1. Upon the completion of the tasks stipulated in Article 2, the RO shall create a completion notice and submit it to JAXA before the end of the Agreement Period.
2. In the event that the research expenses, stated in paragraph 1 of Article 7, exceed one (1) million Japanese yen, RO shall submit a Financial Report containing the expenses breakdown to JAXA within 61 days after the end of contract.

Article 10. Determining the Contract Amount

1. Upon the receipt of the Performance Report stipulated in paragraph 2 in the previous Article, JAXA shall adjust the expenses within the limit of the original contract amount in accordance with the present Article, Article 11 (Investigation of Actual Expenses) and Article 12 (Return of Paid Research Funding), determine and notify the RO of the final contract amount.
2. In the calculation of the actual expenses, the general administrative expenses ratio shall be calculated by using the ratio applied at the time the contract was concluded.

Article 11. Investigation of Actual Expenses

In determining the contract amount stipulated in paragraph 1 in the previous Article, JAXA shall investigate whether the actual expenses conform with the contents of the contract and accompanied conditions, and if necessary, request that the RO submit reports or materials to be referenced, or provide consent for JAXA to enter the RO's office to inspect the books and relevant documents.

Article 12. Return of Paid Research Funding

1. After the payment by the method stipulated in paragraph 1 and 2 of Article 7, if the amount already paid exceeds the final contract amount determined through the process stipulated in paragraph 1 of Article 10, JAXA shall reclaim the excess amount from the RO.
2. In the case of the previous paragraph, the RO shall remit such funds within thirty (30) days from the date when the RO receives an invoice issued by JAXA with regard to such funds.
3. In the event there is no return made by the RO within the set time limit as described in the preceding paragraph, the provisions of paragraph 5 and 6 of Article 7 shall be applied.

Article 13. Ownership of the Rights to the Acquired Equipment

1. The ownership of the equipment acquired with the Research Funding in accordance with paragraph 1 of Article 7 shall be retained by JAXA. However, upon mutual agreement between JAXA and the RO the ownership of the equipment may be transferred to the RO.
2. The RO shall create a ledger for the equipment mentioned in the previous paragraph and manage the equipment with the care of a good manager. When the contract ends, the RO must submit to JAXA a list of acquired property.

Article 14. Providing of the Earth Observation Satellite Data and Rights

1. JAXA will provide the RO with the Earth Observation Satellite Data necessary for the implementation of the Agreement free of charge via internet.

(1) JAXA may not provide all of the Earth Observation Satellite Data, which the RO may request due to limitations on the capacity of the JAXA equipment or resources; Amongst the Earth Observation Satellite Data, which the RO may request JAXA, the each standard data collected from the Advanced Land Observing Satellite (ALOS) and the Advanced Land Observing Satellite-2 (ALOS-2) shall be limited to fifty scenes every fiscal year;

(2) JAXA does not guarantee a specific quality or the timely provisions of the Earth Observation Satellite Data and will not be liable for any deterioration of quality and delay in providing the Data;

(3) JAXA will not be liable for any situation whereby the Earth Observation Satellite Data cannot be supplied to the RO due to faults relating to the satellites,

limitations on their operations, or for any other reason;

(4) RO shall bear the costs of media and shipment if RO requests to provide the Earth Observation Satellite Data via media.

2. With respect to the handling of the Earth Observation Satellite Data provided by JAXA, the RO shall follow the conditions below:

(1) RO may not duplicate the Earth Observation Satellite Data for any purpose other than creating a backup. However, this excludes the duplication to provide for the collaborating research organizations stated in Article 5 and the re-commissioned party (hereinafter "PI etc.") stated in Article 6 that are necessary for the implementation of the Agreement;

(2) The RO may not disclose the Earth Observation Satellite Data except the PI etc.

(3) The RO shall use the provided the Earth Observation Satellite Data solely for the purpose stipulated in the Agreement;

(4) The RO shall return or otherwise appropriately keep the Earth Observation Satellite Data in accordance with the instruction of JAXA upon the termination of this Agreement.

3. Any rights relating to the Earth Observation Satellite Data provided by JAXA to the RO shall confirm to the following;

a) JAXA retains the intellectual property rights of all the Earth Observation Satellite Data, except for ALOS PALSAR data of which METI is the joint owner;

b) If value-added products(modified products with high-level processing which are irreversible to standard data. High-level data processing includes data analysis or combining multiple-satellite data, image processing based on external information, and physical quantity conversion.)are solely developed by RO out of Earth Observation Satellite Data, in the course of executing the Research Projects, RO retains the intellectual property rights of such value-added products;

c) Except for cases under paragraph b), all Intellectual Property Rights of the data or product developed by modifying the Earth Observation Satellite Data shall be owned by JAXA;

d) In case RO uses the modified Earth Observation Satellite Data for commercial purposes, RO shall notify JAXA and comply with a license condition to be set by JAXA.

Article 15. Providing of Meteorological Data and Rights

1. JAXA will provide the RO with the Meteorological Data necessary for the implementation of the Agreement free of charge.
2. The rights concerning the Meteorological Data provided by JAXA shall not be transferred to the RO through the supply. In addition, for the handling of the Data, the RO will follow the instruction of JAXA.
3. The RO may not disclose the provided Meteorological Data to any third party.
4. The RO shall use the provided Meteorological DATA solely for the purpose of the Agreement.
5. The RO shall return or otherwise appropriately keep the Meteorological Data in accordance with the instruction of JAXA upon the termination of this Agreement.

Article 16. Providing of Technical Data

1. JAXA will provide the RO with the technical data such as satellite operation data and ground verification data owned by JAXA as well as Program/Data, excluding the Earth Observation Satellite Data and the Meteorological Data (hereinafter "Technical Data") that are necessary for the implementation of the Agreement free of charge, allow the RO to use it, and provide advice when required.
2. The RO shall not use the Technical Data provided by JAXA for any other purpose than to fulfill the purpose of the Agreement, and must not disclose it to anyone but the PI etc.
3. After the completion of the research period, the RO shall return or otherwise dispose of the Technical Data provided by JAXA following the instruction from JAXA.

Article 17. Ownership of the Research Results

1. Of the Research Results that the RO acquired through the implementation of the Agreement, the ownership of the Research Results specified by JAXA in the Statement of Work shall belong to JAXA. Such Research Results do not include the data that is proved to have had been possessed by the RO at the time of concluding this Agreement.
2. The copyright of the documents, which include the rights regulated in Article 27 and 28 of the Copyright Act, that JAXA specified to be delivered by the RO shall be transferred to JAXA at the point of delivery. In this case, the RO shall not exercise the moral rights.
3. In addition to paragraph 1, for the purpose of confirming the progress of the Research Projects, JAXA may demand to show all the Research Results acquired

through the implementation of the Agreement.

4. JAXA shall obtain the prior written consent of the RO in case JAXA plans to disclose the Research Results (excluding the delivered Research Results) that was presented or submitted by the RO.
5. The RO shall obtain the prior written consent of JAXA if the RO plans to disclose the Research Results, the ownership of which belongs to JAXA, to a third party.

Article 18. Usage of the Research Results

1. Of the Research Results acquired through the implementation of the Agreement, JAXA may use the Research Results other than the one specified in paragraph 1 of the previous Article free of charge only for the purpose of its research development including the case for allowing a third party, which includes partners of joint research projects, to use the Research Results for its own purpose, as well as for its own peaceful and non-commercial purposes.
2. Of the Research Results acquired through the implementation of the Agreement, the RO may use the Research Results other than those delivered in accordance with paragraph 1 of the previous Article free of charge only for the purpose of its research development including the case for allowing a third party to use the Research Results for its own purpose, as well as for its own peaceful and non-commercial purposes, upon the prior consent of JAXA.

Article 19. Industrial Property Rights

1. The RO shall report the existence of Potential Industrial Property Rights generated in the course of the Research Projects, if any, and submit a document with such information to JAXA without delay, as well as taking a procedure to apply for its Industrial Property Rights following JAXA's instructions. If the RO is successfully granted such Industrial Property Rights, it shall notify JAXA without delay.
2. The RO shall consult JAXA each time regarding important matters concerning the application procedure for the Industrial Property Rights described in the previous Article.
3. The expense incurred in applying to the Industrial Property Rights as described in paragraph 1 shall be JAXA's responsibility.
4. In the event the invention etc. that are generated by the commissioned researchers stipulated in Article 5 are properties subject to registration for the Industrial Property Rights under the name of the duty of the commissioned researchers, the RO concludes the Agreement that stipulates the right to apply for the Industrial

Property Rights concerning such invention belongs to the RO shall be concluded with the commissioned researcher, or set the rules for regulating the duties of the employees regarding such a matter.

5. If the technology developed by the RO due to the implementation of the Research Projects is recognized as an invention, JAXA, if necessary, may succeed the right to apply for the Industrial Property Rights from the RO and make an application for such Potential Industrial Property Rights to be registered Industrial Property Rights in JAXA's name, after receiving the materials required for the application from the RO.

Article 20. Foreign Application for Industrial Property Rights

The provisions of the previous Article shall be applied to the application for Industrial Property Rights abroad and the preservation of rights.

Article 21. Ownership of Industrial Property Rights

1. The RO shall transfer the Industrial Property Rights obtained in compliance with paragraph 1 of Article 19. In this case, the cost for the transfer shall be included in the Research Funding stipulated in paragraph 1 of Article 7.
2. If the RO requests a license to use the Industrial Property Rights assigned to JAXA under the preceding paragraph or applied by JAXA under paragraph 5 of Article 19, JAXA will grant the RO such a license unless it is reasonable for it to be deemed to be inappropriate. The conditions for the approval shall be determined by mutual agreement between the Parties as necessary.
3. With regard to the Industrial Property Rights stipulated in paragraph 1 of Article 19, if the RO, before obtaining the Rights, wishes to use it for any purpose other than that of the Agreement, or wishes to grant its use to a third party, shall consult JAXA as necessary.
4. In accordance with the provisions in paragraph 1, JAXA, based on the criteria determined by JAXA, shall bear the total or a portion of the costs, which the RO should pay the commissioned researcher who created the technology, which is subject to the Industrial Property Rights transferred from the RO and the Right to receive the transferred Industrial Property Rights from the RO stipulated in paragraph 5 of Article 19.

Article 22. Ownership of Program/Data Copyrights

1. Upon the completion of the Agreement, the RO shall notify JAXA without delay in

the event that the RO creates a program and/or database (hereinafter "Program/Data") that may potentially constitute the Program/Data copyrights. In this case, the Program/Data that the Statement of Work specifies its delivery shall be excluded from the notification stipulated in this Article.

2. The RO shall transfer the copyrights of the Program/Data, including the rights stipulated in Article 27 and 28 of the Copyrights Act, acquired through the implementation of this Agreement to JAXA. The cost for this transfer shall be included in the Research Funding stipulated in paragraph 1 of Article 7. Regarding the Program/Data of which the RO already had its rights prior to the conclusion of the Agreement as well as among the know-how, routine, subroutine and modules that are commonly used by similar program the RO specified, copyrights of such products are retained by the RO but not transferred to JAXA.
3. In the event that the RO transfer copyrights to JAXA, if the product subject to the copyright is created by the RO, the RO waives any related moral rights. If it is created by a third party but not by the RO, the RO shall take measures to prevent the third party from using any related moral rights.
4. If the RO requests a license to use the Program/Data copyrights assigned to JAXA, JAXA will grant the RO such a license unless it is reasonable for it to be deemed to be inappropriate. The conditions for the approval shall be determined by mutual agreement between the Parties as necessary.
5. In the event that programs are modified/adapted not by JAXA or the RO but by a third party, JAXA shall bear the responsibility related to the use of such programs and the RO shall not be responsible for any liability caused by such programs.
6. With regard to the know-how, routine, subroutine and modules utilized commonly by similar programs, the copyrights of which are retained by the RO in accordance with paragraph 2 of this Article, the RO shall approve JAXA of a royalty-free right to use such products in the form of the program acquired through the implementation of the Agreement without consent from the RO. Such used by JAXA shall include the right of JAXA to grant a third party the right to use the know-how, routine, subroutine and modules without paying any royalties to the RO.

Article 23. Use of Facilities

1. The RO may use JAXA's facilities and equipment (hereinafter "Facilities") free of charge upon the prior consent of JAXA if there is a necessity for the implementation of the Agreement.
2. In the event of using JAXA's Facilities, the RO shall use the Facilities in

compliance with all the regulations stipulated by JAXA.

Article 24. Bringing in Instruments

If necessary for the implementation of the Agreement, the RO may bring instruments and other items into JAXA's facilities with the prior consent of JAXA. In such a case the RO shall be in compliance with all the regulations stipulated by JAXA.

Article 25. Delivery of Rental Items, Storage and Return

1. If required to implement the Agreement, JAXA shall lend the RO any instruments and other items owned by JAXA.
2. At the time of delivery of the instruments and items for lending (hereinafter "Rental Items") in accordance with the preceding paragraph, JAXA shall submit a delivery note to the RO and the RO shall submit a receipt to JAXA.
3. In the event that the RO received the delivery of the Rental Items, the RO shall confirm the presence of any abnormality regarding the list of articles and numbers. If a lack of quantity or abnormality including inappropriate quality and standard for use, with the Rental Items is found, the RO shall notify JAXA of the matter immediately and seek further instruction.
4. The RO shall manage and use the Rental Items delivered with the care of a good manager and shall use items solely for the purpose of the Agreement.
5. The RO shall maintain books of receipts and shipment as well as management regarding the Rental Items delivered, record and organize the receipts, and always make the situation of the Rental Items clear.
6. In the event that the Rental Items are lost or damaged, the RO shall report this to the lender without delay.
7. In the event that all or part of the Rental Items become unnecessary due to the completion of the whole or part of the Agreement as well as of any amendment or termination of the Agreement, the RO shall notify JAXA and undertake a procedure to return the Rental Items in compliance with JAXA's instruction without delay.

Article 26. Confidentiality

1. In this Agreement, "Confidentiality Information" means those that are applicable to any of the following items.

(1) Amongst the outcome as a result of the Agreement, any documents with an indication of confidential notice, tangible objects such as samples, or regardless of

its form in tangible or intangible, any items that have been confirmed in writing as Confidential Information by JAXA and the RO.

(2) Any information that a party discloses or presents as confidential in the forms of document, drawing, photograph, test piece, sample, magnetic tape, and floppy disk.

2. JAXA and the RO must manage Confidential Information properly and may not leak or disclose to anyone other than those involved in the Agreement. However, any information that is applicable to any of the following items may be an exception:

(1) Information that is already known to the public when disclosed by the disclosing party;

(2) Information that becomes known to the public after the disclosure by the disclosing party without intentional misconduct of the receiving party;

(3) Information that the receiving party already had before the disclosure by the disclosing party and that is able to verify this fact;

(4) Information with proof that the receiving party acquires legally from a duly authorized third party not subject to confidentiality obligations;

(5) Information and materials that the receiving party independently acquire without utilizing information obtained from the disclosing party and that are able to verify this fact;

(6) Information with written consent from the disclosing party for the disclosure and the publication; or

(7) Information that is required to be disclosed by applicable laws, judgment or order of a competent court. In this case, the receiving party shall promptly notify the disclosing party of the necessity of disclosure.

3. The confidentiality obligation under paragraph 2 shall remain effective for a period of five (5) years after the termination of the Agreement. However, this period of keeping confidentiality may be extended or shortened by mutual agreement between JAXA and the RO.

Article 27. Publication of Research Results

1. The RO shall be able to present or publish the Research Results, which were acquired through the implementation of the Agreement and delivered in accordance with paragraph 1 of Article 17; provided, however, in compliance with the obligation of Confidentiality Information stated in Article 26 (hereinafter "publication of Research Results").

2. In the case of the preceding paragraph, the RO shall notify JAXA with a written document and obtain written consent from JAXA prior to the publication of

Research Results. JAXA will not unreasonably withhold consent from the publishing party's request.

3. When JAXA receives the notification mentioned in the previous paragraph, if the judgment that the notification contains contents, which potentially cause a loss of anticipated benefit by being published, JAXA shall notify the RO in writing, and the RO shall consult with JAXA. The RO may not publish the part that has been notified as contents, which potentially cause a loss of anticipated benefit by being published as described in this paragraph without consent from JAXA.
4. The RO shall state in the publication of the Research Results that such results have been obtained pursuant to this Agreement and identify the owner of the rights to the Earth Observation Satellite Data and Meteorological Data used in such publication.
5. After disclosing or publishing the Research Results that belong to the RO, the RO shall provide JAXA with a copy of the publication as soon as possible. JAXA is entitled to a royalty-free right to use, photocopy and distribute the provided publications unless the copyright of such publication is owned by an academic society.

Article 28. Security

Upon the implementation of the Agreement, the RO shall take security measures in accordance with the JAXA's regulations and must follow JAXA's instruction.

Article 29. Impossibility of Performance

1. In the event it becomes impossible for the RO to carry out all or any part of the Agreement due to reasons attributable to the RO, JAXA may terminate all or any part of the Agreement.
2. In the case of the termination of the Agreement following the previous paragraph, JAXA shall apply the provisions in paragraph 1 of Article 12 mutatis mutandis and demand the restitution of the disused amount.
3. In the case of the termination of the Agreement in accordance with Article 1, JAXA, based on paragraph 3 of Article 32, shall be able to demand the RO incur a penalty.

Article 30. Incompleteness of Performance

1. If the performance of the RO for the Agreement is confirmed not to be following the purpose of the Agreement due to the liability of the RO, JAXA may claim the RO subsequent completion by setting an appropriate period.

2. In the event that there is no prospect of the completion of the performance by the RO in accordance with the Agreement despite the claim made for the subsequent completion stipulated in paragraph 1, JAXA may terminate all or part of this Agreement.
3. In case the termination of the Agreement is performed in accordance with the preceding paragraph, JAXA shall apply the provisions in paragraph 1 of Article 12 and claim a return of the amount of Research Funding that becomes unnecessary.
4. In case the termination of the Agreement is performed in accordance with paragraph 2 above, JAXA may claim the RO incur a penalty in accordance with paragraph 3 of Article 32.

Article 31. Extension of the Delivery Deadline

1. In case there is an acceptable reason for not fulfilling the obligation until the delivery deadline, the RO may in advance propose JAXA such a reason and planned delivery date and apply for an extension to the delivery deadline in writing. In this case, if the extension of the delivery deadline is approved as not to hinder the achievement of the objective of the Agreement, JAXA may approve the extension.
2. In the event the RO does not fulfill the obligation by the scheduled delivery date, JAXA may terminate all or any part of the Agreement.
3. If the Agreement is terminated as set forth in the preceding paragraph, JAXA shall apply the provisions of paragraph 1 of Article 12 and claim a refund of any unexpended Research Funding.
4. If the Agreement is terminated as set forth in paragraph 2, JAXA in compliance with paragraph 3 of Article 32 shall claim the RO incur a penalty.

Article 32. Termination of the Agreement

1. In the event of any of the following conditions, JAXA and the RO may terminate the Agreement.

(1) Upon the consent of both JAXA and the RO.

(2) When the other party commits a dishonest or inequitable act and the breaching party fails to offer any satisfactory remedial measures within seven (7) days after receiving demands for corrective action.

(3) When the other party violates any of the terms and conditions of this Agreement provided that the breaching party fails to offer any satisfactory remedial measures within seven (7) days after receiving demands for corrective action.

(4) When the events stipulated in paragraph 5 (transfer of the PI) of Article 4 occurs

and there is no one who engages in this joint research project at the RO.

(5) When unavoidable circumstances occur such as natural disasters

2. Upon the termination of the Agreement, the RO shall submit to JAXA all work in progress and completed work based on the research carried out prior to the termination.
3. In the event that the Agreement is terminated in accordance with number 2 or 3 of paragraph 1, JAXA and the RO may claim the other party a penalty equivalent to 10% of the Research Funding stipulated in paragraph 1 of Article 7, which corresponds to the contents of the termination above. However, if the amount of the penalty is less than 10,000 Japanese yen, the payment of such penalty is not required. Where there is a fraction of that amount and if it is less than 1,000 yen, such a fraction shall be omitted.
4. Neither JAXA nor the RO shall claim any compensation in case the termination of the Agreement is exercised in accordance with number 5 of paragraph 1 of the present Article.

Article 33. Effective Term of the Agreement

1. Effective Term of the Agreement shall be the period stipulated in Article 3.
2. Even after the end of the Effective Term of the Agreement stipulated in the previous paragraph, provisions in paragraph 2 to 4 of Article 14 (Providing of the Earth Observation Satellite Data and Rights), paragraph 2 to 5 of Article 15 (Providing of Meteorological Data and Rights), Article 16 (Providing of Technical Data), Article 18 (Usage of the Research Results) to 22 (Ownership of the Copyrights of Program/Data), and Article 27 (Publication of Research Results) continues to be effective for the duration of the continuance of the rights stated in the present Article. Provisions of Article 26 (Confidentiality) and Article 27 (Publication of Research Results) posses the terms effect stipulated in the present Article.

Article 34. Amendment of the Agreement

1. JAXA can amend the contents of this Agreement. In such a case, JAXA announces the amended contents by posting it to the website operated by JAXA, and thereafter the Agreement is handled based on the amended contents.
2. In the case the RO has a legitimate reason for not agreeing with the amendment of the previous paragraph, the RO may terminate the Agreement by notifying JAXA in writing within thirty (30) days from the date the amended contents were posted on the website.

Article 35. Governing Law

The Agreement shall be governed and interpreted under the laws of Japan.

Article 36. Language

All communications between JAXA and the RO under this Agreement shall be either in Japanese or English.

Article 37. Consultation

In the event that any doubt arises with regard to provisions that are not included in the Agreement, it shall be resolved upon mutual agreement between JAXA and the RO as necessary.

Attachment “Earth Observation Satellite Data”

Name of Satellite or Sensor	Observation Period (YYYY/MM/DD)	Observable Area
JERS (Japanese Earth Observation Satellite)	1992/09/01~1998/10/11	Global
ADEOS (Advanced Earth Observation Satellite)	1996/10/15~1997/06/29	Global
ADEOS-II (Advanced Earth Observing Satellite-II)	2003/01~2003/10	Global
ALOS (Advanced Land Observing Satellite) * Limited to 50 scenes per year	2006/05/16~2011/04/22	Global
ALOS-2 (Advanced Land Observing Satellite-2) * Limited to 50 scenes per year	2014/08/04~	Global
GCOM-W (The Global Change Observation Mission - Water)	2012/7~	Global
TRMM (Tropical Rainfall Measuring Mission)	1997/12~2015/04	Global (PR: Approximately 36°S-36°N. TMI and VIRS: Approximately 38°S-38°N)
AMSR-E (Advanced Microwave Scanning Radiometer for EOS-Aqua satellite)	2002/06/19~2011/10/04	Global
GOSAT (Greenhouse Gases Observing Satellite)	2009/04/23~	Global

GPM (Global Precipitation Measurement)	2014/03~	Global (DPR: Approximately 66°S-66°N. GMI: Approximately 68°S-68°N)
GCOM-C (Global Change Observation Mission – Climate)	2018/01~	Global

* EarthCARE will be added by revision of the Agreement pursuant to Article 34 when provision of data becomes available.

COLLABORATIVE RESEARCH AGREEMENT (FUNDED)
FOR THE GLOBAL CHANGE OBSERVATION MISSION

BETWEEN THE
JAPAN AEROSPACE EXPLORATION AGENCY (JAXA)
AND
THE RESEARCH ORGANIZATION
(FOR THE RESEARCH ANNOUNCEMENT)

JAPAN AEROSPACE EXPLORATION AGENCY

6th GCOM SCIENCE RESEARCH ANNOUNCEMENT

COLLABORATIVE RESEARCH AGREEMENT

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

WITNESSETH

WHEREAS, the Global Change Observation Mission ("GCOM") aims to construct, use, and verify systems that enable continuous global-scale observations of effective geophysical parameters for clarifying global climate change and water circulation mechanisms;

WHEREAS, JAXA issued the Research Announcement ("RA") to engage in collaborative research activities directly related to retrieval algorithms for geophysical products, product validation, and data application of GCOM, and the Research Organization applied pursuant to such RA;

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

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

NOW, THEREFORE, in consideration of the mutual agreements hereinafter set forth, and for other good and reasonable consideration, the receipt and adequacy of which are hereby acknowledged, the Parties hereby agree as follows:

Article 1. Definitions

1. The following capitalized terms shall have the following meanings:

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

(2) "Intellectual Property Rights" generated in the course of implementation of the Agreement means the following:

(i)Industrial Property Rights (as defined below);

(ii)Potential Industrial Property Rights (as defined below); and

(iii)Program/Data Copyrights (as defined below).

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

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

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

(3) "Collaborative Research Plan" means the plan described in the Application for Collaborative Research Agreement for the GCOM ("Application").

(4) "Research Period" means a period described in the Collaborative Research Plan. Based on the regulations of this Agreement, in case this Agreement is terminated before the completion date of the Research Period, such date of termination of the Agreement shall be the final date of the Research Period.

(5) "Annual Evaluation" means evaluation by JAXA for the results achieved within the year in which this Agreement was concluded. JAXA evaluates the results by reports presented at the research presentation meeting by the Research Organization and Research Results Report (as defined below).

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

(7) “Meteorological Data” means data sets provided by the Japan Meteorological Agency pursuant to the agreement between JAXA and the Japan Meteorological Agency.

2. In this Agreement, “Invention, etc.” means an invention in terms of a subject of patent rights, a utility model in terms of a subject of utility model rights, a creation in terms of a subject of copyrights such as design rights and programs, and ideas in terms of a subject of algorithm and know-how.
3. In this Agreement, “utilization” of the intellectual property rights and Research Results means act defined in Article 2, Paragraph 3 of the Patent Act, act defined in Article 2, Paragraph 3 of the Utility Model Act, act defined in Article 2, Paragraph 3 of the Design Act, enforcement of right defined in Articles 21 and 27 of Copyright Act (including utilization of secondary work created by JAXA or the Research Organization), and use of algorithm and know-how.
4. In this Agreement, “Principal Investigator” ("PI") means the Research Organization employee who submitted the proposal in response to the RA and was selected to be responsible for the Research Projects. "Co-Investigator" ("CI") means a person who supports the PI in performing the Research Projects with approval by JAXA. Names, affiliation, and other information concerning PI and CI (collectively “Collaborative Researchers”) shall be described on the Collaborative Research Plan.

Article 2. JAXA's Performance for Research Projects and the Research Organization's General Responsibilities for Research Projects

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

a) Deliver the Earth Observation Satellite Data and Meteorological Data required for performing the Collaborative Research to the Research Organization free of charge;
b) Hold research presentation meetings for checking progress of the research and other necessary meetings;
c) Evaluate the Research Result Report submitted at the end of fiscal year for the Annual Evaluation.

2. For the purpose of ensuring the Research Organization's performance of the above obligations, the Research Organization shall perform certain actions including, but not limited to:

a) The Research Organization shall conduct and complete the Research Projects in accordance with the Collaborative Research Plan.
b) Participate in necessary workshops and meetings for the Research Projects such as

the research presentation meeting hosted by JAXA at the end of the fiscal year;

c) Participate in the research presentation meeting hosted by JAXA every year to report on the the Research Results and progress of research to JAXA; and

d) Deliver the reports as a report of all the Research Results obtained during the fiscal year by the end of such fiscal year to JAXA. Furthermore, at the completion of the research period, the Research Organization shall report all the Research Results obtained throughout the entire period of the Collaborative Research in the Final Report and submit it to JAXA. In this case, the Research Organization does not need to separately submit an annual report for the final year of the term. Any report stipulated in this paragraph shall be sent by mail in the form of one hard copy and one CD-ROM containing such report in PDF format.

Article 3. Finalization and Renewal of the Contract

1. The Agreement shall become effective as of the date of the issuance of the Confirmation Sheet prescribed by JAXA in response to an application by the Research Organization. Period of the Agreement shall be the period described in the Confirmation Sheet issued by JAXA. In case of a conflict between the Confirmation Sheet and this Agreement, the terms and conditions stipulated in the Confirmation Sheet will supersede this Agreement.

2. The Research Organization may renew the Agreement by one fiscal year, provided that JAXA approves an extension of the research period in the Annual Evaluation and the Parties mutually agree upon the amount to be paid by JAXA for such extended period; further provided, however, the Research Organization shall submit a renewal Application Form to JAXA and JAXA shall issue a new Confirmation Sheet. Thereafter the procedure shall be the same as above..

Article 4. Researchers

1. The Research Organization shall cause the Collaborative Researchers listed on the Collaborative Research Plan to participate in the Collaborative Research.
2. JAXA shall allow those who are listed on the Collaborative Research Plan to participate in the Research Projects.
3. The Research Organization shall ensure all the Collaborative Researchers engaging in the Research Projects act in accordance with the terms and conditions of the Agreement.
4. In the event that the Research Organization intends to newly select or add CIs, the Research Organization shall first notify to JAXA by a written form in advance and

obtain the consent of JAXA for such personnel. The Research Organization shall take necessary measures to cause such CI to follow the Collaborative Research Agreement.

5. In the event that the PI dies, retires from the Research Organization, takes a leave absent from work, or come to be no longer engaged in the Research Projects, the Research Organization shall immediately notify to JAXA as such and JAXA may at its sole discretion terminate this Agreement; provided however, if the Research Organization designates a researcher who belongs to the Research Organization as the PI's successor and JAXA approves the succession, the Parties may amend this Agreement, with the succeeding researcher being a new PI. The terms and conditions of the amendment to this Agreement shall be determined upon mutual consultation and consent.

Article 5. Subcontract

1. The Research Organization shall not re-commission the whole Research Projects to a third party ("Subcontract"). Provided, however, that the Research Organization may re-commission part of it upon a written prior application to JAXA and a prior written approval of JAXA. Should there be a case where subcontractors re-commission part of the Research Projects to a third party, the company name, address and scope of business of such third party are required to be submitted to the Research Organization in writing.
2. If the Research Organization re-commissions the Research Projects to a third party at any tier (contractor or subcontractor, including any company of any stage of the Projects in connection with the subcontract) of the Research Organization, act of such subcontractor, or, any act of such third party in connection with the subcontract shall be deemed to be an act of the Research Organization and the Research Organization shall be fully responsible therefor.
3. If the Research Organization re-commissions part of the Research Projects to a third party, the Research Organization shall conclude an agreement with the subcontractor on issues necessary for the Research Organization to comply with the Agreement and on issues designated by JAXA.

Article 6. Research Funding

1. The Confirmation Sheet issued on the basis of Article 3 identifies the amount of funding to be provided by JAXA to the Research Organization for the Research Projects ("Research Funding") and JAXA shall pay such amount to the Research

Organization in advance.

2. JAXA shall, within thirty (30) days from the date when JAXA receives an invoice duly issued by the Research Organization, make payment for the Research Funding.
3. If RO wishes to reallocate expenses between Expense Item Categories for more than 50% increase or decrease (3,000,000 Japanese yen, in case the amount of 50% is less than 3,000,000 Japanese yen), RO shall obtain a written approval from JAXA in advance.
4. Provided, however, that the Research Organization shall not conduct the reallocation of budget between the general administrative expenses and the direct expenses.
5. In case that JAXA fails to pay the Research Funding within the above period, the Research Organization may request JAXA to pay default interest of six (6) percent per annum on such unpaid amount for the period from the immediately succeeding day of due date for payment to the date of actual payment.
6. If the interest on late payment is less than 10,000 yen, JAXA shall be exempt from payment of such interest and if there is any amount less than 1,000 yen, such amount shall be rounded off.

Article 7. Accounting

RO shall conduct accounting of the Research Funding stipulated in Article 6.1. RO shall maintain books to record expenses according to items and store documents to prove such expenses. In addition, RO shall keep all the accounting documents for seven (7) years after the end of the contract counting from next fiscal year. JAXA may request RO to submit a copy of such books and documents to clarify the expenses, and RO shall respond to such requests from JAXA.

Article 8. Submission of Financial Statement

In the event that the research expenses, stated in paragraph 1 of Article 6, exceed one (1) million Japanese yen, RO shall submit a Financial Report containing the expenses breakdown to JAXA within 61 days after the end of contract.

Article 9. Determination of Contract Amount

1. Upon the receipt of the Performance Report stipulated in paragraph 2 in the previous Article, JAXA shall adjust the expenses within the limit of the original contract amount in accordance with the present Article, Article 10 (Investigation of Actual Expenses) and Article 11 (Return of Paid Research Funding), determine and notify

the Research Organization of the final contract amount.

2. In the calculation of the actual expenses, the general administrative expenses ratio shall be calculated by using the ratio applied at the time the contract was concluded.

Article 10. Investigation of Actual Expenses

For determination of contract amount stipulated in Paragraph 1 of the previous Article, JAXA shall check whether the amount spent matches the content and conditions of the Agreement. If necessary, JAXA requests the Research Organization to submit reference materials or report, or to investigate books and relevant documents in the offices of the Research Organization.

Article 11. Return of Paid Research Funding

1. After the payment by the method stipulated in paragraph 1 and 2 of Article 6, if the amount already paid exceeds the final contract amount determined through the process stipulated in paragraph 1 of Article 9, JAXA shall reclaim the excess amount from the Research Organization.
2. In the case of the previous paragraph, the Research Organization shall remit such funds within thirty (30) days from the date when the Research Organization receives an invoice issued by JAXA with regard to such funds.
3. In the event there is no return made by the Research Organization within the set time limit as described in the preceding paragraph, the provisions of paragraph 5 and 6 of Article 6 shall be applied.

Article 12. Ownership of the Rights to the Acquired Equipment

1. The ownership of the equipment acquired with the Research Funding in accordance with paragraph 1 of Article 6 shall be retained by JAXA. However, upon mutual agreement between JAXA and the Research Organization the ownership of the equipment may be transferred to the Research Organization.
2. The Research Organization shall create a ledger for the equipment mentioned in the previous paragraph and manage the equipment with the care of a good manager. When the Agreement ends, the Research Organization must submit to JAXA a list of acquired property.

Article 13. Providing of Earth Observation Satellite Data by JAXA

1. JAXA will provide the Research Organization with the Earth Observation Satellite Data for the Research Projects free of charge via internet in accordance with Article

2, Paragraph 1, Item 2 subject to the following conditions:

a) The Research Organization agrees and accepts that JAXA may not provide all the Earth Observation Satellite Data which the Research Organization may request due to restrictions in the allowance range of JAXA's equipment and in resources.
Note that amongst the Earth Observation Satellite Data, which the Research Organization may request JAXA, the each standard Data collected from the Advance Land Observing Satellite (ALOS) and the Advance Land Observing Satellite-2 (ALOS-2) shall be limited to fifty scenes every fiscal year;

b) JAXA does not guarantee a specific quality or the timely provisions of the Earth Observation Satellite Data and does not take responsibility for quality and delay of provisions of such data;

c) JAXA reserves the right to curtail or suspend Earth Observation Satellite Data supply to the Research Organization due to faults or difficulties relating to the satellites, limitations on their operations, or any other reasons and JAXA shall be exempt from any responsibility for such curtailing and for suspension; and

d) Research Organization shall bear the costs of media and shipment if Research Organization requests to provide the Earth Observation Satellite Data via media.

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

a) Not duplicate the Earth Observation Satellite Data except for the purpose of backup. However, this excludes duplication for distributing to authorized Collaborative Researchers stipulated in Article 4 and subcontractors stipulated in Article 5 ("PIs, etc." collectively) which are necessary for the Collaborative Research Project.

b) Not provide or disclose the Earth Observation Satellite Data except to PI;

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

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

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

a) JAXA retains the intellectual property rights of all the Earth Observation Satellite Data, except for ALOS PALSAR data of which METI is the joint owner.

b) If value-added products(modified products with high-level processing which are irreversible to standard data. High-level data processing includes data analysis or combining multiple-satellite data, image processing based on external information, and physical quantity conversion.)are solely developed by Research Organization

out of Earth Observation Satellite Data, in the course of executing the Research Projects, Research Organization retains the intellectual property rights of such value-added products.

c) If Research Organization and JAXA jointly modify the Earth Observation Satellite Data which is provided by JAXA and develop any value-added products, Research Organization and JAXA will discuss the allocation of rights to the value-added products in consideration to degree of contribution or other factors to be considered;

d) Except for cases under paragraph b) and paragraph c), all Intellectual Property Rights of the data or product developed by modifying the Earth Observation Satellite Data shall be owned by JAXA and;

e) In case Research Organization uses the modified Earth Observation Satellite Data for commercial purposes, Research Organization shall notify JAXA and comply with a license condition to be set by JAXA.

Article 14. Providing of Meteorological Data by JAXA

For the purpose of performing the Research Projects, JAXA will attempt to provide the Research Organization with the Meteorological Data based on Article 2, Paragraph 1, Item 1.

Any rights relating to the Meteorological Data provided by JAXA to the Research Organization shall not be transferred to the Research Organization by such provisions. In terms of the intellectual property rights of the data, the Research Organization shall follow instructions of JAXA.

The Research Organization may not disclose the provided Meteorological Data to any third party except for PIs, etc.

The Research Organization shall use the provided Meteorological Data solely for the purpose of conducting the Research Projects.

The Research Organization shall return or otherwise appropriately keep the Meteorological Data in accordance with the instructions of JAXA upon the termination of this Agreement.

Article 15. Disclosure of Technical Data

1. To the extent feasible, each party shall disclose and allow use of all necessary technical information, programs, etc. ("Technical Data"), which does not include the Earth Observation Satellite Data and the Meteorological Data, necessary for performing the Collaborative Research free of charge. The Parties will undertake to handle expeditiously any request for the Technical Data presented by the other

party.

2. The Technical Data shall be used by the receiving party only for the purpose of fulfilling the receiving party's responsibilities under this Agreement and shall not be disclosed to any third party except for PIs, etc.
3. According to directives of the furnishing party, the receiving party shall return or otherwise dispose of Technical Data provided under the Agreement upon completion of the activities under the Agreement.

Article 16. Usage of Research Results

1. All Research Results obtained through the course of the Collaborative Research may be used for non-commercial and peaceful purposes by the Parties (or by the third party including for JAXA or the Research Organization) ("Jointly-Owned Research Results") without consent of the Research Organization.
2. With regard to copyrights in the Final Reports submitted by the Research Organization to JAXA, JAXA may freely use, edit, copy, and distribute such reports. In this case, the Collaborative Researchers shall waive any related moral rights to the copyrights in the Final Reports.

Article 17. Ownership of Research Results

1. Both Parties shall solely own the rights of the Research Results if JAXA or the Research Organization solely generates such Research Results in the course of the Research Projects.
2. The Parties shall jointly own the rights to the Research Results obtained through the course of the Collaborative Research and the ownership of such results shall be determined upon mutual agreement between the Parties, taking into consideration the degrees of contribution by JAXA and the Research Organization.

Article 18. Application etc. of Intellectual Property Rights

1. JAXA or the Research Organization shall give the other party prompt written notice of Intellectual Property Rights generated, such as the Invention, Utility Model, and Creation, in the course of the Collaborative Research and discuss the ownership of such generated Intellectual Property Rights, as well as whether it is necessary to submit an application for registration of such Intellectual Property Rights.
2. JAXA and/or Research Organization shall take any necessary procedures for any Industrial Property Rights owned by and/or held by each Collaborative Researchers (including invention etc. jointly generated by such Joint Researcher and JAXA or

the Research Organization) to be transferred by such Joint Researcher to JAXA or the Research Organization.

3. If JAXA or the Research Organization solely generates Potential Intellectual Property Rights in the course of the Research Projects ("Solely-Owned Intellectual Property Rights"), the party may take steps to apply for the registration of the resulting Intellectual Property Rights as solely-owned ones, provided that it shall obtain prior confirmation of the other party. In this case, expenses for application and rights preservation shall be borne by the party solely holding the Intellectual Property Rights.
4. In the event that the Parties jointly generate an invention etc., and submit an application for Intellectual Property Rights to such invention, the Parties shall enter into a separate joint ownership agreement ("Joint Ownership Agreement") and jointly perform submission of the application and other procedures according to the Joint Ownership Agreement. In this case, expenses for application and rights preservation shall be borne by the both JAXA and the Research Organization depending on the degree of ownership.

Article 19. Application of Intellectual Property Rights Overseas

1. Regulations of the previous Article shall apply to the case of application and rights preservation of the Intellectual Property Rights in foreign countries.
2. In the event of an application of the Intellectual Property Rights jointly owned by the Parties pursuant to Paragraph 4 of the previous Article, the Parties shall discuss whether it is necessary to submit an application for registration of such Intellectual Property Rights.

Article 20. Utilization of Jointly-Owned Intellectual Property Rights

In case either of the Parties utilizes the Jointly-Owned Intellectual Property Rights, such party shall obtain a consent from the other party in advance and pay utilization fee as set forth in a separate utilization agreement, except for the case stipulated in Article 16.

Article 21. License of Utilization of Jointly-Owned Intellectual Property Rights to Third Party

1. The Parties may grant to any third party a license to use the Jointly-Owned Intellectual Property Rights, provided, however that the relevant party shall obtain the written prior consent of the other party, and determine the licensing terms after

discussion with the other party.

2. In the case of granting a license to use the Jointly-Owned Intellectual Property Rights to a third party as in the previous Paragraph, the relevant party shall collect the usage fee from such third party as set forth in the separate usage agreement. The usage fee to be collected from the third party shall be distributed between the Parties pro rata in proportion to their respective interests in those rights.

Article 22. Transfer of Interests to Jointly-Owned Intellectual Property Rights

1. The Parties may transfer their respective interests to the Jointly-Owned Intellectual Property Rights generated in the course of the Collaborative Research only to their respective designees after discussion between the Parties. Such transfer may be carried out pursuant to a separate transfer agreement. In this event, the Parties shall cause its designee to succeed to all of its rights and obligations with respect to those Intellectual Property Rights.
2. If JAXA or the Research Organization disclaims its interests in the Jointly-Owned Intellectual Property Rights, the relevant party shall give the other party prior notice thereof and transfer its interests to the other party, only if the other party wishes to acquire it.

Article 23. Improved Invention

If JAXA or the Research Organization alters or improves the Jointly-Owned Intellectual Property within one (1) year from the application for registration of the original Jointly-Owned Intellectual Property Rights, the party shall provide a written notice without delay to the other party describing the alterations or improvements. Ownership and other issues of the Intellectual Property Rights concerning the altered or improved invention shall be determined through discussion between the Parties.

Article 24. Designation of Know-How

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

Article 25. Utilization of Facilities, etc.

1. The Parties may use facilities and equipment ("Facilities") of the other party free of charge with a prior consent from the other party if it is necessary for implementation of the Research Projects.
2. The Parties shall follow rules and regulations of the other party in case of using the Facilities of the other party.

Article 26. Installation of Equipment

1. The Parties may, if necessary for implementation of the Research Projects, install necessary equipment and other materials into the facility of the other party with a prior consent from the other party. In this case, the party which installs such equipment shall follow the rules and regulations of the other party.
2. In the event that JAXA or the Research Organization uses the material etc. installed by the other party (Installed Material), such party shall obtain a prior consent of the other party and shall not use the Installed Material for other purposes than the Research Projects.
3. In the event that JAXA or the Research Organization loses or damages the Installed Material, such party should immediately notify the other party such fact irrespective of the reason.

Article 27. Delivery, Storage, and Returning of Lent Equipment

1. The Parties may lend machinery or other material to the other party if it is required for implementation of the Research Projects.
2. Upon delivery of the machinery or other material ("Lent Equipment") lent in accordance with the previous Paragraph, owner of the Lent Equipment ("Lessor") shall submit the other party a Note of Delivery and the other party shall submit the Lessor a receipt.
3. The Parties shall confirm items, amount, etc. of the Lent Equipment upon delivery of the Lent Equipment and if there is a shortage in the amount or any defect (including ones whose quality and/or specification does not meet the requirement), JAXA or the Research Organization shall notify such fact to the Lessor and receive an instruction from the Lessor.
4. JAXA and the Research Organization shall manage and use the Lent Equipment with the care of a good manager and should not use the Lent Equipment for the purposes other than the Research Projects.

5. JAXA and the Research Organization shall keep the record of usage and management of the Lent Equipment to record delivery, usage, and returning of the Lent Equipment for the purpose of clarifying the condition of the Lent Equipment.
6. In the case of loss or damage to the Lent Equipment, JAXA and the Research Organization shall immediately notify the fact to the Lessor without delay.
7. The party shall notify the Lessor if any of the Lent Equipment becomes unnecessary due to the reasons such as completion, change, or termination of whole or part of the Research Projects and shall take returning procedures according to the instruction from the Lessor.

Article 28. Confidentiality

1. In this Agreement, "Confidential Information" means any information that corresponds to any of the following:

(1) Any information that includes documents classified “Confidential”, any material object such as a sample, or any information, either material or immaterial, which JAXA and the Research Organization agreed to handle as the Confidential Information by a written agreement, obtained in the course of these Research Projects; and

(2) Any information disclosed or distributed to the other party as Confidential Information in the form of a document, a drawing, a photograph, a specimen, a sample, a magnetic tape, a floppy disk, or the like for the purpose of the Research Projects.

2. The Parties shall appropriately keep the Confidential Information secret, and shall not disclose or divulge any Confidential Information to any party other than those who engage in the Research Projects; provided, however, that any information which corresponds to any of the following is not included in the Confidential Information.

a) Information that is already known to the public when disclosed by the disclosing party;
b) Information that becomes known to the public after the disclosure by the disclosing party without intentional misconduct or negligence of the receiving party;
c) Information that the receiving party already had before the disclosure by the disclosing party;
d) Information that the receiving party acquires from a dully authorized third party not subject to confidentiality obligations;
e) Information that the receiving party independently develops without utilizing information obtained from the disclosing party;

f) Information with a prior written consent of the disclosing party for the disclosure and the publication; or

g) Information that is required to be disclosed by applicable laws, judgment or order of a competent court. In this case, the receiving party shall promptly notify the disclosing party of the necessity of disclosure.

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

Article 29. Publication of Research Results

1. The Parties may disclose or publish the Research Results obtained in the course of the Research Projects (Publication of Research Results") provided that such publishing party follows the obligations stipulated in Article 28.
2. In the case of the previous Paragraph, before publishing, JAXA or the Research Organization ("the publishing party") shall provide the other party with a written document regarding the description of the subjected Research Results to be published and request a written consent of the other party. The other party will not unreasonably withhold consent from the publishing party's request for such publication.
3. The other party, upon receiving the notice, will request correction of the content of the publication in a written form if it is judged that such content includes a portion which may lead to the loss of the future interest of the other party and the publishing party shall consult with the other party about such portion. The publishing party may not publish the portion which the other party notified as having possibility of resulting in the loss of the future interest of the other party without consent of the other party.
4. The Research Organization shall state in the publication that such Research Results have been obtained pursuant to this Agreement and identify the owner of the rights to the Earth Observation Satellite Data and Meteorological Data used in such publication.
5. The period during which the notification pursuant to Paragraph 2 is required shall be one (1) year from the day following the day of termination of the Agreement. However this period may be extended or shortened by mutual agreement between JAXA and the Research Organization.
6. JAXA and the Research Organization shall provide the other party with a copy of

the publication immediately after the disclosure or publishing of such publication. Each party is entitled to an irrevocable and royalty-free right to use the provided publications, unless the copyright of such publication is owned or held by an academic society.

Article 30. Security

In the course of the Collaborative Research, the Parties shall take necessary procedures for maintaining an order in the areas managed by each party, ensuring appropriate and smooth operation of the research, and ensuring protection of important assets and information (security).

Article 31. Termination of the Contract

1. The Parties may terminate the Agreement in any case that corresponds to any one of the following. In such a case, the Parties agree to waive any claim against the other.

(1) Upon the consent of both JAXA and the Research Organization;

(2) When the other party commits a dishonest and/or inequitable act; provided, that breaching party fails to offer any effective and satisfactory remedial measures within seven (7) days after receiving demands for corrective action from the harmed party;

(3) When the other party breaches the Agreement; provided, that breaching party fails to offer any effective and satisfactory remedial measures within seven (7) days after receiving demands for corrective action from the harmed party;

(4) When the Research Organization loses a person who engages in the Research Projects due to the reasons described in Paragraph 5 of Article 4 such as transfer of the PI; and

(5) When an inevitable reason such as the natural disaster arises.

2. In a case where the Agreement is terminated due to the reasons described in the previous Paragraph, JAXA shall request refund of the funding which is no longer necessary pursuant to Paragraph 1 of Article 11.
3. The Parties shall waive any claim against the other if the Agreement is terminated pursuant to Paragraph 1, Item 5 of this Article.
4. Upon the termination of the Agreement, the Research Organization shall promptly deliver to JAXA all work including, but not limited to, all works in progress and all work that is completed and otherwise ready for delivery.

Article 32. Effective Term

1. The effective term of the Agreement shall be the period set forth in Article 3.
2. Termination of this Agreement shall not affect a Party's continuing obligation under Paragraph 2 and 3 of Article 13 (Providing and Rights of Earth Observation Satellite Data by JAXA), Paragraph 2 to 5 of Article 14 (Providing and Rights of Meteorological Data by JAXA), Paragraph 3 of Article 15 (Exchange of Technical Information etc.), and Article 16 (Usage of Research Results) through Article 22 (Transfer of interests to Jointly-Owned Intellectual Property Rights) during the effective period of rights set forth in each Article and Paragraph while Article 23 (Improved Invention), Article 24 (Designation of Know-How), Article 28 (Confidentiality) and Article 29 (Publication of Research Results) shall be effective during the period set forth in each Article.

Article 33. Amendment of the Agreement

1. JAXA can amend the contents of this Agreement. In such a case, JAXA announces the amended contents by posting it to the website operated by JAXA, and thereafter the Agreement is handled based on the amended contents.
2. In the case the Research Organization has a legitimate reason for not agreeing with the amendment of the previous paragraph, the Research Organization may terminate the Agreement by notifying JAXA in writing within thirty (30) days from the date the amended contents were posted on the website.

Article 34. Governing Law

The Agreement shall be governed and interpreted under the laws of Japan.

Article 35. Language

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

Article 36. Consultation

In the event that any doubt arises with regard to provisions that are not included in the Agreement, it shall be resolved upon mutual agreement between JAXA and the Research Organization as necessary.

Attachment “Earth Observation Satellite Data”

Name of Satellite or Sensor	Observation Period (YYYY/MM/DD)	Observable Area
JERS (Japanese Earth Observation Satellite)	1992/09/01~1998/10/11	Global
ADEOS (Advanced Earth Observation Satellite)	1996/10/15~1997/06/29	Global
ADEOS-II (Advanced Earth Observing Satellite-II)	2003/01~2003/10	Global
ALOS (Advanced Land Observing Satellite) * Limited to 50 scenes per year	2006/05/16~2011/04/22	Global
ALOS-2 (Advanced Land Observing Satellite-2) * Limited to 50 scenes per year	2014/08/04~	Global
GCOM-W (The Global Change Observation Mission - Water)	2012 /07~	Global
TRMM (Tropical Rainfall Measuring Mission)	1997/12~2015/04	Global (PR: Approximately 36°S-36°N. TMI and VIRS: Approximately 38°S-38°N)
AMSR-E (Advanced Microwave Scanning Radiometer for EOS-Aqua satellite)	2002/06/19~2011/10/04	Global
GOSAT (Greenhouse Gases Observing Satellite)	2009/04/23~	Global

GPM (Global Precipitation Measurement)	2014/03~	Global (DPR: Approximately 66°S-66°N. GMI: Approximately 68°S-68°N)
GCOM-C (Global Change Observation Mission – Climate)	2018/01~	Global

* EarthCARE will be added by revision of the Agreement pursuant to Article 33 when provision of data becomes available.

COLLABORATIVE RESEARCH AGREEMENT (NON-FUNDED)
FOR THE GLOBAL CHANGE OBSERVATION MISSION
BETWEEN THE
JAPAN AEROSPACE EXPLORATION AGENCY (JAXA)
AND
THE RESEARCH ORGANIZATION
(FOR THE RESEARCH ANNOUNCEMENT)

JAPAN AEROSPACE EXPLORATION AGENCY

6th GCOM SCIENCE RESEARCH ANNOUNCEMENT
COLLABORATIVE RESEARCH AGREEMENT (NON-FUNDED)

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

WITNESSETH

WHEREAS, the Global Change Observation Mission ("GCOM") aims to construct, use, and verify systems that enable continuous global-scale observations of effective geophysical parameters for clarifying global climate change and water circulation mechanisms;

WHEREAS, JAXA issued the Research Announcement ("RA") to engage in collaborative research activities directly related to retrieval algorithms for geophysical products, product validation, and data application of GCOM, and the Research Organization applied pursuant to such RA;

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

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

NOW, THEREFORE, in consideration of the mutual agreements hereinafter set forth, and for other good and reasonable consideration, the receipt and adequacy of which are hereby acknowledged, the Parties hereby agree as follows:

Article 1. Definitions

1. The following capitalized terms shall have the following meanings:

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

(2) "Intellectual Property Rights" generated in the course of implementation of the Agreement means the following:

(i) Industrial Property Rights (as defined below);

(ii) Potential Industrial Property Rights (as defined below); and

(iii) Program/Data Copyrights (as defined below).

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

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

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

(3) "Collaborative Research Plan" means the plan described in the Application for Collaborative Research Agreement for the GCOM ("Application").

(4) “Research Period” means a period described in the Collaborative Research Plan. Based on the regulations of this Agreement, in case this Agreement is terminated before the completion date of the Research Period, such date of termination of the Agreement shall be the final date of the Research Period.

(5) "Annual Evaluation" means evaluation by JAXA of the research results achieved at the end of each Japanese fiscal year, in order to assess the progress of the research.

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

(7) "Meteorological Data" means data sets provided by the Japan Meteorological Agency pursuant to the agreement between JAXA and the Japan Meteorological Agency.

2. In this Agreement, "Invention, etc." means inventions in terms of items subject to patent rights, utility models in terms of items subject to utility model rights, creations in terms of items subject to copyrights such as design rights and programs, and ideas in terms of items subject to algorithms and know-how.
3. In this Agreement, "utilization" of the intellectual property rights and Research Results means activities defined in Article 2, Paragraph 3 of the Patent Act, activities defined in Article 2, Paragraph 3 of the Utility Model Act, activities defined in Article 2, Paragraph 3 of the Design Act, enforcement of rights defined in Articles 21 and 27 of the Copyright Act (including utilization of secondary work created by JAXA or the Research Organization), and use of algorithms and know-how.
4. In this Agreement, "Principal Investigator" ("PI") means the Research Organization employee who submitted the proposal in response to the RA and was selected to be responsible for the Research Projects. "Co-Investigator" ("CI") means a person who supports the PI in performing the Research Projects with approval by JAXA. Names, affiliation, and other information concerning the PI and CI (collectively "Collaborative Researchers") shall be described in the Collaborative Research Plan.

Article 2. JAXA's Performance for Research Projects and the Research Organization's General Responsibilities for Research Projects

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

a) Deliver the Earth Observation Satellite Data and Meteorological Data required for performing the Collaborative Research to the Research Organization free of charge;
b) Hold research presentation meetings (Research Presentation Meeting) to check progress of the research and other necessary meetings;
c) Carry out an Annual Evaluation based on the report made in the Research Presentation Meeting stipulated in the previous Paragraph, or written reports similar to the one stipulated therein.

2. For the purpose of ensuring the Research Organization's performance of the above obligations, the Research Organization shall perform certain actions including, but not limited to:

a) Conduct and complete the Research Projects in accordance with the Collaborative Research Plan.
b) Participate in the Research Presentation Meeting hosted by JAXA every fiscal year

in response to the request from JAXA;

c) Report on the Research Results and progress of research in the Research Presentation Meeting stipulated in the previous Paragraph, or submit in a written form to JAXA by the day before the Annual Evaluation that JAXA implements every fiscal year;

d) Deliver the reports as a report of all the Research Results obtained during the fiscal year by the end of such fiscal year to JAXA. Furthermore, upon completion of the research period, the Research Organization shall report all the Research Results obtained throughout the entire period of the Collaborative Research in the Final Report and submit it to JAXA. In this case, the Research Organization does not need to separately submit an annual report for the final year of the term; and

e) Alternatively may substitute the submission of a thesis published during the Research Period for the submission of the report of Research Results.

Article 3. Finalization of the Contract

1. The Agreement shall become effective as of the date of the issuance of the Confirmation Sheet prescribed by JAXA in response to an application by the Research Organization. The period of the Agreement shall be the period described in the Confirmation Sheet issued by JAXA. In case of a conflict between the Confirmation Sheet and this Agreement, the terms and conditions stipulated in the Confirmation Sheet will supersede this Agreement.

Article 4. Researchers

1. The Research Organization shall ensure that the Collaborative Researchers listed in the Collaborative Research Plan to participate in the Collaborative Research.
2. JAXA shall allow those who are listed in the Collaborative Research Plan to participate in the Research Projects.
3. The Research Organization shall ensure that all the Collaborative Researchers engaging in the Research Projects act in accordance with the terms and conditions of the Agreement.
4. In the event that the Research Organization intends to newly select or add CIs, the Research Organization shall first notify JAXA in written form in advance and obtain the consent of JAXA for such personnel. The Research Organization shall take necessary measures to cause such CI to follow the Collaborative Research Agreement.
5. In the event that the PI dies, retires from the Research Organization, takes a leave

of absence from work, or comes to be no longer engaged in the Research Projects, the Research Organization shall immediately notify JAXA as such and JAXA may at its sole discretion terminate this Agreement; provided however, that if the Research Organization designates a researcher who belongs to the Research Organization as the PI's successor and JAXA approves the succession, the Parties may amend this Agreement, with the succeeding researcher being a new PI. The terms and conditions of the amendment to this Agreement shall be determined upon mutual consultation and consent.

Article 5. Research Funding

Each party shall bear the necessary costs of fulfilling its own responsibilities under this agreement.

Article 6. Ownership of the Rights to the Acquired Equipment

Equipment acquired by each party in the course of the Research Projects shall be owned by the party who purchased such equipment.

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Article 7. Providing of Earth Observation Satellite Data by JAXA

1. JAXA will provide the Research Organization with the Earth Observation Satellite Data for the Research Projects free of charge via internet in accordance with Article 2, Paragraph 1, a) subject to the following conditions:

a) The Research Organization agrees and accepts that JAXA may not provide all the Earth Observation Satellite Data which the Research Organization may request due to rights restrictions of JAXA's equipment and resource limitations.
   Note that amongst the Earth Observation Satellite Data, which the Research Organization may request JAXA, the each standard Data collected from the Advanced Land Observing Satellite (ALOS) and the Advance Land Observing Satellite-2 (ALOS-2) shall be limited to fifty scenes every fiscal year;
b) JAXA does not guarantee a specific quality or the timely provision of the Earth Observation Satellite Data and does not take responsibility for the quality or any delay of provision of such data;
c) JAXA reserves the right to curtail or suspend Earth Observation Satellite Data supply to the Research Organization due to faults or difficulties relating to the satellites, limitations on their operations, or any other reasons, and JAXA shall be exempt from any responsibility for such curtailing or suspension; and
d) Research Organization shall bear the costs of media and shipment if Research

Organization requests to provide the Earth Observation Satellite Data via media.

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

a) Not duplicate the Earth Observation Satellite Data except for the purpose of backup. However, this excludes duplication for distributing to authorized researchers engaged in the Research Project as stipulated in Article 4 and subcontractors stipulated in Article 4 ("Collaborative Researchers" collectively) which are necessary for the Collaborative Research Project.

b) Not provide or disclose the Earth Observation Satellite Data except to the PI;

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

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

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

a) JAXA retains the intellectual property rights of all the Earth Observation Satellite Data, except for ALOS PALSAR data of which METI is the joint owner.

b) If value-added products(modified products with high-level processing which are irreversible to standard data. High-level data processing includes data analysis or combining multiple-satellite data, image processing based on external information, and physical quantity conversion.)are solely developed by Research Organization out of Earth Observation Satellite Data, in the course of executing the Research Projects, Research Organization retains the intellectual property rights of such value-added products.

c) If Research Organization and JAXA jointly modify the Earth Observation Satellite Data which is provided by JAXA and develop any value-added products, Research Organization and JAXA will discuss the allocation of rights to the value-added products in consideration to degree of contribution or other factors to be considered;

d) Except for cases under paragraph b) and paragraph c), all Intellectual Property Rights of the data or product developed by modifying the Earth Observation Satellite Data shall be owned by JAXA and;

e) In case Research Organization uses the modified Earth Observation Satellite Data for commercial purposes, Research Organization shall notify JAXA and comply with a license condition to be set by JAXA.

Article 8. Providing of Meteorological Data by JAXA

1. For the purpose of performing the Research Projects, JAXA will attempt to provide the Research Organization with the Meteorological Data based on Article 2, Paragraph 1, a).
2. Any rights relating to the Meteorological Data provided by JAXA to the Research Organization shall not be transferred to the Research Organization by such provisions. In terms of the intellectual property rights of the data, the Research Organization shall follow the instructions of JAXA.
3. The Research Organization may not disclose the provided Meteorological Data to any third party except for Collaborative Researchers.
4. The Research Organization shall use the provided Meteorological Data solely for the purpose of conducting the Research Projects.
5. The Research Organization shall return or otherwise appropriately keep the Meteorological Data in accordance with the instructions of JAXA upon the termination of this Agreement.

Article 9. Disclosure of Technical Data

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

Article 10. Usage of Research Results

1. All Research Results obtained through the course of the Collaborative Research ("Jointly-Owned Research Results") may be used for non-commercial and peaceful purposes by the Parties (or by a third party including for JAXA or the Research Organization) without prior consent of the other party.

2. With regard to copyrights in the Final Reports submitted by the Research Organization to JAXA, JAXA may freely use, edit, copy, and distribute such reports. In this case, the Collaborative Researchers shall waive any related moral rights to the copyrights in the Final Reports.

Article 11. Ownership of Research Results

1. Both Parties shall solely own the rights of the Research Results only if JAXA or the Research Organization solely generates such Research Results in the course of Research Projects.
2. The Parties shall jointly own the rights to the Research Results obtained through the course of the Collaborative Research and the ownership of such results shall be determined upon mutual agreement between the Parties, taking into consideration the degrees of contribution by JAXA and the Research Organization.

Article 12. Application, etc., of Intellectual Property Rights

1. JAXA or the Research Organization shall give the other party prompt written notice of Intellectual Property Rights generated in the course of the Collaborative Research, such as Inventions, Utility Models, and Creations, and discuss the ownership of such generated Intellectual Property Rights, as well as whether it is necessary to submit an application for registration of such Intellectual Property Rights.
2. JAXA and/or the Research Organization shall take any necessary procedures for any Industrial Property Rights owned by and/or held by each Collaborative Researcher (including inventions, etc., jointly generated by such Joint Researcher and JAXA or the Research Organization) to be transferred by such Joint Researcher to JAXA or the Research Organization.
3. If JAXA or the Research Organization solely generates Potential Intellectual Property Rights in the course of the Research Projects ("Solely-Owned Intellectual Property Rights"), the party may take steps to apply for the registration of the resulting Intellectual Property Rights as solely-owned ones, provided that it shall obtain prior confirmation of the other party. In this case, expenses for application and rights preservation shall be borne by the party solely holding the Intellectual Property Rights.
4. In the event that the Parties jointly generate an invention, etc., and submit an application for Intellectual Property Rights to such invention, the Parties shall enter into a separate joint ownership agreement ("Joint Ownership Agreement")

and jointly perform submission of the application and other procedures according to the Joint Ownership Agreement. In this case, expenses for application and rights preservation shall be borne by both JAXA and the Research Organization in accordance with the degree of ownership.

Article 13. Application of Intellectual Property Rights Overseas

1. Regulations of the previous Article shall apply to the case of application and rights preservation of the Intellectual Property Rights in foreign countries.
2. In the event of an application of the Intellectual Property Rights jointly owned by the Parties pursuant to Paragraph 4 of the previous Article, the Parties shall discuss whether it is necessary to submit an application for registration of such Intellectual Property Rights.

Article 14. Utilization of Jointly-Owned Intellectual Property Rights

In case either of the Parties utilizes the Jointly-Owned Intellectual Property Rights, such party shall obtain the consent of the other party in advance and pay a utilization fee as set forth in the separate utilization agreement, except for the case stipulated in Article 10.

Article 15. License of Utilization of Jointly-Owned Intellectual Property Rights to Third Party

1. The Parties may grant to any third party a license to use the Jointly-Owned Intellectual Property Rights, provided, however that the relevant party shall obtain the written prior consent of the other party, and determine the licensing terms after discussion with the other party.
2. In the case of granting a license to use the Jointly-Owned Intellectual Property Rights to a third party as in the previous Paragraph, the relevant party shall collect the usage fee from such third party as set forth in the separate usage agreement. The usage fee to be collected from the third party shall be distributed between the Parties pro rata in proportion to their respective interests in those rights.

Article 16. Transfer of Interests to Jointly-Owned Intellectual Property Rights

1. The Parties may transfer their respective interests to the Jointly-Owned Intellectual Property Rights generated in the course of the Collaborative Research only to their respective designees after discussion between the Parties. Such transfer may be carried out pursuant to a separate transfer agreement. In this event,

the Parties shall cause its designee to succeed to all of its rights and obligations with respect to those Intellectual Property Rights.

2. If JAXA or the Research Organization disclaims its interests in the Jointly-Owned Intellectual Property Rights, the relevant party shall give the other party prior notice thereof and transfer its interests to the other party, only if the other party wishes to acquire it.

Article 17. Improved Invention

If JAXA or the Research Organization alters or improves the Jointly-Owned Intellectual Property within one (1) year from the application for registration of the original Jointly-Owned Intellectual Property Rights, the party shall provide a written notice without delay to the other party describing the alterations or improvements. Ownership and other issues of the Intellectual Property Rights concerning the altered or improved invention shall be determined through discussion between the Parties.

Article 18. Designation of Know-How

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

Article 19. Utilization of Facilities, etc.

1. The Parties may use facilities and equipment ("Facilities") of the other party free of charge with the prior consent of the other party if it is necessary for implementation of the Research Projects.
2. The Parties shall follow the rules and regulations of the other party in case of using the Facilities of the other party.

Article 20. Installation of Equipment

1. The Parties may, if necessary for implementation of the Research Projects, install necessary equipment and other materials into the facility of the other party with

the prior consent of the other party. In this case, the party which installs such equipment shall follow the rules and regulations of the other party.

2. In the event that JAXA or the Research Organization uses the materials, etc., installed by the other party (Installed Material), such party shall obtain the prior consent of the other party and shall not use the Installed Material for other purposes than the Research Projects.
3. In the event that JAXA or the Research Organization loses or damages the Installed Material, such party should immediately notify the other party of such fact irrespective of the reason.

Article 21. Delivery, Storage, and Returning of Lent Equipment

1. The Parties may lend machinery or other materials to the other party if it is required for implementation of the Research Projects.
2. Upon delivery of the machinery or other materials ("Lent Equipment") lent in accordance with the previous Paragraph, the owner of the Lent Equipment ("Lessor") shall submit to the other party a Note of Delivery and the other party shall submit to the Lessor a receipt.
3. The Parties shall confirm the items, amount, etc. of the Lent Equipment upon delivery of the Lent Equipment and if there is a shortage in the amount or any defect (including ones whose quality and/or specification does not meet the requirements), JAXA or the Research Organization shall notify such fact to the Lessor and receive an instruction from the Lessor.
4. JAXA and the Research Organization shall manage and use the Lent Equipment with the care of a good manager and should not use the Lent Equipment for purposes other than the Research Projects.
5. JAXA and the Research Organization shall keep a record of usage and management of the Lent Equipment to record the delivery, usage, and returning of the Lent Equipment for the purpose of clarifying the condition of the Lent Equipment.
6. In the case of loss or damage to the Lent Equipment, JAXA and the Research Organization shall immediately notify the fact to the Lessor without delay.
7. The receiving party shall notify the Lessor if any of the Lent Equipment becomes unnecessary due to reasons such as completion, change, or termination of whole or part of the Research Projects and shall take procedures to return the Lent Equipment according to the instructions of the Lessor.

Article 22. Confidentiality

1. In this Agreement, "Confidential Information" means any information that corresponds to any of the following:

(1) Any information that includes documents classified "Confidential", any material object such as a sample, or any information, either material or immaterial, which JAXA and the Research Organization agreed to handle as Confidential Information by a written agreement, obtained in the course of these Research Projects; and

(2) Any information disclosed or distributed to the other party as Confidential Information in the form of a document, a drawing, a photograph, a specimen, a sample, a magnetic tape, a floppy disk, or the like for the purpose of the Research Projects.

2. The Parties shall appropriately keep the Confidential Information secret, and shall not disclose or divulge any Confidential Information to any party other than those who engage in the Research Projects; provided, however, that any information which corresponds to any of the following is not included in the Confidential Information.

a) Information that is already known to the public when disclosed by the disclosing party;

b) Information that becomes known to the public after the disclosure by the disclosing party without intentional misconduct or negligence of the receiving party;

c) Information that the receiving party already had before the disclosure by the disclosing party;

d) Information that the receiving party acquires from a duly authorized third party not subject to confidentiality obligations;

e) Information that the receiving party independently develops without utilizing information obtained from the disclosing party;

f) Information with prior written consent of the disclosing party for disclosure or publication; or

g) Information that is required to be disclosed by applicable laws, judgment or order of a competent court. In this case, the receiving party shall promptly notify the disclosing party of the necessity of disclosure.

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

Article 23. Publication of Research Results

1. The Parties may disclose or publish the Research Results obtained in the course of

the Research Projects ("Publication of Research Results") provided that such publishing party follows the confidentiality obligations stipulated in Article 22.

2. In the case of the previous Paragraph, before publishing, JAXA or the Research Organization ("the publishing party") shall provide the other party with a written document regarding the description of the Research Results to be published and request the written consent of the other party. The other party will not unreasonably withhold consent from the publishing party's request for such publication.
3. The other party, upon receiving the notice, will request correction of the content of the publication in written form if it is judged that such content includes a portion which may lead to the loss of the future interest of the other party and the publishing party shall consult with the other party about such portion. The publishing party may not publish the portion which the other party has notified as having the possibility of resulting in the loss of the future interest of the other party without the consent of the other party.
4. The Research Organization shall state in the publication that such Research Results have been obtained pursuant to this Agreement and identify the owner of the rights to the Earth Observation Satellite Data and Meteorological Data used in such publication.
5. The period during which the notification pursuant to Paragraph 2 is required shall be one (1) year from the day following the day of termination of the Agreement. However this period may be extended or shortened by mutual agreement between JAXA and the Research Organization.
6. JAXA and the Research Organization shall provide the other party with a copy of the publication immediately after the disclosure or publishing of such publication. Each party is entitled to an irrevocable and royalty-free right to use the provided publications, unless the copyright of such publication is owned or held by an academic society.

Article 24. Security

In the course of the Collaborative Research, the Parties shall take necessary procedures for maintaining order in the areas managed by each party, ensuring appropriate and smooth operation of the research, and ensuring the protection (security) of important assets and information.

Article 25. Termination of the Contract

1. The Parties may terminate the Agreement in any case that corresponds to any one of the following. In such a case, the Parties agree to waive any claim against the other.

(1) Upon the consent of both JAXA and the Research Organization;

(2) When the other party commits a dishonest and/or inequitable act; provided that the breaching party fails to offer any effective and satisfactory remedial measures within seven (7) days after receiving demands for corrective action from the harmed party;

(3) When the other party breaches the Agreement; provided that the breaching party fails to offer any effective and satisfactory remedial measures within seven (7) days after receiving demands for corrective action from the harmed party;

(4) When JAXA determines that it cannot continue the Research Projects with the Research Organization as a result of the Annual Evaluation stipulated in Article 2, Paragraph 1, c).

(5) When the Research Organization loses a person who is engaged in the Research Projects due to the reasons described in Paragraph 5 of Article 4, such as transfer of the PI; and

(6) Due to an unavoidable occurrence such as a natural disaster.

2. Upon the termination of the Agreement, the Research Organization shall promptly deliver to JAXA all work including, but not limited to, all works in progress and all work that is completed and otherwise ready for delivery.

3. The Parties shall waive any claim against the other if the Agreement is terminated pursuant to Paragraph 1, Item 6 of this Article.

Article 26. Effective Term

1. The effective term of the Agreement shall be the period set forth in Article 3.

2. Termination of this Agreement shall not affect a Party's continuing obligation under Paragraph 2 and 3 of Article 7 (Providing and Rights of Earth Observation Satellite Data by JAXA), Paragraph 2 to 5 of Article 8 (Providing and Rights of Meteorological Data by JAXA), Paragraph 3 of Article 9 (Exchange of Technical Information etc.), and Article 10 (Usage of Research Results) through Article 16 (Transfer of interests to Jointly-Owned Intellectual Property Rights) during the effective period of rights set forth in each Article and Paragraph while Article 17 (Improved Invention), Article 18 (Designation of Know-How), Article 22 (Confidentiality)and Article 23 (Publication of Research Results)shall be effective during the period set forth in each Article.

Article 27. Amendment of the Agreement

1. JAXA can amend the contents of this Agreement. In such a case, JAXA announces the amended contents by posting it to the website operated by JAXA, and thereafter the Agreement is handled based on the amended contents.
2. In the case the Research Organization has a legitimate reason for not agreeing with the amendment of the previous paragraph, the Research Organization may terminate the Agreement by notifying JAXA in writing within thirty (30) days from the date the amended contents were posted on the website.

Article 28. Governing Law

The Agreement shall be governed and interpreted under the laws of Japan.

Article 29. Language

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

Article 30. Consultation

In the event that any doubt arises with regard to provisions that are not included in the Agreement, it shall be resolved upon mutual agreement between JAXA and the Research Organization as necessary.

Attachment “Earth Observation Satellite Data”

Name of Satellite or Sensor	Observation Period (YYYY/MM/DD)	Observable Area
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GOSAT (Greenhouse Gases Observing Satellite)	2009/04/23~	Global

GPM (Global Precipitation Measurement)	2014/03~	Global (DPR: Approximately 66°S-66°N. GMI: Approximately 68°S-68°N)
GCOM-C (Global Change Observation Mission – Climate)	2018/01~	Global

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