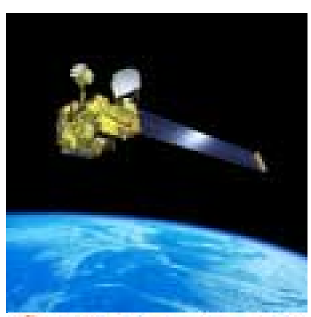
ADEOS-II

- Advanced Earth Observing Satellite-II -

Reference Handbook



NASDA

Introduction

Chapter 1 ADEOS-II Science Research Plan

Introduction

The Advanced Earth Observation Satellite-II (ADEOS-II) is an Earth environmental observation satellite launched on December 14, 2002, to take over the missions of its predecessor ADEOS, which was launched in August 1996 but stopped operating in June 1997. It is eventually to complement the GPM missions as well as the mission of satellite GOSAT, which is planned to be launched in 2007 or later. The missions of ADEOS-II are, therefore, not only to serve as the ADEOS successor but also to continue the advancement of the Earth's observation mission pioneered by Japan ADEOS and lay a solid foundation for the uses of satellite observation in research on the Earth's environmental problems as well as in applications to social and other problems.

ADEOS-II is designed to observe the distribution of chlorophyll, distributions of water vapor and seawater, sea-surface temperature, and other indices critical to the main objective of the satellite—to study the processes of water, energy, and carbon circulation. These data will then be used for the Global Energy Water Circulation Experiment Plan (GEWEX) and the Climate Variation Research Plan (CLIVER) of the World Climate Joint Research Plan (WCRP) as well as for the International Global and Biological Joint Research Plan (IGBP); contribution to global climate change research is expected.

ADEOS-II is equipped with a global imager (GLI) and a high-performance microwave radiometer (AMSR) developed by NASDA as the core sensor, an improved atmospheric infrared spectrometer (ILAS-II), a wind observation instrument for the sea (Sea Winds), and a land-surface reflective light observation instrument (POLDER). Combined use of these observation sensors is expected contribute to the discovery of new information about the Earth's environment and the development of new application fields using satellite data. Along with large platform satellites of other countries already in operation, such as Terra and Aqua (NASA, the United States) and ENVISAT (ESA, Europe), it is important that attempts be made to pioneer new research areas and enhance the field of applications through international harmony and cooperation.

This handbook has been designed to provide basic information on ADEOS-II with the hope that it will promote the actual use of the data by researchers and a variety of remote-sensing users interested in global environmental problems. We sincerely hope that, through the use of this reference handbook, not only will new information be gained concerning global environmental problems, but also the application of satellite remote sensing will be promoted.

Chapter 1 ADEOS-II Science Research Plan

1. Targets and objectives

1.1 Targets

This chapter describes scientific objectives based on observed parameters provided by the sensors aboard ADEOS-II. The scientific objectives of ADEOS-II are to use various sensors comprehensively and to contribute to clarifying Earth environmental changes. Such results won't come out or exist without the science based on each of the sensors. Thus, one scientific objective may overlap with a scientific objective of the sensors mentioned above.

ADEOS-II is an Earth environment observing satellite, so the related sciences are Aeronomy, Oceanography, Hydrology, Cryology, and Vegetation. Basically it is science related to water on the Earth's surface. Above all, it is important to obtain new knowledge about clouds, water vapor, soil moisture, snow runoff, snow ice, plant and organic materials in oceans that used to be difficult to estimate.

The next most important thing is to establish the point of view to make that knowledge comprehensive. For this, we must combine numerical models or ground validation data, and develop techniques and systematization that mobilizes all the knowledge and information we have. In other words, ADEOS-II science seeks to clarify climatic mechanisms of the Earth's environment based on establishing of this comprehensive technique.

1.2 Objectives

The ADEOS-II scientific objectives can be summarized into three parts.

(1) Understand the fixed quantity of the water-energy cycle in the climate system.
(2) Estimate the quantity of biomass and primal production in relation to the carbon cycle, which is responsible for global warming.
(3) Detect signal changes in long-term climatic changes, through continuous observations by ADEOS.

The investigation into "(1) water-energy cycle" is a distinguishing characteristic of the ADEOS-II mission. To support this objective, GLI will estimate clouds, water vapor, and aerosols; AMSR will estimate hydrology parameters like water vapor, precipitation, soil moisture, and snow runoff; Sea Winds will estimate ocean stress; POLDER will estimate aerosols; and ILAS-II will estimate ozone and the vertical distribution of very small amounts of gaseous components in the polar regions. Such data will be useful in understanding the fixed quantity of water-energy cycle on global scale. Continuous observations of ocean stress by SeaWinds, successor to NSCAT and QuickScat, will greatly contribute to explaining ocean dynamics.

At the same time, these estimates of parameters using satellites will never be accurate without precise and accurate ground validation programs. The Validation Plan must clearly describe the scientific objectives, implementation plan, data management, and major researchers, and it must be internationally open. Such a research plan cannot be prepared in a day or a night but will take a long time and will require international coordination. In this sense, we are planning to acquire the ground validation sites developed for ADEOS and GEWEX/GAME, expand them, and prepare and implement a comprehensive validation program. Fortunately, an international program called the Coordinated Enhanced Observing Period (CEOP) held in 2001 and 2002 proposed that the Japanese researchers serve as the leaders. We also need to consider joining forces with these projects.

Estimates of yield and chlorophyll a in relation to the carbon cycle are other distinguishing characteristics of ADEOS-II. GLI, which was improved from OCTS that flew aboard ADEOS, has multiple channels for receiving data and a high resolution of 250 meters. GLI continues from the successful OCTS and will work effectively to estimate ocean biomass, ocean primary productivity, land biomass, land primary productivity, and their fluctuations. ILAS-II, a follow-on satellite of ILAS, is capable of observing ozone in the polar regions and the vertical distribution of very small amounts of gaseous components. As such it will greatly contribute to developing stratospheric chemistry.

In addition, POLDER, that will fly aboard ADEOS-II and previously flew aboard ADEOS, will continuously tell us the global distribution of aerosol, which will be essential information for improving global warming predictions.

2. Aeronomy

2.1 Aeronomy with ADEOS-II

The ADEOS-II is a follow-on satellite of the ADEOS mission to monitor greenhouse effects and ozone depletion in the stratosphere. ADEOS ceased operating in the middle of its mission, so ADEOS-II basic objective in Aeronomy is long-term monitoring by continuing the ADEOS observations.

ADEOS will observe carbon circulation and the energy cycle to monitor greenhouse effects. Observation targets for energy cycle research include clouds, aerosols, air-ocean fluxes, and the Earth's surface (snow ice) albedo. For ADEOS-II observations, it is important to research the distribution and changes in properties of these parameters. Such a long-term monitoring mission will contribute to GCOS.

In addition, ADEOS-II will enable microwave observations and investigating the hydrologic cycle on a global scale as a research subject in the field of Agronomy. The water-energy cycle on global scale literally means global climatic changes. Our Earth is known as "the planet of water," and its environment is greatly influenced by water in a liquid state as ocean, inland water, soil moisture, and cloud water; in solid state as snow ice, ocean ice and ice crystal cloud grain, and in gaseous state as water vapor in the atmosphere. Hydrogical transfer among atmosphere, water, and ground involves transformation among these three states. It is thus an important phenomenon that generates short-term atmospheric changes and long-term climatic changes due to the interaction of sensible and latent heat, exchange of heat between the atmosphere and ocean, and radiation properties. It also influences ecosystems and geographical features. Observing changes in clouds and water vapor (cloud water amount and possible rain off amount) using GLI and AMSR (over the ocean) will be an important research theme. Also, observing ocean stress will rapidly progress in accuracy of estimating ocean surface fluxes.

Even though ADEOS-II was planned in Japan, it is necessary to promote global analysis of the three dimensional distribution of ocean near-surface wind and climatic value and changes in water vapor, clouds and precipitation, and to participate in related international projects such as GEWEX and CLIVAR. In recent years, researchers have pointed out the importance of observing aerosols. This is also an important research theme for ADEOS-II. General progress, including algorithm development, is desired.

The ADEOS-II is expected to contribute significantly to atmospheric chemistry in the stratosphere as well. Observing ozone and other atmospheric trace elements using ILAS-II will clarify various aspects of atmospheric chemistry for the stratosphere in the polar regions, which can be called natural laboratories.

2.2 Investigation into water cycle involving clouds

In climate models, it is difficult to qualitatively assess clouds. On the whole, ADEOS-II seeks to investigate the water-energy cycle, and both GLI and AMSR are ideal for investigating the water cycle involving clouds.

Lately, two new theories about the influences of clouds on the climate system have been proposed. One is "the thermostat theory" proposed by Ramanusam. It first notes that the maximum tropical sea-surface temperature has hardly changed throughout Earth's history. It then explains a mechanism by which the rising sea-surface temperature increases the cumulonimbus cloud top height. This subsequently reduces the ice grain size of the expanding anvil cloud, causing more sunlight to the reflected and thus reducing the sea surface temperature. It is doubtful whether the sea-surface temperature is stable. Even if it is stable, it is doubtful whether the sea-surface temperature was stable because of the thermostat effect. However, this proposal is significant at least in that it reminds us that cloud grain-size distribution can significantly affect radiation properties. Fortunately, GLI has channels that can estimate the cloud grain-size distribution. If the global distribution of cloud grain size were known, it would contribute to understanding our climate system.

The second new theory concerns cloud absorption of solar radiation. It says that, compared with the former theory, real clouds absorb more solar radiation than we thought. Similar results have been reported based on observations using satellites and aircraft. This theory has not been proven right or wrong. If is right, it would be necessary to rewrite the radiant codes for atmospheric models. Likewise, we would not able be to ignore the effects on atmospheric circulation. This problem should be resolved immediately. ADEOS-II is considered capable of solving this kind of problem.

The important global water-energy-cycle parameters are the quantity of water vapor transport and rainfall. Spatial fluctuation of water vapor and precipitation is small in the horizontal plane, and it is difficult to analyze the parameters using only existing data. Thus, there is need to develop a method of analyzing parameters by using microwave data. Precipitation is the primary theme of TRMM, and results of precipitation distribution estimated by the developed TMI will be continued by AMSR. As a result, ADEOS will continue TRMM's global observations of precipitation. In this regard, joint observation by TMI and AMSR is indispensable.

2.3 Investigation into influence on aerosols

In cloud physics, aerosols have been of scientific interest as an atmospheric component and as a factor in the cloud condensation nucleus and in the circulation of matter. Recently, the influence of aerosols on the radiation process, however, has been getting more attention from scientists. One reason is that it has been reported that the solar incidence onto the sea surface used for global numerical prediction models tends to exceed actual observations. The fact is that we are unable to verify it because of the lack of observations indicating how much aerosol actually exits in the atmosphere.

Another reason is that a recent experiment has shown that the simulation of global warming agrees with actual data if it takes into account that aerosols have been increasing due to development of economic activities. (For this experiment, refer to the second report of the Intergovernmental Panel on Climate Change (IPCC).) Aerosols affect and restrain global warming by reflecting solar radiation due both to the increase of aerosols and to the increase of lower-layer clouds caused by emitted aerosols. However, aerosols do not produce a "soot-covered effect." If aerosols did create black clouds, they would absorb solar radiation, which is far from restraining the global warming.

For this reason, ADESO-II will carry a sensor that builds upon the ADEOS sensor to observe aerosols. If the global aerosol distribution and its seasonal change were provided for the data set, it would contribute significantly to solving the global-warming problem.

2.4 Investigation into aeronomy in the polar regions

The stratospheric ozone depletion problem has been severe, particularly in the polar region. As concern about the trend increased all over the world, an international cooperative outline was developed. The Vienna protocol of 1995 was drafted to protect the ozone layer, and the Montreal protocol was concluded in 1987. In the field of observations, member countries of the treaty are required to promote organized observations, including use of satellites, to monitor the ozone layer condition. ADEOS-II will carry the ILAS-II sensor that builds upon the ILAS sensor flown on ADEOS. The scientific objective of ILAS-II is to keep continuous watch over the ozone layer fluctuation and to resolve chemical and physical processes of the ozone layer. It will significantly contribute to organized ozone-layer observations from space. In addition to the ozone layer, this sensor also monitors nitrogen oxide, CFC, and other atmospheric trace elements. Those data will give us important information, particularly for understanding atmospheric chemical reactions in the polar regions, such as the ozone hole. Improving ozone hole detection and prediction and investigating the role of polar stratosphere clouds (PSC) will contribute to the atmospheric science of polar regions.

3. Oceanography

3.1 Oceanography with ADEOS-II

Although ADEOS-II is an ADEOS follow-on satellite, it builds up the fundamental scientific objectives even more clearly. The scientific objectives are (1) to investigate the water-energy cycle, and (2) to investigate chlorophyll a /vegetation distribution that plays an important role in carbon circulation. The ocean clearly plays a very important role in both research subjects, and the most important tasks assigned to ADEOS-II is to investigate the role of the ocean in the circulation of water-energy and carbon. Both of those research subjects are important task that correspond to international research projects such as the WCRP/GEWX&CLIVAR, IGBP (JGOFS, LOICZ), and GOOS. In the water-energy cycle, marine meteorology and physical oceanography that involve momentum fluxes and heat fluxes in the seawater surface will take a leading part in the research on carbon circulation. Marine biophysics will have a major role in the research. Together, they are two pillars in oceanography research supported by ADEOS-II.

Frequent abnormal weather phenomena have increased social concern about climate change problems. To solve such climate change problems, it is necessary to understand the climate system. In recent years, we have rapidly come to understand that the ocean plays very important roles in the global climate system. The climate system is fundamentally considered as a water-energy cycle. The roles of the ocean in the process can be categorized into two parts: water-energy transfer between oceans and the atmosphere, and water-energy transfer below the ocean surface. Clarifying the role of oceans in both processes is necessary for understanding the global climate system. Satellite use may make this possible for the first time.

Global warming caused by increased carbon dioxide gas in the atmosphere has unveiled important implications for earth environmental problems in recent years. As a result, investigations into the carbon circulation process on a global scale have been accelerated. The ocean accounts for about a half of the biogeochemical cycle of carbon compounds. Serious efforts to clarify the role of the ocean in global carbon cycle processes should thus be promoted. However, we are now at a turning point concerning how we look at the ocean as a source of food production for human beings. Most major marine resources have already been developed, and it is the necessary to plan more effective and lasting use of sea productivity. Research on the food chain cycle based on sea primary productivity is related to the research on the carbon cycle. Humans must conduct research on ocean primary productivity on a global scale from the viewpoints of both environmental and food resources concerns.

3.2 Marine metrology and physical oceanography

3.2.1 Sea surface fluxes measurement using the satellite

The first problem we encounter when thinking of the water-energy cycle is the surface fluxes between the atmosphere and the ocean. Surface fluxes set up the boundary conditions of circulation of the ocean or the atmosphere. Understanding sea fluxes is necessary for understanding atmosphere-ocean interactions. Heat flux from the ocean to the atmosphere is a dynamic in the atmosphere cycle. If its value can be estimated precisely on a global scale, more accurate and precise weather forecasting and longer period forecasting will be possible. However, it is logically impossible to observe regions below the ocean from a satellite. Basically, only information about the sea surface can be observed, so accurate and precise estimates of sea-surface fluxes are important objectives for ADEOS-II. There are two types of seawater surface fluxes. One is a parameter of first-order that can be estimated directly from the sensors aboard ADEOS-II. The other is a parameter of second–order that can be estimated from the several sensors together.

(1) First-order Parameter Calculation Algorithm Development

The near sea surface velocity considered a first-order surface flux is parameter. Here we will omit the specific explanation about the near sea surface velocity since we have already explained it in GLI chapter. Although the momentum fluxes are important dynamic factors for the ocean, we suppose they can be easily calculated from first-order parameters. The most desired first-order parameter is the sea-surface temperature that can be provided by AMSR even under cloud cover. Estimating sea-surface temperature under cloudy cover was impossible with a thermal infrared radiometer. This used to be a major impediment to the progress of oceanography. AMSR is expected to provide continuous space-time sea surface temperature observations from space, greatly reducing system errors in previous turbulent heat flux calculations.

Moreover, we expect that simultaneous observation of sea surface temperature with other data will lead to highly accurate evaluation of turbulent heat fluxes. These points are considered as remarkable, and the ADEOS-II can make it possible for the first time

(2) Second-order Parameter Algorithm Development

Not all composites of higher-order parameters can be computed for surface fluxes as second-order parameters. Also, it is necessary to note that surface fluxes are computed generally by bulk methods. For instance, estimating latent heat fluxes requires saturation specific humidity, sea surface specific humidity, wind velocity, etc. However sea-surface specific humidity is computed empirically using the rainfall amount because it is not a first-order parameter. Consequently it is also necessary to develop a method of estimating parameters like this one that require the bulk method.

Sea-surface fluxes expected to be estimated by using the sensors aboard the ADEOS-II are turbulent heat fluxes (sensible heat/latent heat fluxes), momentum fluxes, fresh-water fluxes, radiation fluxes, carbon dioxide fluxes, and others. Most flux data were supposed to be estimated using ADEOS, but this was impossible due to ADEOS's failure. Real acquisition of flux data will thus be made possible by ADEOS-II for the first time

(3) Development of Techniques for Combining and Assimilating Remote Sensing Data with Numerical Models

We will reach a limitation if we only improve algorithms in order to estimate each atmosphere-ocean flux over greater areas and with higher accuracy, which is the fundamental purpose of ADEOS-II. Combination with or assimilation into numerical models like an air circulation model is surely needed. Development of techniques for such combination or assimilation is an important research subject. Each weather organization has already assimilated satellite data and atmospheric circulation models or has started discussing this, and the results are very promising. Such activities will advance the assimilation method itself, and it is predicted that this field will be expanded.

(4) In Situ Observations, or Evaluation of Outcome by using Numerical Model

Estimated sea surface fluxes must be evaluated by using in situ data acquired by buoys or vessels. However, buoy and vessel observations cannot evaluate fluxes that are estimated in very limited locations. It is thus necessary to evaluate fluxes using the results from the models of the oceanic or atmospheric circulation with estimated flux inputs.

3.2.2 Investigation into ocean circulation mechanism

What the scientific objectives and results to can be achieved using each flux? As we mentioned previously, the most important scientific objective of ADEOS-II is to investigate the role of the ocean in the water-energy and matter cycle. If we perfectly and precisely understand the quantity of each flux over the ocean, we will understand the static oceanography. However, this won't solve the essential part of the role of the ocean in the water-energy and matter cycle. We need to understand the sea-surface fluxes or ocean circulation mechanisms, involved in distribution in the ocean. A number of researchers input or assimilate surface fluxes obtained from the satellite into ocean circulation models to understand and predict these phenomena. These researchers perform monitoring. We emphasize here that developing a numerical model is essential for both research endeavors.

(1) Quantitative Estimates of Oceanic Heat Transfer

Much research has been conducted on oceanic heat transfer, primarily using satellite data. However, because of the low space-time density of observations data, the research results have had very large average scales. Since the errors were very large, the results obtained differed considerably. If we cloud understand ocean circulation accurately, we could improve the accuracy of estimating heat flow.

(2) Understanding Ocean Circulation in Tropical Regions

A large amount of thermal energy is accumulated in tropical regions, and changes beneath the tropical ocean like El Niño greatly affect global climatic change. Thus, understanding the ocean circulation is very important, not only in tropical but also in global climate systems. The problem of the Indonesian through-flow is very important from the viewpoint of ocean heat flow.

(3) Ocean Circulation in Subtropical Regions including Kuroshio Current and Other West Coast Boundary Layer Currents

Kuroshio Current is one of the west-coast boundary currents that forms the ocean circulation in the subtropical regions and greatly affects the climate and fisheries industry in Japan. Thus, understanding the ocean circulation in the subtropical regions including Kuroshio Current by using the satellite data will be very socially significant. Also, the development of data assimilation systems will enable us to predict changes in the Kuroshio Current. Highly accurate observations of sea-surface height using TOPEX/POSEIDON have rapidly advanced the data assimilation of the ocean circulation models in recent years. Moreover, JASON 1, the follow-on to TOPEX/POSEIDON, will continuously conduct highly accurate observations on the sea surface and will greatly affect the observational data of ADEOS-II.

(4) Investigation into Water Mass Formation and Transfer Process

The water masses with distinguishing characteristics are North Pacific mesothermal layer, the Sub-tropical mode water, and other. Although the existence of the water mass already have been known, its formation, transfer, and transform process have not been understood well. We can easily imagine that interaction between the sea surface and the atmosphere is essentially important for the water mass formation. Thus, the sea-surface fluxes estimated by satellites will be important information for water mass formation of ocean surface layer and will play the important role in solving its mechanism.

(5) Research on ocean pollutants and floating wreckage

The problems of tanker oil spills and the spread of illegally dumped pollutants have raised severe public criticism. Those are very significant problems for mankind. These subjects are directly connected to the ocean circulation and definitely need information about sea-surface fluxes. Thus, it is urgently necessary to solve problems like those using satellite data and ocean circulation models.

(6) Development of Techniques to Forecast Water Condition in Fisheries Zones

We know that the ocean circulation greatly influences the fisheries industry. Thus, it is important to accurately forecast water conditions in the fisheries zone by using information obtained from sea-surface fluxes or by combining these fluxes with information obtained from ocean circulation models. Also, this subject is strongly by related to research on marine biophysics.

3.3 Marine biophysics

3.3.1 Estimates of biomass and productivity

Carbon-containing material is transformed from inorganic to organic elements by photosynthesis by phytoplankton in seawater. This is called primary production, and it is an important food chain process supporting fishery resources and helps account for circulation beneath the ocean. Photosynthesis by phytoplankton beneath the ocean is thought to account for 30% or more of the total photosynthesis on the Earth. Techniques for creating maps of chlorophyll a concentration, an indicator of phytoplankton near the ocean surface, were almost completed using OCTS and POLDER aboard ADEOS and in the SeaWiFS project. We have been acquiring knowledge on the seasonal fluctuation in the chlorophyll a distribution. GLI will replace OCTS and SeaWiFS in playing an important role in mapping the chlorophyll a concentration during the next decade. In addition to conducting follow-on observations of chlorophyll a, we expect to gain an understanding of phytoplankton pigments along the coastal region, the material originating from land, pigments in phytoplankton, and primary production and export production measurements and CO2 fluxes between the atmosphere and the oceans.

(1) Distribution of Chlorophyll a Concentration under Oceans

The in-situ chlorophyll a concentration near the ocean surface can be measured globally from OCTS. Moreover, the chlorophyll a concentration has been measured similarly by the US SeaWiFS even after the failure of ADEOS. The ADEOS-II mission will take over data collection from OCTS, POLDER, and SeaWIFS and clearly reveal global changes in chlorophyll a distribution in ocean regions over about a decade. To compare the data of these different sensors, GLI will improve its accuracy of chlorophyll a concentration measurement by a factor of 1.5. We will then need to clarify the accuracy of the standard upward radiation brightness, which serves as a basis of the chlorophyll a concentration measurement.

(2) Estimates of Chlorophyll a Concentration and Dissolved Colored Organic material/Weight of Suspended Minerals

A technique to measure chlorophyll a in open oceans where optical characteristic are determined by phytoplankton (called water I) was established using OCTS. However, the technique still had difficulties measuring chlorophyll a in coastal areas where dissolved colored organic material and/or suspended minerals and matter other than phytoplankton might influence optical properties (called water II). GLI aboard ADEOS-II is expected to estimate dissolved colored, suspended minerals, and other matter and is also expected to measure the exact chlorophyll a concentration in mixed waters.

(3) Estimates of Other Phytoplankton Pigments

Different oceans have different formations of taxon of chlorophyll a phytoplankton, and they are categorized by their copigments. GLI has observation bands that can estimate important pigments and copigments of phytoplankton, enabling GLI to distinguish different water masses for formation of taxon. Since these taxons each play different roles in matter circulation or the food chain, categorizing taxons will be a major advancement.

(4) Estimates of Primary Production

An objective of an ocean color sensor is to monitor primary productivity over large area. OCTS and SeaWiFS have not been able to create an internationally agreed primary production algorithm. GLI is expected to produce a series of space-time distributions of primary production by completing a primary production algorithm based on sea-surface temperature, sea-surface chlorophyll a, and bottom radiance.

(5) Estimates of Export Production/CO2 Fluxes

The carbon transformed from inorganic into organic constituents by ocean primary production, which transfers from, carbon the sea surface to mesobenthic sediment, is called export production. Export production is a very important process in the carbon circulation cycle because it transfers the carbon from the surface, where it contacts carbon in the atmosphere, to the mesobenthic, where it does not contact the atmosphere directly. Methods to compute export production have been studied with OCT, and will continue to be important research with ADESO-II. Also, SeaWinds ocean near-surface wind data is expected to yield the CO2 molecular concentration due to living creatures in the sea surface and to support research to obtain CO2 fluxes between the atmosphere and the oceans.

3.3.2 Investigation into mechanism of constituents circulation and food chain in ocean

(1) Understanding the Mechanism of Constituent Circulation and Food Chain in Ocean

ADEOS enabled more accurate measurements of chlorophyll a concentration in open oceans, which an index of phytoplankton producing primary production. A time series of chlorophyll a on a global scale extending nearly a decade will be acquired by ADEOS-II, including ADEOS and SeaWiFS. In particular, we expect to clarify the chlorophyll a fluctuation, as ADEOS has already proven that a combination with ocean near surface wind is effective. Moreover, estimates of primary production and new production based on chlorophyll a concentration have become possible to a certain degree, as has observation of the fluctuation in speed of constituent export. Also, separating taxons that play different roles in constituent circulation is expected to expand our horizons with regard to the relationship of the mechanism of constituent circulation and the ecosystem.

(2) Understanding Constituent Circulation in Continental Shelf Regions

ADEOS enabled measuring chlorophyll a in open oceans where phytoplankton determines the optical properties. However, use of ADEOS was limited along the coasts where dissolved colored organic materials, suspended minerals and matters other than phytoplankton might significantly influence optical properties. ADEOS-II will enable us to measure a certain amount of chlorophyll a in these kinds of oceans, so that it will be possible to understand biomass production along continental shelves that play important roles in constituent circulation and production of fisheries resource. Moreover, many dissolved colored organic materials, suspended minerals and others originate from land and have been playing important roles in matter circulation. If we could understand the fluctuations, it might be possible to clarify the mechanism of constituent circulation and the food chain along continental shelves.

(3) Monitoring Red Tide and Toxic Algae Bloom

Recently, red and toxic algae bloom phenomena and their influence on fisheries have become serious problems in Southeast Asia. ADEOS-II will enable monitoring red tides and toxic algae blooms by clarifying the distribution and fluctuation land originating materials like phytoplankton pigments along coast. In particular, the environment in the South Asia has been heavily impacted by human activity, and monitoring is greatly needed.

(4) Research on Fluctuation in Higher Order Production and Use of Maintain of Marine Organism Resource

Organic materials produced by phytoplankton support marine resources like fish, which human beings then use. Today, continued availability of marine organism resources has become doubtful due to over hunting or environmental destruction. To quantitatively estimate marine organism resources, we have depended on empirical information, and the relationship between the oceanic environment and fluctuation in quantitative resources has been getting clear. We need accurate research on how much of the organic materials produced by phytoplankton are supplied to marine organism resources, how it is processed, and what should be done to maintain marine organism resources. Information that is being proven by ADEOS-II will be essential for this research.

(5) Development of Efficient Use System of Marine Organism Resource

An efficient system is needed in order to use marine organism resources. By further advancing extraction of fishery information that is being proven by ADEOS-II data, we expect to develop a system to use marine organism resources more efficiently.

(6) Development of Technique Combining Satellite Data with Numerical Models of Matter Circulation and Ocean Ecosystem

Today, circulation models and food chain models have been advanced for various ocean areas from global to the coastal regions. These numerical models are expected to provide a means to predict important items in the near future. ADEOS-II data is expected to be used as information for the input to these numerical models, for verification, and for further assimilation.

4 Hydrology

4.1 Development of Hydrology with ADEOS-II

Modeling the water-heat cycle on a global scale is important for predicting climatic change and evaluating its effects. In particular, understanding a fixed quantity of heat and water fluxes of the Earth's surface on a global scale based on interaction between the atmosphere and soil surface, which plays a role in climate system, is essential to improving global climatic change prediction accuracy. However, the work has not been started yet since it is difficult to measure fluxes of the Earth's surface directly on a global scale and to collect information of precipitation and inland water content (soil moisture and snow cover) to estimate the data over a large region.

ADEOS-II is a global observation satellite that will provide high-resolution temporal and spectral data of the visible spectrum, near infrared, thermal infrared, and microwave regions that are useful for estimating inland primary order water such as precipitation, vegetation, ground temperature, albedo, radiation balance, soil moisture/water content, and snow cover. In particular, AMSR will attempt to globally observe soil moisture and snow in a fixed quantity for the first time, and to improve the estimate accuracy by incorporating GLI data. GLI's 250m channels will provide global detailed data on vegetation, ground temperature, and albedo for the first time and acquire information for effective research on the influences of human activities on the hydrologic cycle as well as evaluate climate influences on human activities. Moreover, the combination of TRMM products and improved accuracy in estimating inland precipitation with combed data of AMSR and GLI will be important for hydrology.

To estimate sensible heat fluxes, latent heat fluxes, and river runoff on a global scale by using these primary order water amounts, we must develop heat-water export and river runoff models of the land-atmosphere interface based on an understanding and global analysis of hydrologic processes in various soil surfaces. These subjects have been studied internationally by WCRP/GEWEX. The hydrologists and meteorologists in Japan have been cooperating in and promoting GAME, an international joint study for the water-heat cycle on the Eurasian Continent in order to predict and understand fluctuations in Asian monsoons. Comprehensive observation data covering a very wide area that was previously impossible have been simultaneously acquired with the satellite data, and various analyses have been conducted. The success in water-energy cycle observation research, based on close cooperation among international science projects and the satellite observation plans, demonstrated that cooperation with these international projects is more important when considering effective use of the ADEOS-II data as well as effective algorithm development and validation.

4.2 Estimates of Primary Order of Water Amount

(1) Soil Moisture

Land-atmosphere interaction through the hydrologic cycle is very influential on the climate system. To manage seasonally and yearly water resources and predict long-term fluctuations in water resources due to climate change, we must establish a system to observe hydrologic conditions on a global scale, where fluctuations are spatially and temporally large. Simulations using climate models indicate that soil moisture is a major factor in fluctuation in climatic formation and controls transfer of energy to or from fluxes of infraction radiate, sensible heat, latent heat and underground heat by suppressing evapotranspiration. Soil moisture controls heat and water export into the atmosphere by controlling the evaporation efficiency and changing the Bowen ratio in the short term and works as a climate memory in the intermediate and long term. To calculate the radiation balance, we must determine sensible heat/latent heat fluxes, soil moisture, and runoff. For this calculation, the surface-boundary layer scheme of the ECMWF has been improved from surface data obtained by FIFE. This research developed into research to improve the accuracy of precipitation prediction accuracy of the 1993 Mississippi massive flood period. The importance of global mapping of soil moisture to improve the accuracy of long-term weather forecasting has been recognized all over the world and was the reason for initiating the Global Soil Wetness Project (GSWP). Seasonal snow melting of permafrost over the Eurasian Continent, the North American Continent, and the Tibetan Plateau affects soil moisture results in the seasonal change of the field capacity (water volume remaining in the soil after rain is drained by gravity) due to changes in the active layer. Furthermore, the frozen ground is presumed to influence atmospheric circulation as much as or more than snow coverage by the weather conditions of the previous year, i.e. the active layer and soil moisture of summer or autumn are conserved until spring of the next year.

Ideally, soil moisture observations should be made by instruments installed uniformly and equally over the Earth’s surface. In reality, however, the density of instruments already installed as observation points is very low. For instance, soil moisture has been regularly observed only in Russia, Chiba, and a part of the US. In recent years, advances in microwave instrument technology have suggested the possibility of observing land water amounts under all weather conditions. Since water has a high dielectric constant, microwave remote sensing can observe fixed, quantitative water amounts by directly measuring the dielectric constant. Also, microwave remote sensing has the advantage that polarization dependence of emission effects of microwave transfer can be accommodated in the algorithm. Research on algorithm development for microwave radiometers that measure soil moisture considering the effects of vegetation was initiated based on an experimental study using the microwave radiometers on the ground and in the air. Furthermore, research on satellite use, employing AMMR and AAM/I, has been conducted. These research activities are categorized into three parts.

#1 Soil Moisture Statistic Calculation Method, Taking Account of Vegetation Effects
#2 Estimates of Vegetation by Index
#3 Real-Time Estimates of Soil Moisture/Vegetation/Surface Temperature

The first activity category calculates soil moisture with the effect of vegetation removed by statistical methods, and introduces a vegetation index obtained from visible –near infrared spectrum data or vegetation effects estimated from land use sections. The second category calculates vegetation biomass based on polarization characteristics of scattering due to vegetation. The third category obtains the parameters corresponding to each hydrologic category by solving simultaneous equations of radioactive transfer obtained from the observation data with various frequencies and multiple polarizations. It is a generalized method based on physics. Based on #3, E. Njoke formulizes problems as three simultaneous equations and proposes a numerical solution method. Koike invokes method #2, building his argument on the fact that a numerical solution method produces an unstable solution and makes it difficult to physically understand the grast convergence of the solution. He proposes an algorithm that calculates surface physical temperature, removes the effects of surface physical temperature from three unknowns, obtains soil moisture and vegetation water content, and substitute its results into the radioactive transfer equation.

(2) Snow Accumulation

Effects of continental seasonal heating on seasonal or yearly changes in climate were investigated from the viewpoint of changes in snow accumulation. Hahn and Shukula have shown that there is an inverse correlation between the snow cover area during winter on the Eurasia Continent and precipitation during Indian monsoons the following summer. Observations have not yet verified observations that snow cover variations between winter and spring greatly affect Asian monsoons of the summer and atmospheric circulation. However, this has been verified with the Global Circulation Models (GCM) that Burnet and Yasunari worked on. The mechanism is remarkable not only due to the albedo effects of snow cover surface but also the influence that moisture due to melting snow has on the surface heat budget of summer.

Numerous of algorithms have been applied to estimate snow accumulation. Most of these are basically intended for dried snow, estimating only extinction when radiation from the ground is transmitted into the of snow-cover layer, estimating only extinction when emission due to scatters transmits energy into the layer of snow cover, or adding emission to it. Most of them used 19GHz or 37GHz. If information about grain size is added, snow accumulation water content could be estimated with high accuracy, and incorporating information about grain size is key to algorithm development. Tsang combines snow cover models and microwave radioactive transfer models and develops snow accumulation calculation models considering grain size change using neural networks. The effect vegetation has on the snow accumulation calculation is also important. Cheung has thus introduced statistical vegetation effect models that correspond to the vegetation categories into a snow accumulation calculation algorithm. Koike proposed a method that introduces extinction effects of vegetation estimated by NDVI into the microwave radioactive transfer equation and estimates snow accumulation water content and snow temperature simultaneously by using 19GHz and 37GHz. If snow cover were deep or grain size long, or extinction due to the vegetation layer large, high-frequency information would be lost due to extinction effects. Consequently, for snow cover observation in regions with heavy snowfall, frost crust layers, or forests, it is important to develop algorithms using low-frequency observation data, which AMSR enables for the first time.

(3) Vegetation, Ground Temperature, and Albedo

A number of algorithms have already been proposed for land-surface information acquisition, and global products based on NOAA/AVHRR data have been provided. However, GLI has high spectral resolution and channels of 250m, the same as LANDSAT/TM. Consequently, it will be possible to develop more quantitatively accurate global products than ever before possible.

Current problems include the lack of observation data about spectrum reflectance factors and radiation from the visible spectrum to infrared received from various types of land surfaces. Real-time quantitative observation data for land-surface classification has been acquired. However, parameters such as surface albedo, absorbed photo synthetically active radiation (APAR), and land surface physical temperature have rarely been observed with atmospheric parameters such as the atmospheric permeability factor, path radiance, or rate of directly diffused solar radiation, and this has obstructed algorithm development. Intensive and comprehensive real-time satellite observations with ground observations are required, and long-term ground observation systems must be prepared.

Moreover, methods to measure land surface features even more accurately have been advanced in recent years by the improved spatial resolution of the sensors. These methods enable calculating the area rate of category items for each pixel and are important research subjects when we consider higher-level land-surface observation by GLI, which has moderate to high spectrum resolution. To establish analysis methods and create global data sets, we must perform real-time specific satellite observations within 1km pixel under various climatic and geographical conditions and collect basic data for pixel resolutions.

(4) Precipitation

Precipitation is a hydrological process that balances moisture in lands regions. We really need to perform the actual observations because estimates by atmospheric models have been unreliable. Precipitation phenomena occur in a shorter period and are more local than other hydrological phenomenon. Moreover, there are remarkable regions that show daily fluctuation. With the global observation of precipitation, monthly data (2.5-degree grids) have been created by combining ground rain gauge data, infrared data from geostationary satellites, and microwave radiometer data for the Global Precipitation Climate Project (GPCP) under WCRP/GEWEX. Attempts to create one-degree grid data sets have also been made. However, the relationship between precipitation in land regions and satellite measurements has remarkable regional and seasonal characteristics. The observation accuracy is low, especially in high-latitude regions and land regions where only precipitation observations are performed.

In recent years, precipitation estimating algorithms have been developed by combining microwave radiometers and thermal infrared radiometers. However, this is effective only over the ocean where the surface emission is limited. The accuracy of estimates over land regions prepared using scatter algorithms is quite low. The problems in observing precipitation over land are shown below.

#1. Since the land surface has a high rate of emission and is quiet uneven, it is difficult to acquire signals for precipitation in the atmosphere.

#2. The precipitation system is influenced by topography and hydrologic states of the surface, and has complex spatial and timely changes.
It influences the vertical profile of precipitation and greatly affects the accuracy of precipitation calculations.

#3. Precipitation in high-latitude regions usually is solid, but solid precipitation calculation algorithms have not been developed yet.

For #1, an algorithm for calculating soil moisture, ground temperature, and vegetation water content for land surfaces using information acquired at low frequencies (6.9 to 36.5GHz) has been proposed in recent years, and the accuracy of estimating the land surface radiation rate has been improved. Moreover, algorithm to calculate the state of the land surface and precipitation system simultaneously has been developed by combing the low-frequency band and high-frequency band (85GHz). However, in #2, the vertical profile of precipitation has great influence, so active sensors for vertical profile observations and microwave from low to high frequency require integrated observations using a radiometer. In particular, the relevance of the vertical profile of solid rain grains in the upper precipitation system has been pointed out, and integrated observations using high-frequency (35GHz) radar for solid precipitation and low-intensity precipitation are expected in addition to the TRMM type 14GHz radar. Since it is difficult to distinguish between snow cover and snowfall especially when the land surface is covered by snow, problem #3 and its related algorithm development are expected to receive attention in the future.

Combining the precipitation radar, the microwave radiometer, and the visible thermal infrared radiometer aboard TRMM, which was launched in 1997, has enabled acquiring the vertical profile of raindrop backscatters as well as microwave and visible thermal infrared radiation simultaneously for the first time. Based on these data, development of new algorithms for estimating precipitation over land will be developed. However, TRMM is limited to observing areas between 35 degrees north and south latitude. Increased sampling frequency is also necessary for precipitation data when changes are not remarkable. To solve this, we plan to conduct observations every three hours using microwave radiometers aboard eight satellites (GPM). Improved accuracy of the microwave radiometer for global precipitation is also expected.

Combining AMSR and GLI will provide higher resolutions for real-time global data acquisition in microwave and visible thermal infrared bands. It raises the possibility of global precipitation mapping in land regions based on algorithms for estimating precipitation in land regions obtained by the TRMM. Also, by combing products derived from ANSR-E and MODIS aboard EOS-PM1, we can expect to improve of daily change observations and sampling frequency. This will enable providing basic data sets for global observation by GRM.

4.3 Tasks of Algorithm Development and Validation

The major problem with algorithm development and validation for primary water quantity is that land is much more uneven than the atmosphere or the sea surface. Determining how to acquire ground validation data at 50km spatial resolution in 6.9GHz bands of the AMSR and what kind of effects unevenness in pixels has on antenna brightness are especially important subjects. In this case, we must acquire data over a large area with a uniform pixel size, consider its spatial distribution characteristics, and estimate the average scale of spatial resolution of the satellite sensor. Airborne observations are indispensable for data collection. In recent years, the average hydrologic estimate method applied to complex land surfaces has been thoroughly researched as a part of scheme development. This method integrated land surface-atmosphere interaction into the GCM. It has been called the development of “macro hydrology model” and has become an important subject in the Japan-led GAME project. “Macro” here does not mean a certain size but a method of converting small-scale hydrology models to large-scale hydrology models without losing non-linear properties. GAME seeks to improve the GCM, and research focusing on a meso-scale grid several tens of kilometers in size has been promoted. This is on the same scale as AMSR’s spatial resolution at 6.9GHz and is a very effective strategy for using satellite data and developing models to advance research and development.

Basic parameters of electromagnetic transfer needed to determine primary water quantity must also be acquired for algorithm development. I particular, visible-infrared spectrum reflectance factor data, satellite real-time observation data of land surface water quantity, and atmospheric physics are unsatisfactory, and joint research should be promoted in hydrology, vegetation, and the atmosphere

5. CRYOLOGY

5.1 Development of Cryology with ADEOS-II

The tendency of increasing temperature since the Little Ice Age of the 18th century and the effects of global warming due to recent increasing green house effect strongly influence fluctuation in the snow ice sphere, especially in the polar regions. Continuous observations are required because continuous monitoring of the sea ice distribution and the ice sheet distribution in the snow and ice cover regions on the Earth take a long time. Some effects directly caused by global warming directly are the reduction of sea-ice distribution, the increase in snowfall above the ice sheet, the increasing of the melting area surrounding the ice sheet, and the increasing outflows of icebergs. Continuous, long-term observations to investigate the processes of these cryological phenomena centered in the Polar Regions are very important.

The most important way to continue observing and monitoring the snow ice sphere and the Polar Regions is to use satellite observations. The combined use of multiple sensors covering the visible spectrum to microwave frequencies is important in understanding fluctuations in the distribution of the snow-ice sphere. However, use of microwaves is more effective since it is usually cloudy and nights are long in the Polar Regions.

With GLI and the AMSR playing the central roles, ADEOS-II mission will be able to perform observations at higher resolutions than conventional sensors. For instance, glaciers, ice sheets, and changes in the ice sheet edges can be mapped to monitor the snow-ice sphere change due to the greenhouse effect. Albedo of ice sheet and change in the characteristics of surface snow cover can be observed by using SeaWinds and POLDER.

Earth glaciers have been receding due to rising temperatures since the Little Ice Age. Although we have gained observational experience and conducted research using the models, we still do not know in detail the speed and process by which glaciers grow due to the severe environment in the polar regions.

GLI has multiple channels and high resolution, and its stereovision might enable detecting changes in topography and thickness. Moreover, GLI can detect optical properties of the snow ice surface as changes in the albedo of glacier, ice sheet surface, and sea that are closely related to temperature increases. In addition, spectrum information obtained from GLI and POLDER us useful for detecting minerals in the snow-ice surface and dirt due to bio-bacteria activity based on changes in the albedo and spectrum. Polarization information provided by POLDER are useful for estimating atmospheric correction and changes in albedo of the snow-ice surface.

The long-wave multiple polarization information provided by AMSR helps us understand the interaction of snow-ice areas and the surrounding large ice sheets and the interaction between the atmosphere and the snow-ice surface. These data are important for understanding the ice sheet-atmosphere interaction with matter and the process of mass balance in ice.

Interactions among sea ice in the polar regions, the ocean, and the biosphere are subjects for sea-ice research. Monitoring the distribution of the water surface and thin ice in sea ice and thick sea ice is useful for understanding primary biomass production. To acquire information needed for these research subjects, we will investigate the mass balance of sea ice calculated from sea-ice thickness and flow speed, heat transfer between the atmosphere and the ocean, fluxes of gas and water vapor, effects of snow cover on sea-ice growth processes, sea-ice growth rate, brine discharge rate ocean concentration and circulation, radiation balance and change as reflected in the albedo of the sea-ice surface, temperature of the sea-ice, and seasonal and spatial changes in primary biomass production and their processes.

5.2 Change in distribution of Ocean Ice, Glacial and Ice Sheet /Science with Microwave

AMSR can extract various hydrologic parameters, such as water vapor in the atmosphere, cloud water, precipitation, snowfall on land, soil moisture, sea near surface wind velocity, ocean temperature, sea ice, and snowfall on ice sheet in Antarctica by estimating weak microwave signals emitted by the Earth's surface. Since microwave characteristics depend on the state of matter, water (H_2O) gas, liquid, or solid phases can be discriminated with high accuracy multi-frequency techniques.

AMSR has a 2m diameter antenna that enables high spatial resolution and data acquisition in low frequency bands (6 and 10GHz). By emphasizing high spatial resolution and low-frequency data analysis, we will monitor and investigate phenomena occurring in the snow ice sphere. Furthermore, microwave radiometer data obtained from GLI and AMSR will be used together for analysis. Since global data can be obtained in near real time, we will attempt to demonstrate practical use of microwave radiometer data for forecasting and other activities.

To accomplish these research objectives, we will develop and improve algorithms for AMSR using airborne microwave radiometer (AMR) data, for airborne observation and the microwave radiometer (SSM/I) data of DMSP. Calibration and data creation methods will be established to guarantee data quantity.

(1) Snowfall distribution, snowfall area, permafrost

Investigating the changes in snow cover distribution and area is very important for monitoring greenhouse effects. There are many research themes since the rate of radiation is not well known for land. First, seasonal changes in vertically and horizontally polarized microwave radiation from the land surface in each category will be investigated from the SSM/I data. Second, we will investigate AMSR data and examine whether snow cover and soil moisture can be derived from temperature data. Since microwave radiation rapidly changes its phase as it passes from water to ice or from ice to water, it will be relatively easy to detect the surface condition.

(2) Sea-ice distribution and sea ice density

Seasonal changes of sea ice regions surrounding Antarctica are significant. A vast area of 3,500,000 square km is covered by sea ice during the summer, and 20 million square km, during winter. Furthermore, the Eurasian Continent and the North American Continent surround the Arctic Ocean. Since most of the Arctic Ocean is covered by sea ice, the increase and decrease of sea ice play important roles in controlling the heat balance and the ocean circulation. Yearly changes in sea-ice distribution are important early indicators of global warming. It will be possible for AMSR to roughly determine the distribution in the southern and northern hemispheres.

Although many sea ice observations have been performed since the early 1970s using microwave radiometers, the relationship between emissive of sea ice and physical characteristics has not been well understood. This is because the spatial resolutions of the radiometers aboard the satellites were several kilometers, producing a large mesh and the kind of sea ice was not uniform in that range. When snow accumulates on sea ice, emissivity changes, and the temperature of sea ice or snow sometimes changes by 10 degrees depending on the atmospheric temperature. To obtain basic data, it is necessary to match AMR the observations using to truth data.

(3) Fluctuation in ice sheet distribution

Continuous microwave observations of changes in the ice-sheet distribution in Greenland and Antarctica are important for determining the influences of global warming. The observations of snow accumulation on ice sheets, peripheral melting regions, outflow of glaciers, and seasonal and yearly changes of brightness temperature of the entire area of the ice sheet are also important.

In observing the ice sheet mass balance in the Antarctic, changes due to accumulation of ice contained in ice sheets in inland regions will contributes to the balance of mass as snow ice of ice sheet, and the accumulation of ice contribute to changes of the ocean surface. For that reason, it is important to develop basic research algorithms development for ice sheet mass balance in Antarctic and its elementary process by using AMSR and GLI. To understand the present state of global warming and ice sheet mass balance in the Antarctic, algorithm development for estimating the quantity of surface snow cover using AMSR has been accelerated. It is important to compare data related to mass balance with other Earth scientific data and investigate elementary processes of mass balance of glaciers and ice sheets.

5.3 Science with Optical Observations

(1) Snowfall distribution and snowfall area

A problem that usually occurs in snow-cover distribution is how to distinguish between cloud and snow cover. The research on AVHRR has shown the effectiveness of combining infrared and thermal infrared, and we expect that the 1.6μ m channels of GLI will further improve the accuracy. In addition, an algorithm for estimating snowfall distribution in continental forests will be developed, and improved accuracy is also expected in this area.

(2) Sea-ice distribution and sea-ice concentration

It will be possible to roughly estimate the overall sea-ice distribution by using AMSR. However, GLI will be needed to investigate polynyas that occur locally and the difference in sea-ice concentrations because GLI performs real time observations with higher resolutions than AMSR. Also, AMSR and GLI together should provide highly accurate estimates of sea-ice distribution. Knowing the surface state of sea ice (snow cover distribution and emissivity above the sea ice) and surface temperature will be essential for determining the heat balance of the sea-ice sphere. Furthermore, the combination of AMSR and GLI will be able to categorize the thickness of sea ice and types of ice bars.

(3) Ice-sheet fluctuation in the Polar Regions

Observations of changes in ice sheets in Antarctica and Greenland, and especially glacial outflow, are important for monitoring greenhouse effects. Recently, a large-scale (exceeding several tens of kilometers) shelf ice collapse has been reported in the Arctic Peninsula. GLI might observe this phenomenon. Although high-resolution sensors are required for examining changes of glaciers in detail, the observations are important from the aspect of observing change in large areas.

(4) Monitoring gigantic icebergs

In recent years, numerous outflows of gigantic icebergs have been reported and their relationship to global warming has been discussed. Moreover, monitoring icebergs is important because gigantic icebergs are very dangerous to vessels under way. GLI will effectively monitor gigantic icebergs because it will be able to observe the Polar Regions in 250m resolutions almost every day.

(5) Snow-ice surface Albedo

The albedo of snow ice regions is an important parameter for examining the Earth heat balance and global warming. In particular, ice-albedo and feedback is the greatest factor involving climate in the snow ice sphere on the Earth. The albedo of snow ice changes depending on the wavelength, snow cover grain size and shape, impurities in snow cover, snow cover density, water content, state of the surface, and other factors. Research on developing models of wavelength, snow grain size, snow shapes, and snow cover depth has been advanced with albedo. It should become possible to estimate snow cover distribution and snow depth by observing albedo. Since the GLI has 36 wavelengths for observing snow-ice regions, it will bring important data that may reveal relationships between the detailed snow ice state of the surface and albedo.

(6) Snow-ice surface temperature

The surface temperature of snow ice regions is important for estimating the snow ice surface. It is also important information for estimating heat balance and atmosphere-snow ice interaction in snow-ice regions, provided that better information cannot be expected for only surface temperatures. It is additional information for analysis on combination with other wavelength ranges.

(7) Physical characteristics of snow cover

The albedo of snowfall changes depending on wavelength, snowfall grain shapes, impurities in snowfall, snowfall concentration, water content, state of surface, and other factors, but the relation between them has not been understood yet. These characteristics of snow cover change depending on weather conditions in the regions, atmospheric precipitation or elapsed time after it stops snowing. Consequently, the physical properties of snow cover tell the history of that snow cover. For instance, snow grain size can be estimated by using wavelengths from 1.1 to 1.3μ m. Because fresh snow grains are generally small, it might be possible to estimate whether or not there is fresh snow in snow covered regions. In addition, the albedo in the near infrared range increases when a blizzard occurs. It thus might be possible to estimate the velocity of land near surface wind by using this. In this way, since the GLI will observe snow ice regions at 36 wavelengths, GLI is expected to reveal the detailed relation between the snow-ice state of the surface has with albedo.

6. Vegetation

6.1 Importance of observing vegetation with ADEOS-II

ADEOS-II is a general Earth-observing satellite. It seeks to investigate the energy-water cycle process and carbon circulation, estimate primary production, and monitor greenhouse gasses to advance Earth science and understanding of the Earth's environment. AMSR, GLI, ILAS-II, SeaWinds, and POLDER will be carried by the ADEOS-II and perform comprehensive observations for this purpose.

Vegetation plays an important role in the energy and water budgets in land areas through energy-water cycle processes. To investigate carbon circulation and estimate plant primary production, it is important to estimate carbon fixed quantity in forests, grassy fields, and farms. From the viewpoint of monitoring greenhouse gasses, it is also essential to estimate vegetation change due to global warming. Global observations of vegetation by ADEOS-II will enable research to clarify the energy and material cycle for the first time. It will thus make it possible for us to comprehensively understand the Earth's environment.

6.2 Investigation into water-energy cycle process

The atmosphere-ocean interaction is important in the global energy balance and cycle and is the main theme for the ADEOS-II mission. Effects of vegetation in land areas on the global energy cycle might be less than over ocean areas. However, human beings have developed their civilization by developing vegetation on land areas, and vegetation has been influenced greatly by human beings. This results in a global energy balance. The albedo of a forest area is 0.11 or less. In comparison, the albedo of soil in bare land areas is 0.5 or more. Because changes in vegetation influence the Earth's energy balance and cycle, it is very important to estimate vegetation change.

Vegetation significantly influences land-water interaction in the hydrologic cycle process. All vegetation has a high water content. Furthermore, plants reduce the speed of outflow and increase underground percolation. In this way, vegetation retains rainwater in and under the ground. There is concern that the reduction in vegetation is increasing the area of dry land.

AMSR microwave observations will be used to estimate soil moisture and vegetation; GLI will observe vegetation and the ground temperature to produce high-resolution global optical data.

6.3 Assumption of carbon cycle and plant primary productivity

Research on the carbon budget and gas budget indicates large differences between the models and actual measurements of carbon dioxide gas sinks. One cause is the uncertainty in estimates of absorbed carbon dioxide gas in land vegetation. For this reason, it is necessary to create precise land cover and vegetation maps on a global scale and to obtain biomass carbon precisely by using these maps.

The global vegetation maps used the most are based on the normalized differences in vegetation index maps (NDVI) calculated by NOAA/AVHRR. AVHRR is sensitive to soil colors but greatly disturbed by snow cover. It is thus necessary to develop a new method to estimate biomass using the GLI data and to conduct observations in the short wave infrared range.

To precisely estimate carbon circulation in land regions, we must acquire time series data of absorbed photosythetically active radiation data. If we know the distribution of plant primary production, we can determine the carbon-fixing ability from plants and contribute to estimating carbon circulation. At the same time, we can obtain important data that contributes to estimating the maximum population that will be able to live on the Earth.

GLI aboard ADEOS-II will play a central role in estimating the carbon and primary production mentioned above.

6.4 Monitoring greenhouse effects

It is important to monitor permafrost and investigate the melting to understand greenhouse effects. When permafrost melts, it releases the greenhouse gas methane into the atmosphere. GLI is expected to directly measure permafrost melting.

It is important to estimate conditions in marshy areas of Siberia and to calculate the greenhouse gas methane discharged from marshy areas to understand current global warming and to predict it in the future. The global sensors AMSR and GLI, Monitor such marshy areas.

The GLI and the AMSR will play central roles in monitoring greenhouse gasses.

6.5 Contribution to vegetation research and practical use

It is important to properly estimate the agricultural area to determine food reserves to quickly understand food shortages and problems, and to predict the maximum population that can live on Earth. The Food and Agriculture Organization of the United Nations (FAO) has been collecting information from agricultural agencies and organizations in each country. However, it is now necessary to perform things more quickly and precisely. Use of Earth-observing satellite has been considered for this purpose.

It is important to estimate the planting and growing crops and to create agricultural production maps and estimated yields maps. The growing period of major agricultural crops is four to nine months, and several observations are required in this period. Water is necessary for growing crops, and the agricultural products of most areas are grown in the rainy season. In many cases, high-resolution optical sensors can observe crops only once in this period. Frequent observations and moderate high resolution of GLI will enable creating those maps.

By overlapping data from many observations, we can detect deforestation and desertification regions and create maps. By using the GLI data from many observations, we will detect fires in forests and grasslands and regions made arable by slash-and-burn methods. We will also be able too create biomass maps. These frequent observations and the moderate high resolution of GLI will enable us to estimate emergency situations, such as forest fires.

GLI will play a central role in vegetation research.

7. For Comprehensive understanding

ADEOS-II is a complex Earth-observing satellite carrying various sensors on a large platform. The reason for carrying various sensors on a large platform like ADEOS-II is not only to reduce the number of launches by sending many sensors up at once, but also to provide various data about the Earth environment. Therefore, we must consider how to use such sensor data to realize specific scientific purposes. Furthermore, various sensors being carried means the volume of data acquired will become huge and there will be various data processing systems. By combing such data, we will be able to gain new knowledge.

ADEOS-II scientific purposes

(1) Estimate the fixed quantity of the water-energy cycle in the climate system
(2) Estimate the fixed quantity of biomass and primary production involved in greenhouse effects.

The on-board sensors have been selected to accomplish these scientific purposes.

First, sensors such as GLI, AMSR, POLDER and SeaWinds will comprehensively estimate the water-energy cycle. Radiation characteristics of clouds and aerosols, global precipitation distribution, cloud water, water-vapor distribution, sea-ice distribution, and soil moisture distribution are important subjects in the global water and energy cycle. Estimates of biomass in land and ocean regions area important for calculating the chlorophyll a distribution and vegetation distribution. Considering these points, the following are specific tasks for multiuse of the sensors aboard ADEOS-II.

#1 Estimate cloud water and cloud grain size distribution by complex analysis of AMSR and GLI data.
#2 Analyze aerosols over oceans and land by complex analysis of GLI and POLDER data.
#3 Estimate snow cover and sea ice distribution by complex analysis of the AMSR and the GLI.
#4 Improve the estimate accuracy of water using AMSR and GLI.
#5 Improve the estimate accuracy of sea surface conditions, such as sea-surface temperature, sea near-surface wind, and surges by combining AMSR and GLI.
#6 Improve the accuracy of estimating vegetation biomass by combining GLI and AMSR.
#7 Investigate chemical processes in the Arctic and Antarctic atmosphere by combing ILAS2 and AMSR.

Practical algorithms will be developed in the next task. One example of the analysis methods expected from the research currently being conducted will be to distinguish cloudy regions and clear sky regions in the visible spectrum using GLI. Another algorithm for water vapor and cloud water is applied to the AMSR data. Water vapor and cloud water data will thus be acquired with high accuracy.

Finally, we major points for understanding. The important thing is that simply increasing data does not simply meaning improve understanding.

(1) Data are related, not independent. For instance, the cloud data provided from GLI and the water vapor data provided by AMSR will be related, and there is no guarantee that information about clouds or water vapor will get better just because these two sources are used. Algorithm must be developed with careful attention to these points.

(2) The relation may not be known at all. For instance, suppose that ocean color data is provided correctly from GLI, and we try to combine this with data of the ocean near-surface wind provided by the SeaWinds. It seems there is a relation between living creature's activity and the physical condition of ocean. However, if someone asks what specific relations there were, and we would find that we have only a general common sense. In such cases, we would have to start from understanding the relation background.

(3) New errors are introduced by introducing other data. These errors involve calculations as well as physical aspects. It is therefore necessary to validate the data while developing an algorithm.

Considering the above, a practical approach to comprehensive understanding by using ADEOS-II data in each category is presented below.

(1) Since the problems are difficult, we should not use all data comprehensively but should pursue subjects that we can understand now recognizing like #1 to #7.

(2) We should consider algorithm development for Four-dimension analysis. We can say that combined use of satellite data and the climatic models is a key to comprehensive understanding. For example, information about temperature provided by the infrared radiometer aboard the polar-orbiting satellite is used by inputting it into a dimension data assimilation system, and we have thought of various approaches like static methods or using models. We must think about how to use cloud information acquired by ADEOS-II because we have hardly ever considered this before.

This is a fundamental problem in achieving scientific purposes with ADEOS-II. Since this is not an easy or simple task, long-term measures will be needed.

8. Combination of remote sensing data with numerical value models

In the previous chapter, we stated that combining satellite data and climate models is a key to using satellite data. In this chapter, we describe this more specifically.

Satellite observation from space has the advantage of observing the Earth uniformly with the same instrument. However, it also has the disadvantage of limited observational accuracy due to indirect measurement. The former uniform observation is best used for mapping invisible spectrum channels, but this advantage becomes a disadvantage of limited observational accuracy if parameters for monitoring climate change are conducted.

To improve the accuracy of estimating parameters provided by satellite observations, it is necessary to develop a highly accurate algorithm. Such algorithm development generally requires understanding physical phenomenon and ground validation data. However, ground validation data cannot always be obtained whenever or wherever we want. Furthermore, not all parameters can be observed.

In other words, estimating parameters is the inverse problem, meaning that we will seek the cause after we know the effects. To solve this inverse problem, we must solve the order problems to find causes and effects. The knowledge to solve this order problem is the same knowledge that supports the numerical models.

The history of combing satellite data and numerical models goes back to the1970's when researchers groped for how to use data to build the FGGE observation system. The major parameters at that time were the temperature provided by the infrared radiometers aboard the polar orbiting satellite and the cloud migratory vector provided by geostationary satellites.

To obtain the temperature distribution from the infrared radiometer data, it is necessary to solve the radiation transfer problem the other way around. The expression for radiation transfer is a nonlinear equation. To solve it, we have to make it linear by using the gaps from the first estimated value or by using successive approximations. Furthermore, this is an inverse problem, and uniqueness of the solution is not guaranteed. In the 1970's, the first estimated values were inaccurate, so there were few vertical levels and few channels, and the accuracy was not high enough. For this reason, the temperature distribution used to be obtained by using statistically relational formula with the observed values of the temperature and infrared radiation. The rough accuracy data was previously obtained using this method. However, forecasting values improved with the advance of numerical forecasting models. As a result, the polar-orbiting satellite data and the cloud transfer vector at middle to high latitudes are no longer used because their accuracy is inadequate. The accuracy is poor because the algorithm is bad. Numerical-forecast models now have significant effects because of the physical method for satellite data used by the European Centre for Medium Range Weather Forecast (ECMWF). In the future, satellite data will be used by introducing the four-dimension variation method. However, this method requires enormous computer resources, so cooperation with other projects like the Earth simulator is necessary.

Furthermore, basic parameters, like wind and temperature, and various other parameters, like clouds and cloud water, and soil moisture needed for describing climate systems, tend to be observed using the same satellite. However, numerical models are still necessary to estimate these new parameters over a large area from satellite data. One reason is that parameters needed directly do not come from satellite observations. For example, consider cloud water. Cloud water is obtained from corresponding microwave radiation levels. In this case, values of temperature and water vapor are required. It is generally impossible to determine all of these data simultaneously from satellite observations. Moreover, the temperature field and water vapor field obtained from four-dimensional analysis based on numerical models are not observational data. Instead, they are proper combinations of sonde data, forecast models, and forecast values, with high accuracy. The accuracy of cloud water estimates can be improved by using such cloud water values.

Another approach is to estimate quantities like soil moisture, which is not observed directly (some argue that it is possible to determine soil moisture by using microwave signals, but the accuracy is bad). In this case, we can consider soil moisture to be determined by precipitation, evaporation, and water streaming into rivers. The soil moisture will be obtained by applying precipitation and evaporation, which are estimated from observations of atmosphere models, to soil moisture models and accumulating time. Evaporation from the ground requires ground heating by sunlight or other sources. These quantities can be estimated from satellite observations. Consequently, combining satellite data and numerical models generates parameters that cannot be derived from satellite data or numerical models alone. In this sense, the combination of the numerical models and satellite data is a beginning of a new age.

The ADEOS-II satellite is suitable for such a new age. It will be necessary to establish various methods combining analysis, numerical models, and satellite data suitable for this new age. A specific example is shown below.

(1) Estimating and Checking Cloud and Cloud Water

Cloud distribution and cloud water are the least accurate parameters among numerical models. So far, each model has used a scheme considered most likely to be right, though not fully satisfactory, and it has been impossible to validate these models until today. ADEOS-II carries both AMSR and GLI and will make it possible to estimate cloud water and cloud quantity. In so doing, it will also enable checking the schemes of models by using cloud water and cloud fraction obtained from ADEOS-II. Consequently, forecasting accuracy of numerical models will improve, as will the accuracy of primary estimated values for cloud and cloud water obtained from ADEOS-II data. This will improve the accuracy of cloud and cloud water estimation. Thus, combing of models and satellite data enables improving the accuracy of both.

(2) Retrieving Temperature Field below the Ocean by Using Sea-Surface Temperature and Ocean Near-Surface Wind

Satellites cannot observe subsurface ocean water directly. However, the condition of such subsurface water is basically determined by boundary conditions of the ocean surface. By inputting ocean surface fluxes, we can retrieve the condition of the subsurface ocean with ocean circulation models.

ADEOS-II will carry a microwave scatterometer called SeaWinds, which is the follow-on to the NSCAT satellite that flew aboard ADEOS. Oceanographers worldwide have been anticipating its use. Ocean stress obtained from this sensor can drive ocean circulation models. Of course, there are other data such as ocean temperature. It should be possible to describe the temperature field of subsurface ocean water using these data and the stress on the ocean surface.

9. Field program

The field program that accompanies the satellite launch is not only a ground-observation program to acquire validation data for the sensor aboard the satellite. It is also a scientific project having definite scientific objectives and will conduct research by combining various data such as satellite observations, ground-observation data, and numerical modeling. This scientific project must be open to researchers worldwide and must incorporate an implementation plan, data management, and project centers. Previous field programs for satellite observations have lacked this aspect. The previous satellite validation experiments were conducted separately only for satellite observations. Data for validation was limited since it used to be difficult to implement a global scale field campaign encompassing land, atmosphere, and ocean data. Also, data obtained for validation or data products was rarely used for Earth-science research. The Earth-science research groups, taking the satellite observations into account, have proposed a satellite launch project with research objectives. Nonetheless, it is rare to implement field observations simultaneously with a new satellite from practical viewpoints and usually goes no further than using products of the satellite. In 1998, the cooperative GAME validation experiment and the TRMM project, which observed the Asia monsoon under WCRP/GEWEX, were conducted in the Tibet plateau and Thailand, and comprehensive, valuable data for energy-water cycle research was acquired. Based on this cooperative and successful research, it is even more desirable to establish an effective and cooperative observation system of field observations of satellite validation experiments and Earth-science research.

A subprogram of the World Research Climate Program (WCRP), the Global Energy and Water Cycle Experiment (GEWEX), has proposed an international observation system synchronized with new Earth observing satellites (ADEOS-II, EOS-AM/PM, and ENVISAT) launched by 2000, with the cooperation of five continental-scale observation experiments in progress, cloud and radiation research panels, and model panels. Based on this, WCRP has planned the Coordinated Enhanced Observing Period (CEOP) for the atmosphere, land, and ocean to address problems such as yearly climate change and teleconnection, with the cooperation of CLIVAR, which is also one of the subprograms. GEWEX investigates this global energy-water cycle, modeling and evaluating influences on water resources. In contrast, CLIVAR seeks long-term prediction of climate change including global warming, focusing on investigation into the role the ocean plays in long-term climatic change and on development of models. CEOP was proposed as the first international project for WCRP, which connects these two subprograms. The objective of CEOP is summarized as follows.

To understand and model the influence of continental hydro climate process on the predictability of global atmospheric circulation and changes in water resources, with a particular focus on the heat source and sink regions that drive and modify the climate system and anomalies.

As mentioned above, the main research objective of CEOP is to understand the diversity of interaction between the atmosphere and land surface; to develop, validate, and improve the scheme to confirm its transferability; and to improve the accuracy of Predicting influence that teleconnection and seasonal and yearly changes in the climate system have on water resources. For that purpose, it is necessary to continuously observe a fixed quantity of kinetic momentum of energy and water in the atmosphere, land surface, and ocean on various scales. Ideally observation instruments should be distributed equally over the Earth, but ocean and land distribution and large mountains make this impossible. As a result, the concept of observing the entire Earth with instruments carried by satellite has been adopted. In this regard, researchers have been eagerly awaiting ADEOS-II. CEOP will provide the first opportunity for building an Earth-observing system by a practical group work of the WCRP and satellite organizations and to promote the research of climate and water resources.

For several years, beginning in 2001, it will be possible for the first time in human history to observe the energy-water cycle multilaterally and comprehensively on local to global scales and on large temporal scales from daily changes to seasonal and yearly changes. Performing observational experiments under various weather conditions on a global scale synchronized with ADEOS-II and other large satellites is necessary to acquire data for algorithms and data set validation and to establish global satellite technology. These experiments will contribute to research on seasonal and yearly climatic change due to interaction between the atmosphere, land surface, and ocean and on the influence such change has on water resources, and to build fundamental to develop the results on a global scale. This is the CEOP strategy, and it seeks to be effective by using the GEWEX heritage, adjusting the observation plan of the on-going LIVAR, revising the plan concept if necessary and performing intensive observations in the same timeframeing cooperation with satellite ground validation experiments and the weather forecast organizations that are supported by space agencies.

Chapter 2 Mission Instruments and Products

1. GLI

1.1 Scientific objectives

One of NASDA's two sensors aboard ADEOS-II, the Global Imager (GLI), is Japan's first middle-scale optical sensor that produces spectral resolutions and spatial resolutions with 36 channels, arranged in a mechanically scanning model. The GLI characteristics are summarized below.

(1) GLI has more visible spectrum radiation channels than other ocean-color sensors and atmospheric sensors. It also has atmospheric correction channels necessary for ocean-color observations and large dynamic range channels necessary for land observations.

(2) It has a tiltable scanning mirror to observe ocean color in the middle latitude regions.

(3) It has channels with 250-meter resolution that are based on LANDSAT/TM; these will perform global surface observations with intermediate resolution.

(4) It has important spectrum channels, such as 0.38 μm in the near-ultraviolet region, 0.76μ m in the oxygen-absorption band, and 1.4μ m in the water-vapor absorption band. For comparison, the EOS-AM/MODIS doesn't have the 0.38 μm or 0.76μm channels.

(5) It has 1.6, 2.2, 3.7, 8.3, 10.9, and 12.0μm channels as atmospheric windows. Only MODIS and a few other middle-scale sensors are equipped with these channels. The GLI also has 6.0, 7.6, 7.0, 7.3μ m channels that will provide indices of water vapor vertical distribution.

With these characteristics, GLI and the Advanced Microwave Scanning Radiometer (AMSR) aboard ADEOS-II will be a good combination for monitoring the lower layer of the atmosphere and the surface of the Earth. Specifically, the GLI has absorption channels for atmospheric molecules extending from the visible spectrum to thermal infrared and many channels in atmospheric windows. AMSR contributes a 6.9GHz channel and other channels that are sensitive to both the surface of the Earth and clouds. These channels have better S/Ns than OCTS and the AVHRR, and improvement of each sampling parameter is expected.

Employing the full abilities of GLI, the mission has the important purpose of developing and providing the following higher order processed products.

(1) Biomass and Primary Productivity Related to Ocean and Its Annual Change on a Global Scale
The activities of marine creatures will be observed by the great ocean color sensor, GLI, to enable more precise and accurate prediction of the matter and energy cycle in the ocean. To investigate the oxygen cycle on a global scale, it is necessary to make a time series of long-term biomass and primary productivity measurements and to analyze average values and patterns of yearly changes. Use of various GLI wavelengths of the ocean channels will enable obtaining not only

chlorophyll a under the ocean but also the concentration of dissolved organic materials and suspended minerals in coastal regions and other materials originating from land. It will also improve the precision and accuracy of estimating chlorophyll a in the coastal regions.

(2) Biomass and Primary Productivity Related to Land and Its Seasonal and Annual Changes on a Global Scale.

Research on land vegetation, considered one of the missing carbon dioxide sinks, will be carried out. Using six channels with 250-meter resolution, we will generate global maps of detailed land biomass. Such maps will reveal seasonal and annual changes in quantitative land carbon accumulation and the precise details of the carbon cycle process. Interaction between vegetation and the climate is remarkable and will be analyzed as well.

(3) Clouds, Water Vapor, and Aerosols

Research will be conducted on quantitative dynamics to understand various feedback mechanisms in simulations of the global warming caused by clouds, water vapor, and aerosols and other indefinite factors. It seems important especially to investigate the quantity of lower layer and upper layer clouds, very small physical characteristics of clouds, water vapor distribution, and the interaction between clouds and tropospheric aerosols.

(4) Full Monitoring of Processes Near the Surface of the Earth

Monitoring the lower layer of the atmosphere and the surface of the Earth is an important GLI task to facilitate understanding of Earth-surface processes. It is especially important to monitor the Polar Regions since these areas are very sensitive to greenhouse effects. GLI will have a four-day sub-current orbit and has 250m-resolution channels. It is thus suitable for investigating Earth surface conditions. For that reason, the data sets of geophysical parameters suitable for detailed monitoring of the surface of the Earth will be generated.

1.2 Overview of Mission Instruments

GLI is an optical sensor that carries out frequent global observation of the solar and infrared radiative light reflected from the atmosphere as well as from the Earth's surface, including land and sea areas. The objective of this system is to measure geophysical parameters such as the chlorophyll concentration, dissolved organic matter, surface temperature, vegetation distribution, vegetation biomass, aerosols, cloud water distribution, and snow-ice albedo. These data are to replace dada that was acquired by OCTS which was installed on ADEOS. The data should also further expand the observation accuracy and objects. These missions include understanding the global circulation of carbon; monitoring clouds, cloud-ice, and sea-surface temperatures (which are indices of climate change); and understanding the basic marine productivity.

GLI has 23 channels in the visible near infrared range (VNIR), six channels in the short-wave infrared range (SWIR), and seven channels in the mid-thermal infrared range (MTIR) for carrying out multispectral observation. The land-surface resolution is 1km for a point directly below it. Some of the VNIR and SWIR channels have a resolution of 250m directly below the satellite and are capable of observing vegetation and clouds. The observation range with one scanning is 12 pixels (12km) in the along-track direction and 1600km wide. The GLI carries out observation by mechanically rotating its two-sided mirror and scanning in the direction perpendicular to the along-track direction. In order to request solar rays reflected from the sea surface from directly entering the sensor and saturating it (sun glitter), the system is equipped with a tilt function, whereby the views point of observation can be moved by approximately 20 degrees in either way with respect to the along-track direction. Furthermore, out of the 36 observation wavelengths of the GLI, three VNIR bands (443, 565, and 666 nm) and one MTIR band (12.0 μm) transmit data, spread to a ground resolution of 6 x 6 km, to local users via the 467.7 MHz (UHF) band (DTL). The main specifications of the GLI are shown in Table 1.2-1. Figure 1.2-1 shows the observation concept of the GLI.

Table 1.2-1 GLI Main Specifications

Item			Specification
Observation Wavelength Band	VNIR (nm)	1 km	380, 400, 412, 443, 460, 490, 520, 545, 565, 625, 666, 678, 680, 710, 710, 749, 763, 865, 865
		250 m	460, 545, 690, 825
	SWIR (nm)	1 km	1050, 1135, 1240, 1380
		250 m	1640, 2210
	MTIR (μm)		3.715, 6.7, 7.3, 7.5, 8.6, 10.8, 12.0
Space Resolution			1 km or 250 m
Measured Width			1600 km
Data Rate			1 km Resolution: 3.9 Mbps 250 m Resolution: 16 Mbps*1 6 km Resolution: 23,529 Mbps

*1. During downlink, dummy data are added, and the rate will be 60 Mbps.

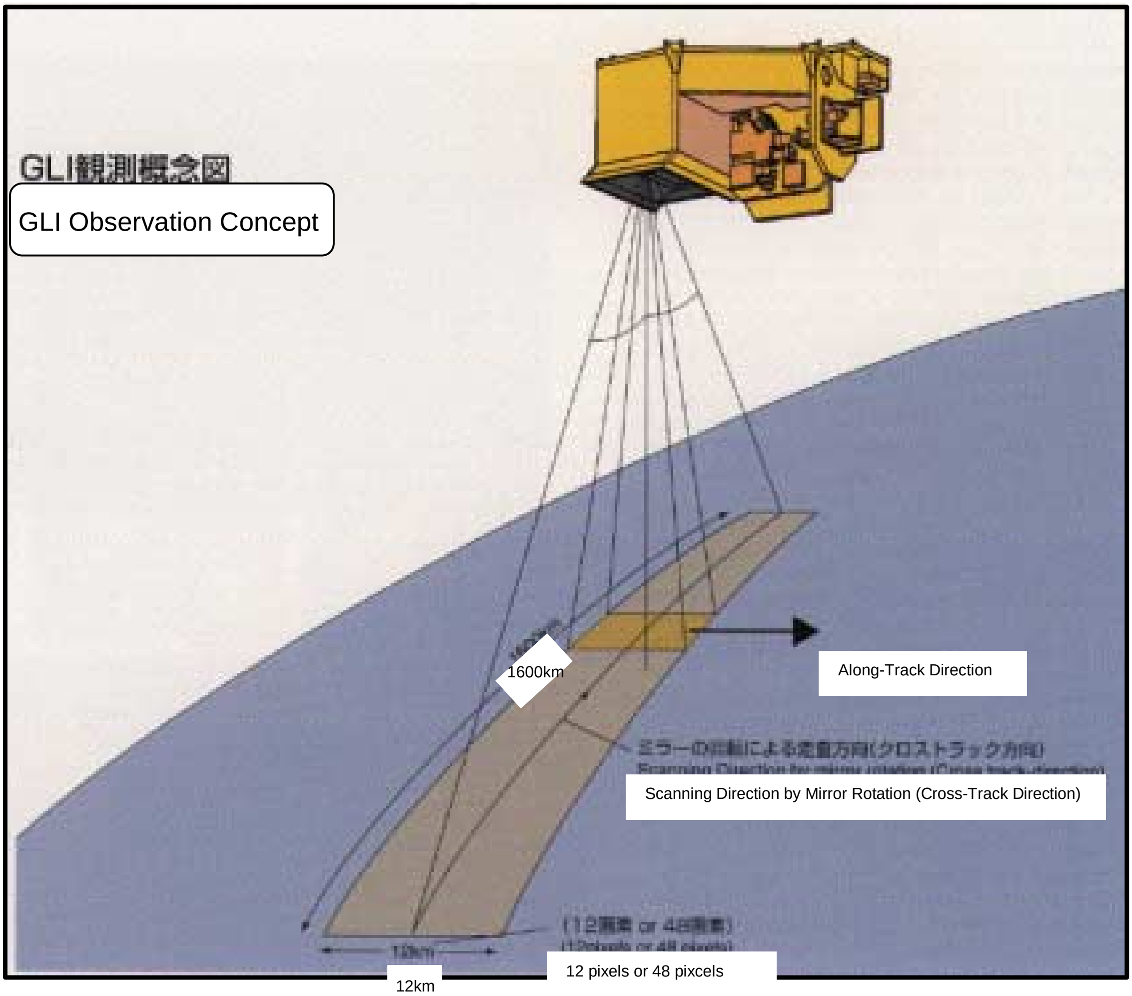


Figure 1.2-1　GLI Observation Concept

Table 1.2-2 shows the GLI operation mode during a regular operation period. The GLI mode-transition pattern for one complete rotation is shown in Table 1.2-2.

Table 1.2-2 GLI Operation Mode during a Regular Operation Period

Mode	Operation Overview	Application Conditions
Daytime Observation Mode	Observation is made on all channels in ground daytime zones; depending on the tilt angle, there are 0 degree mode, 20 degree mode, and – 20 degree mode.	Normal observation mode for ground daytime zones
Night Observation Mode	Observation is made using MTIR channels in ground nighttime zones.	Normal observation mode for ground nighttime zones.
Solar Ray Calibration Mode	Mode to obtain calibration output for VNIR for solar ray entering the GLI solar calibration window when the solar ray begins to enter the sensors.	Mode to which the satellite shifts from the night observation mode or other calibration modes during each rotation when the solar ray begins to enter the sensors.
Internal Lamp Calibration Mode	Optical calibration of VNIR and SWIR is performed using the halogen lamp inside the GLI. The "A" mode has 0 tilt angle; the "B" mode has a tilt angle of +20 degree.	Mode to which the satellite shifts from the night observation mode once a week during satellite's night time.
Electric Calibration Mode	The electrical system is calibrated by the input of six-step pseudo signals to pre-amp (VNIR, SWIR) and post-amp (MTIR). The electric calibration mode has 0 tilt angle; the electric +20 degree calibration mode has a tilt angle of +20 degree.	Mode to which the satellite shifts from the internal-lamp calibration mode once a week during satellite's night time.
Maintenance/ Safe Mode	The temperature of instruments is maintained within the operational temperature range.	Mode when a light-load-mode (LLM) command*1 is issued or during orbit-attitude angle control

*1. When there is trouble with the satellite, this command is issued by the on-board computer (OBC) installed on ADEOS-II to each installed instrument as an autonomous operation of the satellite.

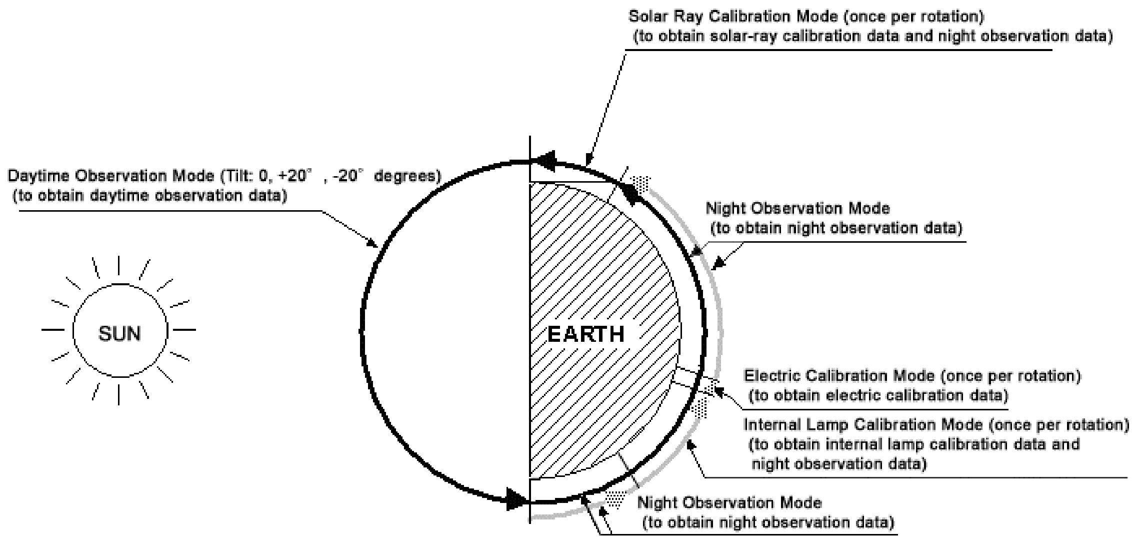


Figure 1.2-2 GLI Mode-Transition Pattern

1.3 Specific

1.3.1 Types of Higher-order Products

(1) Products created in EOC (including geophysical parameter):
    Standard product, Near-real-time products, Browse data
(2) Products created in EORC (including geophysical parameter):
    Near-real-time products, Research products

1.3.2 Definition of Higher-order Products

1.3.2.1 Standard Products

Standard products are created by EOC and divided into planning production and order production. After products are produced, they are stored in EOC and provided for general users.

(1) A transition diagram for the standard product until Level 3 STA Map is shown in Figure 1.3.2-1.
(2) The standard products described in Figure 1.3.2-1 and the geophysical parameter comprising each product are shown in Table 2.2.1-1.
(3) The standard algorithm code described in Figure 1.3.2-1 is listed in Table 1.3.2-2.

(4) The standard products produced in Level 2 processing from Table 1.3.2-1 and the list of the geophysical parameters comprising each product are shown in Table 1.3.2-3.

1.3.2.2 Near-Real-Time Products

Near-real-time products will be created and distributed by EORC until EOC's data processing system enters the regular operation phase. (See NEB-98020 for more specific information.) Its purpose is to distribute products in real time to special organizations and agencies. When EOC's data processing system enters the regular operation phase, EOC will create and distribute near-real-time products.

(1) Near-real-time products are created by applying standard algorithms to GLI-1km data received at EOC.
(2) Level-2 sea-surface temperature (ST), level-2 map sea-surface temperature (ST), chlorophyll a (CHLA), and normalized water-leaving radiance (NW) are produced in near real time.

1.3.2.3 Browse Data

Browser data is the source data used to create the image catalog in EOC.
Chapter 1.3.5. describe services to display the image catalog (browse image) through EUS/GUI or EUS/WWW.

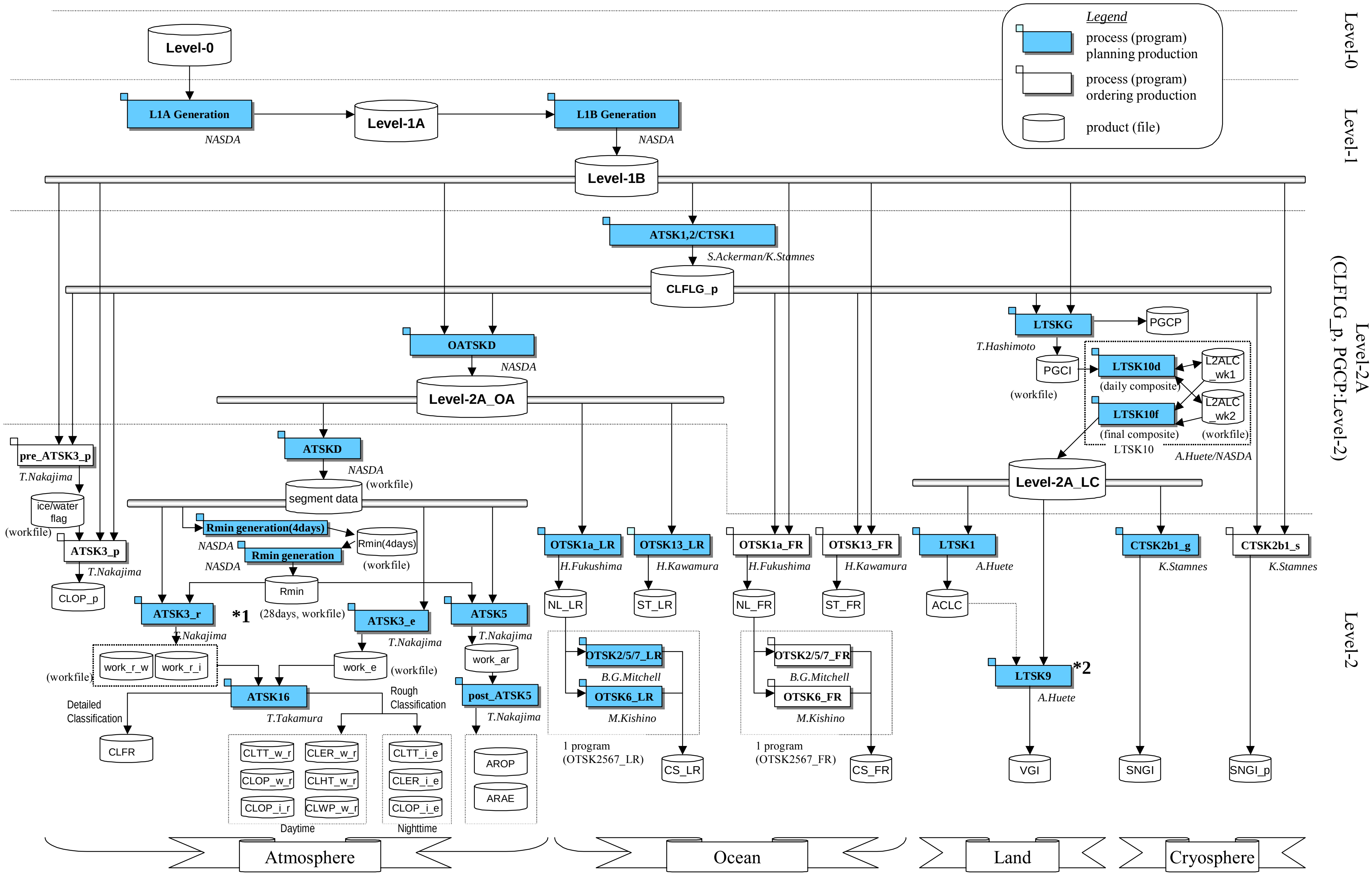
1.3.2.4 Research Product

Research products are created from algorithms developed by EORC. The algorithm to create this product is for research purposes and its quality is not guaranteed. Furthermore, it is not defined as a product to be created by EOC.

(1) Table 1.3.2-4. lists geophysical parameters comprising the research products.

GLI Standard Product Flow(1/3)

Ver.1.9b
Jun. 19, 2000



*1) ATSK3_r should be executed 2 times. One is to calculate *_w_r products and another is for *_i_r products.

*2) The input data of LTSK9 is L2A_LC at the launch time. But ACLC will be used instead of L2A_LC after ACLC validated.

Figure 1.3.2-1 GLI Standard Product Flow (1/3)

GLI Standard Product Flow (2/3)

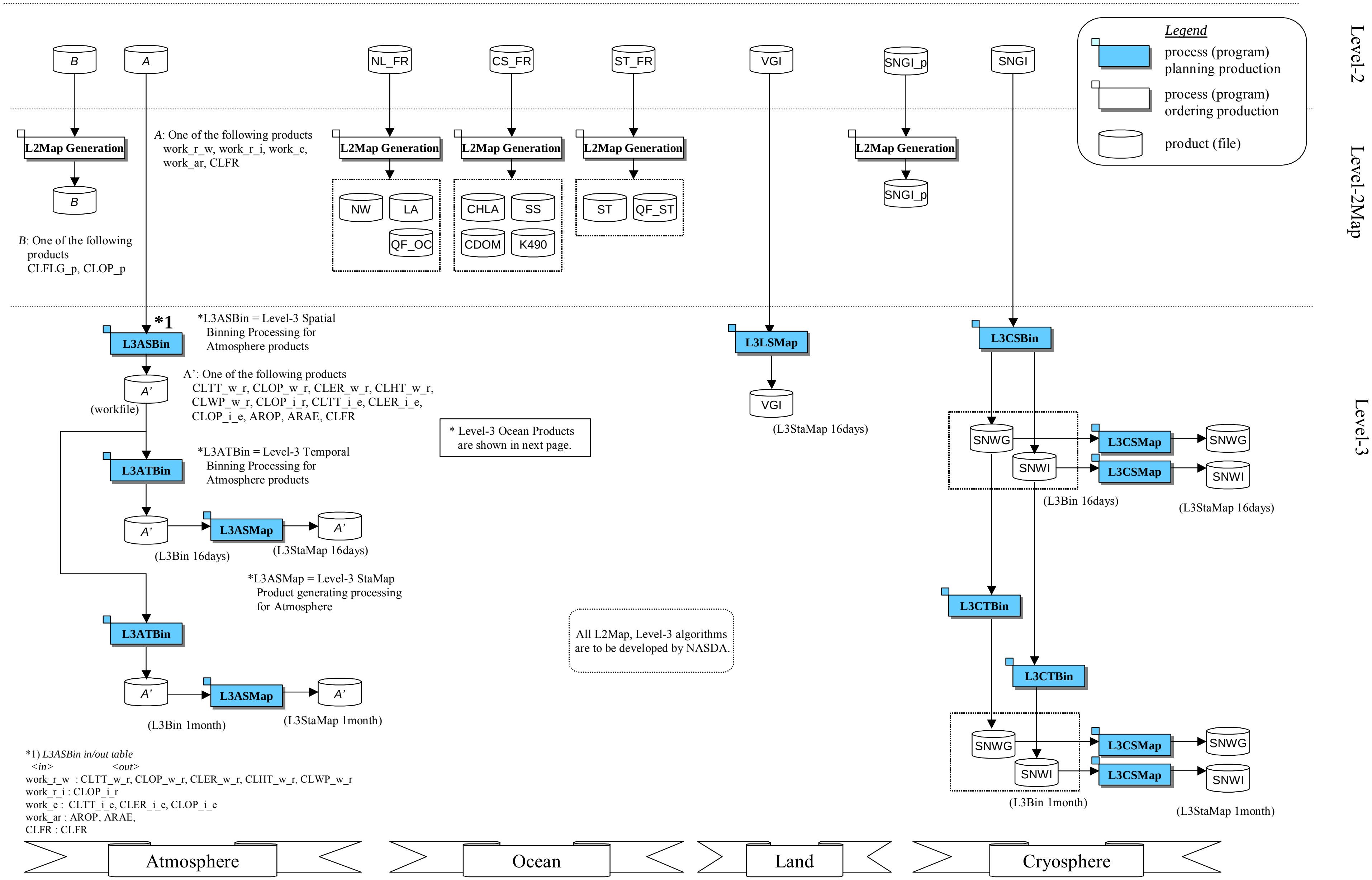


Figure 1.3.2-1 GLI Standard Product Flow (2/3)

GLI Standard Product Flow (3/3)

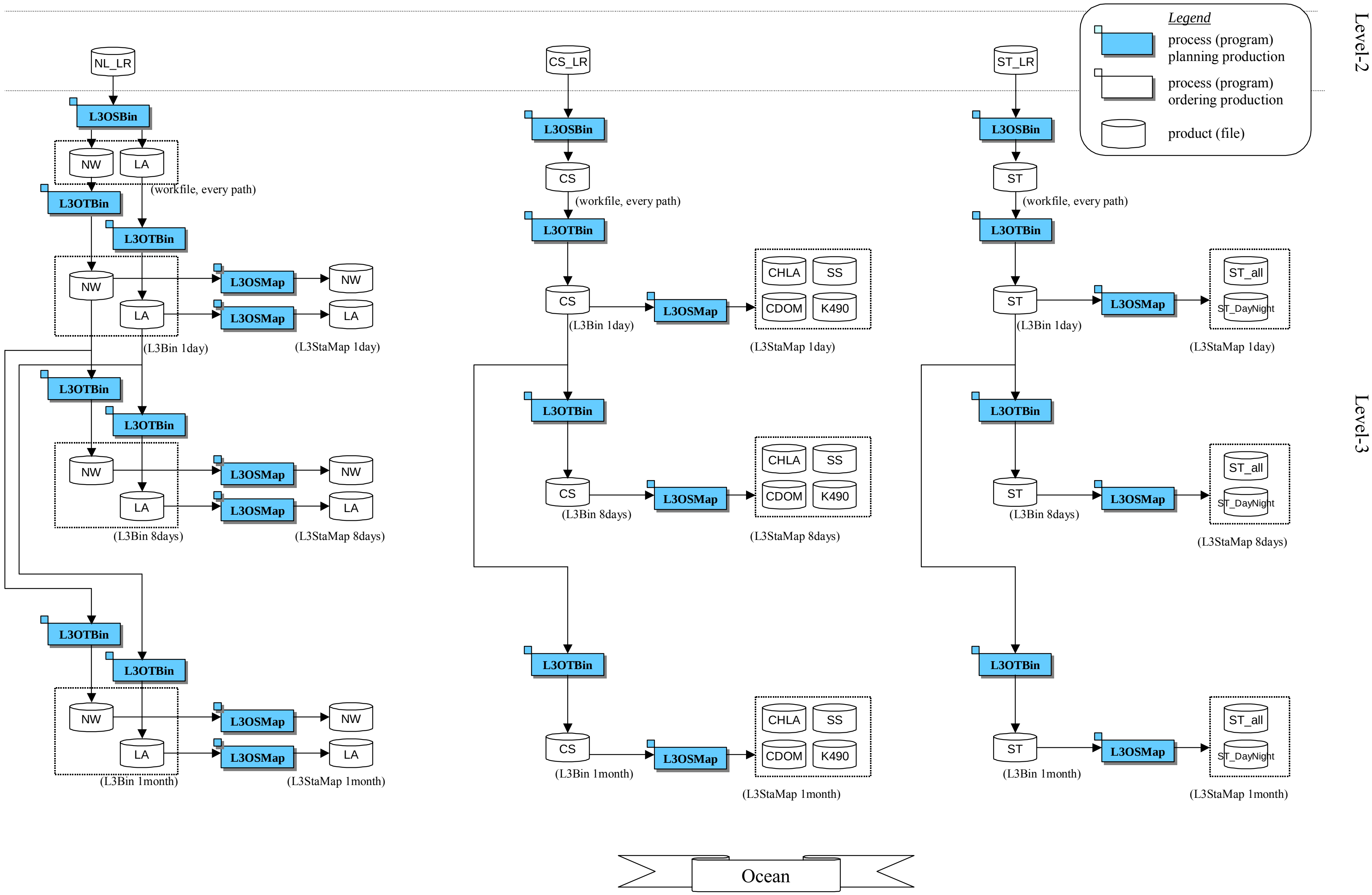


Figure 1.3.2-1 GLI Standard Product Flow (3/3)

Table 1.3.2-1 Product Codes and Geophysical Parameters

discipline	product code	coverage	time resolution	Geophysical parameters
Atmosphere	ARAE	global	once/4days	Aerosol angstrom exponent
	AROP	global	once/4days	Aerosol optical thickness
	CLER_w_r/i_e	global	once/4days	Cloud effective particle radius
	CLFLG_p	scene		Cloud flags
	CLFR	global	once/4days	Cloud fraction of 10 cloud types. (10 geophysical parameters, CLFR0, CLFR1, ..., CLFR9)
	CLHT_w_r	global	once/4days	Cloud top height
	CLOP_p	scene		Cloud optical thickness(pixel by pixel)
	CLOP_w_r/i_r/I_e	global	once/4days	Cloud optical thickness
	CLTT_w_r/i_e	global	once/4days	Cloud top temperature
	CLWP_w_r	scene	once/4days	Cloud liquid/ice water path

_w:water cloud, _i:ice cloud, _r:by reflection method, _e:by emission method

discipline	product code	coverage	time resolution	Geophysical parameters
Ocean	NL_LR	path	14.25path/day	Normalized water-leaving radiance
				-NWLR(Normalized water-leaving radiance (13bands), Aerosol radiance(4bands), α(749/865), τ a at 865nm)
				-QF_OC(Quality flag for ocean color)
	CS_LR	path	14.25path/day	Chlorophyll, SS and other parameters
				-CHLA(Chlorophyll-a),
				-CDOM(Absorption of colored dissolved organic matter)
				-K490(Attenuation coefficient at 490nm)
				-SS(Suspended solid weight)
				-QF_OC(Quality flag for ocean color)
	ST_LR	path	14.25path/day	Sea surface temperature
				-SST_b(Bulk sea surface temperature)
				-QF_ST(Quality flag for SST)
	NL_FR	scene		Normalized water-leaving radiance
				-NWLR(Normalized water-leaving radiance (13bands), Aerosol radiance(4bands), α(749/865), τ a at 865nm)
				-QF_OC(Quality flag for ocean color)
	CS_FR	scene		Chlorophyll, SS and other parameters
				-CHLA(Chlorophyll-a),
				-CDOM(Absorption of colored dissolved organic matter)
				-K490(Attenuation coefficient at 490nm)
				-SS(Suspended solid weight)
				-QF_OC(Quality flag for ocean color)
	ST_FR	scene		Sea surface temperature
				-SST_b(Bulk sea surface temperature)
				-QF_ST(Quality flag for SST)
Land	ACLC	global	once/16days	Atmospheric corrected data for land and cryosphere
	PGCP	scene		Precise geometric corrected parameter
	VGI	global	once/16days	Vegetation index
Cryosphere	SNGI_p	scene		Snow grain size and impurities
				-SCFG(Snow/Cloud flag)
				-SNWI(Snow impurities)
				-SNWG(Snow grain size)
	SNGI	global	once/16days	Snow grain size and impurities
				-SCFG(Snow/Cloud flag)
				-SNWI(Snow impurities)
				-SNWG(Snow grain size)

Table 1.3.2-2 Algorithm Codes

discipline	algorithm code	product	processing interval	process
Common	OATSKD	plan	each path	Data processing for Level-2A_OA(sampling, scene connection, etc)
Atmosphere	ATSK1/2	plan	each scene	Algorithms for identifying clear sky and cloudy region
	ATSK3_p	order	---	Retrieval algorithms of cloud parameters(pixel by pixel)
	ATSK3_r	plan	4 days	Retrieval algorithms of cloud parameters(segment) (by reflection method)
	ATSK3_e	plan	4 days	Retrieval algorithms of cloud parameters(segment) (by emission method)
	ATSK5	plan	4 days	Retrieval algorithms of aerosol parameters
	ATSK16	plan	4 days	Algorithms for cloud type and fraction
	ATSKD	plan	4 days	Data segmentation algorithm for atmosphere
	Rmin Gen.4	plan	4 days	Minimum reflectance generation program (4 atm. seg. → Rmin-4days)
	Rmin Gen.	plan	4 days	Minimum reflectance generation program (7 Rmin-4days → Rmin)
Ocean	OTSK1a_LR	plan	each path	Atmospheric correction algorithm
(LR)	OTSK2_LR	plan	each path	Chlorophyll-a algorithm
	OTSK5_LR	plan	each path	K490 algorithm
	OTSK6_LR	plan	each path	Suspended solid algorithm
	OTSK7_LR	plan	each path	Colored dissolved organic matter algorithm
	OTSK13_LR	plan	each path	SST(bulk) Algorithm
(FR)	OTSK1a_FR	order	---	Atmospheric correction algorithm
	OTSK2_FR	order	---	Chlorophyll-a algorithm
	OTSK5_FR	order	---	K490 algorithm
	OTSK6_FR	order	---	Suspended solid algorithm
	OTSK7_FR	order	---	Colored dissolved organic matter algorithm
	OTSK13_FR	order	---	SST(bulk) Algorithm
Land	LTSKG	plan	each path	Precise geographical position
	LTSK1	plan	16 days	Algorithms for atmospheric correction and reflectance
	LTSK9	plan	16 days	Vegetation Index Algorithm
	LTSK10d	plan	1 day	Data mosaicking (daily mosaicking)
	LTSK10f	plan	16 days	Data mosaicking (final selection)
Cryosphere	CTSK1	plan	each scene	Cloud detection algorithm (1a:cloud/snow discriminator,1b:snow/ice discriminator)
(global)	CTSK2b1_g	plan	16 days	Algorithm for snow grain size and impurities
(scene)	CTSK2b1_s	order	---	Algorithm for snow grain size and impurities
L2Map	L2Map Gen.	order	each scene	Map projection algorithm for scene type products
L3	L3ASBin	plan	1day, 4 days	Atmosphere Spatial Binning algorithm
	L3ATBin	plan	16days, 1month	Atmosphere Temporal Binning algorithm
	L3ASMap	plan	16days, 1month	Atmosphere L3Sta Map product generation algorithm
	L3OSBin	plan	each path	Ocean Spatial Binning algorithm
	L3OTBin	plan	1, 8days, 1month	Ocean Temporal Binning algorithm
	L3OSMap	plan	1, 8days, 1month	Ocean L3Sta Map product generation algorithm
	L3LSMap	plan	16days	Land L3Sta Map product generation algorithm
	L3CSBin	plan	16days	Cryosphere Spatial Binning algorithm
	L3CTBin	plan	1month	Cryosphere Temporal Binning algorithm
	L3CSMap	plan	16days	Cryosphere L3Sta Map product generation algorithm

Table 1.3.2-3 List of GLI Level-2 Standard Products

Discipline	Standard Product Classification	Product Details (Product Code)		Geophysical Parameter (Code)
1. Atmosphere (14 products)	Aerosol property	Segment analysis	Aerosol Angstrom Exponent (**ARAE**)	
			Aerosol Optical Thickness (**AROP**)	
	Cloud property	Pixel-by-pixel analysis	Cloud flag (**CLFLG_p**)	
			Cloud Optical Thickness (**CLOP_p**)	
		Segment analysis	Cloud Effective Particle Radius of water cloud by reflection method (**CLER_w_r**)	
			Cloud Effective Particle Radius of ice cloud by emission method (**CLER_i_e**)	
			Cloud Optical Thickness of water cloud by reflection method (**CLOP_w_r**)	
			Cloud Optical Thickness of ice cloud by reflection method (**CLOP_i_r**)	
			Cloud Optical Thickness of ice cloud by emission method (**CLOP_i_e**)	
			Cloud Top Height of water cloud by reflection method (**CLHT_w_r**)	
			Cloud Top Temperature of water cloud by reflection method (**CLTT_w_r**)	
			Cloud Top Temperature of ice cloud by emission method (**CLTT_i_e**)	
			Cloud Liquid / Ice Water Path of water cloud by reflection method (**CLWP_w_r**)	
			Cloud fraction of 10 cloud types (**CLFR**)	
2. Ocean (6 products)	Atmospheric Correction Products	Full resolution (*1-km resolution, scene unit*) (**NL_FR**)		- Normalized water-leaving radiance (**NWLR**) that consists of Normalized water-leaving radiance (13 bands), Aerosol radiance (4 bands), Angstrom exponent, Aerosol thickness - 4-byte quality flag (**QF_OC**)
		Low resolution (*4-km resolution, path unit*) (**NL_LR**)		
	In-water Particles Products	Full resolution (*1-km resolution, scene unit*) (**CS_FR**)		- Chlorophyll-a (**CHLA**) - Absorption of colored dissolved organic matter (**CDOM**) - Attenuation coefficient at 490nm (**K490**) - Suspended solid weight (**SS**) - 4-byte quality flag (**QF_OC**)
		Low resolution (*4-km resolution, path unit*) (**CS_LR**)		
	SST Products	Full resolution (*1-km resolution, scene unit*) (**ST_FR**)		- Bulk Sea surface temperature (**SST_b**) - 2-byte quality flag (**QF_ST**)
		Low resolution (*4-km resolution, path unit*) (**ST_LR**)		
3. Land (3 products)	Atmospheric correction	Atmospheric correction (**ACLC**) 1)		- Atmospheric corrected radiance data
	Precise Geolocation	Precise Geometric Corrected Parameter (**PGCP**)		- Precise geometric corrected map projection parameter
	Vegetation index	Vegetation index (**VGI**) 2)		- NDVI - EVI
4. Cryosphere (2 products)	Snow grain size/ Impurities	Scene data (*1-km resolution)* (**SNGI_p**)		- Snow grain size (**SNWG**) - Snow impurities (**SNWI**) - Snow/Cloud flag (**SCFG**)
		Global data (**SNGI**) 3)		

1）ACLC has 56 localized areas: The North and South Polar Regions (>50N, <50S) are divided into four areas each. Middle latitude region (60S-60N) is divided into 48 areas (30degree by 30degree)

2）VGI has five localized areas: North Polar Region (>50N), North middle latitude region (20N-60N), Equator region (20S-20N), South middle latitude region (20S-60S), South Polar Region (>50S)

3）SNGI (global) has four localized areas: North Polar Region (>50N), North middle latitude region (20N-60N), South middle latitude region (20S-60S), South Polar Region (>50S)

Table 1.3.2-4 Research Products (Geophysical parameter)

Sphere	Geophysical parameter		Notes
Atmosphere	CLTT i refl	Cloud top temperature	
	CLWP i refl	Cloud liquid/Water path	
	CLWP i emi	Cloud liquid/Water path	
	CLER i refl	Cloud equivalent grain size	
	CLHT i refl	Cloud top height	
	CLHT i emit	Cloud top height	
	CLGTHK	Cloud geometrical thickness	
	CFSR	Fine weather short wave radiation volume	
	WVP	Total water vapor	
	WVP p	Total water vapor（pixels）	
	ARER	Aerosol etc. grain size	
	ARTY	Aerosol type	
	PRCP	Rainfall	
	SSRB	Surface solar short wave radiation volume	
	TSRB	Atmospheric peak short wave radiation volume	
	PAR	PAR	
Ocean	CAROT	Carotenoid	FR（Note）、LR
	PHYCO	Phycobilin	FR（〃）, LR（〃）
	ONPP	Basic production volume (Chlorophyll a method)	FR（〃）, LR（〃）
	COCCO	Cocorris density	FR（〃）, LR（〃）
	FLUO	Fluorescent strength	FR（〃）, LR（〃）
	TRICO	Tricodesmium	FR（〃）, LR（〃）
	AP	Suspended particle absorption coefficient	FR（〃）, LR（〃）
	APH	Phytoplankton absorption coefficient	FR（〃）, LR（〃）
	PAR	PAR	FR（〃）, LR（〃）
	SST s	Sea surface temperature (Skin)	FR（〃）, LR（〃）
Land	LCI	Earth insulation classification map	
	LBMSS	Biomass carbon volume	
	VGCI	Vegetation change map	
	LBBN	Biomass combustion map	
	APAR	Photosynthesis valid radiation absorption map	
	LNPP	Plant basic production volume	
	LBMSS2	Precision biomass map	
	LST	Surface temperature	
	SA	Albedo	
Snow	AOS	Aerosol properties over snow and ice	
	COS	Cloud properties over snow and ice	
	ICEB	Iceberg monitoring	
	ICES	Level of proximity to sea/ice	
	PAC	Spectrally-Integrated planetary albedo	
	PAR	PAR	
	SAC	Snow surface albedo	
	SIC	Sea/ice distribution	
	SIE	Polar region ice sheet／Ice edge pattern	SIE 1~4
	SNWA	Snow distribution	SNWA 1~4
	SPA	Spectral planetary albedo	
	SRB	Solar radiation budget at TOA and surface	
	SSA	Spectral surface albedo	
	STC	Surface temperature	
	AMCD	AMSR Combined data	

Note FR means Full resolution (1-km resolution, scene unit). LR means Low resolution (4-km resolution, scene unit).
See chapter 2.2.1, Table 2.2.1-1 2. Ocean.

1.3.3 Scene Definition

Scenes for Level 2 and Level 2 Map have a ground area of 1600km×1600km. Details conform to “ADEOS-II GLI, AMSR Level-1 Product Specification (NEB-98016).”

1.3.4 Processing Level Definitions

1.3.4.1 Level 1

Level 1 product definitions and specifications are based on “ADEOS-II GLI, AMSR Level-1 Product Specifications (NEB-98016). ”

1.3.4.2 Level 2A (GLI-1km)

(1) Common processes for each science group are defined in Level 2A, and a prerequisite is that all processes are performed.
(2) The level 2A types are as shown below.
  (i) Atmospheric/oceanic Level 2A: Data from simple crop of level 1B every 4 pixels 4 lines.
  (ii) Level 2A for land/snow and ice areas: 16-day cycle cloud-free composite data
(3) Table 1.3.4-1 lists level 2A data (geophysical parameter).
(4) Data size is the approximate size for each data unit、

Table 2.4.2-1 GLI Standard Higher-order Level 2A Geophysical Parameter List

Code	Geophysical parameter	Data unit	Process frequency	Data size	Storage/project format
L2A_OA	Common to atmospheric/oceanic	Path	Each path	219 MB	4 pixel 4 line crop
L2A_LC*1	Common to land/snow and ice	Area	Once/16 days	1498 MB	Polar stereo
L2A_LC*1	Common to land/snow and ice Area	Area	Once/16 days	775 MB	Equi-rectangular

*1. Areas are shown below. The South/North latitude Polar region of 50 degrees or more is expressed in PS as a map projection in four parts. The central latitude band of 60 degrees or less is expressed in equi-rectangular (30-degree) intervals as a map projection in 48 parts. This makes 56 parts in total (South Pole 4 parts+ North Pole 4 parts + central latitude band of 48 parts). The figures surrounded by ○ are fixed as numbers for each area.

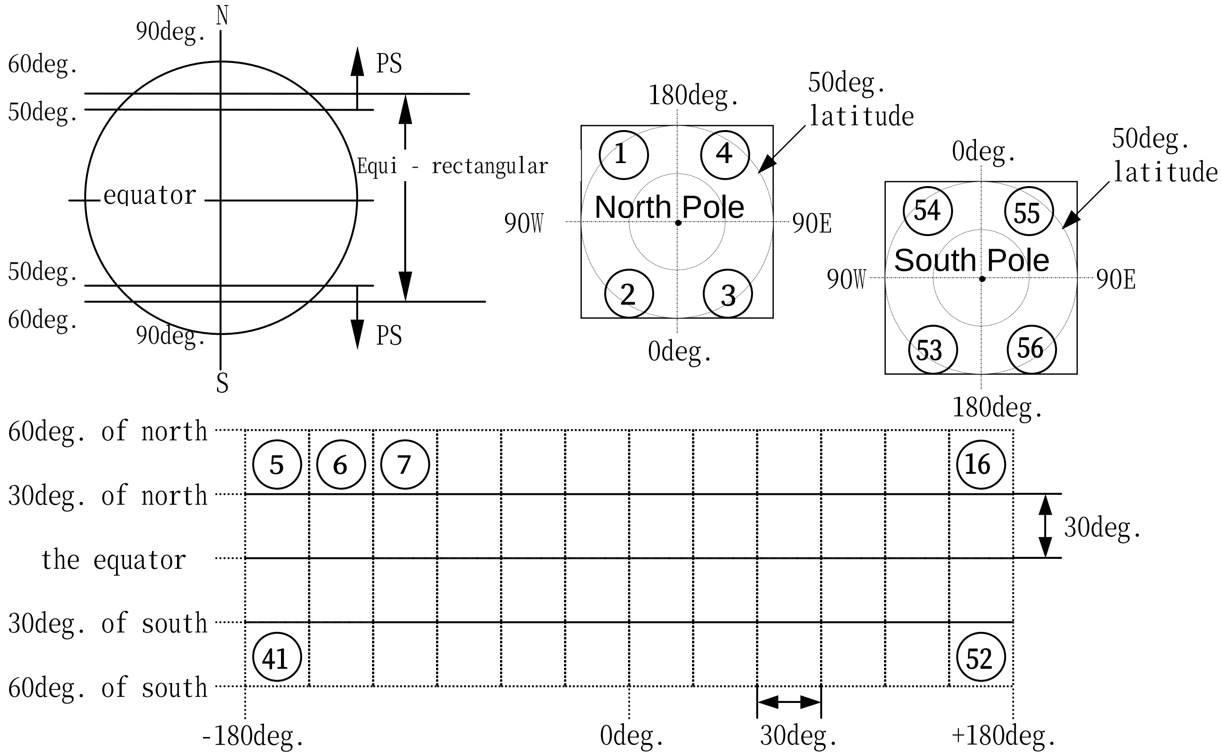


Figure 1.3.4-1 Area division

1.3.4.3 Level 2

(1) Geophysical parameters are calculated from Level 1B data and processed as parameters.
(2) Table 1.3.4-2 lists Level 2 products.
(3) Projection method is equi-rectangular and polar stereo (PS).
(4) Data storage format is the method of laying out the pixels. The format is described for those products not map projected.
(5) Data size is the approximate size for each data unit.
(6) For products created in 4-day cycles and 16-day cycles according to process frequency; they are counted from the start of the year and reset from the start of the following year. Fractional days arising from the end of the year are processed as those days only.

Table 1.3.4-2 GLI Standard Higher-Order Level 2 Product List

Sphere	Code	Product	Data Unit	Process frequency	Data size	Projection method	Data Storage Format
Atmosphere	ARAE	Aerosol Angstrom Index	Global	Once/4 days	2.2 MB	Equi-rectangular	
	AROP	Aerosol optical thickness	Global	Once/4 days	2.2 MB	Equi-rectangular	
	CLFLG_p *1	Cloud flag	Scene	Per scene	8.6 MB		L1B
	CLFR	Cloud fraction	Global	Once/4 days	2.2 MB	Equi-rectangular	
	CLOP_p *1	Cloud optical thickness	Scene	Order	4.3 MB		L1B
	CLER_w_r *2	Cloud equivalent grain size	Global	Once/4 days	2.2 MB	Equi-rectangular	
	CLER_i_e *2	Cloud equivalent grain size	Global	Once/4 days	2.2 MB	Equi-rectangular	
	CLOP_w_r *2	Cloud optical thickness	Global	Once/4 days	2.2 MB	Equi-rectangular	
	CLOP_i_r *2	Cloud optical thickness	Global	Once/4 days	2.2 MB	Equi-rectangular	
	CLOP_i_e *2	Cloud optical thickness	Global	Once/4 days	2.2 MB	Equi-rectangular	
	CLTT_w_r *2	Cloud top temperature	Global	Once/4 days	2.2 MB	Equi-rectangular	
	CLTT_i_e *2	Cloud top temperature	Global	Once/4 days	2.2 MB	Equi-rectangular	
	CLHT_w_r *2	Cloud top height	Global	Once/4 days	2.2 MB	Equi-rectangular	
	CLWP_w_r *2	Cloud liquid/Water path	Global	Once/4 days	2.2 MB	Equi-rectangular	
Ocean	NL_FR *3	Atmospheric adjustment	Scene	Order	90.2 MB		L1B
	NL_LR *4	Atmospheric adjustment	Path	Per path	73.3 MB		L2A_OA
	CS_FR *3	Ocean color	Scene	Order	19.3 MB		L1B
	CS_LR *4	Ocean color	Path	Per path	15.7 MB		L2A_OA
	ST_FR *3	Sea-surface temperature	Scene	Order	8.6 MB		L1B
	ST_LR *4	Sea-surface temperature	Path	Per path	14 MB		L2A_OA
Land	VGI	Vegetation index	Zone *5	Once/16 days	435 MB	Equi-rectangular	
	VGI	Vegetation index	Zone *5	Once/16 days	210 MB	PS	
	PGCP *6	Precision geometric correction pattern	Scene	Per path	0.1 MB		
	ACLC	Atmosphere corrected global data	Area *7	Once/16 days	489 MB	Equi-rectangular	
	ACLC	Atmosphere corrected global data	Area *7	Once/16 days	946 MB	PS	
Snow	SNGI	Cloud grain and impurities	Zone *5	Once/16 days	1958 MB	Equi-rectangular	
	SNGI	Cloud grain and impurities	Zone *5	Once/16 days	946 MB	PS	
	SNGI_p	Cloud grain and impurities	Scene	Order	19.3 MB		L1B

*1 Pixel unit parameters
*2 w_r: water cloud reflectance, _i_r: ice cloud reflectance, _i_e: ice cloud emission
*3 Product according to resolution 1km at Full Resolution
*4 Product according to resolution 4km cropped Low Resolution.
*5 See “Figure 1.3.4-2 Zone division.”
*6 This parameter can be used in combination with L1B to obtain the precision geometrical corrected image (PGCI) (work file).
*7 See chapter 1.3.4.2 “Figure 1.3.4-1 Area division.”

The zone division is as shown below. The South/North latitude polar region is expressed in PS as a map projection of 50 degrees or more, and the central latitude band of 60 degrees or less （South/North latitude of 60 degrees or less is three parts of a 40 degree latitude band） is expressed as a map projection in equi-rectangular format of 1 degree intervals of 120 parts. The figures in circles are fixed as numbers for each area.
However, for snow and ice, there is no data for area from 20N to 20S.

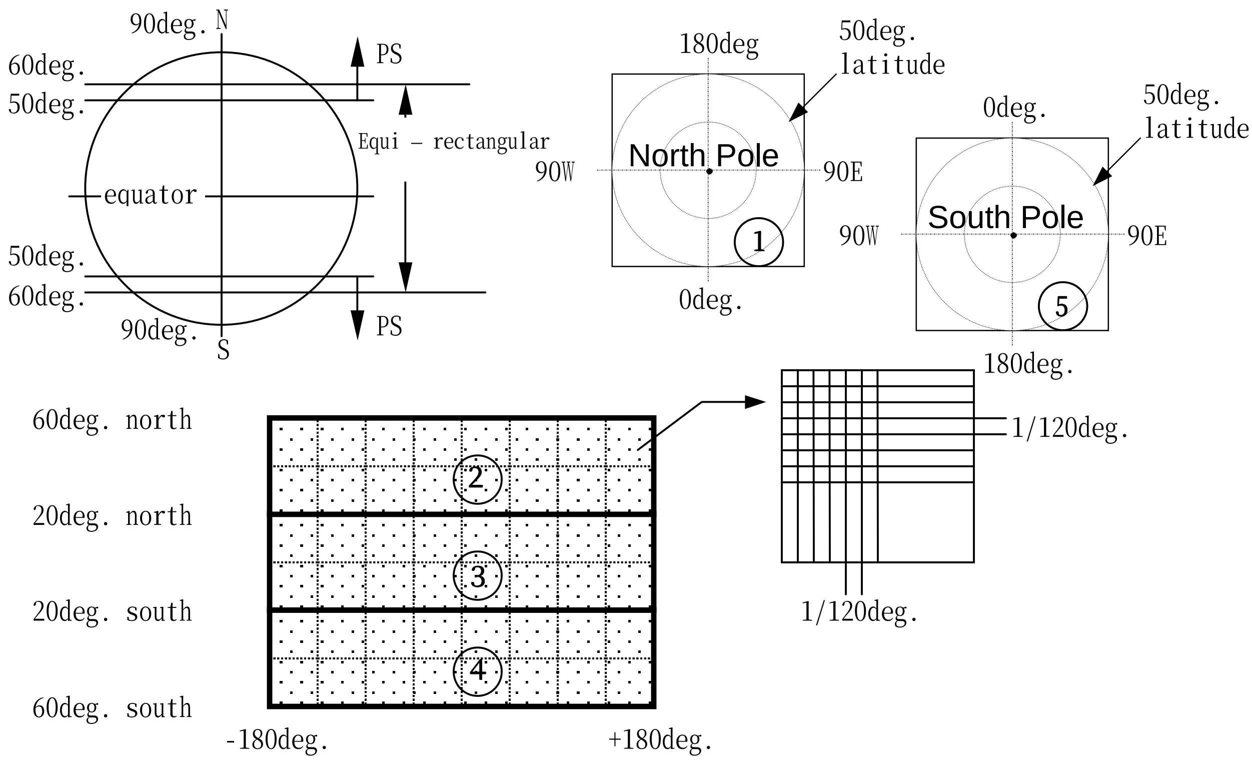


Figure 1.3.4-2 Zone Division

1.3.4.4 Level 2MAP

(1) Level 2 data is map projected, but this does not include the land VGI （vegetation index）product already converted to the equi-rectangular map in level 2.
(2) Table 1.3.4-3lists level 2MAP products.
(3) Oceanic products are Full Resolution at a resolution of 1KM,
(4) Choose bi-linear (BL), nearest neighbor (NN), or cubic convolution (CC) and make the order.
(5) Choose map projection from equi-rectangular, Mercator (MER) or Polar stereo (PS) and order（Figure 1.3.4-3 Map projection method, Table 1.3.4-4 Map projection method）.
(6) Earth shape（standard ellipsoid）is WGS84.
(7) Choose basic latitude for map projection from scene-centered and specific latitude (five point intervals) and order.
(8) Use half path 13 scenes and one path 26 scenes.
(9) Data size is the approximate size for each data unit.

Table 1.3.4-4 GLI Standard Higher-Order Level 2 Map Product List

Sphere	Code	Product	Data Unit	Process Frequency	Data size	Projection method
Atmosphere	CLFLG_p*1	Cloud flag	Scene	Order	18.7 MB	Equi-rectangular, MER, PS
	CLOP_p	Cloud optical thickness	Scene	Order	9.4 MB	Equi-rectangular, MER, PS
Ocean	NW	Normalized water-leaving radiance	Scene	Order	121.8 MB	Equi-rectangular, MER, PS
	LA	Aerosol	Scene	Order	56.2 MB	Equi-rectangular, MER, PS
	CHLA	Chlorophyll a	Scene	Order	9.4 MB	Equi-rectangular, MER, PS
	SS	Weight of suspended soil	Scene	Order	9.4 MB	Equi-rectangular, MER, PS
	CDOM	Dissolved organic matters	Scene	Order	9.4 MB	Equi-rectangular, MER, PS
	K490	K490 extinction coefficient	Scene	Order	9.4 MB	Equi-rectangular, MER, PS
	ST	Sea-surface temperature	Scene	Order	9.4 MB	Equi-rectangular, MER, PS
	QF_OC*1	Ocean color quality flag	Scene	Order	18.7 MB	Equi-rectangular, MER, PS
	QF_ST*1	SST quality flag	Scene	Order	9.4 MB	Equi-rectangular, MER, PS
Snow	SNGI_p	Cloud grain and impurities	Scene	Order	23.4 MB	Equi-rectangular, MER, PS

*1 Orders for each product of CLFLG_p (cloud flag), QF_OC (ocean color quality flag), QF_ST (SST quality flag) are limited to nearest neighbor (NN).

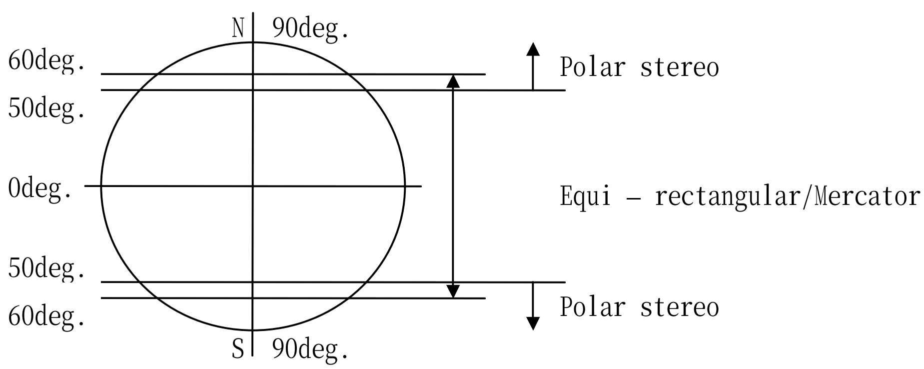


Figure 1.3.4-3 Map projection method

Table 1.3.4-4 Map Projection Method

Scene-centered latitude is shown in the following table.

Latitude＼Projection method	Equi-rectangular	Mercator	Polar stereo
North/South latitude 0-50 degrees	○	○	×
North/South latitude 50-60 degrees	○	○	○
North/South latitude 60-90 degrees	×	○	○

1.3.4.5 Level 3 Binned

(1) Level 3 binned data refers to the sampled Binned data in the spaces between level 2 data.

(2) A Level 3 binned product list (no products for land) is shown in Table 1.3.4-5.

(3) The level 3 binned data includes the sum, root sum, number of samples and other information required for each sphere.

(4) Excluding land area, the binned grid definition for each sphere is as follows (see Figures 1.3.4-4, 1.3.4-5, and 1.3.4-6).

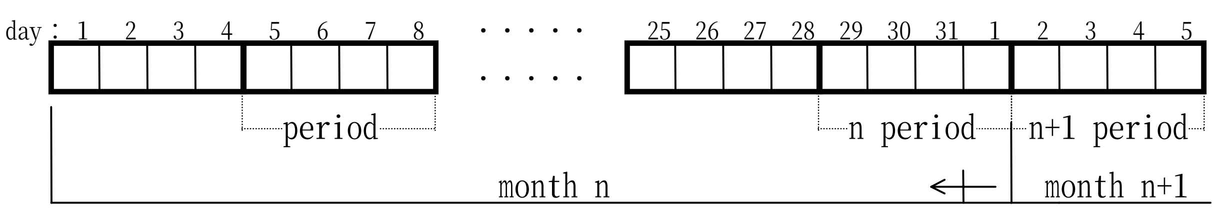
- Atmosphere: Equi-rectangular in the same way as for Level 2 global (0.25 degree equi-rectangular mesh).
- Ocean: 9kmx9km equal area grid same as ADEOS OCTS.
- Snow: With the equi-rectangular diagram method, it is the global North/South latitude of 0 to 90°. The space size is latitude direction 360 degrees/5 minutes=4320 points and latitude direction 180 degrees/5 minutes＝2160 points. In the polar stereo (PS) diagram method, the equator (0 degrees) is taken as a border and divided into Northern and Southern hemispheres. The space size at this time is up to 10KM to the center of the projection.

(5) Products created with processing cycles of eight days and 16 days, are calculated and counted respectively from the start of the year and reset at the beginning of the next year. Fractional days emerging at the end of the year are processed as those days only.

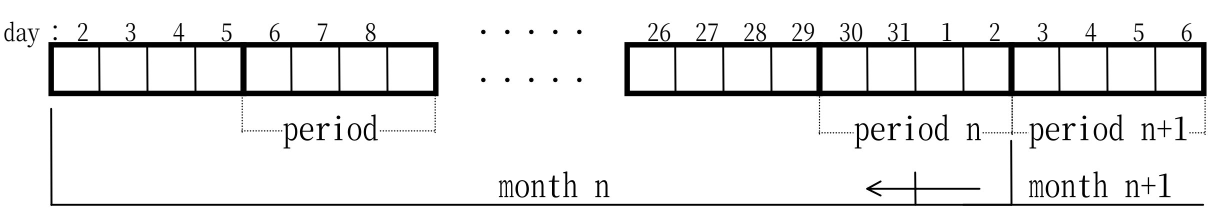
(6) Definitions of monthly processing according to the processing frequency are as follows.

- Atmosphere: There are two types of data, created from one-day units and four-day units. At present, the monthly bin created from four-day data was four integers amount. At this time, there is a rule that four-day data (defined as a period) is not double-counted over two months. Therefore, periods that straddle two months go to the time bin for the month for which there are more days.

  Example 1: If for period n, there are three days in n month and one day in month n+1, month n rather than month n+1 is assigned to the time bin.



  Example 2: If for period n, there are two days in month n and two days in month n+1, the time bin is assigned to month n.



- Ocean: Follows calendar (Western)
- Snow/Ice: Follows calendar (Western)

(7) Data size is the approximate size for each data unit.

Table 1.3.4-5 GLI Standard Higher-Order Level 3 Binned Product List (1/2)

Sphere	Code	Product Name	Data Unit	Processing Frequency	Data size	Binned grid
Atmosphere	ARAE	Aerosol angstrom index	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	AROP	Aerosol optical thickness	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	CLFR	Cloud fraction	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	CLER_w_r *[1]	Cloud equivalent grain size	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	CLER_i_e *[1]	Cloud optical thickness	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	CLOP_w_r *[1]	Cloud optical thickness	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	CLOP_i_r *[1]	Cloud optical thickness	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	CLOP_i_e *[1]	Cloud optical thickness	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	CLTT_w_r *[1]	Cloud top temperature	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	CLTT_i_e *[1]	Cloud top temperature	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	CLWP_w_r *[1]	Cloud and water volume	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
	CLHT_w_r *[1]	Cloud top height	Global	16 days	28.5 MB	Equi-rectangular
	〃	〃	〃	Month	28.5 MB	〃
Ocean	NW *[2]	Normalized water-leaving radiance	Global	Day	477.3 MB	Equivalent area grid
	〃	〃	〃	8 days	561.5 MB	〃
	〃	〃	〃	Month	561.5 MB	〃
	LA *[2]	Aerosol	Global	Day	250.8 MB	Equivalent area grid
	〃	〃	〃	8 days	295 MB	〃
	〃	〃	〃	Month	295 MB	〃
	CS *[2]	Ocean color	Global	Day	194.2 MB	Equivalent area grid
	〃	〃	〃	8 days	228.4 MB	〃
	〃	〃	〃	Month	228.4 MB	〃
	ST *[2]	Sea-surface temperature	Global	Day	194.2 MB	Equivalent area grid
	〃	〃	〃	8 days	228.4 MB	〃
	〃	〃	〃	Month	228.4 MB	〃

Table 1.3.4-5 GLI Standard Higher-Order Level 3 Binned Product List (2/2)

Sphere	Code	Product Name	Data Unit	Processing Frequency	Data size	Binned grid
Snow	SNWG	Snow grain size	Global	16 days	76.9 MB	Equi-rectangular
	〃	〃	〃	Month	76.9 MB	〃
	SNWG	Snow grain size	Northern hemisphere	16 days	62.3 MB	PS
	〃	〃	〃	Month	62.3 MB	〃
	SNWG	Snow grain size	Southern hemisphere	16 days	62.3 MB	PS
	〃	〃	〃	Month	62.3 MB	〃
	SNWI	Snow impurities	Global	16 days	76.9 MB	Equi-rectangular
	〃	〃	〃	Month	76.9 MB	〃
	SNWI	Snow impurities	Northern hemisphere	16 days	62.3 MB	PS
	〃	〃	〃	Month	62.3 MB	〃
	SNWI	Snow impurities	Southern hemisphere	16 days	62.3 MB	PS
	〃	〃	〃	Month	62.3 MB	〃

*1: _w_r: water cloud reflectance, _i_r: ice cloud reflectance, _i_e: ice cloud emission
*2: Made from level2 ocean "_LR" product (see chapter 1.3.4.3, Table 1.3.4-2)

The diagram in Fig.1.3.4-4 shows each binned number as an atmosphere Level 3 binned grid 0.25 degree geocentric mesh（same latitude and longitude as Level 2 global）.This binned number is fixed.

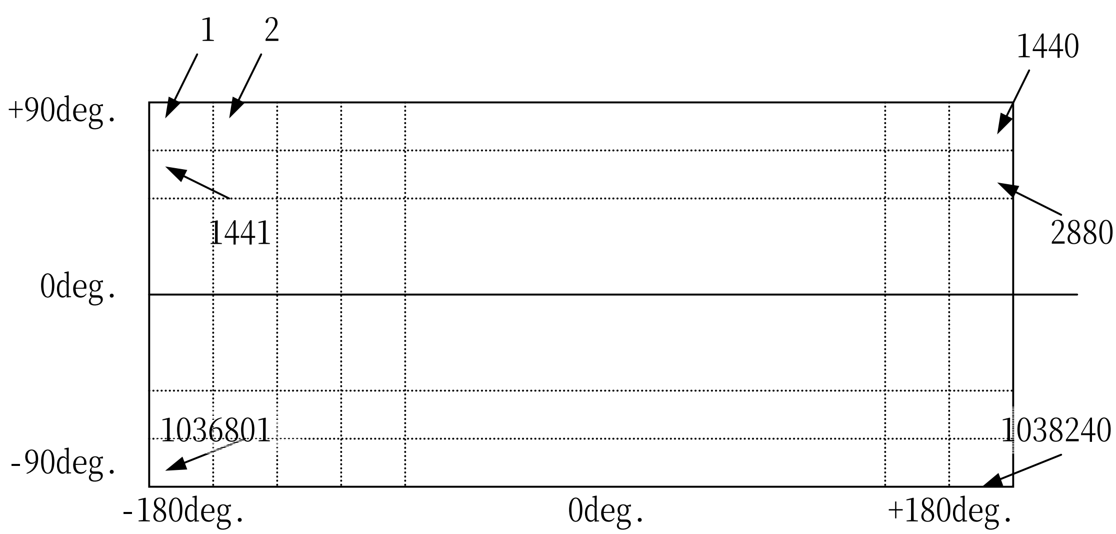
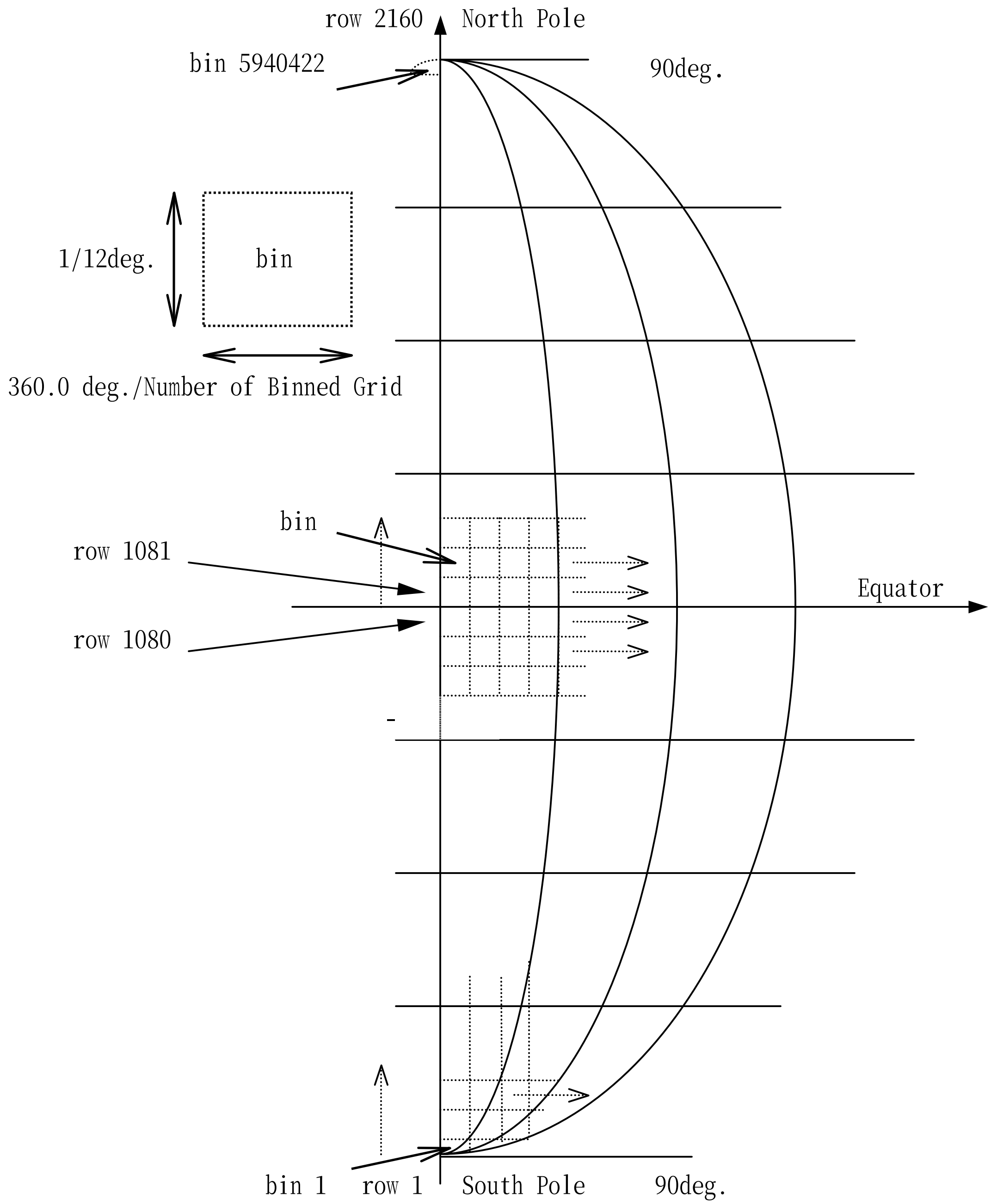


Figure 1.3.4-4 Atmosphere Binned Grid

The ocean Level 3 binned grid is a 9km×9km equal area grid as in the ADEOS OCTS, and the binned number is the same as for OCTS. Each binned number is shown in the following diagram. This binned number is fixed.

The binned numbers for the ocean are applied from the South Pole to the North Pole.



In the above diagram, if the central latitude for a row is Φ, the number of binned grids for that row can be obtained using the following formula.

Number of Binned grids = [4320×cosΦ] (Note) The [ ] to the left of the numeric formulas indicate rounding up and rounding down.

Example: The following shows an example of the number of binned grids for the row using this formula.

row1 : 3, row2 : 9, row3 : 15,……, row1080 : 4320, row1081 : 4320,……, row2160 : 3

Figure 1.3.4-5 Ocean Binned Grid

Two projection diagram methods, equi-rectangular (zone 1) and PS (zone 2,3), are used for snow.

The equi-rectangular diagram method is global at 0 to 90 degrees North and South latitude. The size at this time is 360 degrees/5 minutes = 4320 points in the latitude direction and 180 degrees/5 minutes in the longitude direction with each binned number as shown in the diagram in Fig.1.3.4-6. These binned numbers are fixed.

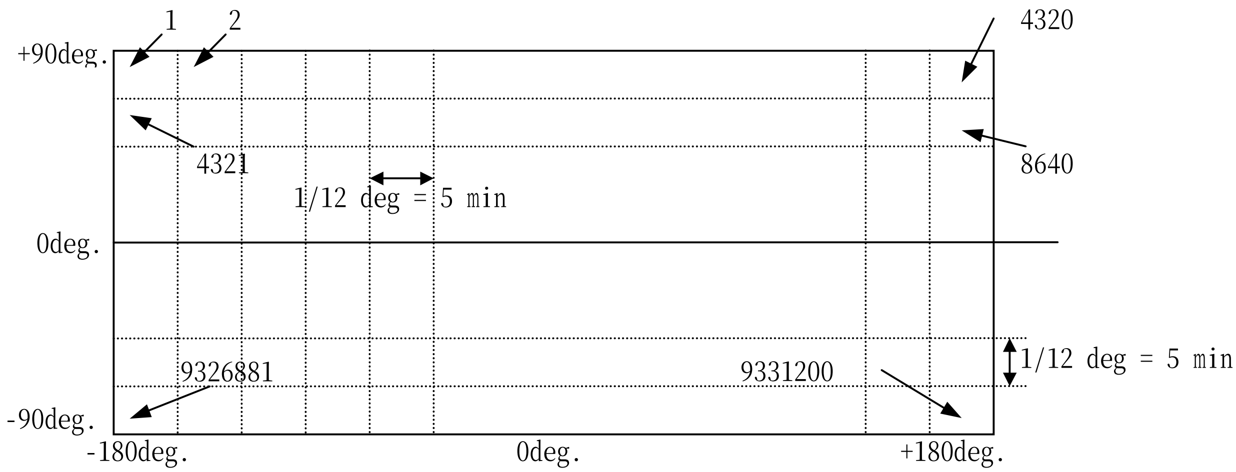


Figure 1.3.4-6 Snow Binned Grid (1/2)

In the PS diagram method, there are two types with the equator (0 degrees) as a border between the northern hemisphere and the southern hemisphere. The size at this time is up to 10km from the projection center. Each Binned number is shown in the diagram below and these binned numbers are fixed.

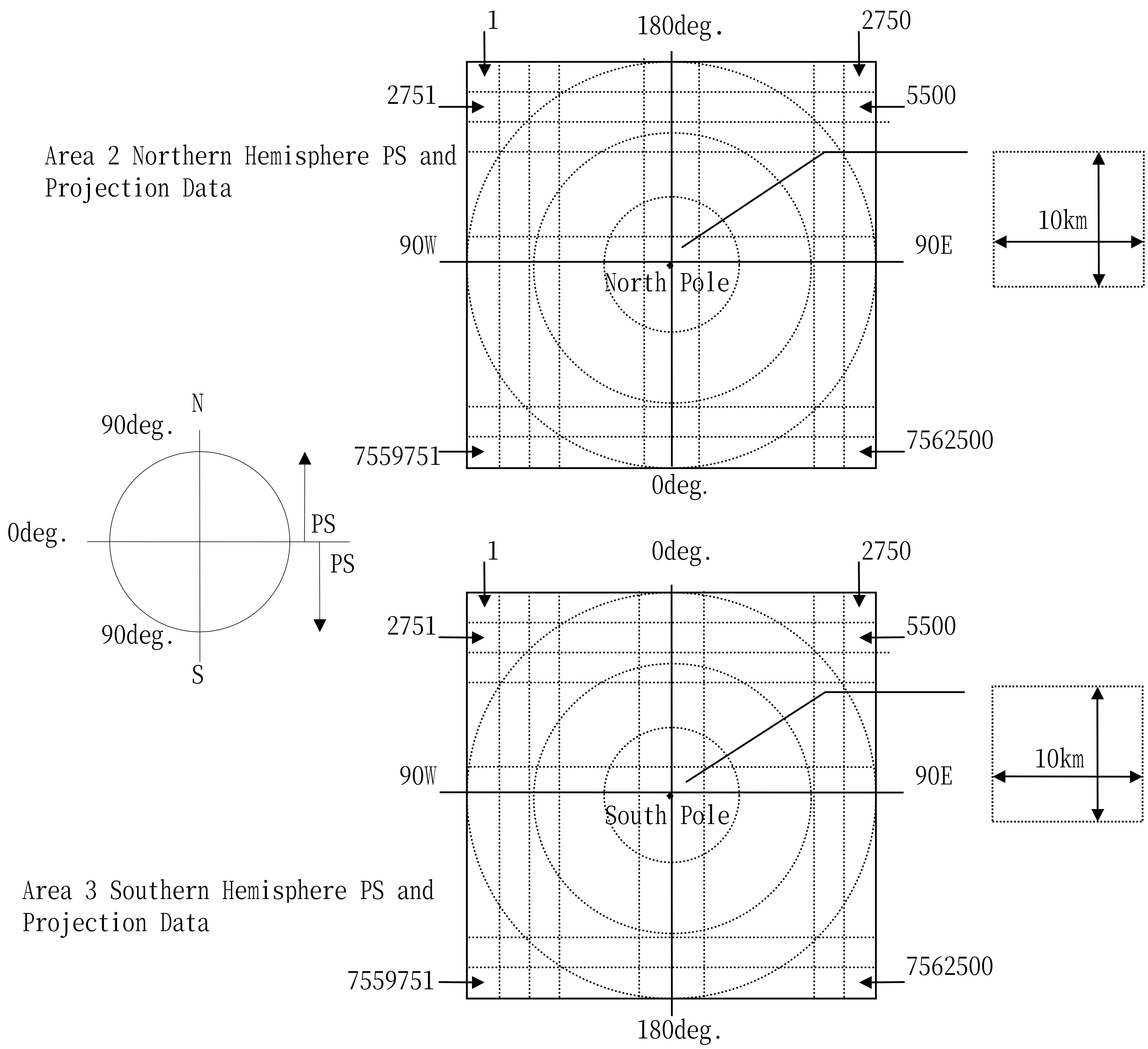


Figure 1.3.4-6 Snow Binned Grid (2/2)

1.3.4.6 Level 3 STA Map

(1) The atmosphere, ocean and snow level 3 STA (statistics) MAPs are maps projected using estimated representative values for each type of data from Level 3 Binned. Tree types of statistical values are used in this estimate method, the simple arithmetic mean, simple geometric mean, MLE（maximum estimate）. An appropriate value is selected for the calculation.

(2) The land Level 3 STA (statistics) MAP is projected using representative values estimated from the corresponding data for Level 2. The statistical value used for the estimation this time is the simple arithmetic mean.

(3) Table 2.4.6-1. lists level 3 STA MAP products.

(4) The data size is approximate.

(5) The projection methods are equi-rectangular and polar stereo (PS).

- Atmosphere: Equi-rectangular at 0.25 degrees (25km×25km) intervals
- Ocean: Equi-rectangular at 0.1 degrees (9km×9km) intervals
- Land: This is global from 90 degrees South latitude to 90 degrees North latitude, and equi-rectangular with a grid of 12 parts in 1 degree.
- Snow: There are three types - equi-rectangular (global) PS, (Northern hemisphere) and PS (Southern hemisphere). With the equi-rectangular diagram method, this is global from 90 degrees South latitude to 90 degrees North latitude. With the PS diagram method, the Northern hemisphere is 90 degrees North latitude from the equator (0 degrees) to 90 degrees South latitude.

(6) Products created in 8-day cycles and 16-day cycles are counted from the start of the year and reset from the start of the following year. Fractional days arising from the end of the year are processed as those days only.

Table 1.3.4-6 GLI Standard Higher-Order Level 3 STA Map Product List (1/2)

Sphere	Code	Product Name	Data Unit	Process frequency	Data size	Projection method
Atmosphere	ARAE	Aerosol angstrom index	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	AROP	Aerosol optical thickness	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	CLFR	Cloud fraction	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	CLER_w_r*1	Cloud equivalent grain size	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	CLER_i_e*1	Cloud equivalent grain size	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	CLOP_w_r*1	Cloud optical thickness	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	CLOP_i_r*1	Cloud optical thickness	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	CLOP_i_e*1	Cloud optical thickness	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	CLTT_w_r*1	Cloud-top temperature	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	CLTT_i_e*1	Cloud-top temperature	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	CLWP_w_r*1	Cloud liquid/Water path	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃
	CLHT_w_r*1	Cloud-top height	Global	16 days	2.4 MB	Equi-rectangular
	〃	〃	〃	Month	〃	〃

Table 1.3.4-6 GLI Standard Higher-Order Level 3 STA Map Product List (2/2)

Sphere	Code	Product Name	Data Unit	Process frequen	Data size	Projection method
Ocean	NW	Normalized water-leaving radiance	Global	Day	124.8 MB	Equi-rectangular
	〃	〃	〃	8 days	〃	〃
	〃	〃	〃	Month	〃	〃
	LA	Aerosol	Global	Day	57.6 MB	Equi-rectangular
	〃	〃	〃	8 days	〃	〃
	〃	〃	〃	Month	〃	〃
	CHLA	Chlorophyll a	Global	Day	8.5 MB	Equi-rectangular
	〃	〃	〃	8 days	〃	〃
	〃	〃	〃	Month	〃	〃
	SS	Weight of suspended soil	Global	Day	8.5 MB	Equi-rectangular
	〃	〃	〃	8 days	〃	〃
	〃	〃	〃	Month	〃	〃
	CDOM	Ocean color	Global	Day	8.5 MB	Equi-rectangular
	〃	〃	〃	8 days	〃	〃
	〃	〃	〃	Month	〃	〃
	K490	K490 extinction coefficient	Global	Day	9.6 MB	Equi-rectangular
	〃	〃	〃	8 days	〃	〃
	〃	〃	〃	Month	〃	〃
	ST_DayNight*2	Sea-surface temperature (day and night)	Global	Day	19.2 MB	Equi-rectangular
	〃	〃	〃	8 days	〃	〃
	〃	〃	〃	Month	〃	〃
	ST_all*3	Sea-surface temperature	Global	Day	8.5 MB	Equi-rectangular
	〃	〃	〃	8 days	〃	〃
	〃	〃	〃	Month	〃	〃
Land area	VGI	Vegetation index	Global	16 days	9.8 MB	Equi-rectangular
	SNWG	Snow grain size	Global	16 days	9.8 MB	Equi-rectangular
	〃	〃	〃	Month	9.8 MB	〃
	〃	〃	Northern hemisphere	16 days	7.9 MB	PS
	〃	〃	〃	Month	7.9 MB	〃
	〃	〃	Southern hemisphere	16 days	7.9 MB	〃
	〃	〃	〃	Month	7.9 MB	〃
Snow	SNWI	Snow impurities	Global	16 days	9.8 MB	Equi-rectangular
	〃	〃	〃	Month	9.8 MB	〃
	〃	〃	Northern hemisphere	16 days	7.9 MB	PS
	〃	〃	〃	Month	7.9 MB	〃
	〃	〃	Southern hemisphere	16 days	7.9 MB	〃
	〃	〃	〃	Month	7.9 MB	〃

*1. _w_r: water cloud reflectance, _i_r: ice cloud reflectance, _i_e: ice cloud emission
*2. There are two types of geophysical parameter - ST_Dayn (Sea surface temperature in sunny areas) and ST_Night (Sea surface temperature in shaded areas).
*3. Average temperature for sunny areas and shaded areas.

1.3.5 Image Catalog (GLI 1km)

The image catalog allows image browsing of planning production products at the various levels shown below.

(1) Level 1 processing browse images follow the EOSD definition.

(2) Level 2A processing browse images are not created for the following reasons.
- (i) L2A_OA are not map-projected, furthermore, their location is difficult to determine from the browse image, so they are not practical and therefore are not required.
- (ii) L2A_LC is taken from an average over 16 days. Judging of whether or not the clouds are map-projected is difficult, so they are not required.

(3) Level 2 processing browse images
- (i) Atmosphere products: All products for planning production
- (ii) Ocean products: CS_LR CHLA and ST_LR SST
- (iii) Land products: ACLC by VGI and channel 19 (865nm).
- (iv) Snow /ice products: SNGI SNWG

(4) Level 2 Map and Level 3 Binned are not required.

(5) Level 3 STA Map processing browse images
- (i) Atmosphere products: All products for planning production
- (ii) Ocean products: NW, LA, CHLA, SS, CDOM, K490, ST_DayNight, ST_all
- (iii) Land products: VGI
- (iv) Snow/ice products: SNWG, SNWI

1.3.6 Standard Product Processing Format

The standard product processing format（total number processed and process order）is shown in Figure 1.3.6-1.

Primary process	
L1A	Total number of pixels processed
L1B	Total number of pixels processed
L1B Map	Process order

	Higher-order process	
	L2A for atmosphere/ocean Low Resolution (4km simple cropping)	L2A for land/snow Below 60 degrees latitude South/North : Equi-rectangular Above 50 degrees latitude South/North : Polar stereo
L2A	Process total number	Process total number

	Higher-order process							
	Atmosphere		Ocean		Land		Snow	
Data unit	Global	Scene	Path	Scene	Area	Scene	Zone	Scene
L2	Process total number	Process order	Process total number	Process order	Process total number	Process total number	Process total number	Process order
L2 Map	------	Process order	------	Process order	------	------	------	Process order

	Higher-order process			
	Atmosphere	Ocean	Land	Snow
Data unit	Global	Global	Global	Global
L3 Binned	Process total number	Process total number	------	Process total number
L3 STA Map	Process total number	Process total number	Process total number	Process total number

1) L2A processes the total number. This total number includes all products planned for production.
2) All CLFLG_p from the atmosphere L2 and L2 Map scene unit products are processed.
3) The land area is map projected by L2, so L2 Map and L3 Binned are not processed.

Figure 1.3.6-1 Standard Product Processing Format (Process total number, process order)

1.3.7 GAIT

1.3.7.1 GAIT Organization

GAIT (GLI Algorithm Integration Team) is involved in the tasks of protecting the intellectual property rights of the researchers (PIs) while sharing their results and tools in an effective way and integrating one of these research results—the algorithm modules—into operational systems. The individual members of this team are also actively involved in research and development of the algorithms. The four GAIT modules are introduced below. They are defined in such a way that the GLI observation data can be most effectively utilized.

1.3.7.2 GAIT Analysis and Evaluation Functions

GAIT, in cooperation with the PIs, designs and creates the following four modules: GSS (GLI Signal Simulator), GRS (GLI Retrieval System), GSD (GLI Synthetic Data), and GMD (GLI Measured Data). The first two modules are based on hardware and software. The latter two are data modules consisting of various datasets. These modules are organically combined to form the GLI data-analysis environment.

The relationship among these four modules is explained via a simple example, based on Figure 1.3.7-1. In this system, information on geophysical parameters is collected from data (GMD) obtained by observation through sensors on existing satellites or by observation on aircraft and vessels. This data then becomes input information for the GSS, which simulates GLI observation radiance based on geophysical parameters. Based on these geophysical parameters, which are independent of sensor-specific conditions such as the response function and orbit, the GSS then prepares data (GSD) for all GLI channels as if the actual location were actually observed.

The GRS reverses the data flow performed by the GSS. One can validate the GRS entering the GSD (radiance data) obtained earlier into the GRS (GLI Retrieval System) and by comparing the GMD output (geophysical parameters) with the output of the GRS, which are the same geophysical parameters. As demonstrated here, the four modules of the GAIT are organically combined. In such a data-analysis environment, the performance of the GRS depends heavily on the performance of the GSS. Hence, the validation work of the GRS is directly connected with the performance evaluation of the GSS. The performance of the GSS basically means modeling natural phenomena, an index showing the level of our understanding of nature. Investing in the GSS thus provides a tremendous advantage in that it will directly contribute to the improved performance of radiation-calculation codes used in various modeling situations, e.g., atmospheric large-scale circulation models.

The followings explain various functions of these individual modules, promoting further understanding of the reader.

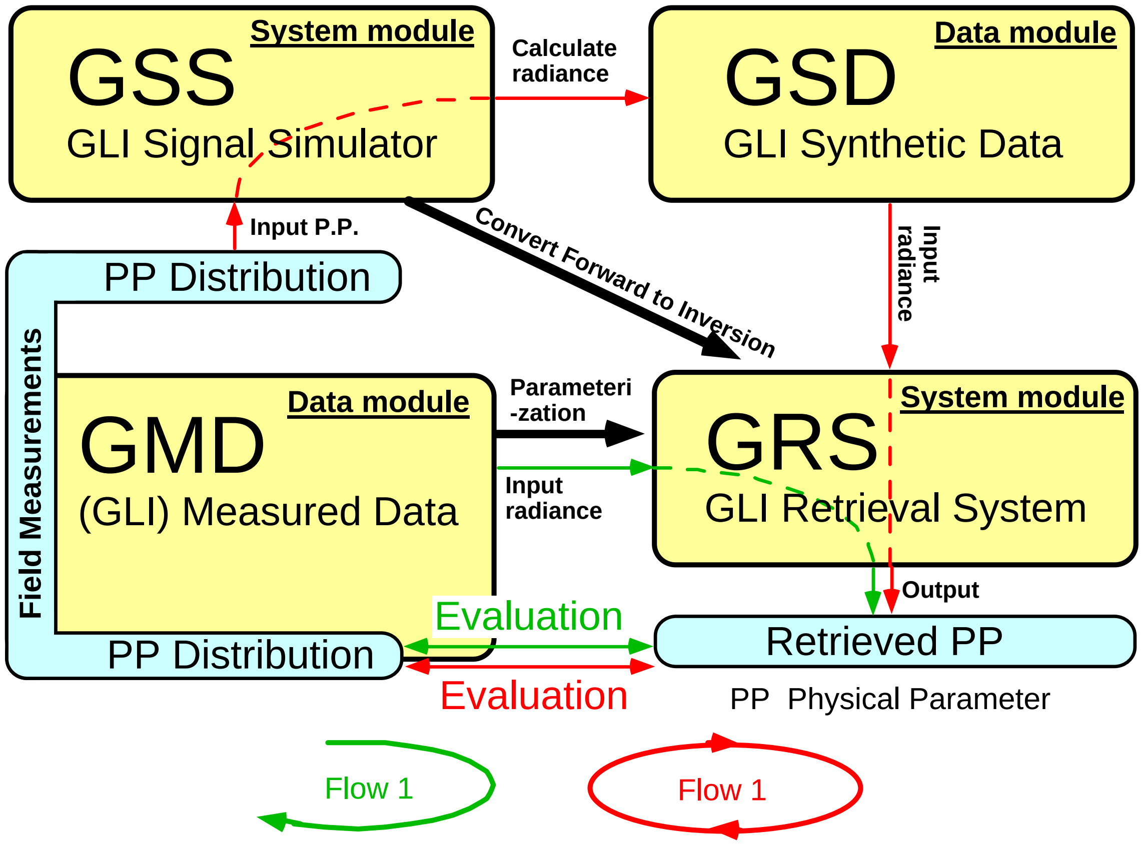


Figure 1.3.7-1 The Four GAI Modules

(1) GSS (GLI Signal Simulator)

The GSS is formed by taking a conventional radiative-transfer calculation program and adding various extension modules to it. It is installed on a dedicated computer as a system module that simulates the observed radiance of the GLI. Extension modules include scattering of atmospheric molecule, scattering of small particles such as clouds and aerosol, sea-surface reflection, snow-ice surface reflection, and vegetation surface reflection. Some of these extension modules were originally integrated as basic modules in the radiative-transfer calculation program while others were submitted to GAIT as PI result and then integrated by GAIT (such as the snow-ice surface reflection and vegetation surface reflection). However, if the GSS, whose performance has been improved by the newly integrated extension modules, is returned to all the PIs, with the program codes distributed to them, the intellectual-property rights of the PIs that have developed these individual extension modules cannot be protected. Hence, GAIT has constructed a system that keeps the most recently updated version of the GSS on a WWW site all the time and provides it as an automatic calculation service to general users (Figure 1.3.7-2, 3). The GSS user can use a general browser to access the Web site and use the GSS by entering appropriate parameters in a dialogue format. The calculation results are automatically sent to the user via email.

The performance of radiative-transfer calculations, extension modules, and interfaces determine the overall performance of the GSS. For the reasons presented in the next section, the performance of the GSS is also very closely related to the performance of the GRS, the other system module produced by GAIT.

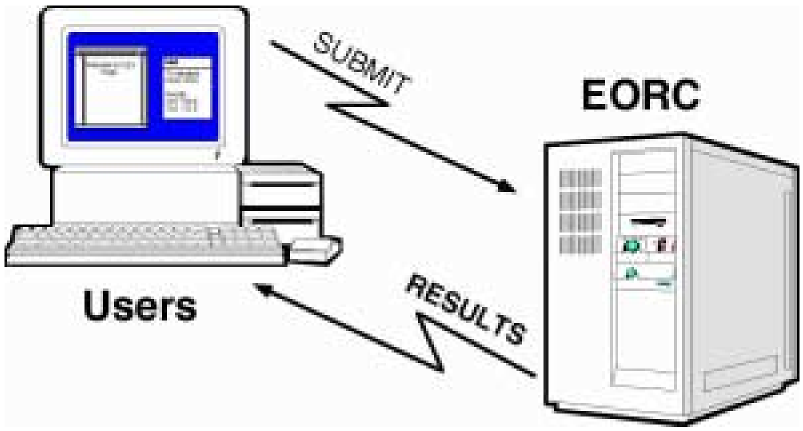


Figure 1.3.7-2 GSS Server and a Client

Figure 1.3.7-3 Web page of the GSS Automatic Calculation Service
(http://bishamon.eorc.nasda.go.jp/ENTGSS/index.html)

(2) GRS (GLI Retrieval System)

The GRS system module estimates geophysical parameters based on radiance data. In other words, it is a higher-order analysis system of the GLI. Note that the GRS and the GSS perform inverse tasks each other. There are various methods for estimating geophysical parameters from observed radiance. Recently, a powerful tool has appeared to solve the inverse problem based on the "textbook" forward problem of neural network. Therefore, efforts made to improve GSS performance as a prior investment for constructing of the GRS provide a head start in the remote-sensing method as an aggressive strategy with a view to the future. When using the conventional remote-sensing method, i.e., applying an algorithm that faithfully solves the inverse problem of a physical model, ultimately one uses datasets that are the sets of the forward problem and its solution as references. Hence, this strategy is highly effective. For this reason, the performance of GRS is closely related to that of GSS.

Using GSS, each PI will create an algorithm module for the corresponding GRS part. To these algorithm modules submitted by the PIs, GAIT adds data input/output parts and login functions compatible with GLI higher-order analysis systems. The team then completes the products by optimization procedures until final operational forms are achieved. Because the program codes written by the PIs basically make up the core of these higher-order analysis systems, it will be relatively easy to update the program codes to reflect the most recent research results.

(3) GSD (GLI Synthetic Data)

GSD is one of the GSS output. While the GSS is disclosed to general users and PIs through Web browsers, the GAIT is also actively utilizing the GSS to prepare GSD. If the geophysical parameters to be estimated can be presented on distribution maps, the estimates can be entered into the GSS, enabling us to create data (GSD) that emulate actual data as if all wavelengths available in the GLI were actually used to observe the spot. Furthermore, if the distribution maps thus prepared are sufficiently large in the area covered, it is also possible to cover an actual observation region of the GLI. Figure 1.3.7-4 is an example of GSD prepared in this way. The geophysical parameters estimated here include the sea-surface temperature estimated by remote-sensing via the TRMM/TMI sensor, the snow-ice distribution estimated by the SSM/I sensor, the cloud characteristics estimated by the NOAA/AVHRR sensor, and aerosol characteristics calculated with a model. These geophysical parameters do not include information specific to existing satellites, such as the orbit, response function, and wavelength. Therefore, it is possible to obtain observation images at sensor wavelengths never possessed by mankind in history even prior to the launch of the satellite.

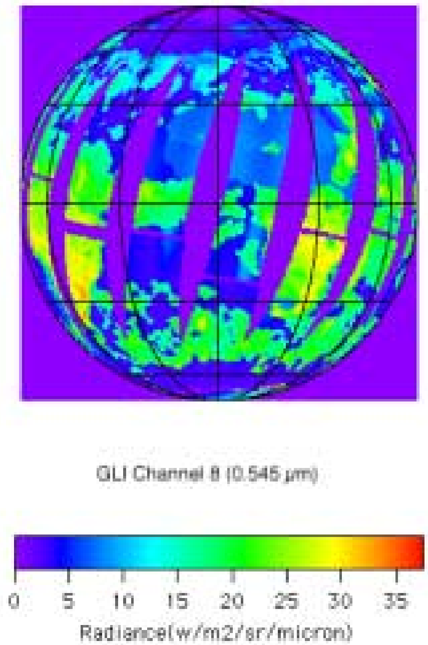


Figure 1.3.7-4 Output Example of GSD: Observed radiance of GLI Channel 8 (0.545 µm). The orbit is a simulation of the daylight region on January 29, 2001.

(4) GMD (GLI Measured Data)

Whereas GSD simulates radiance observed by a sensor, GMD refers to all data observed and measured by existing sensors and measuring instruments. This includes radiance data measured by NOAA/AVHRR, LANDSAT/TM, and ADEOS/OCTS, as well as radiance and geophysical parameters observed and measured on vessels, aircraft, and other means. As mentioned earlier, geophysical information is extracted from GMD and entered into the GSS in order to create GSD. In addition, the radiance information observed by ADEOS/OCTS can be geometrically transformed to the GLI observation region to create input data for the GRS. The radiance data thus obtained, however, contain information specific to the existing satellites, such as the orbit, observation region, and response function. It thus requires understanding and caution to use this information for research on future sensors.

1.3.8 GLI First-light images

(1) Kyushu Island, southern Japan, and the East China Sea

This image was observed by the Global Imager (GLI) aboard Midori-II (ADEOS-II) at 11:30 (JST) on January 25, 2003. The color composite image was derived from the GLI spectral channels 28 (1640nm), 23 (825nm), and 22 (660nm). The spatial ground resolution is 250m. Thick cloud systems stretching from the Asian continent to the East China Sea are visible in the image, with low altitude warm clouds appearing white and higher altitude ice clouds appearing blue. Kyushu Island and the northern part of Taiwan can be seen through chinks in the cloud systems.

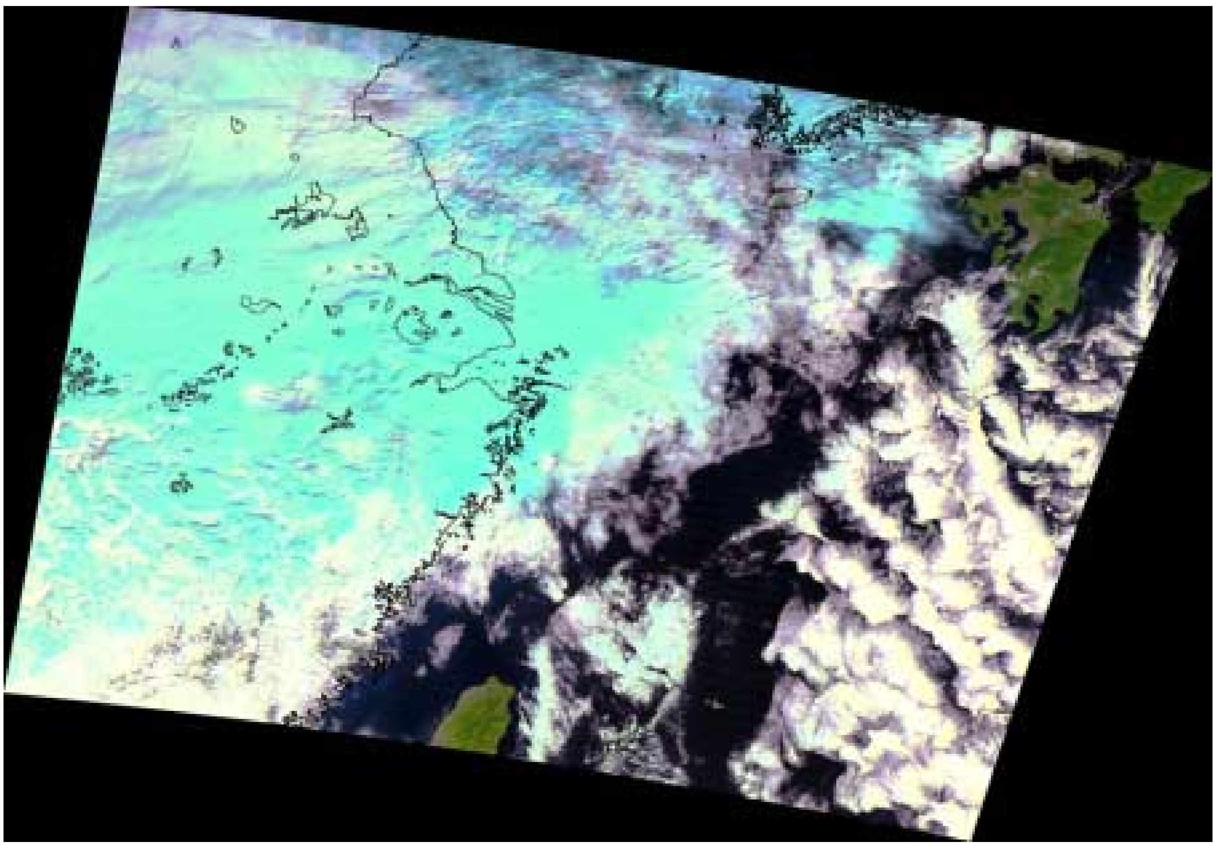


Figure 1.3.8-1 View of Kyushu Island, Southern Japan, and the East China Sea

The GLI instrument has 36 spectral channels ranging from ultraviolet to infrared. It is designed for high-accuracy observations of the atmosphere, ocean, land, and cryospehre.

(2) Great winter cyclone

This image of a winter cyclone was captured at 9:45 (JST) on January 25, 2003. This color composite image was derived from the GLI spectral channels 13 (678nm), 8 (545nm), and 5 (460nm). It has a spatial resolution of 1 km. A great cloud system formed as a result of the cyclone over the eastern Hokkaido can be identified in the image.

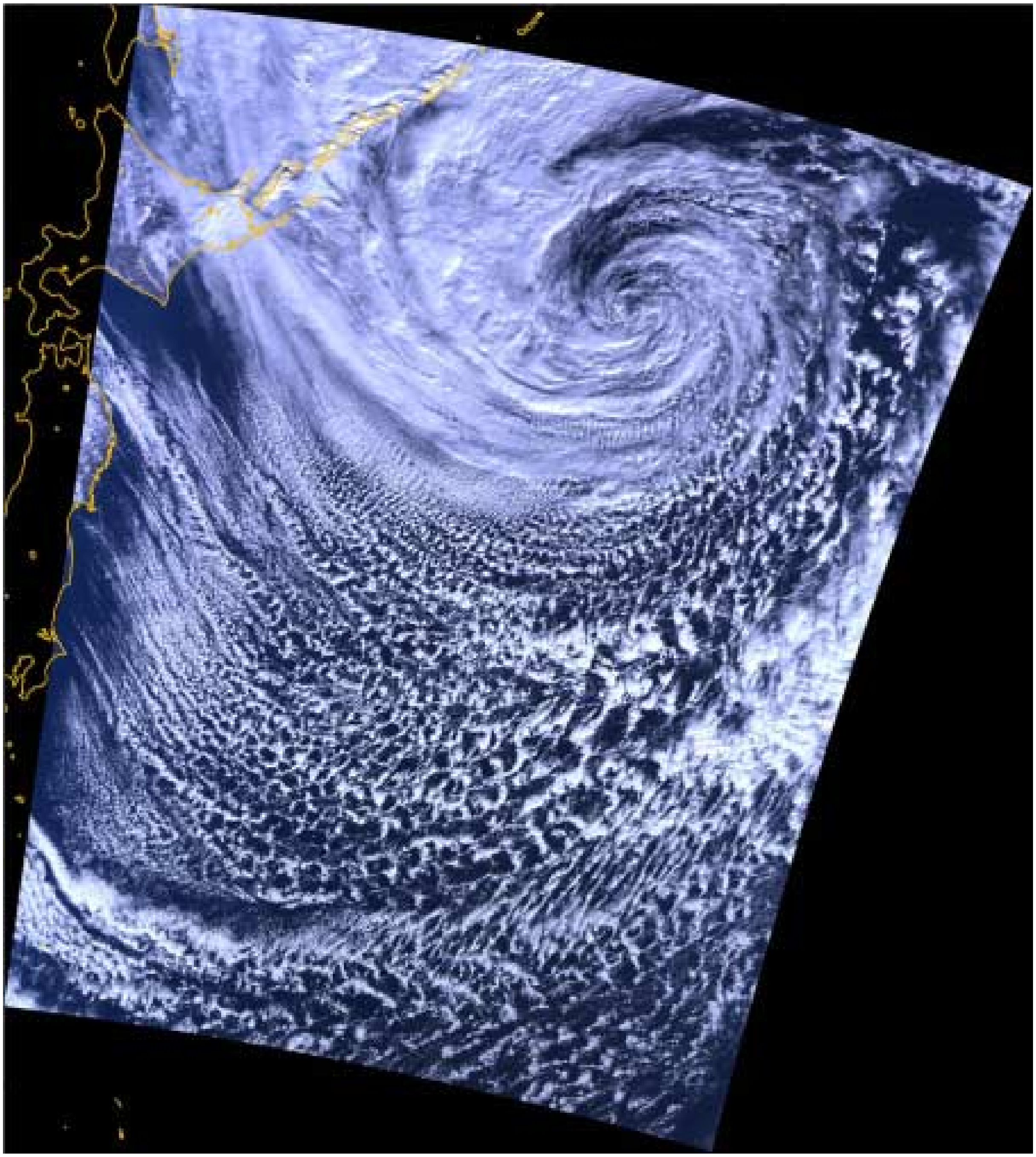


Figure 1.3.8-2 A great winter cyclone

The cyclone developed off the Pacific coast of Tohoku area between January 23 and 24, during which it brought severe weather conditions to eastern and northern Japan. The GLI instrument observes and measures the types and structures of clouds using a large number of spectral channels.

1.4 Calibration and Validation

1.4.1 Calibration and Validation Plan

1.4.1.1 Overview

GLI, a multi-purpose sensor used in observation research of the atmosphere, ocean, land, and cryosphere, is the core sensor in the ADEOS-II mission. The GLI has 19 visible channels, 4 intermediate infrared channels, and 7 infrared channels with a resolution of 1 km as well as 4 visible channels and 2 intermediate infrared channels with a resolution of 250 m, thus having a total of 36 channels. Each channel observes the arriving spectral radiance at the satellite level. Furthermore, by combining the spectral radiance values of channels established in various regions, it estimates various Earth geophysical parameters. GLI is capable of global observation, providing observation data for helping to mitigate the Earth's environmental problems and predicting the changing patterns of the global climate. In order to accomplish this goal, it is necessary to provide consistent observation data on the geophysical parameters of the Earth, the amounts of which vary among the different land and ocean regions. Other Earth-observation sensors, such as MODIS and MERIS will operate simultaneously. The Earth's environmental problems cannot be discussed without consistent observations of the Earth's geophysical parameters. Hence, calibrating and validating GLI is expected to archive sufficiently accurate global observations to tackle global problems.

Calibration refers to the procedure of determining the absolute value of spectral radiance arriving at the satellite. The response characteristics of multiple detectors for each of the GLI channels, spectral-reflection characteristics of both sides of the scanning mirror, polarization characteristics, and other performance properties need to be evaluated, and the accuracy of observation data must be maintained. Ground calibration before launch, in-orbit calibration using the internal lamp and solar rays, vicarious calibration using the spectral radiance observation data near the land surface, and other methods of calibration are used to maintain the accuracy of spectral radiance values during operation.

Validation refers to the procedure of validating the Earth's geophysical parameters estimated from the spectral radiance measured by each channel. Either standard products or research products of geophysical parameters will be established for each region, and validated each region will be using validation standards. When upward spectral radiance is used as a geophysical parameter, Level-1B data will be validated.

1.4.1.2 Definitions

(1) Calibration

(i) Ground Calibration

Pre-launch calibration coefficients are given by measuring the GLI's optical characteristics on the ground.

(ii) On-Orbit Calibration

In the visible range, the internal lamp and diffused solar rays will be used as calibration sources to calibrate each channel. The saturation radiance varies between the ocean channels and other (atmosphere, land, and cryosphere) channels, so it is necessary to calibrate them by appropriately selecting the calibration source, either the diffused solar rays or the internal lamp.

In the intermediate infrared and heat infrared wavelength ranges, the calibration sources will be the internal black-body heat source and the radiant temperature of deep space. Because it is difficult to monitor the installed black body while there is a tilt, some appropriate method of calibration must be discussed.

(iii) Vicarious Calibration

Vicarious calibration refers to the procedure of estimating the satellite-arrival radiance on the upper surface of the atmosphere through an optical model by combining the radiance measured upward on the ground with other in-situ measured data such as the optical thickness of aerosols observed on the ground. By comparing the values of this satellite-arrival radiance with the satellite-arrival radiance obtained by the GLI, correction coefficients will be calculated for each wavelength band of the GLI.

(2) Validation

This procedure is used to validate the geophysical parameters estimated based on the radiance arriving on the satellite, measured by the GLI, using in-situ data and data collected at other locations.

Validation is mainly carried out with match-up data sets. A match-up data set is a set of data consisting of in-situ observation data and GLI-generated data, collected at the same time or almost at the same time at the same location. The method, period, and frequency of in-situ observation vary, depending on the geophysical parameters under consideration. Eventually, however, parameters for higher-order processes will be adjusted and algorithms will be revised based on the calculations of errors of GLI higher-order products by comparing the geophysical parameters calculated from these two sets of data. It is therefore necessary to have a system in which necessary data are collected and match-up data sets are created efficiently and a system by which these data can be disclosed according to disclosure policy.

1.4.1.3 System

The GLI will be calibrated mainly by NASDA staff members, together with contractors, manufacturers, and PIs. Groups 1 through 6 have been established to discuss various problems regarding calibration, each group includes a cross section of the NASDA departments. The actual calibration will be done by installation, ground, and analysis groups. The NASDA-GLI Calibration Meeting supervises these groups, and the GLI-CAL Working Group (Calibration Committee) handles calibration from the PI side.

The group assignment for each theme is as follows; the GLI calibration implementation system is shown in Figure 1.4.1-1.

- Calibration by solar rays or internal lamp, VNIR/SWIR: Calibration Group 1
- Black-body calibration: Calibration Group 2
- Geometric calibration: Calibration Group 3
- Sensor characteristics, picture-quality evaluation: Calibration Group 4
- Vicarious calibration, cross calibration: Calibration Group 5
- L1-process software: Calibration Group 6

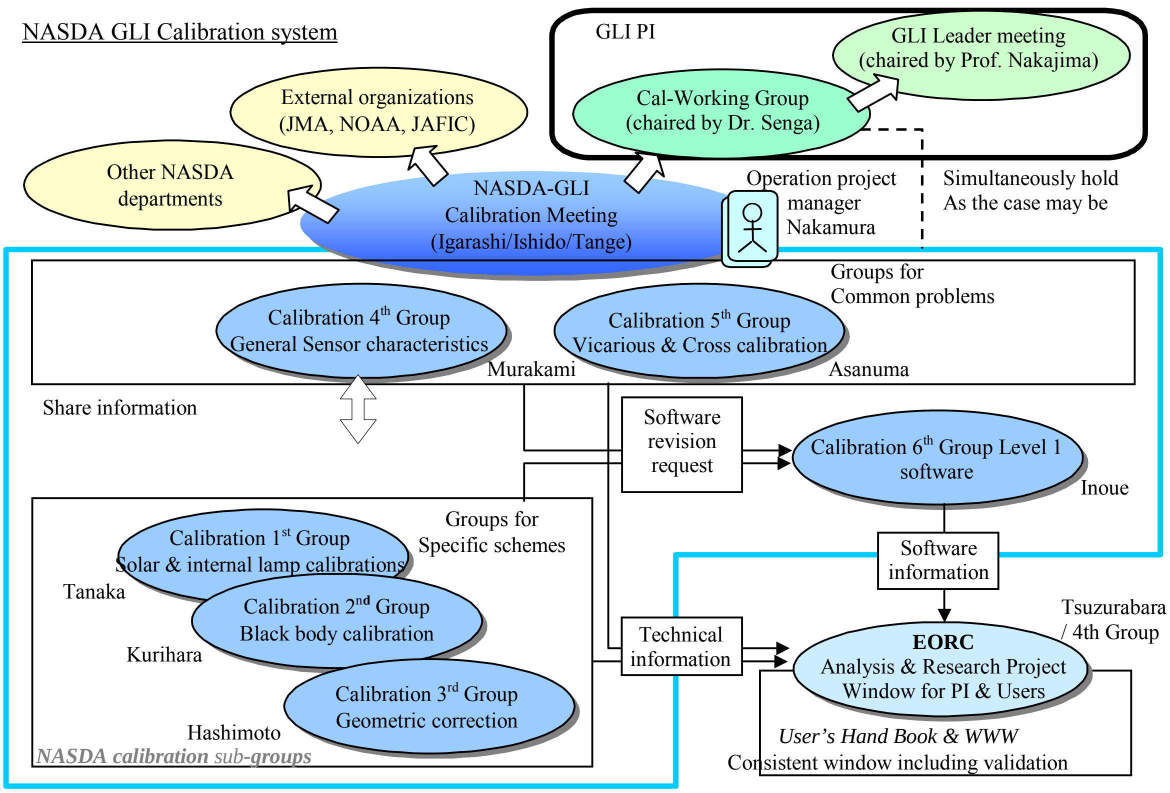


Figure 1.4.1-1 GLI Calibration Implementation System

GLI products will be validated in cooperation with PIs and NASDA staff members. PI and NASDA staff members will organize four groups: the Atmosphere, Ocean, Land, and Cryosphere Groups. The actual work will be done cooperatively within each group. The GLI-Val Working Group (Validation Committee) coordinates these four groups.

Important decisions concerning calibration and validation will be made at the GLI Leader Meeting. Figure 1.4.1-2 shows the GLI validation workflow.

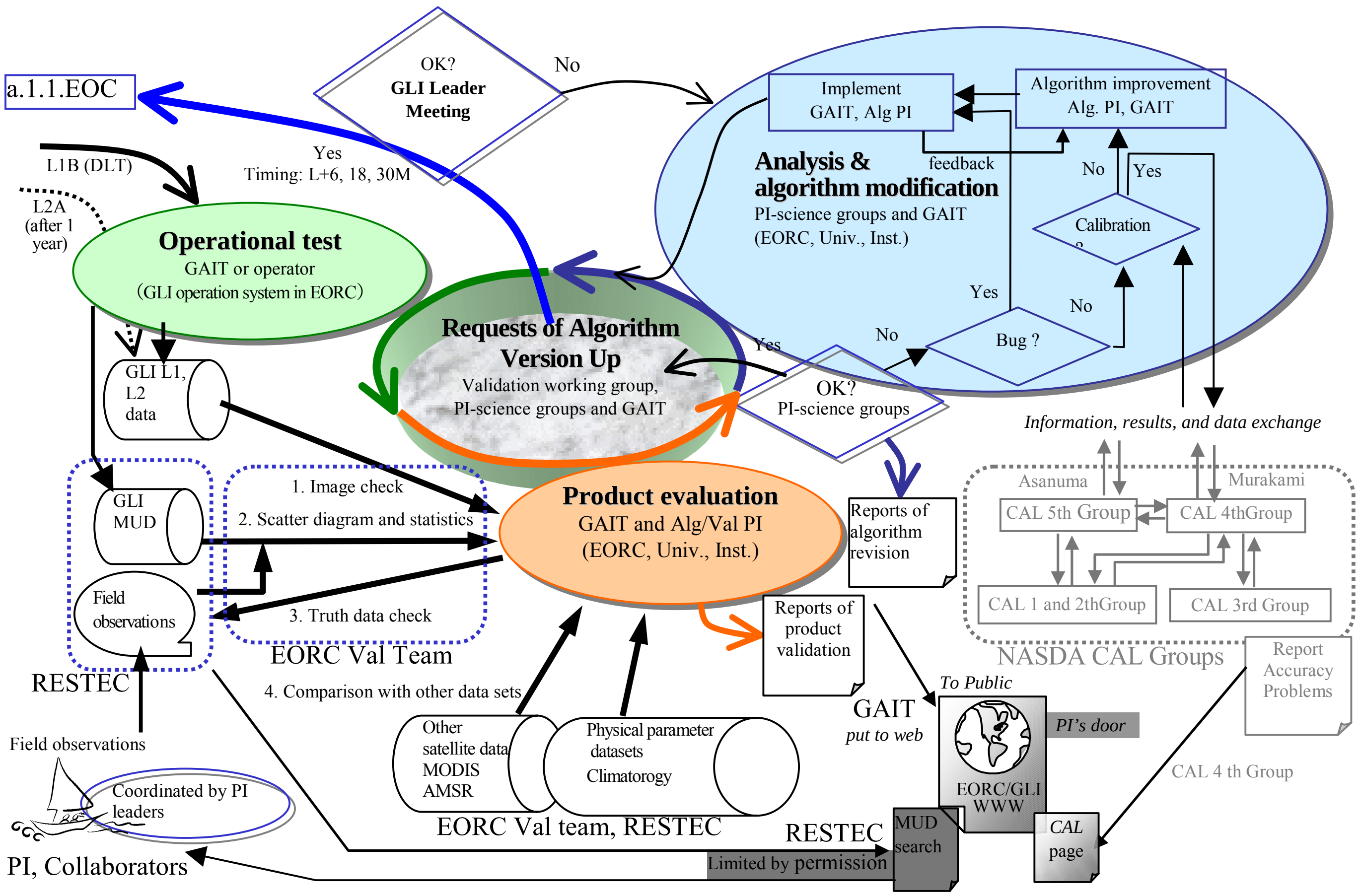


Figure 1.4.1-2 Work Flow of GLI Validation

1.4.1.4 Schedule

There are four main phases in the GLI mission. The periods are denoted such that L + 0M represents the first month after the launch. Calibration and validation results will be reflected in parameters and algorithms during the data-processing stage, so their timing will constitute milestones for calibration and validation work. Table 1.4.1-1 shows the main milestones in GLI calibration and validation.

- Prior to Launch: L – 1M
- Initial Checkout Phase: L + 0M to 3M
- Calibration and Validation Phase: L + 4M to 11M
- Regular Operation Phase: L + 12M

Table 1.4.1-1 Main Milestones of GLI Calibration and Validation

	～	L-4M	L-3M	L-2M	L-1M	L+0M	L+1M	L+2M	L+3M	L+4M	L+5M	L+6M	L+7M	L+8M	L+9M
	Prior to Launch					Initial Checkout				Calibration and Validation					
Calibration Group						Launch of ADEOS-II									△ L1 Process Ver. 1 fix
EORC							(Algorithm Developing PI, Calibration and Validation PI)			▲ Start Providing L1-Ver. 0					△ L2/3 Process Ver.1 fix
EOC															△ L1/2/3 Process Start Implementation

	L+10M	L+11M	L+12M	L+13M	L+14M	L+15M	L+16M	L+17M	L+18M	L+19M	L+20M	L+1M	L+22M	L+23M	L+24M
	Calibration and Validation		Regular Operation												
Calibration Group						(△*) (L1 Process Ver.2) (fix)									
EORC						△ L2/3 Process Ver.2 fix									
EOC			▲ Start Providing L1/2/3-Ver.1			△ Start Implementing L(1)/2/3 Process Ver.2		Start Re-Processing Past L(1)/2/3	▲ Start Providing L(1)/2/3-Ver.2						

	L+25M	L+26M	L+27M	L+28M	L+29M	L+30M	L+31M	L+32M	L+33M	L+34M	L+35M	L+36M	L+37M	L+38M	～
	Regular Operation														
Calibration Group			(△*) (L1 Process Ver.3) (fix)												
EORC			△ L2/3 Process Ver.3 fix												
EOC			△ Start Implementing L(1)/2/3 Process Ver.3		Start Re-Processing Past L(1)/2/3	▲ Start Providing L(1)/2/3-Ver.3									

* : Dates and frequencies of L1-version upgrading after L + 12M are T.B.D.

1.4.1.5 Information Disclosure Policy

(1) Calibration Information

The NASDA-GLI Calibration Group will establish the following five grades of disclosure restrictions concerning the calibration information and other data. The grades will be determined by mutual agreement of the provider of each type of information and the NASDA Calibration Group members. Information falling under (i) or (ii) below, i.e., information that should be widely published, will be disclosed after the completion of calibration work for each item, using the CAL pages of the EORC/GLI Web sites as well as PI's Door and GLI workshops.

(i) Publicly disclosed (to the extent possible, restrictions on information will be minimized).

(ii) Disclosed only to the NASDA Calibration Group, GAIT, and NASDA GLI PI (Disclosure restrictions are not necessary in the future for this information, but some restrictions provisionally apply because the information may be in the process of being organized or may be necessary for developing higher-order algorithms even though its disclosure may cause problems due to issues related to intellectual property. Equivalent to PI's Door.)

(iii) Disclosed only to validation-related staff members in the NASDA Calibration Group, GAIT, and EORC. (The information may not be organized and may be misleading, or it may be necessary for creating initial images and images for PR even though its disclosure may cause problems due to issues related to intellectual property.)

(iv) Disclosed only to the NASDA Calibration Group. (The information may not be organized and may be misleading, or it does not fall under (iii) above even though its disclosure may cause problems due to issues related to intellectual property.)

(v) Disclosed only within each calibration group. (The information may not be organized and may lead to gross misunderstanding, or there are serious problems with disclosure due to issues related to intellectual property.)

(2) Match-Up Data Sets

Policies are established as follows for match-up data sets used in validating GLI higher-order products. These data will be classified according to their disclosure levels and will be disclosed through the EORC/GLI Web sites and other means.

(i) NASDA will provide match-up data sets (in-situ observation data and GLI-generated data) for calibration and validation (algorithm development) of the GLI as well as Earth-scientific research.

(ii) Data sets will not be provided to a third organization.

(iii) Results of data collection will be disclosed publicly.

Tables 1.4.1-2 and 1.4.1-3 show the disclosure levels and level transition of in-situ observation data; Table 1.4.1-4 shows the disclosure levels of GLI-generated data.

Table 1.4.1-2 Disclosure Levels of In-Situ Observation Data

Disclosure Level Specified by In-Situ Data Provider		EORC staff members	GLI-related PI			Registered users including in-situ data providers	Usages
			Calibration PI	Validation and algorithm PI	Earth science PI		
3	Internal use within EORC	○	×	×	×	×	- GLI calibration and validation results (scatter diagrams, graphs, statistical data, and others where raw data are difficult to read or to estimate) are to be disclosed, clearly stating that NASDA databases are used and clearly stating the data-collecting organization (based on NASDA's product usage). - Disclosure of raw data prohibited.
2	Calibration / validation PI (PI group) - Only during PI contract - Terminates after PI contract expires	○	○	○	×	×	- GLI calibration and validation results are to be disclosed, clearly stating that NASDA databases are used and clearly stating the data-collecting organization (based on NASDA's product usage). - Usage for other purposes prohibited. - Re-disclosure of data prohibited.
1	Other PIs (PI group) - Other PIs in and out of Japan (e.g., SIMBIOS)	○	○	○	○	×	- Results that are useful in Earth-science research are to be disclosed with the data provider's consent (co-authorship or acknowledgment), clearly stating that NASDA databases are used (based on NASDA's product usage). - Calibration and validation results of other satellite sensors are to be disclosed, clearly stating that NASDA databases are used and clearly stating the data-collecting organization (based on NASDA's product usage). - Re-disclosure of data prohibited.
0	Others (general registered users including in-situ data provider)	○	○	○	○	○	- For data use, the fact that NASDA databases are used is to be clearly stated. Research results based on the data are to be reported to NASDA (based on NASDA's product usage). - Re-disclosure of data prohibited.

Table 1.4.1-3 Disclosure Level Transition of In-Situ Observation Data

Transition of Disclosure Levels	**According to the policy of the data provider. Levels are to be entered when the data are registered.**
(i)	Disclosure Level 1 from the beginning
(ii)	Disclosure Level is set to 2; automatically changed to Level 1 three years later
(iii)	Disclosure Level 2 is maintained; to be used only by Calibration/Validation PI
(iv)	Disclosure Level 3 is maintained; to be used only within EORC

Table 1.4.1-4 Disclosure Levels of GLI-Generated Data

Disclosure Level of Match-Up Data		**EORC staff**	**GLI-related PI**			**Registered users including in-situ data providers**	**Usages**
			Calibration PI	**Validation/ Algorithm PI**	**Earth Science PI**		
1	Including all PIs (PI groups) and organizations with contractual agreements	○	○	○	○	○	- Products using match-up data are to be disclosed, clearly stating that NASDA has collected the data (based on NASDA's product usage).

1.4.2 Calibration Plan

1.4.2.1 Solar-Ray Calibration and Internal-Lamp Calibration

(1) Overview

GLI Calibration Group 1 shall perform solar-ray calibration and internal-lamp calibration. The solar-ray calibration shall be carried out for each path every 5 minutes while the angle between the satellite's direction of motion and the direction of the Sun decreases from 20 degrees to 0 degrees upon passing the North Pole. The solar-ray calibration data shall be obtained in the visible near-infrared band and short-wavelength infrared band (channels 1 to 29). The solar rays are attenuated through a solar-ray calibration window, diffused at a diffuser panel, and injected into the detector through a scanning mirror. Therefore, the high-gain band (channels 1–12, 14, 16, 18, 20, and 21) plays a major role in this calibration.

The internal-lamp calibration shall be carried out for night paths and lasts approximately 10 minutes each time (this calibration period will be adjusted after the launch); this is done every two regressions (eight days). The internal-lamp calibration data shall be obtained in the visible near infrared band and short-wavelength infrared band. Due to the intensity of the halogen lamp light source, the low-gain band (channels 6–10, 13, 15, 17, 19, 21–29) plays a major role in this calibration.

Other in-orbit calibration methods include electric calibration and deep-sphere calibration. For electric calibration, six-step signals generated at the analog signal processor are input to the pre-amp for visible near infrared and short-wavelength infrared bands or into the post-amp (analog signal processor) for the intermediate heat infrared band in order to calibrate electric circuits). For deep-space calibration, offset terms are calculated using more than 10 samples taken by observing deep space during each scan.

Data from calibration, other than deep-space calibration, do not undergo normal processing by the processing system; rather, they are a means for estimating the calibration coefficients as part of the calibration work.

(2) Items

(i) Solar-Ray Calibration

a. Prior to Launch

- Evaluation of the GLI solar-ray calibration function
- Proposal of GLI standard solar illumination (decided as Thuillier 2002)
- Creation of an algorithm for deriving calibration coefficients
- Organization of calibration products (file specifications, processing facility)

b. After Launch

- Re-consideration of the GLI solar-ray calibration function
- Evaluation of the solar-ray calibration results
- Monitoring of secular change in the sensitivity of sensors

(ii) Internal-Lamp Calibration

a. Prior to Launch

- Evaluation of the GLI internal-lamp calibration function
- Creation of an algorithm for deriving calibration coefficients
- Organization of calibration products (file specifications, processing facility)
- Discussion of ideas for a calibration-mode operation pattern during regular operation period (including the calibration/validation phase)

b. After Launch

- Re-consideration of the GLI internal-lamp calibration function
- Evaluation of the internal-lamp calibration results
- Monitoring of secular change in the sensitivity of sensors

(3) Sharing of Responsibilities

The GLI-NASDA Calibration Group is jointly organized such that the specialty field of each of its subgroups — Analysis subgroup, Ground subgroup, and Installation subgroup — can be fully utilized. Therefore, the Group works together as appropriate under each circumstance for almost every task. The primary work responsibilities are below shown for each group.

(i) Installation Subgroup

- Analysis of ground test data (drawing calibration curves, SNR, stray light, cross talk, transient response, etc.)
- Initial checkout work (evaluating the functionality of VNIR/SWIR sensors, the installed calibration function, etc.)
- Analysis of installed calibration source data after the launch (evaluating A/B surface deviation and SNR)
- Evaluation of sensor characteristics after the launch (evaluating stray light, cross talk, and transient response)

(ii) Ground Subgroup

- Implementation of L1 algorithm
- Preparation of data for calibration (preparing products of solar-light, internal-lamp, and electric calibration)

(iii)Analysis Subgroup

- Analysis of Earth observation data (evaluating the deviation of scanning mirror surface, SNR, stray light, cross talk, and transient response)
- Evaluation of effects on higher-order products
- Evaluation of secular change in sensitivity

1.4.2.2 Black-Body Calibration

(1) Overview

GLI Calibration Group 2 shall perform black-body calibration. Black-body calibration will use the installed standard black-body and black-body temperature monitor data and will be performed during each scan for the MTIR channels. Black-body data cannot be obtained while there is a tilt, so gain information during Nadir observations will be effectively utilized.

(2) Items

(i) Before Launch

- Drawing calibration curves and non-linear tables
- Evaluating dynamic range
- Evaluating sensitivity deviations among MTIR pixels
- Evaluating the GLI black-body calibration function
- Proposing a GLI in-orbit black-body calibration algorithm

(ii) After Launch

- Re-discussion of the GLI black-body calibration function
- Re-discussion of in-orbit calibration methods
- Monitoring of secular change in the sensitivity of sensors
- Discussion of calibration methods using C1 tables while there is tilt

(3) Sharing of Responsibilities

The GLI-NASDA Calibration Group is jointly organized such that the specialty field of each of its subgroups — Analysis Subgroup, Ground subgroup, and Installation Subgroup — can be fully utilized. Therefore, the Group works together as appropriate under each circumstance for almost every task. The primary work responsibilities are shown below for each group.

(i) Installation Subgroup

- Analysis of ground test data (drawing calibration curves, calculating NEΔT, etc.)
- Initial checkout work (evaluating the functionality of MTIR sensors, the black-body calibration function, etc.)
- Analysis of installed calibration source data (evaluating A/B surface deviation and NEΔT)

(ii) Ground Subgroup

- Implementation of L1 algorithm (processing black-body calibration, preparing C1 tables for periods when there is tilt)
- Preparation of data for calibration (preparing archive data)

(iii)Analysis Subgroup

- Analysis of Earth-observation data (evaluating the deviation of scanning mirror surface and NEΔT)
- Evaluation of effects on higher-order products
- Evaluation of secular change in sensitivity

1.4.2.3 Geometric Calibration

(1) Overview

Calibration Group3 is primarily responsible for Geometric calibration. Sensor alignment will be calculated using L1A images and GCP. Evaluation will be divided into Sides A and B of the mirror, with and without tilt, and by scene units. Secular changes will also be considered, and the trend will be tracked. Registration between bands will be evaluated for L1A images and L1B images. Although the focal-point surface (whether the same or different) and difference in scanning angles are briefly considered here, emphasis will be placed on the situation with no tilt.

(2) Items

(i) Sensor Alignment

a. Prior to Launch

- Develop GCP-obtaining tools.
- Organize GCP candidate-point library.
- Prepare error patterns on images for each error-causing factor.

b. Initial Checkout Phase

- Obtaining GCP
- Discussion of error patterns on images

c. Calibration and Validation Phase

- Obtaining GCP (mainly by the Analysis Subgroup and Ground Subgroup)
- Calculations of sensor alignment (mainly by the Analysis Subgroup and Ground Subgroup)

d. Regular Operation Phase

- Validation of sensor alignment trend (mainly by the Analysis Subgroup and Ground Subgroup)

(ii) Registration Between Bands

a. Prior to the Launch

- Section of channels to be discussed through simulation

b. Initial Checkout Phase

- Evaluation of registration between bands

c. Calibration and Validation Phase

- Evaluation of registration between bands (mainly by the Analysis Subgroup and Ground Subgroup)

d. Regular Operation Phase

- None

(3) Sharing of Responsibilities

The Analysis Subgroup and Ground Subgroup within Group 3 calculate error patterns by GCP, calculate sensor alignment errors, and evaluate registration between bands. Sensor alignment will be evaluated jointly by the Installation, Analysis, and Ground. The Installation group will primarily evaluates star tracker and compare results with other sensors installed on ADEOS-II.

1.4.2.4 Evaluation of Sensor Characteristics and Image Quality

(1) Overview

Calibration Group 4 shall primarily correct the image quality and evaluate sensor characteristics other than the GLI in-orbit calibration (black-body calibration, internal-lamp calibration, and solar-ray calibration). In addition, this subgroup provides opportunities for discussion and information exchange in inter-group settings.

(2) Items

(i) Correction of Image Quality

a. Deviation between pixels, mirror surface, and scanning angle sensitivity

- Calculations of sensitivity deviation on the low-radiance side by the solar-ray calibration data
- Calculations of sensitivity deviation on the high-radiance side by the internal-lamp calibration data
- Calculations of sensitivity deviation by black-body observation data
- Calculations of correction coefficients by Earth-observation data

(ii) Evaluation of Sensor Characteristics

a. Noise

- Calculation of SNR on the low-radiance side by solar-ray calibration data
- Calculation of SNR on the high-radiance side by internal-lamp calibration data
- Comparison between SNR/NE Δ T based on Earth-observation data and SNR/NE Δ T based on installed calibration source

b. Dynamic Range, and Non-Linear/Saturation Characteristics

- Comparison between adjacent bands after the launch

c. Piecewise Linear Continuity

- Comparison between adjacent bands after the launch

d. Stray Light, Cross Talk, Transient Response

- Actual sample analysis of Earth-observation data
- Evaluation of cross talk from MTIR band to VNIR/SWIR bands using night VNIR/SWIR observation data
- Discussion of flags

(iii) Monitoring Sensor Characteristics

- Monitoring temperature changes of various parts of the sensors, mainly contained in archived data
- Monitoring levels in the dark

(iv) Coordination with Higher-Order Product Development

- For calibration changes that significantly influence higher-order products, process testing shall be delegated to the higher-order processing group, and the influence of revising the L1 algorithm on higher-order products will be evaluated.

(3) Sharing of Responsibilities

The GLI-NASDA Calibration Group is jointly organized such that the specialty field of each of its subgroups — Analysis subgroup, Ground subgroup, and Installation subgroup — can be fully utilized. Therefore, the Group works together as appropriate under each circumstance for almost every task. The primary work responsibilities are shown below for each subgroup:

(i) Installation Subgroup

- Analysis of ground test data
- Initial checkout work
- Analysis of installed calibration source data

(ii) Ground Subgroup

- Implementation of L1 algorithm
- Preparation of data for calibration

(iii) Analysis Subgroup

- Analysis of Earth-observation data
- Evaluation of effects on higher-order products

1.4.2.5 Vicarious Calibration, Cross Calibration

(1) Overview

Calibration Group 5 shall perform vicarious calibration. In this procedure, in-situ data and atmospheric radiative-transfer simulation are combined to estimate the GLI observation radiance. The vicarious calibration coefficient Gcal is obtained by comparing the result with the radiance of the L1B data. In calculating this coefficient, the accuracy of Earth-observation data and the accuracy of the atmosphere simulation conditions are crucial, so ample preparation and discussion are necessary. GLI observation spans a large range from high radiance to low radiance, and a high level of accuracy in observation is required at all radiance levels. Therefore, it is necessary to cover both the high-radiance and low-radiance ranges in ground observation for vicarious calibration.

Before the launch, a vicarious calibration test shall be conducted for SeaWiFS or MODIS. Upward spectral radiance, downward spectral luminance, aerosol optical thickness, etc. are to be measured on the sea surface or land surface, synchronously with either SeaWiFS or MODIS. Ozone data are then collected from TOMS. Applying these data to the radiative-transfer model, upward spectral radiance arriving at the satellite will be calculated and compared with the corresponding radiance value obtained by either SeaWiFS or MODIS. This test will yield the calibration coefficient for SeaWiFS or MODIS.

In the initial checkout phase, vicarious calibration will, if possible, be carried out synchronously with the GLI check period. As before the launch, vicarious calibration combined with other usable satellites will also be carried out in a similar fashion.

During the calibration and validation phase and the regular operation phase, vicarious calibration will be carried out four times a year — at the spring equinox, summer solstice, autumn equinox, and winter solstice — considering the change in the Sun's zenith angle.

After completion of the GLI checkout phase, vicarious calibration will be once again carried out at an early time in order to determine the calibration coefficient. A proposal for a permanent vicarious calibration coefficient will be considered every six months.

(2) Items

(i) Vicarious Calibration in Low-Radiance Regions

- Observing upward spectral radiance, downward spectral luminance, and atmospheric parameters near the sea surface. (Buoy will be installed off the coast of Ishigaki Island, or NASA's Moby will be used for this purpose.)
- Estimation of satellite-arrival radiances using radiative-transfer model (RSTAR, MODTRAN, etc.)
- System organization for calculating observation and calibration coefficients (prior to the GLI operation)

(ii) Vicarious Calibration in High-Radiance Regions

- Measuring upward spectral radiance, downward spectral luminance, and atmospheric parameters in desert and snow fields
- Estimation of satellite-arrival radiance values using a radiative-transfer model (RSTAR, MODTRAN, etc.)
- System organization for calculating observation and calibration coefficients (prior to the GLI operation)

(iii) Cross-Comparison with Other Satellites

- Tentative vicarious calibration using values of ocean-color sensors that have already been vicariously calibrated such as SeaStar/SeaWiFS and Terra/MODIS.
- System organization for data-handling and calculating calibration coefficients (prior to the GLI operation).

(iv) Simple Vicarious Calibration of Heat Infrared Based on Global Data

- Using one day's GLI L1B data, Reynolds SST data, JMA's objectively analyzed data, and the radiative-transfer model (LOWTRAN 7), a correction coefficient will be obtained such that the GLI radiance values will match the values obtained through simulation by LOWTRAN on a global scale.

(3) Sharing of Responsibilities

Calibration Group 5 mainly consists of members of the analysis group. However, in evaluating the absolute calibration coefficients found and their secular change, the Group will work together with Calibration Groups 1 and 2, comparing and discussing other calibration results (results of solar-ray, internal-lamp, and black-body calibration).

1.4.2.6 L1-Process Software

(1) Overview

Initial checkout support work shall be carried out in accordance with the document "GLI Proper Parts Initial Operation Evaluation Plan (NEB-01026)." The evaluation results will be incorporated in the L1-process software. This will be done by Calibration Group 6.

(2) Items

- Preparing and providing data requested by MEP (including preparing and providing archived data for calibration)
- Incorporating the evaluation results in the L1-process software

(3) Sharing of Responsibilities

(i) Installation Subgroup

- Preparing MEP
- Revising the algorithm standard document based on the evaluation results

(ii) Ground Subgroup

- Preparing and providing data requested by MEP
- Incorporating the evaluation results in the L1-process software

(iii) Analysis Subgroup

- Preparing revision requests for the L1-process software based on the analysis results

1.4.3 Validation Plan

1.4.3.1 Atmosphere

GLI atmosphere products must be validated to accomplish the final objectives of the ADEOS-II mission, as there is a considerable level of uncertainty in the conversion process from radiance to geophysical parameters. Furthermore, it is crucial that the validation and vicarious calibration of satellite sensors be comprehensively integrated in order to create an effective validation system.

Validation data of the GLI atmosphere products are gathered through continuous observation at several validation sites as well as through intensive field experiments conducted several times after the launch; existing data will also be used. At validation sites, several parameters are continuously measured, including the radiance for each wavelength and for all wavelengths, radiative flux, and geophysical parameters concerning clouds, aerosols, and the amount of water vapor. In intensive field tests, it is essential to carry out in-situ observation of the atmospheric conditions from aircraft, including physical movements of aerosols and clouds as well as the reflection from the land surface. Existing data sets used for meteorological purposes are indispensable, particularly the sonde data and radiance data for various individual wavelengths and for all wavelengths. In addition, it is useful to compare and study these products from other satellite sensors with the GLI products. Because validation and vicarious calibration require long-term, global observation as well as data collection, it is important to establish a close relationship with domestic and international projects such as WCRP/GEWEX and IGBP/IGAC/ACE-ASIA.

The fundamental validation strategy is to collect large-scale, long-term validation/ vicarious calibration data through regular observation at a network of sites. Of course, such a network cannot be maintained by one organization, so this will be done in partnership with international joint research projects. Validation sites must be selected with the objective of spanning diverse atmospheric and ground conditions and a variety of scientific interest. Sites in China and southeast Asia are crucial in order to collect data concerning the effects of atmospheric pollution and aerosol accumulation caused by human activity in Asia. Ocean observation by vessels is necessary for collecting data in areas with clean air mass and for research on marine aerosols and clouds. Other sites with present plans will also be useful as sites for international joint work. Some of these sites are already in operation and some are in the planning stage. Investment in instruments must be carefully coordinated for each site.

The validation work of the GLI atmosphere products can be summarized as follows; details of the implementation plan are found in “GLI Atmosphere Validation Implementation Plan” (NDX-000234).

(1) Asia Land Continuous Observation: Observation at Si Samrong, Hefei, Yinchuan, Dunhuang, Mandalgovi, Miyakojima Island, Fukuejima Island, Chiba, Amami Oshima Island, Minami Torishima Island
(2) Vessel Observation: Observation on Mirai, Yasaku Maru, Shinzan Maru
(3) Pre-Launch Validation Observation: Fukuejima Island intensive observation, aircraft observation near Amami
(4) Intensive Observation: Initial Validation Test, Test of the Effects of Aerosols Caused by Human Activity, Follow-Up Intensive Test

Table 1.4.3-1 GLI Atmosphere Products and Target Accuracy

Product Code	Algorithm Code	Geophysical Parameter Code	Geophysical Parameter	Target Accuracy
ARAE	ATSK5 post_ATSK5	ARAE	Aerosol Angstrom Exponent	0.5
AROP		AROP	Aerosol Optical Thickness	*1 10% or 0.05
CLOP	Pre_ATSK3_p ATSK3_p	CLOP	Cloud Optical Thickness	*1 10%
CLER	ATSK3_r ATSK3_e ATSK16	CLER	Cloud Equivalent Grain Size	20%
CLFR		CLFR	Amount and Type of Clouds	*2 10%
CLHT		CLHT	Cloud -Top Altitude	1.0 km
CLTT		CLTT	Cloud -op Temperature	0.5 K
CLWP		CLWP	Cloud-Liquid Water Percentage	20%

*1 The optical thicknesses of aerosols and of clouds are measured at a wavelength of 500 nm.
*2 The amount of clouds is the target error corresponding to the monthly average.

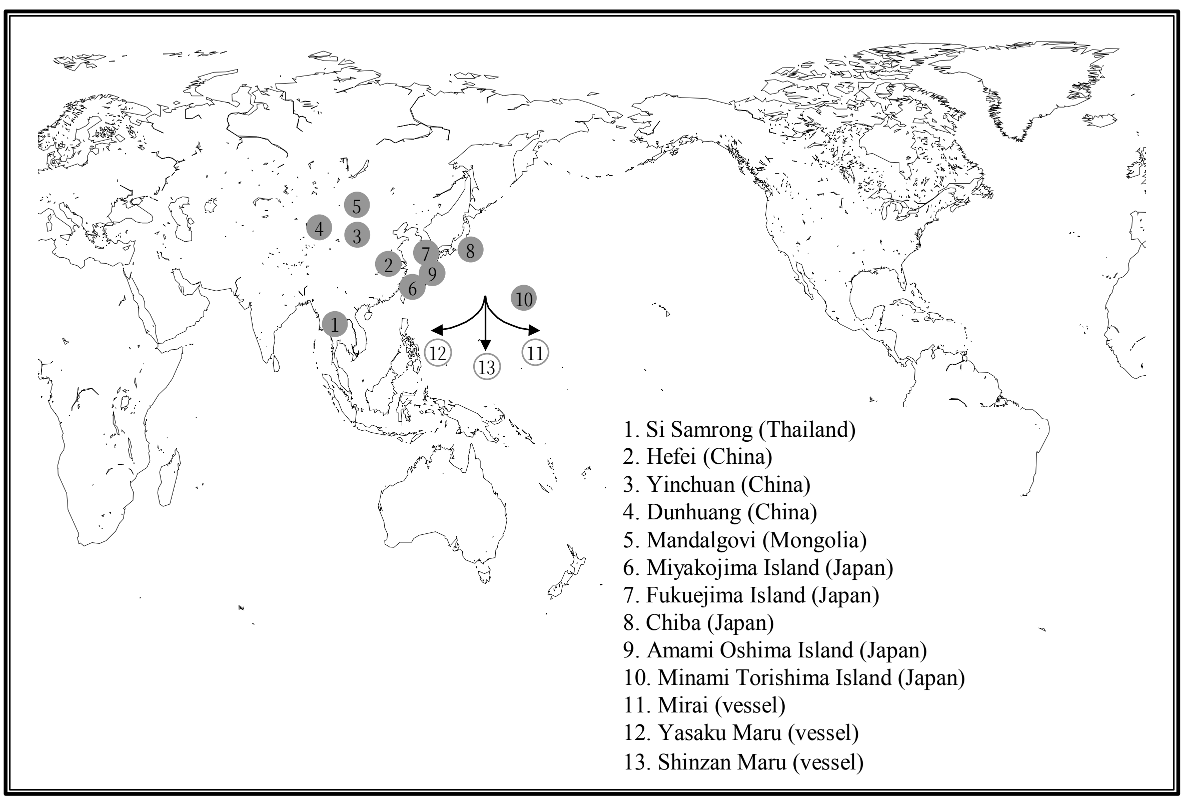


Figure 1.4.3-1 GLI Atmosphere Validation Sites

1.4.3.2 Ocean

Validation of the GLI Ocean products can be classified into validation of ocean color and validation of sea-surface temperature.

In validating ocean color, vicarious calibration using data collected on the ocean is indispensable. For this reason, validation ocean color is closely linked to vicarious calibration. In the validation that follows this, satellite-measured radiance (which incorporates the results of vicarious calibration) will be used to validate the normalized water-leaving radiance (nLw), chlorophyll (CHL), suspended substances (SS), and colored dissolved organic matters (CDOM), clarifying the accuracy of these values and paving the way to discuss the algorithm for the next algorithm revision.

Data collection for validating ocean color can be mainly divided into global collection and collection around Asia. Global validation is carried out through international cooperation with PI, SIMBIOS, etc. and collects data corresponding to large-area standard products. Regional data collection around Asia can be roughly classified into (1) field campaigns, (2) cooperative measurement with universities, (3) cooperative measurement with the Fisheries Agency, and (4) cooperative measurement with researchers in Asia.

Sea-surface temperature is validated as follows. In order to validate GLI bulk sea-surface water temperature continuously around the globe, it is essential to have a well-planned strategy and a system to implement it. The Ocean Group of the GLI Science Team has a goal of maintaining an RMS accuracy of 0.6 K or less throughout the duration, globally, for GLI bulk sea-water surface temperature. This target was established based on the target accuracy of past global sensors. After the launch of ADEOS-II, the accuracy will be further improved through close cooperation with the algorithm developers.

The validation plan has been carefully made such that the bulk sea-surface water temperature products will be validated soon after the launch of ADEOS-II, and the accuracy-validated products will be introduced at the start of the regular operation phase. The basic policy of this plan is as follows. In validating GLI sea-surface water temperature, satellite-observed SST will be used in order to make sufficient comparisons with GLI products prior to the beginning of the regular operation phase. After that, as the frequency of GLI observation increases, more match-up data with in-situ observation will be made, leading to the creation of more reliable algorithms.

The validation work of the GLI ocean products can be summarized as follows; details of the implementation plan are found in “GLI Ocean Validation Implementation Plan” (NDX-000235).

(1) Sea Water: Validation through data collection on vessels
(2) Sea Surface Water Temperature: Validation through in-situ data and satellite data

Table 1.4.3-2 GLI Ocean Products and Target Accuracy

Product Code	Algorithm Code	Geophysical Parameter Code	Geophysical Parameter	Target Accuracy
NL_FR NL_LR	OTSK1a_FR OTSK1a_LR	NWLR	Normalized Water-Leaving Radiance (outer sea)	×1.5
			Normalized Water-Leaving Radiance (coastal waters)	×2.0
		QF_OC	Ocean Color Product Quality Flag	-
CS_FR CS_LR	OTSK2_FR OTSK5_FR OTSK7_FR OTSK6_FR OTSK2_LR OTSK5_LR OTSK7_LR	CHLA	Chlorophyll a Concentration (outer sea)	×1.5
			Chlorophyll a Concentration (coastal waters)	×2.0
		CDOM	Dissolved Organic Matters Light-Absorption Coefficient	×2.0
		K490	40nm Dissipation Coefficient	×1.5
		SS	Suspended Substance Concentration	×2.0
ST_FR ST_LR	OTSK13_FR OTSK13_LR	SST_b	Bulk Sea-Surface Temperature	0.6 K
		QF_ST	Sea-Surface Temperature Product Quality Flag	-

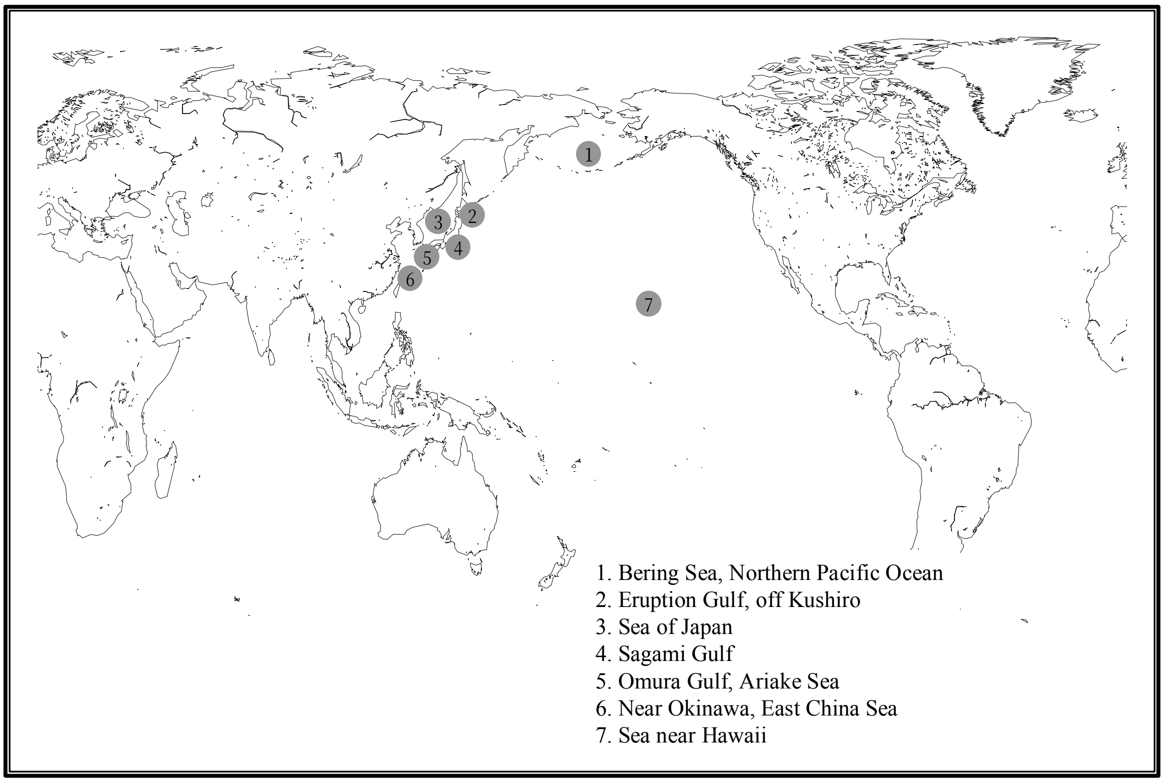


Figure 1.4.3-2 GLI Ocean Validation Sites

1.4.3.3 Land

The land group of the GLI Science Team has used visible and near infrared-range channel data to create an algorithm that determines the vegetation index as a standard product. Ground observation tests are planned to validate this algorithm and calibrate accuracy and sensors, starting prior to the satellite launch and lasting for two years after the launch. The standard product to be studied is the vegetation index. By obtaining vertical spectral information, bidirectional reflection, and atmospheric characteristics on the land surface synchronously with the satellite, the vegetation index can be calculated through ground observation. It is then possible to determine how much of the influence caused by the atmospheric and bidirectional reflection characteristics was eliminated by using the standard algorithm. By analyzing the sensitivity of vegetation index, the accuracy in terms of plant monitoring can be analyzed.

Before the launch of ADEOS-II, field-related ground tests will be carried out at Mandalgovi (Mongolia), New Mexico (United States), and Yatsugatake (Japan). Spectral information on land surface, bidirectional reflection characteristics, and atmospheric characteristics will be gathered, and a system will be organized to find the standard product quantities through ground observation. After the launch, observation will continue at sites including Amburla (Australia), Miri (Malaysia), and Ho Chi Minh (Viet Nam). In order to complete the first round of validation activities within half a year of the launch, it is necessary to partially change the geographical regions for validation activities for the year, depending on the season in which the launch will take place. For example, if the launch is in the winter in the northern hemisphere, validation data on fields will be collected in Mandalgovi during the summer in the northern hemisphere. If the launch is in the summer in the northern hemisphere, validation data will be collected in Amburla during the winter in the northern hemisphere; validation activities are to be carried out as early as possible.

In actual validation activities, the vertical spectral information on the land surface will be measured by a hand-held spectroradiometer and by a spectrometer on an RC helicopter. The bidirectional reflection characteristics can also be obtained by the method in which an RC helicopter observes one point on the land surface from the air. The atmospheric characteristics are to be synchronously measured by sun photometer. Biomass, a geophysical parameter for plants, needs to be obtained by cutting and collecting samples. The leaf-area index can be obtained by measurement using devices such as the LAI2000. The coverage rate can be determined by analyzing digital images taken from an RC helicopter. It is impossible to measure everything at all the sites, so the items to be measured for each validation region will be coordinated.

Precise geometric correction parameters are used in creating higher-order products for GLI land and cryosphere, for which precise geometric correction is already completed; these parameters are land standard products themselves. Hence, as a part of the GLI land validation process, the precise geometric correction parameters will also be validated.

The validation work of the GLI land products can be summarized as follows; details of the implementation plan are found in "GLI Land Validation Implementation Plan" (NDX-000236).

(1) Observation at Mandalgovi
(2) Observation at Amburla
(3) Observation at New Mexico
(4) Observation at Yatsugatake
(5) Observation at Miri
(6) Observation at Ho Chi Minh
(7) Observation at Kii Peninsula
(8) Observation at Tomakomai
(9) Validation of Precise Geometric Correction Parameters

Table 1.4.3-3 GLI Land Products and Target Accuracy

Product Code	Algorithm Code	Geophysical Parameter Code	Geophysical Parameter	Target Accuracy
VGI	LTSK9	NDVI	Normalized Vegetation Index	10%
		EVI	Extended Vegetation Index	10%
ACLC	LTSK1	ACLC	Reflectance with Atmospheric Correction Done	10%
PGCP	LTSKG	--	Precise Geometric Correction Parameter	<1 pixel
Level-2A_LC	LTSK10	--	Data Composite	-

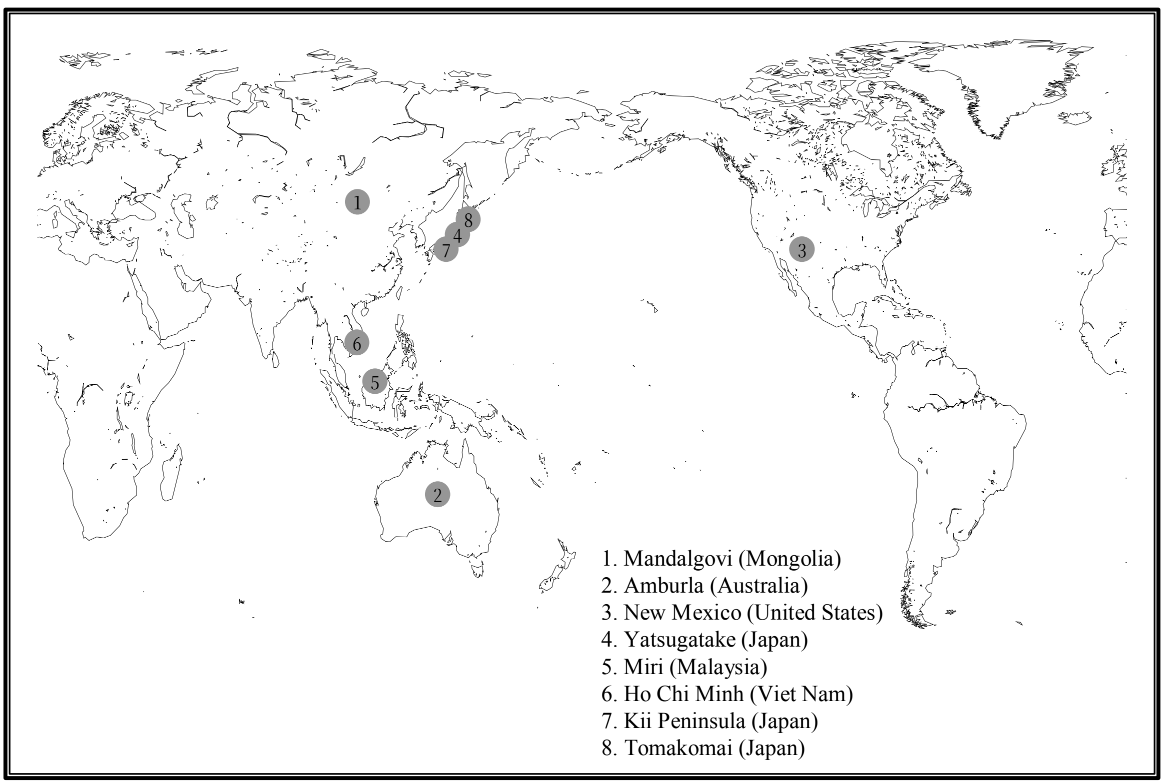


Figure 1.4.3-3 GLI Land Validation Sites

1.4.3.4 Cryosphere

In the cryosphere, the following standard and research products will be made. Standard products are the snow grain size, snow impurity, and cloud search; research products are snow and sea-ice distribution, snow-ice surface temperature, snow-ice surface albedo, snow in forests, vertical distribution of snow grain size, and sea-ice classification. These snow-ice geophysical parameters will be validated by direct observation and optical observation of geophysical parameters on the ground as well as remote observation from aircraft. Snow grain size, snow impurity, snow-ice surface temperature, snow-ice surface albedo, snow in forests, and vertical distribution of snow grain size are directly measurable geophysical parameters. By combining optical observations by spectrometer, FTIR, etc. with snow-ice cross-section observations, we can study the effects that these snow-ice geophysical parameters may have on the radiance characteristics, thus enabling the algorithm and radiative transfer model to be improved prior to the satellite launch. After the launch, the accuracy of the products thus produced will be validated; if the accuracy is insufficient, the algorithm will be improved. Cloud search, snow and sea-ice distribution, and sea-ice classification are geophysical parameters that are difficult to measure directly; the accuracy of these parameters will be validated using remote observations from aircraft and/or other satellites as well as statistical methods through fixed-point observations.

Locations where tests will be conducted for validation are snow-ice surfaces at the Shinjou Branch of the Nagaoka Snow Ice Hazard Prevention Research Institute, around Lake Saroma in Hokkaido, around Fairbanks and Barrow (both in Alaska), and the Syowa Base and interior of Antarctica. Observations at the Shinjou Branch of the Nagaoka Snow Ice Hazard Prevention Research Institute are intended to clarify basic BRDF characteristics, so these will be done prior to the GLI launch. In eastern Hokkaido, where the snowfall amount is relatively high, the rate of clear sky is high. Lake Saroma is located in this area, where fresh water is mixed with sea water; the sea water is uniform in this lake, which faces the Sea of Okhotsk. Therefore, snow in the inland and forests, as well as various types of sea-ice, can be observed and measured in a short period of time. In addition, this is a suitable site for aircraft observation, so most products can be measured here. The only exception is that the site is not suitable for validating of snow-forest relationship products synchronous with the GLI because there is no uniform snow-ice surface over the GLI pixel size of 1 km x 1 km, except in the sea-ice of Lake Saroma. Here, algorithm validation observations will be carried out every year before and after the launch. For observations synchronous with the satellite, Fairbanks and Barrow in Alaska are suitable as these sites have large, uniform land surfaces. Products on snow-in-forest will be mainly validated around Fairbanks, and products on snow and sea-ice will be mainly validated around Barrow. Barrow also has NOAA’s observation facilities for CMDL and ARM, where aerosol and meteorological data can be collected. Validation and calibration work will be carried out in Fairbanks and Barrow immediately after the launch. Antarctica is a very geologically and scientifically interesting site. The snow contains very few impurities, and the study of snow grain size there is expected to reveal variations with respect to altitude, ranging from about 4000 m from the shoreline to the interior, as well as season and time over years. One or two staff members will be sent to Antarctica to conduct validation and calibration work.

The validation work of the GLI cryosphere products can be summarized as follows; details of the implementation plan are found in "GLI Cryosphere Validation Implementation Plan" (NDX-000237).

(1) Indoor and ground tests at the Shinjou Branch of the Nagaoka Snow Ice Hazard Prevention Research Institute
(2) Ground observation in eastern Hokkaido
(3) Ground observation at Fairbanks and Barrow
(4) Ground observation at Syowa Base

Table 1.4.3-4 GLI Cryosphere Products and Target Accuracy

Product Code	Algorithm Code	Geophysical Parameter Code	Geophysical Parameter	Target Accuracy
CLFLG_p	CTSK1	SCFG	Snow and Cloud Flags	5%
		SCFG	Snow and Sea-Ice Distributions	5%
SNGI_p SNGI	CTSK2b1_s CTSK2b1_g	SNWG	Snow Grain Size	20%
		SNWI	Snow Impurity	30%
-	-	-	Snow-Ice Surface Temperature	2°C
-	-	-	Snow-Ice Land Surface Albedo	3%
-	-	-	Distribution of Snow in Forests	30%
-	-	-	Vertical Distribution of Snow Grain Size	25%
-	-	-	Sea-Ice Distribution	10%

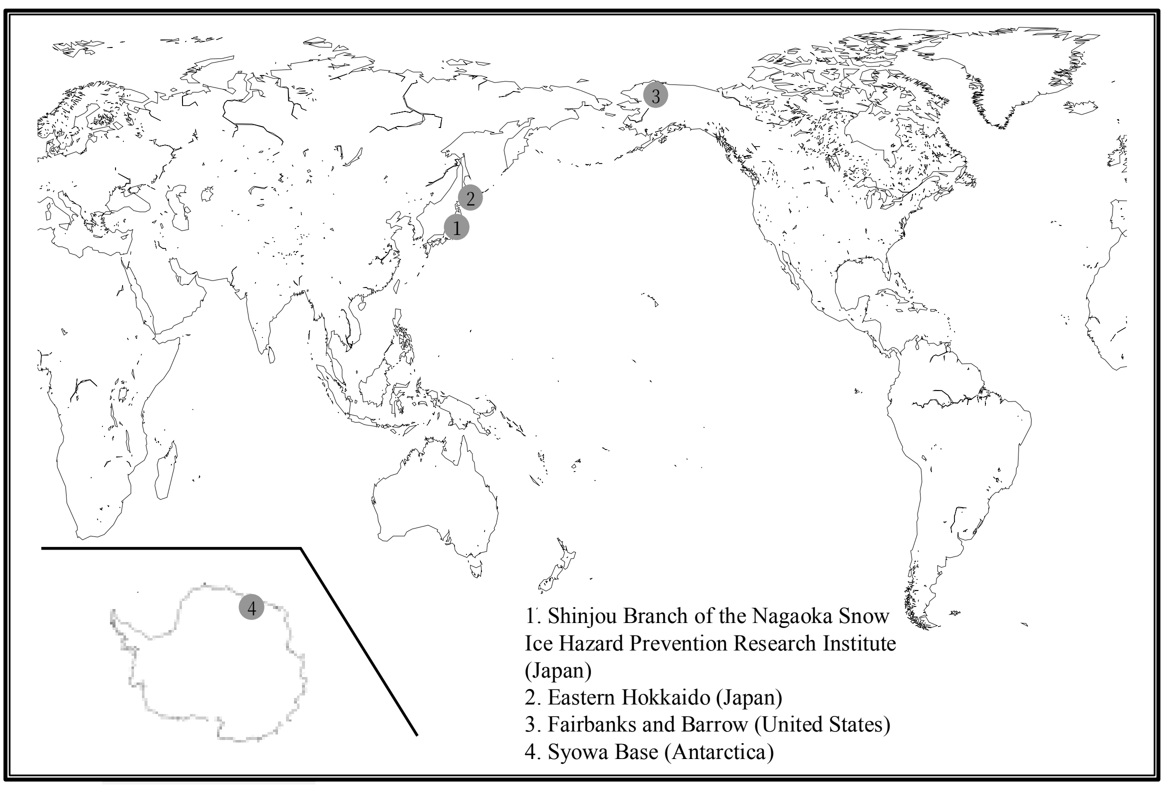


Figure 1.4.3-4 GLI Cryosphere Validation Sites

2. AMSR

2.1 Scientific Objectives

The Advanced Microwave Scanning Radiometer (AMSR) is a passive microwave radiometer that measures weak microwave radiation emitted from the Earth. A characteristic of microwave radiometers like AMSR is that they can measure fixed geophysical parameters under almost any weather conditions, even during day and night. Combining 14 channels of data, AMSR aims at observing the following geophysical parameters related to water on the Earth.

(1) Accumulated atmospheric water vapor
(2) Precipitation
(3) Accumulated atmospheric cloud liquid water
(4) Sea surface wind/speed
(5) Sea surface temperature
(6) Sea ice distribution
(7) Snow runoff depth
(8) Soil moisture amount

AMSR's main mirror is 2 meters in diameter, and this is the biggest in all microwave radiometers today. A big mirror enables observations with low frequency of 6.9 GHz. As a result, it will acquire geophysical parameters like the sea surface temperature and soil moisture that the conventional microwave radiometers cannot observe. AMSR also will observe water vapor, cloud water, and precipitation like conventional microwave radiometers, but with improved observation accuracy and precision due to high spatial resolutions.

AMSR will be fly on both ADEOS-II and NASA's EOS-PM1. The sensor aboard EOS-PM-1 is called "AMSR-E" both sensors are called "AMSR." Observational time for ADEOS-II is 10:00 AM local time; that of EOS-PM1 is 1:30 PM. More observations will be performed, and those two sensors will enable observing daily changes. AMSR-E' main mirror is 1.6 meters in diameter.

The AMSR data can be obtained as global data in near real-time through the data relay satellites. It is expected to be used as initial values for of weather forecasting models and to enable proving the practical use of AMSR. In the future, satellite data and numerical values will be assimilated, to provide analysis. Use of fixed AMSR data for this is considered a future promising field.

2.2 Overview of the Mission Instruments

The advanced microwave signal radiometer (AMSR) performs high-accuracy observation by receiving extremely weak microwave signals naturally emitted from the land surface and atmosphere in multiple bands, measuring a variety of geophysical parameters relating to water (H_2O), day and night and even under cloud cover. Its primary purpose is to collect data for understanding water and energy circulation on a global scale.

The AMSR microwave signal radiometer measures eight frequency bands from 6.9GHz to 89GHz using both vertically and horizontally polarized waves (except the two frequency bands in the 50GHz band). Its antenna and other parts are mechanically rotated to do the scanning and to collect radiance data from land surface.

The AMSR has an antenna aperture, with a diameter of 2m; it is capable of collecting data with spatial resolution of 5 km in the 89GHz band (the band with the shortest wavelength) and 60 km in the 6.9 GHz band (the band with the longest wavelength). It also reduces the influence of sea winds on the sea-surface temperature by performing conical scanning so that the angle of incidence with respect to the land surface is maintained constant at 55 degrees. With a scanning width of 1600 km, it is capable of wide, large-scale observation. Furthermore, it obtains the radiant temperature of deep space (2.7 K) as well as a high-temperature calibration source to calibrate observation data. Table 2.2-1 lists the major AMSR specifications. Figure 2.2-1 shows the AMSR observation concept.

Table 2.2-1 AMSR Main Specifications

Item	Specifications							
Central Frequency (GHz)	6.9	10.65	18.7	23.8	36.5	89.0	50.3	52.8
Ground Resolution	50km		25km		15km	5km	10km	
Band Width (MHz)	350	100	200	400	1000	3000	200	400
Polarization	Horizontal and Vertical						Vertical	
Observation Width	1600 km							
Data Rate	111.09 Kbps[*1]							

1. During one scan (one rotation) of the AMSR, there is a period of time in which no data are collected; hence, the essential average data rate is 87.38 Kbps.

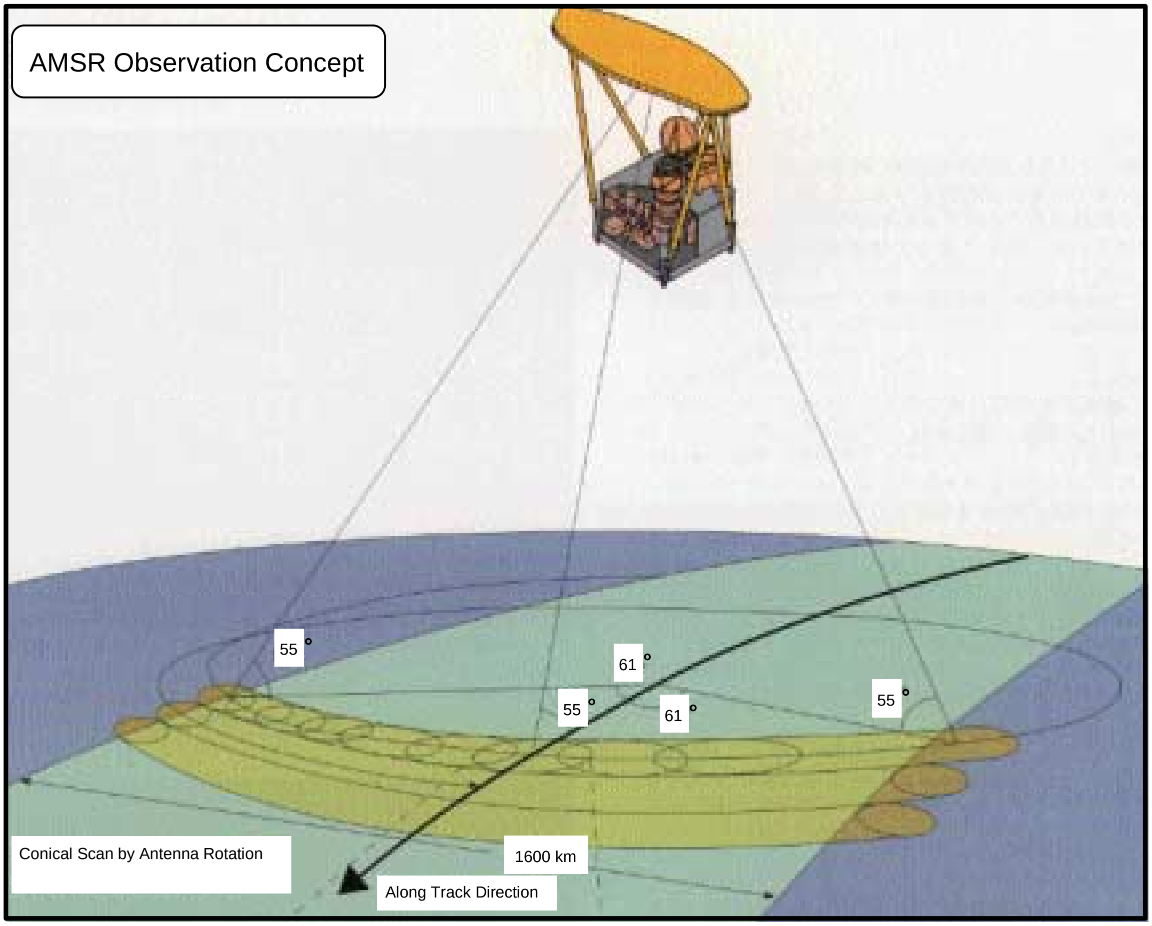


Fig. 2.2-1 AMSR Observation Concept

Table 2.2-2 shows the operation mode of the AMSR during a regular operation period.

Table 2.2-2 AMSR Operation Mode during a Regular Operation Period

Mode	Operation Overview	Conditions for the Mode
Normal Mode	Mode in which observation data are collected or stand-by mode for collecting observation data	During the regular operation, this is the default mode that is maintained.
Sleep Mode	Rotating instruments maintain their normal constant rotation rates, maintaining the instrument temperature within the operational temperature range.	Mode when a light-load-mode (LLM) command[*1] is issued or during orbit-attitude angle control

1. When there is trouble with the satellite, this command is issued autonomous by on the ADEOS-II onboard computer (OBC) to each installed instrument.

2.3 Specific

2.3.1 Products

(1) Products created in EOC
Standard products, near real time products、browse data
(2) Products created in EORC
Research products

2.3.2 Definition of higher-order products

2.3.2.1 Standard products

Standard products are created by EOC as planning production and created from a standard algorithm. After data production, they are saved in EOC and distributed to general users.

(1) Table 2.3.2-1 lists Level 2 standard products.

Table 2.3.2-1 Standard Products

Processing Level	Product	
L2	WV	Water Vapor
	CLW	Cloud Liquid Water
	AP	Precipitation
	SSW	Sea Surface Wind
	SST	Sea Surface Temperature
	IC	Sea Ice Concentration
	SWE	Snow Water Equivalence

2.3.2.2 Near real time products

Near real time products conform to " ADEOS-II / EOS-PM1 Near-real-time Products (NEB-98020) . "

2.3.2.3 Browse data

Browse data is the source data that creates the image catalog in EOC.
Image catalog provision Services to display the image catalog (browse image) through EUS/GUI or EUS/WWW are described in Chapter 2.3.5.

2.3.2.4 Research products

Research products are created from algorithms developed by EORC. The algorithms used for this product are for research purposes and quality is not guaranteed. These are not defined as products to be created in EOC.

(1) Table 2.3.2-2 lists research products.

Table 2.3.2-2 Research Products

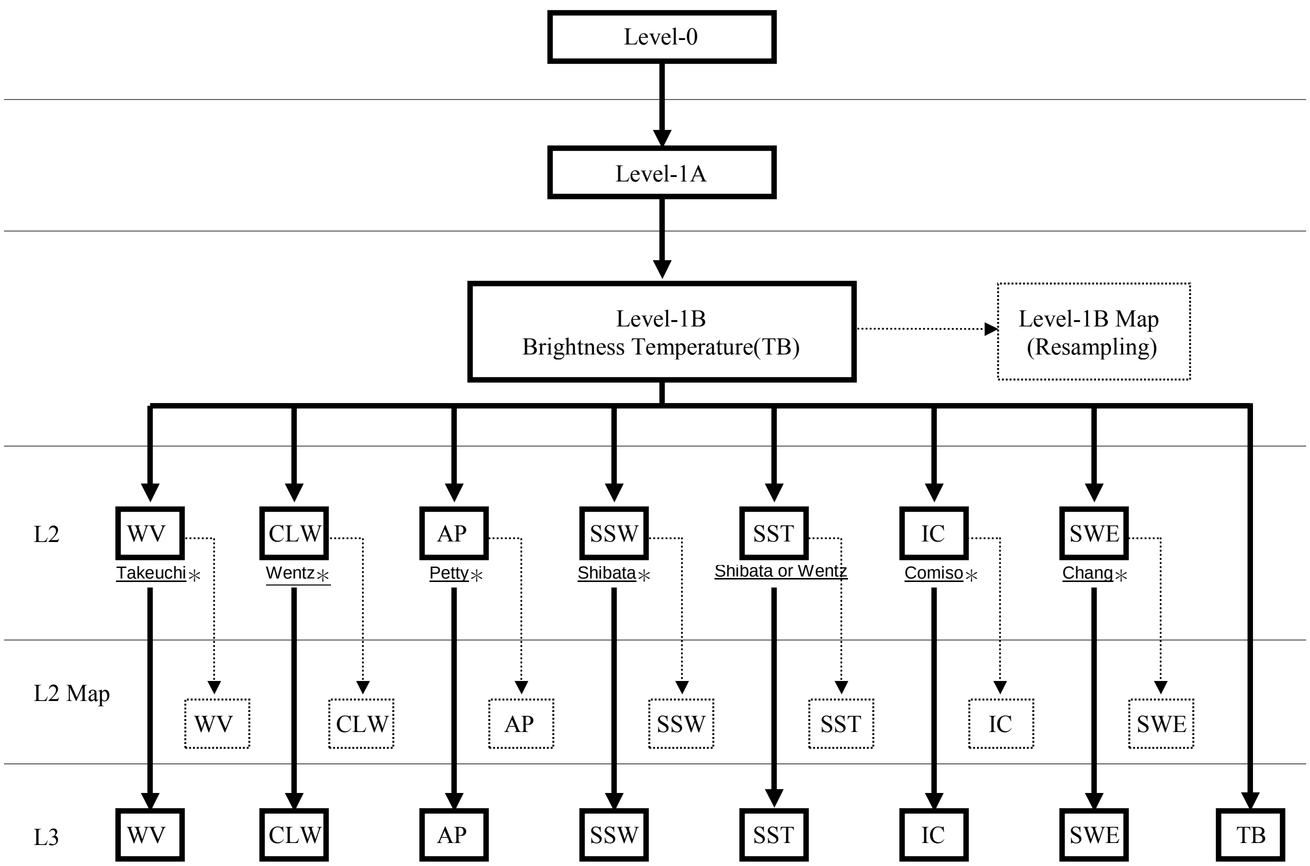
Product	
RWV	Research of Water Vapor
RCLW	Research of Cloud Liquid Water
RAP	Research of Precipitation
RSSW	Research of Sea Surface Wind
RSST	Research of Sea Surface Temperature
RIC	Research of Ice Concentration
RSWE	Research of Snow Water Equivalence
RSM	Research of Soil Moisture

2.3.3 Scene definition

(1) Scenes for level 2 are basic observational units. Taking half of one cycle (half cycle), this definition includes pole to pole for each orbit.
(2) Scenes for level 2 Maps use 1600km (observed width)×1600km (orbit direction) .
(3) Level 3 contains not only scene units but also data for the whole globe.

2.3.4 Processing level definitions

The flow of the whole process is shown in Fig.2.3.4-1.



*Described as reference information by the algorithm developers.

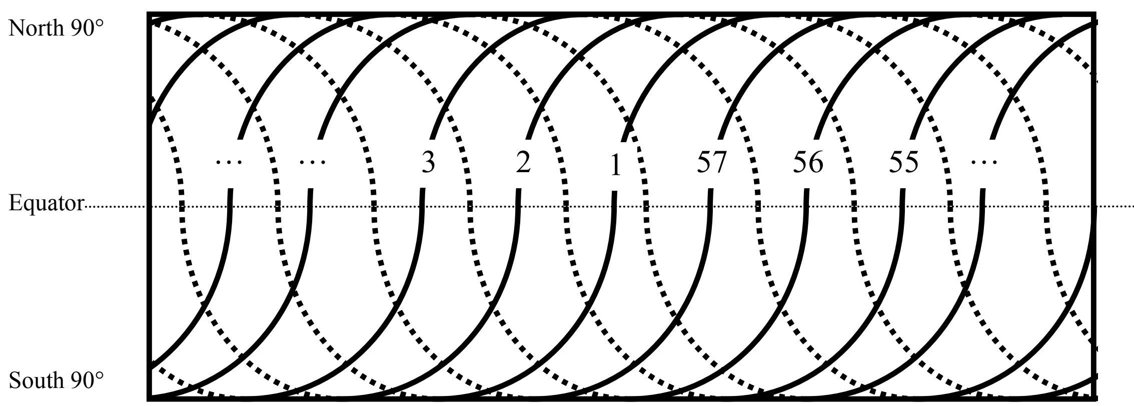
Figure 2.3.4-1 AMSR Total Process Flow

2.3.4.1 Level 1

The Level 1 product definitions and specifications conform to " ADEOS-II GLI, AMSR Level-1 Product Specification（NEB-98016）. "

2.3.4.2 Level 2

(1) Each geophysical parameter is calculated based on the Level 1B data.
(2) Geometrical correction information is added in the same way as for level 1B. Quality information (1 bit - 8 bits of data=1 byte data) and additional information (in international digital time, the time of each scan, orbit number (Fig.2.3.4-2) conforming to TAI93, which is the number of seconds passed since 1993).
(3) Shown in AMSR Standard Higher-order Level 2 Product List in Table 2.3.4-1.
(4) Data storage format is L1B（pixel layout）.
(5) Data size is the approximate size of each data unit.



The definition of the Orbit number conforms to "ADEOS-II Orbit Number and Path Number (NEB-97005)."

Figure 2.3.4-1 Orbit Numbers

Table 2.3.4-1 AMSR Standard Higher-Order Level 2 Product List

Code	Product	Data Unit	Process frequency	Data size	Data storage format (Note)
WV	Water vapor	Scene	Half-cycle	2.7 MB/scene	L1B
CLW	Cloud liquid/water	Scene	Half-cycle	2.7 MB/scene	L1B
AP	Precipitation	Scene	Half-cycle	2.7 MB/scene	L1B
SSW	Sea surface wind	Scene	Half-cycle	2.7 MB/scene	L1B
SST	Sea surface temperature	Scene	Half-cycle	2.7 MB/scene	L1B
IC	Sea ice concentration	Scene	Half-cycle	4.9 MB/scene	L1B
SWE	Snow water equivalent	Scene	Half-cycle	4.9 MB/scene	L1B

Note LIB in the data storage format is defined in Chapter 2.3.4.1.

2.3.4.3 Level 2 Map

(1) Level 2 data is map projected.
(2) AMSR Standard higher-order Level 2 Map product list is shown in Table 1.4.3-1.
(3) 1600km（observed width）×1600km（orbit direction）size is used as a unit.
(4) The pixel size is re-sampled at 10km intervals.
(5) Select nearest neighbor (NN) and bi-linear (BL) and make an order.
(6) Select the map projection method from equi-rectangular, Mercator (MER) and Polar stereo (PS) and order (Table 2.3.4-3 Map projection methods, Figure 2.3.4-3 Map projection methods).
(7) Global form（standard ellipsoid） is WGS84.
(8) For standard latitude when cutting a scene, match with level 1 (see Chapter 2.3.4.1) and select from the three types shown below - standard latitude, scene-centered, specific latitude (5 degree interval).
    - Definition of basic latitude: This is the latitude of the connecting point when the globe is projected on a flat map.
    - Standard latitude: Standard latitude for equi-rectangular or MER is taken as 0 degrees (equator). Standard latitude for PS is ±90 degrees (pole).
    - Scene-centered: Scene centered is literally the same as centered latitude specified when the user cuts the map in the middle of a scene.
    - Specific latitude: User specifies separately. However, the cutting of the specified latitude is in 5-degree intervals.
(9) Data size is the approximate size for each data unit.

Table 2.3.4-2 AMSR Standard Higher-Order Level 2 Map Product List (1/2)

Code	Product	Data Unit	Process frequency	Data size	Projection method	Basic latitude
WV	Water vapor	Scene	Order	683.6 KB	Equi-rectangular	Scene centered
〃	〃	〃	〃	〃	MER	Scene centered
〃	〃	〃	〃	1093.8 KB	Equi-rectangular	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	MER	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	PS	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
CLW	Cloud/water	Scene	Order	683.6 KB	Equi-rectangular	Scene centered
〃	〃	〃	〃	〃	MER	Scene centered
〃	〃	〃	〃	1093.8 KB	Equi-rectangular	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	MER	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	PS	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
AP	Precipitation	Scene	Order	683.6 KB	Equi-rectangular	Scene centered
〃	〃	〃	〃	〃	MER	Scene centered
〃	〃	〃	〃	1093.8 KB	Equi-rectangular	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude

Table 2.3.4-2 AMSR Standard Higher-Order Level 2 Map Product List (1/2)

Code	Product	Data Unit	Process frequency	Data size	Projection method	Basic latitude
AP	Precipitation	Scene	Order	1093.8 KB	MER	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	PS	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
SSW	Sea surface wind	Scene	Order	683.6 KB	Equi-rectangular	Scene centered
〃	〃	〃	〃	〃	MER	Scene centered
〃	〃	〃	〃	1093.8 KB	Equi-rectangular	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	MER	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	PS	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
SST	Sea surface temperature	Scene	Order	683.6 KB	Equi-rectangular	Scene centered
〃	〃	〃	〃	〃	MER	Scene centered
〃	〃	〃	〃	1093.8 KB	Equi-rectangular	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	MER	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	PS	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
IC	Sea ice concentration	Scene	Order	703.1 KB	Equi-rectangular	Scene centered
〃	〃	〃	〃	〃	MER	Scene centered
〃	〃	〃	〃	1250 KB	Equi-rectangular	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	MER	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	1250 KB	PS	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
SWE	Snow water equivalent	Scene	Order	703.1 KB	Equi-rectangular	Scene centered
〃	〃	〃	〃	〃	MER	Scene centered
〃	〃	〃	〃	1250 KB	Equi-rectangular	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	MER	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude
〃	〃	〃	〃	〃	PS	Standard latitude
〃	〃	〃	〃	〃	〃	Specific latitude

Table 2.3.4-3 Map Projection Method

Latitude＼Projection Method	Equi-rectangular	Mercator	Polar stereo
North/South 0～50 degrees	○	○	×
North/South 50～60 degrees	○	○	○
North/South 60～90 degrees	×	×	○

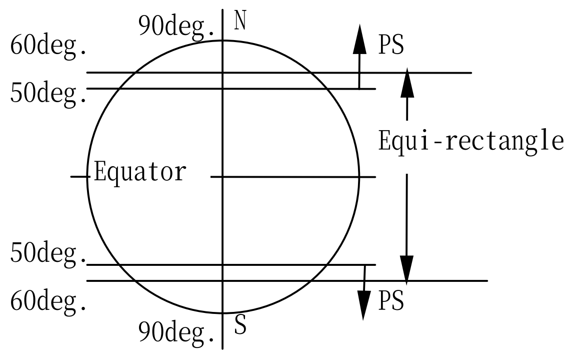


Figure 2.3.4-3 Map Projection Method

2.3.4.4 Level 3

(1) Level 3 data is used for processing mapping using the simple arithmetic mean of the level 1B brightness temperature (TB) and level 2 geophysical parameter data for the each global size (grid point interval *1).

Grid point interval *1: An interval of 0.25 degrees for the equi-rectangular diagram method an interval of 25km, for the polar stereo diagram method.

(2) Table 2.3.4-4 lists AMSR standard higher-order level 3 products.

(3) Data units are the global data for each product. There are two types of global data ascending global data and descending global data（see ascending/descending below）.
Ascending: Data when cutting the North/South polar points of the globe and observing from the Southernmost point to the Northernmost point.
Descending: Data when cutting the North/South polar points of the globe and observing from the Northernmost point to the Southernmost point.

(4) Two different projection methods are created in equi-rectangular and polar stereo (PS) (Figure 1.4.4.1 diagram method definition ((a) to (d)).
The PS diagram method is defined in Figure 2.3.4-4 diagram method definitions (b) to (d).

(5) The data size is the approximate size for each data unit.

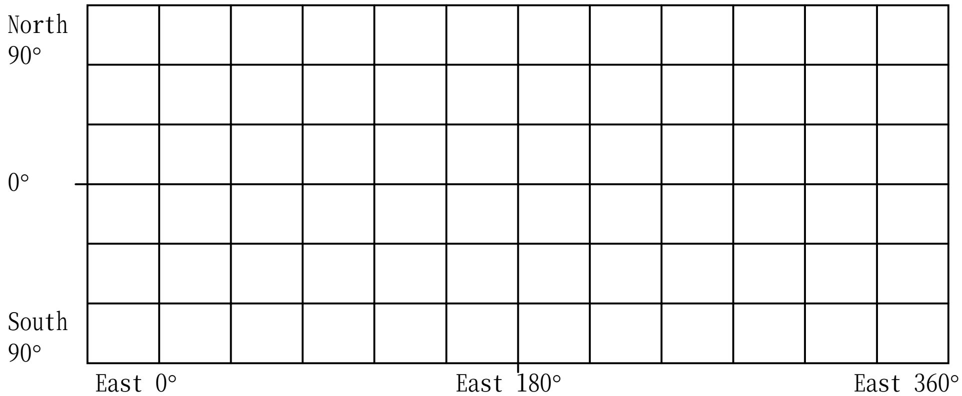
Table 2.3.4-4 AMSR Higher-Order Level 3 Product List

Code	Product	Data Unit	Process frequency	Data size	Projection method
TB	Brightness temperature	Global (ascending/descending	Day	1.98 MB / Global[*1]	Equi-rectangular
TB	Brightness temperature	Global (ascending/descending)	Month	1.98 MB / Global[*1]	Equi-rectangular
TB	Brightness temperature	Global (ascending/descending)	Day	0.26 MB / Northern Hemisphere[*1]	PS
TB	Brightness temperature	Global (ascending/descending)	Month	0.26 MB / Northern Hemisphere[*1]	PS
TB	Brightness temperature	Global (ascending/descending)	Day	0.20 MB / Southern Hemisphere[*1]	PS
TB	Brightness temperature	Global (ascending/descending)	Month	0.20 MB / Southern Hemisphere[*1]	PS
WV	Water vapor	Global (ascending/descending)	Day	1.98 MB / Global	Equi-rectangular
WV	Water vapor	Global (ascending/descending)	Month	1.98 MB / Global	Equi-rectangular
CLW	Cloud/water	Global (ascending/descending)	Day	1.98 MB / Global	Equi-rectangular
CLW	Cloud/water	Global (ascending/descending)	Month	1.98 MB / Global	Equi-rectangular
AP	Precipitation	Global (ascending/descending)	Day	1.98 MB / Global	Equi-rectangular
AP	Precipitation	Global (ascending/descending)	Month	1.98 MB / Global	Equi-rectangular
SSW	Sea-surface wind	Global (ascending/descending)	Day	1.98 MB / Global	Equi-rectangular
SSW	Sea-surface wind	Global (ascending/descending)	Month	1.98 MB / Global	Equi-rectangular
SST	Ocean temperature	Global (ascending/descending)	Day	1.98 MB / Global	Equi-rectangular
SST	Ocean temperature	Global (ascending/descending)	Month	1.98 MB / Global	Equi-rectangular
IC	Ocean distribution／ocean proximity	Global (ascending/descending)	Day	0.26 MB / Northern Hemisphere	PS
IC	Ocean distribution／ocean proximity	Global (ascending/descending)	Month	0.26 MB / Northern Hemisphere	PS
IC	Ocean distribution／ocean proximity	Global (ascending/descending)	Day	0.20 MB / Southern Hemisphere	PS
IC	Ocean distribution／ocean proximity	Global (ascending/descending)	Month	0.20 MB / Southern Hemisphere	PS
SWE	Snow	Global (ascending/descending)	Day	1.98MB / Global	Equi-rectangular
SWE	Snow	Global (ascending/descending)	Month	1.98MB / Global	Equi-rectangular
SWE	Snow	Global (ascending/descending)	Day	0.47 MB / Northern Hemisphere[*2]	PS
SWE	Snow	Global (ascending/descending)	Month	0.47 MB / Northern Hemisphere[*2]	PS

1. Brightness temperature (TB) is 14ch in total. The data size is 1ch=1 file.
   The types of TB data (14ch) are as below.
   Horizontal polarization (6ch): 6.9 GHz, 10.65 GHz, 18.7 GHz, 23.8 GHz, 36.5 GHz, and 89.0 GHz
   Vertical polarization (8ch): 6.9 GHz, 10.65 GHz, 18.7 GHz, 23.8 GHz, 36.5 GHz, and 50.3GHz, 52.8 GHz, 89.0 GHz

2. A map projection for the Southern Hemisphere for snow (SWE) is not map-projected using PS.

(a) Map projection using equi-rectangular methods cover the Southern latitude 90 degrees to Northern latitude 90 degrees as shown below.



Note The latitudes given in the above diagram are not especially regulated.

(b) Map projections using PS (Northern hemisphere, TB/IC) cover the areas surrounded by the thick frame lines in the following diagram.

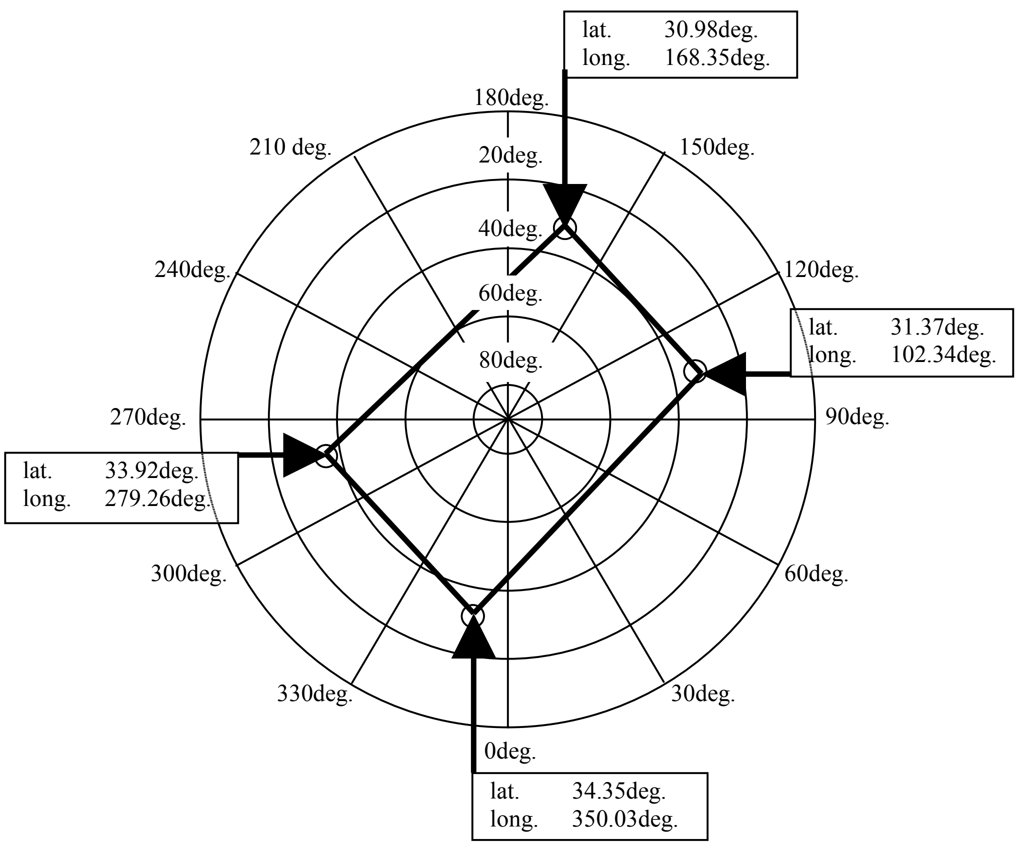
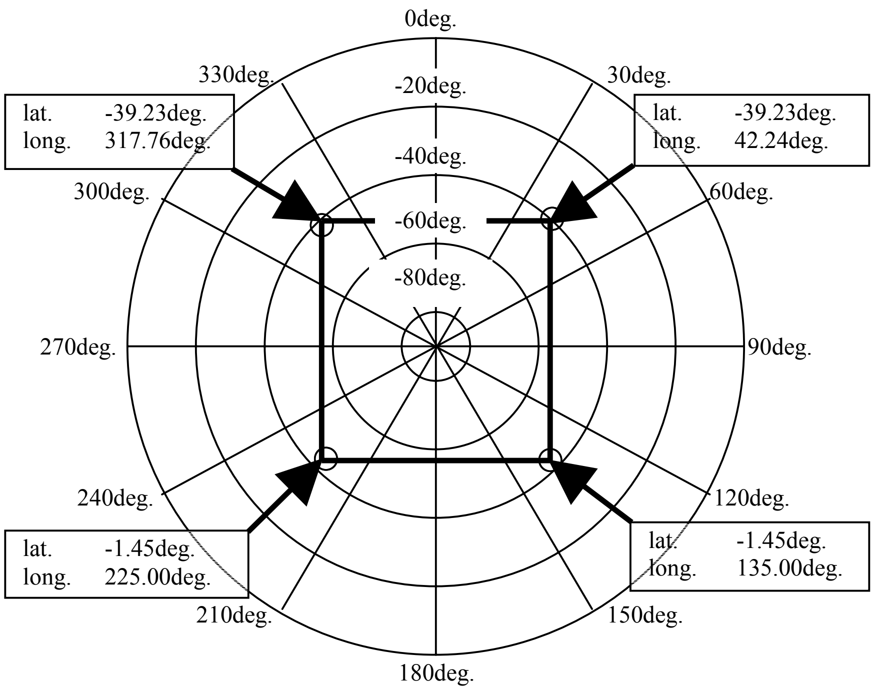


Fig. 2.3.4-4 Diagram Method Definition (1/2)

(c) Map projections using PS (Southern hemisphere, TB/IC) cover the areas surrounded by the thick frame lines in the following diagram.



(d) Map projections using PS (Northern hemisphere, SWE) cover the areas surrounded by the thick frame lines in the following diagram.

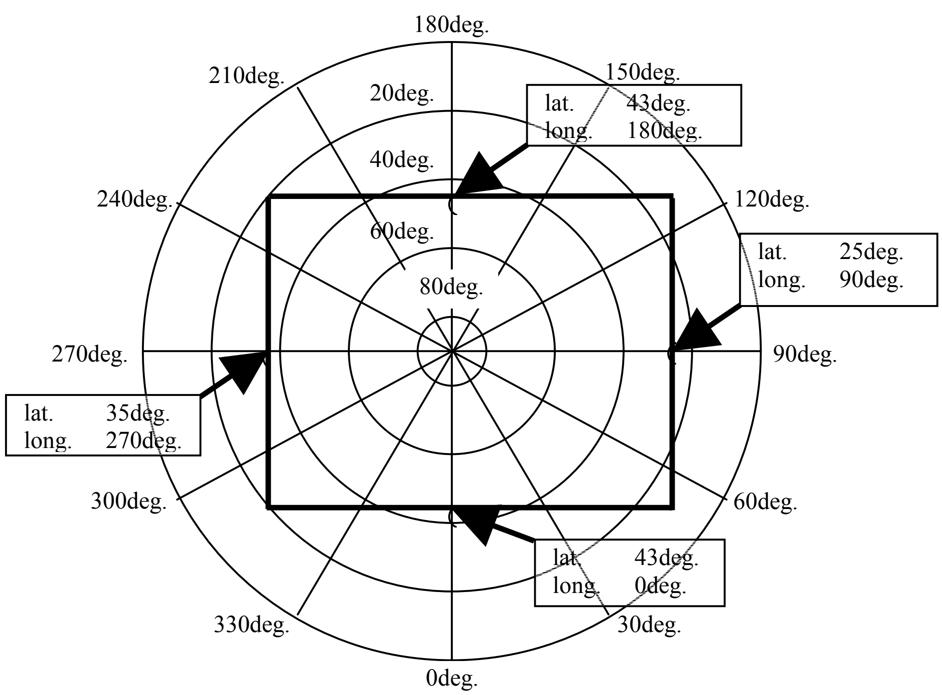


Fig. 2.3.4-4 Diagram Method Definition (2/2)

2.3.5 Image Catalog

The services provided by the image catalog are the browse images using data processed in 1-day units in level 3 as shown below.

TB	Brightness temperature (3ch)	1（Projection method：equi-rectangular）*2（ascending/descending）*3（6.9GHz, 36.5GHz, 89GHz） = 6 types.
WV	Water vapor	1（Projection method：equi-rectangular）*2（ascending/descending） = 2 types
CLW	Cloud water	1（Projection method：equi-rectangular）*2（ascending/descending） = 2 types
AP	Precipitation	1（Projection method：equi-rectangular）*2（ascending/descending） = 2 types
SSW	Sea wind speed	1（Projection method：equi-rectangular）*2（ascending/descending） = 2 types
SST	Sea surface temperature	1（Projection method：equi-rectangular）*2（ascending/descending） = 2 types
IC	Ocean distribution / Ocean proximity	1（projection method：PS）*2（ascending/descending）*2（South/North） = 4 types
SWE	Snow water equivalent	1（Projection method：PS）*2（ascending/descending） = 2 types

Note 3ch (6.9GHz, 36.5GHz, 89GHz) used by TB（Brightness temperature）are all vertically polarized.

2.3.6 Standard Product Processing Format

The standard processing format is shown in Fig 2.3.6-1 (process total number、process order).

Primary process	
L1A	Process total number of all pixels
L1B	Process total number of all pixels
L1B MAP	Process order

Higher-order process	
L2	Process total number
L2MAP	Process order
L3	Process total number

Figure 2.3.6-1 Standard Product Processing Format (Process Total Number, Process Order)

2.3.7 AMSR First-light images

A false-color composite image is developed from the data obtained by the Advanced Microwave Scanning Radiometer (AMSR) on board Midori-II (Advanced Earth Observing Satellite-II (ADEOS-II)).

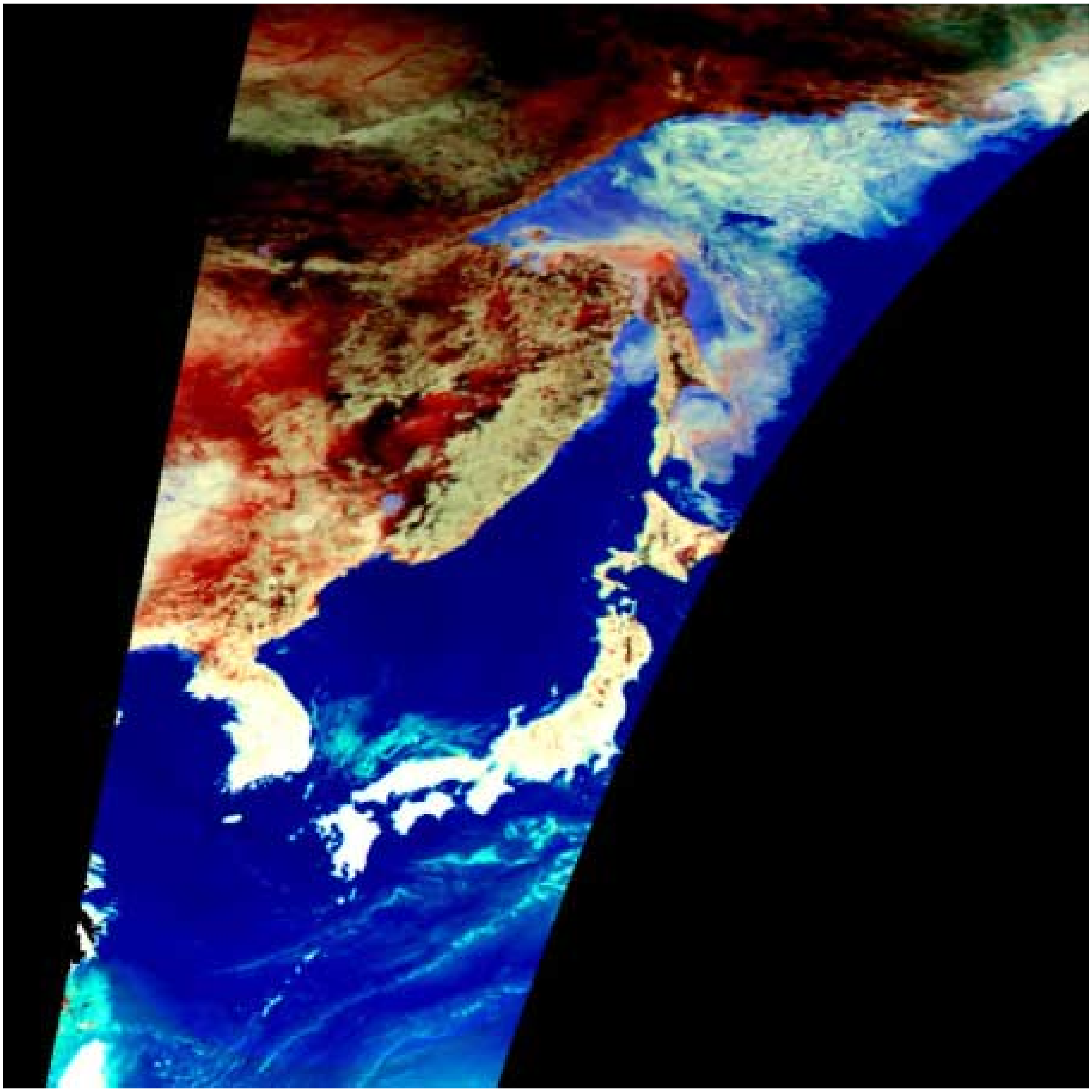


Fig. 2.3.7-1 False-color composite image

Brightness temperatures of 36.5-GHz (horizontal polarization) and 89.0-GHz (both vertical and horizontal polarization) channels were used. The data was acquired around 11 a.m. on January 18, 2003 JST. Over the Pacific Ocean and Japan Sea, the areas of light blue correspond to high-concentration liquid water clouds. In the Sea of Okhotsk, colors varying from light blue to white correspond to sea ice distribution.

Figure 2.3.7-2 is a false-color composite using data acquired at night (around 2030) on January 18, 2003 JST. Brightness temperatures of 36.5-GHz (horizontal polarization) and 89.0-GHz (both vertical and horizontal polarization) channels were used. In the Sea of Okhotsk, colors varying from light blue to white correspond to sea ice. Newly formed sea ice is indicated by light blue. Areas of light blue over the Pacific Ocean correspond to high-concentration liquid water clouds. An advantage of microwave observation is the ability to make measurements night and day. Thus, the sea ice extension can be easily distinguished through non-precipitating clouds using nighttime images.

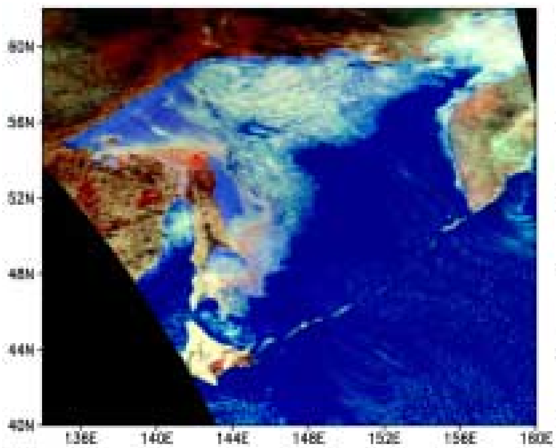


Figure 2.3.7-2
False-color composite image

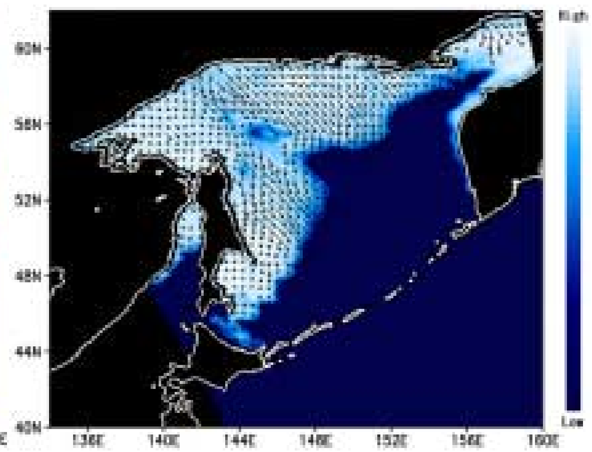


Figure 2.3.7-3
Sea ice distribution and motion vector

2.4 Calibration and Validation

2.4.1 Basic Plans for AMSR Calibration

Initial checks must be conducted for the first six months after launch, and monitoring must be conducted until the end of the sensor observation. In order to perform monitoring, EORC will produce necessary items from level 1B every day.

2.4.1.1 Brightness Temperature Calibration

(1) Initial check

(i) Absolute calibration

a. Evaluation of CSM count and hot load

The data acquired from eight measured CSM counts and hot loads at each frequency must be evaluated. First, relative differences among the eight points and time changes are carefully evaluated. The relations between hot load and counts, as well as the relation between hot loads and heater on and off, are investigated. Second, the number of data points used, the weight function, the number of scans for averaging, etc. are determined. The data term is one week.

b. Scan bias error

The TB bias between scanning positions is determined for each frequency and polarization. For each scanning position, the data consists of one to three months observation after launch.

c. Correction of 89 GHz difference

AMSR-E has two horn antennas for 89 GHz (A and B). Differences in the incident angles of horns A and B differ (55.1 degrees and 54.6 degrees) and receiver characteristics may also cause the brightness temperature to differ. This difference is investigated, and a correction coefficient is determined as necessary. The data consists of two to three days observation.

d. Cosmic observation

Aqua performs deep space observation on the fortieth day after launch simultaneously with MODIS moon calibration.

(ii) Multiple calibration

Evaluating the calibration of brightness temperature involves a method-based ambiguity, so a fixed method cannot be achieved. Multiple methods for evaluating calibration are prepared, and the agreements of results from each method are viewed.

a. Inter-satellite calibration

Mutual calibration of former AMSR-E and SSM/I or AMSR-E and TMI is performed. Accurate mutual calibration of AMSR and AMSR-E might be difficult since both AMSR and AMSR-E are Sun-synchronous satellites, resulting in a time lag of five hours between observations. Accurate mutual calibration of later AMSR-E and TMI also might be difficult since there are 3K errors with TMI calibration although TMI is the not a Sun-synchronous satellite and the time lag is only tens of minutes. Inter-satellite calibration, thus, is comprehensively evaluated after the results are obtained. The central frequency and incident angle have already been calculated by using an ocean radiative transfer model. The term of calibration is six months.

Using a 0.25 scale grid of the entire sphere compares AMSR-E and SSM/I. The SSM/I data is acquired from Marshall Space Flight Center (MSFC). The average values, the numbers, and the scattering of the data are input as grid data.

Using 0.1 scale grid match-up data, obtained within ten minutes enables comparison of AMSR-E and TMI.

AMSR and AMSR-E data will also be compared with SSM/I data of the past 14 years (1987 to 2000) and with its climate values every month.

b. Evaluation by model calculation

Absolute values are evaluated by comparing the satellite-observed brightness temperature computed with a radiative transfer model using truth data with observed values. By using upper air data acquired over observation vessels and small islands, brightness temperature compared with a radiative transfer model and AMSR observed value are compared. The comparison must be made on a sunny day with bright wind. The evaluation term is three to six months; however, match-up data will be produced all the time during the satellite operation.

c. Comparison with AMR

For one to two months after satellite launch, the flight of AMR will be performed in the same period with ADEOS-II satellite. AMR’s flight altitude is supposed to be 4 to 5 km, and its two flight courses are supposed to be from north to south, from Hokkaido to Sendai, and then from Sendai to Hachijo-jima Island. POS data, which is simultaneously acquired aircraft position and attitude data, is used to correct the angle of incidence. The difference between the brightness temperature and the antenna temperature resulting from the antenna patterns is supposed to be determined in advance using data from test flights over and around Aoga-shima Island. This depends on the AMR’s flight altitude. AMR cannot validate channels of the 50 GHz band.

(2) Monitoring

The following items will be constantly monitored and sensor performance observed.

(i) Radiometric noise

Radiometric noise is computed from CSM and hot load calibration source data. Monitoring is done for each revolution, seasonal change, short- and long-term trends, and other time scales.

(ii) Calibration counts

Counts of CSM and hot load are monitored.

(iii) Physical temperature

Physical temperatures of the main reflector, calibration sources, receivers, etc. are monitored.

(iv) Receiver gain variations

Receiver gain variations and AGC telemetry are monitored.

(v) Scan bias error

Scan bias errors, as described in Para. (1), are monitored regularly.

2.4.1.2 Geometric Calibration

(1) Initial calibration

(i) Rough evaluation of beam patterns

Beam width is roughly confirmed using coastlines and other domains with major contrasts in brightness temperature and clearly defined boundaries. (However, this is only possible for low- frequency bands with a large overlap.)

(ii) Inter-channel co-registration

The accuracy of the positional agreement between frequencies is evaluated using data of coastlines and regions with clearly defined boundaries. The accuracy of the positional agreement between t 89GHz horn A and B horn is evaluated. Based on this, sensor alignment might be corrected if necessary. The term is a few days to one week.

(2) Monitoring

(i) Antenna rotation speed

Antenna rotation speed is monitored.

(ii) Attitude fluctuations

Attitude data is monitored.

2.4.2 Post-launch validation

2.4.2.1 Water Vapor

(1) Outline

The main activity related to total water vapor quantity will be validation using the worldwide radiosonde network.

(2) Product accuracy

Total water vapor will be calculated for all of the world's oceans and sea areas (excluding areas of sea ice). The required accuracy is 3.5 kg/m2 for values in the range 0 to 70 kg/m2.

(3) Ground-based observation and vessel observation

(i) Hegura-jima Island and Minamidaito-jima Island (May 2002 to Mar. 2006)

Ground-based microwave radiometry observation

Total water vapor will be estimated by using a ground-based microwave radiometer that has an observation frequency band in the 20 to 30 GHz region; results will be compared with AMSR/AMSR-E estimated values. Collecting data while scanning through different azimuth and elevation angles will enable calculating spatial averages to some extent. In addition, it will be possible to collect data continuously over long periods of time. Since AMSR/AMSR-E estimated values are only valid over sea areas, the microwave radiometers will be set up on Hegura-jima Island and Minamidaito-jima Island, which are both small island situated more than 50km from other larger islands. Total water vapor will then be observed continuously (Oct. 2000 to Mar. 2006). The equipment will basically operate automatically, although a supervisor will visit each observation site as necessary. The supervisor will recover the collected data and inspect the equipment (from the outside only).

The WVP-1500 Water Vapor Profiling Radiometer, which incorporates an azimuth turntable, a fan (TBD) and a computer for data collection and is made by the US company Radiometrics Corp., will be used.

(ii) Oceanographic Research Vessel MIRAI (Aug. 2002 to Mar. 2006)

Vessel-based microwave radiometer and radiosonde observations

Truth data for validating water vapor estimated from AMSR/AMSR-E data will be acquired using the Oceanographic Research Vessel MIRAI provided by JAMSTEC as the observation platform. MIRAI will observe the region from the Arctic Ocean to equatorial ocean for 280 days per year. MIRAI will be the best facility observing various geophysical parameters about water over the ocean without influence of land. Since AMSR/AMSR-E will estimate water vapor only over the seas, in-situ vessel observation will be useful for to validating AMSR/AMSR-E data.

A microwave radiometer (Water Vapor Radiometer WVR-1100 made by Radiometrics Corp.) will be carried on MIRAI and will measure two frequencies (23GHz and 31GHz). Water vapor will be estimated using the microwave radiometer data and compared with the AMSR/AMSR-E data. Moreover, radiosonde observations will be made from MIRAI. Water vapor estimated from radiosonde data will also be used for comparison with AMSR/AMSR-E data. Radiosonde observation will be performed simultaneously with satellite overflights as much as possible.

(4) Creating match-up data

(i) Match-up with global radio sonde data

Once a day (from Apr. 2002 to Mar. 2006), total water vapor calculated from air temperature, air pressure and relative humidity profiles collected by radiosonde will be compared with the AMSR and AMSR-E estimated values. For worldwide radiosonde data, standard isobaric surface data that is distributed over GTS lines and data that include singular points will be used.

Since AMSR estimates values only for sea areas, radiosondes will be installed in places such as small islands. Radiosondes that are not influenced by radiation coming from land areas will be selected. Datasets that match the radiosonde data with the AMSR and AMSR-E footprints in both space and time will be created regularly, and will be validated. The Meteorological Agency has agreed to provide the radiosonde data. The data will include both standard isobaric surfaces and singular points.

· AMSR vs. GTS/sonde (Dec. 2002 to Mar. 2006)
· AMSR-E vs. GTS/sonde (May 2002 to Mar. 2006)

(ii) Match-up with microwave radiometer data

Total water vapor will be calculated from the microwave radiometer data collected at Hegura-jima and Minamidaito-jima. The values will be compared with AMSR and AMSR-E estimated values.

· AMSR vs. microwave radiometer (Dec. 2002 to Mar. 2006)
· AMSR-E vs. microwave radiometer (May 2002 to Mar. 2006)

(iii)Match-up with vessel observation data

Match-up data between AMSR/AMSR-E and water vapor data calculated from the vessel-based (MIRAI) observations will be created.

· AMSR vs. microwave radiometer (Dec. 2002 to Mar. 2006)
· AMSR-E vs. microwave radiometer (Aug. 2002 to Mar. 2006)
· AMSR vs. radiosonde (Dec. 2002 to Mar. 2006)
· AMSR-E vs. radiosonde (Aug. 2002 to Mar. 2006)

(5) Relationship to organizational setup and other research projects

The match-up datasets will be created at EORC; assessment and validation using these datasets will be conducted by EORC and the algorithm development PIs. The two ground-based microwave radiometers will be the property of EORC, and EORC will perform the observations at Hegura-jima Island and Minamidaito-jima Island. For Minamidaito-jima Island, suitable cooperation will be sought, for example cooperation involving joint research with the Meteorological Agency. In addition, other organizations within Japan, such as the Meteorological Research Institute, possess similar equipment. It will thus be desirable to seek the cooperation of such organizations in order to form a multipoint observation network. In particular, in order to obtain data for a number of different latitudes, observations at high latitudes are required.

The collected data will be analyzed by both the algorithm development and validation PI and by EORC. NASDA hopes to form a multipoint observation network through collaboration with the AMSR-E Team, ARM, CLIVAR (EPIC), CRYSTAL and the GLI Atmosphere Team.

2.4.2.2 Cloud Liquid Water

(1) Outline

Cloud liquid water will be validated primarily through comparison with observation values obtained using ground-based (vessel) radiometers.

Cloud liquid water is a physical element that is difficult to validate quantitatively. There are a number of ways of measuring cloud liquid water. One involves use of video sondes; another, radar measurement from aircraft. However, clouds are scattered widely through space and cloud formations change rapidly over time, but a video sonde takes observations at one point only. Observations by aircraft are also limited both in the area in which they cover and the frequency with which they can be taken. Moreover, such observations do not constitute perfectly quantitative measurements. Estimating cloud liquid water quantity by ground-based microwave radiometer observation is an indirect remote sensing technique. However, the observation background is background radiation from space that is uniform and remains at a stable level. This means that the accuracy is higher than estimates from satellite orbits.

Cloud bottom height will be observed by ceilometers. The presumed accuracy of cloud liquid water will be improved by estimating cloud temperature from cloud bottom height data.

(2) Product accuracy

Total cloud water will be calculated for all of the world's oceans and sea areas (excluding areas of sea-ice). The required accuracy is 0.05 kg/m2 for values from 0 to 1.0 kg/m2.

(3) Ground-based observation and vessel observation

(i) Hegura-jima Island and Minamidaito-jima Island (May 2002 to Mar. 2006)

Ground-based microwave radiometer and ceilometer observation

As in 2.4.2.1(3)(i), a ceilometer is installed and the cloud bottom height is observed at Hegura-jima Island. At Minamidaito-jima Island, the data of the ceilometer installed at the airport can be used.

(ii) Oceanographic Research Vessel MIRAI (Aug. 2002 to Mar. 2006)
Vessel-based microwave radiometer and ceilometer observation
As in 2.4.2.1(3)(ii), the ceilometer installed on MIRAI is also used.

(4) Creating match-up data

(i) Match-up with microwave radiometer data

Total cloud water will be calculated from the microwave radiometer data collected at Hegura-jima Island and Minamidaito-jima Island. Match-up data sets between these and AMSR / AMSR-E will then be created.

· AMSR vs. microwave radiometer (Dec. 2002 to Mar. 2006)
· AMSR-E vs. microwave radiometer (May 2002 to Mar. 2006)

(ii) Match-up with vessel observation data

Match-up data between AMSR/AMSR-E and cloud liquid water data calculated from the vessel-based (MIRAI) observations will be created.

· AMSR vs. microwave radiometer (Dec. 2002 to Mar. 2006)
· AMSR-E vs. microwave radiometer (Aug. 2002 to Mar. 2006)

(5) Relationship to organizational setup and other research projects
As in 2.4.2.1(5).

2.4.2.3 Sea-surface Wind Speed

(1) Outline

Sea-wind velocity will be validated primarily through comparison with observation values obtained using buoys.

(2) Product accuracy

Sea-wind velocity will be calculated for all of the world s oceans and sea areas (excluding areas of sea-ice). The required accuracy is 1.5 m/s for values form 0 to 30 m/s.

(3) Vessel observation (Aug. 2002 to Mar. 2006)
Vessel-based wind-speed observation
Oceanographic Research Vessel MIRAI

(4) Creation of match-up data

(i) Match-up with buoy observation data

Sea-wind velocities obtained using ocean buoys and AMSR / AMSR-E estimated values will be compared. At present, the buoy data that can be used are from sources such as the National Data Buoy Center (NDBC), the TAO array, and JAMSTEC. Datasets that match the buoy measurements (which also include information such as wind direction and sea-surface temperature) with the AMSR footprints in both space and time will be created and validated regularly. The height at which wind velocity observations are made will vary according to the type of measuring instrument used on the buoy, so the comparison will be made after adjusting for this factor.

The latest TAO buoy data are always distributed over the Internet, so this will be used. For NDBC buoys, it will be necessary to use the Internet.

· AMSR vs. GTS/buoy (Dec. 2002 to Mar. 2006)
· AMSR-E vs. GTS/buoy (May 2002 to Mar. 2006)
· AMSR vs. Internet/buoy (Dec. 2002 to Mar. 2006)
· AMSR-E vs. Internet/buoy (May 2002 to Mar. 2006)

(ii) Match-up with vessel observation data

Match-up data between AMSR/AMSR-E and wind-speed data calculated from the vessel-based (MIRAI) observations will be created.

· AMSR vs. wind vane and anemometer (Dec. 2002 to Mar. 2006)
· AMSR-E vs. wind vane and anemometer (Aug. 2002 to Mar. 2006)

(5) Relationship to organizational setup and other research projects

NASDA hopes to collaborate with the Japan Meteorological Agency, the Frontier Observational Research Program for Global Change, and CLIVAR.

2.4.2.4 Precipitation

(1) Outline

Observations from ground-based radar and rain gauges will be compared. Since AMSR-estimated values for precipitation volume exist only for sea areas, it will be necessary to select observation values for rain gauges that are installed on islands that are as small as possible.

The AMSR precipitation intensity retrieval will have to satisfy the following requirements.

(i) A high-accuracy data set that covers all of the world's oceans and sea areas.

In particular, the presumed accuracy for high latitudes can still be improved, and there is a lack of reliable measurement data.

(ii) Capable of contributing to the meteorological and water budget research of GEWEX, CLIVAR, etc.

WCRP has decided to draw up plans for a Cooperative Enhanced Observation Period (CEOP) that will focus on 2002 to 2004. Collaboration with CEOP will be necessary for precipitation validation.

(iii)Data assimilation with the NWP model must be considered.

In order to fulfill these goals, it will be necessary to prepare cases that are complete with as wide a variety of data as possible.

Accuracy of land precipitation measurements by the microwave radiometers has not been confirmed since information on atmosphere above land is relatively limited because emission from the Earth's surface is strong and very unstable in space and time. AMSR/AMSR-E will estimate geophysical parameters of soil moisture and vegetation water content that affect emissivity enabling, accurate land precipitation measurement. Comprehensive data about the three-dimensional distribution of precipitation, rain grain size distribution, water vapor, cloud water, air temperature, surface emissivity, and ground temperature must therefore be acquired in order to estimate and validate precipitation with relatively less information.

For this reason, soil moisture validation measurements soil moisture will be made in the Tibet Plateau, and the three-dimensional distribution of precipitation, vertical profile of rain grain size distribution, cloud water and water vapor, cloud bottom and top height, vertical distribution of water vapor and temperature, and air temperature and wind distribution will be acquired using three-dimensional Doppler radar, micro-rain radar, microwave radiometer, lidar, sonde, wind profiler and RASS instruments. Combining these acquired data will enable describing the radiative transfer process when a satellite detects microwaves emitted by the land surface. It will also enable validating algorithms dealing with radiative transfer processes. Combined data will be very valuable as observation data of assimilated precipitation and will contribute to estimating precipitation by AMSR and AMSR-E. Two types of algorithms have been developed: one to calculate soil moisture supposing no precipitation, and another to calculate soil moisture supposing either precipitation or no precipitation. Comprehensive observation data will enable validating the latter algorithm.

(2) Product accuracy

Precipitation volume will be calculated for all of the world's oceans and sea areas (excluding areas of sea ice). The required accuracy is 10% for precipitation volumes of up to 20 mm per hour. Accuracy on land will be defined one year after the satellite launch.

(3) Ground-based, vessel and aircraft observation

Data will also be acquired in land regions or snowfall regions because precipitation volume will also be calculated in land regions one year after satellite launch.

(i) Wakasa Bay (Jan. to Feb. 2003)

a. Ground-based radar observations

Collect Ministry of Land, Infrastructure and Transport radar and private company multi-parameter radar data, and directly compare this data with that of TMI and PR.

Solid precipitation can at Wakasa Bay observed by TRMM.

b. Rain-gauge and Disdrometer observations

Observe precipitation on the ground and precipitation grain size.

c. Aircraft observation

NASA will observe by aircraft.

(ii) Tibet (May 2002 to Mar. 2005)

a. Automatic weather instrument (AWS) observation

b. Ground-based radar observations (Aug. 2003, Jun. to Aug. 2004)

c. Wind profiler and rain gauge observations (Jul. to Oct. 2002, Apr. to Aug. 2003, Apr. to Aug. 2004)

(iii)Miyako and Yaeyama Islands (May to Sep. 2003)

a. Ground-based precipitation intensity observation

b. Japan Meteorological Agency radar observations

Precipitation Intensity Observation Systems will be installed, and truth data will be acquired on the small islands of Miyako and Yaeyama to estimate precipitation on the ocean.

(iv)Oceanographic Research Vessel MIRAI (Aug. 2002 to Mar. 2006)

a. Vessel-based radar observations

b. Rain-gauge and disdrometer observations

(v) Siberia (Oct. 2005 to Mar. 2006)

a. Ground-based radar observations

b. Rain-gauge and snow particle observation system observations

(4) Creating match-up data

Match-up data between AMSR and AMSR-E and data from the above-mentioned ground-based observations will be created.

· AMSR	vs.	Radar AMeDAS (Dec. 2002 to Mar. 2006)
· AMSR-E	vs.	Radar AMeDAS (May 2002 to Mar. 2006)
· AMSR	vs.	Truth Data (Dec. 2002 to Mar. 2006)
· AMSR-E	vs.	Truth Data (May 2002 to Mar. 2006)

(5) Relationship to organizational setup and other research projects

NASDA hopes to collaborate with the Japan Meteorological Agency, the NASA/AMSR-E Team, the GAME-Siberia Team, CEOP, the TRMM Team, and the AMSR Snowfall and Soil Moisture Team.

2.4.2.5 Sea-ice Concentration

(1) Outline

Sea-ice concentration will be validated primarily through comparison with observation values obtained using other satellites or airplanes.

(2) Product accuracy

Sea-ice concentration will be estimated for places like polar regions and the Sea of Okhotsk. The required accuracy is within 10%.

(3) Ground-based, vessel and aircraft observation

(i) Okhotsk (Jan. to Feb. 2003, Jan. to Feb. 2004, Jan. to Feb. 2005)

a. Aircraft observation (AMR and PSR) will be conducted.

b. Photographs will be taken and video observations conducted from ships.

(ii) Antarctic (Jul. to Sep. 2002, Dec. 2002 to Feb. 2003)

a. Aircraft observation (PSR and AVIRIS) will be carried out (Aug. 2002).

b. Ground-based observation

(4) Creating match-up data

Match-up data between AMSR/AMSR-E and data from the above-mentioned ground-based observations or other satellites will be created.

· AMSR	vs.	GLI (Dec. 2002 to Mar. 2006)
· AMSR-E	vs.	GLI (Dec. 2002 to Mar. 2006)
· AMSR	vs.	AVHRR (Dec. 2002 to Mar. 2006)
· AMSR-E	vs.	AVHRR (May 2002 to Mar. 2006)
· AMSR	vs.	RADARSAT (Dec. 2002 to Mar. 2006)
· AMSR-E	vs.	RADARSAT (May 2002 to Mar. 2006)
· AMSR	vs.	Truth Data (TBD)
· AMSR-E	vs.	Truth Data (TBD)

(5) Relationship to organizational setup and other research projects

NASDA hopes to carry out joint observations with the AMSR-E Team and to collaborate with the GLI Cryosphere Group; CRL; and the Japanese, USA and European Antarctic Survey Teams.

2.4.2.6 Sea-surface Temperature

(1) Outline

Sea-surface temperature will be validated, predominantly through comparison with buoy observation values.

(2) Product accuracy

Sea-surface temperature will be estimated for all of the world's oceans and sea areas; the desired accuracy is 0.5 deg. C for temperatures from -2 to 35 deg. C.

(3) Vessel observation (Aug. 2002 to Mar. 2006)

Vessel-based sea-surface temperature observation

The Oceanographic Research Vessel MIRAI

(4) Creating match-up data

(i) Match-up with buoy observation data

Sea-surface temperatures collected using ocean buoys and AMSR/AMSR-E estimated values will be compared. The same buoys can be used for sea-wind velocity (see above). Datasets that match the buoy (fixed and drifting) measurements (which include information on sea winds as well as on sea-surface temperature) within the AMSR footprints in space and time will be created and validated regularly.

· AMSR vs. GTS/buoy (Dec. 2002 to Mar. 2006)
· AMSR-E vs. GTS/buoy (May 2002 to Mar. 2006)

(ii) Match-up with vessel observation data

Match-up data between AMSR/AMSR-E and sea-surface temperature data calculated from the vessel-based (MIRAI) observations will be created.

· AMSR vs. thermometer (Dec. 2002 to Mar. 2006)
· AMSR-E vs. thermometer (Aug. 2002 to Mar. 2006)

(5) Relationship to organizational setup and other research projects

NASDA hopes to collaborate with the Japan Meteorological Agency, the Frontier Observational Research Program for Global Change, and the GLI Ocean Team.

2.4.2.7 Snow-Water Equivalent

(1) Outline

Profiles of the snow-water equivalent, snow depth and grain size of snow and snow temperature will be targeted and will be validated by acquired truth data. It will also be necessary to observe the changes in these items over time (in a time series). In addition, it will be necessary to confirm the influence of the forest canopy on snow parameter estimation.

Snowfall will be estimated by microwave radiometers using the naturally occurring radiation emitted by the ground beneath a snow cover and scattered in a snow pack. The microwave radiometer will measure changes in amount of emission. Although the change in the amount of emission also depends on the diameter of snow particles, it fundamentally depends on the total ice quantity (snow depth x snow cover density) of the snow cover. The quantity directly obtained by a microwave radiometer is the snow-water equivalent. Snow depth measured by ground-based observations is usually used to validate snow-water equivalent because there are few measurement points for snow-cover density. In addition to snow water equivalent, snow depth will also be provided as a sub product. Snow-water equivalent products are generally employed to investigate water resources. In contrast, snow-depth products are generally employed to investigate disasters.

Two algorithms have been proposed for snow-water equivalent estimates by AMSR/AMSR-E, but results from algorithm comparison test using SSM/I indicate the following three problems.

(i) Footprint size data for validating sensors on satellites have not been acquired.

(ii) Effects of vegetation, especially taiga, have not been sufficiently evaluated.
(iii) Snow metamorphosis leads to deterioration of estimates

Consequently, a special observation plan considering these problems will be necessary to validate snow cover.

To deal with problem (i), (a) it will be necessary to perform simultaneous satellite observations considering footprint-scale data in observational areas that are as uniform as possible, and (b) a ground observation system configuration that produces a variety of footprints will be necessary. The observations that will be performed in Tibet Plateau and Yakutsk, Siberia, are planned to resolve the problems (a) and (b). Validation data will be acquired to deal with the problem (ii). Five flat and extensive areas of the Tibet Plateau will be chosen for the observations, and a snow depth sensor and an automatic weather station will be set up in the middle of these four areas. An area of Yakutsk, Siberia, will be chosen for footprint scale observation, and seven automatic snow depth sensors will be set up in this area. Six of these seven sensors will be set up in taiga. Snow density and snow grain size will be estimated in all theses areas during the winter for problem (iii). To resolve (iii), it will be necessary to perform in-situ measurement and observe state variables of snow (change in grain size) and microwave brightness temperature during winter. However, it will be very difficult to perform in-situ measurement simultaneously with footprint scale satellite observations. For this reason, we will work out our strategy for validation with long-term observation using the microwave radiometer on the ground and will acquire fundamental data. The results will be reflected in algorithms, and products will be validated by footprint size data. Long-term ground observations will be performed in the Colorado Rocky Mountains with the cooperation of the AMSR-E team from the University of Colorado.

WCRP has decided to draw up plans for a Cooperative Enhanced Observation Period (CEOP) that will focus on 2002 to 2004. Collaboration with CEOP will be necessary for snowfall validation.

(2) Product accuracy

· SWE 20% or 10 mm
· SD 20% or 5 cm

(3) Ground-based and aircraft observation

Ground-based observations using both ultrasonic snow depth gauges and manual observation will be conducted in areas of GAME concentrated observation in Tibet and Siberia. Ground data, on snow depth, snow density, snow temperature, grain size, and vegetation moisture content will be collected.

(i) Siberia

a. Ground-based snow observation (Nov. 2002 to Mar. 2003, Nov. 2003 to Mar. 2004, Nov. 2004 to Mar. 2005)
b. Snow-depth measurement using automatic gauges (May 2002, Nov. 2002 to May 2003, Nov. 2003 to May 2004, Nov. 2004 to May 2005)

(ii) Tibet
 a. Snow observation on the ground (Jan. 2003, Jan. 2004, Jan. 2005)
 b. Snow depth measurement using automatic gauges (May to Jun. 2002, Nov. 2002 to Jun. 2003, Nov. 2003 to Jun. 2004, Nov. 2004 to Jun. 2005)

(iii)Colorado
 a. Aircraft observation (Feb. to Mar. 2003).
 b. Ground-based microwave radiometer observation (Sep. 2002 to Mar. 2003)

(4) Creating match-up data

Match-up data between AMSR/AMSR-E and the above-mentioned ground-based observation data (GTS/snow and snow depth gauge) will be created.

· AMSR vs. GTS/snow (Dec. 2002 to Mar. 2006)
· AMSR-E vs. GTS/snow (May 2002 to Mar. 2006)
· AMSR vs. truth data (Dec. 2002 to Mar. 2006)
· AMSR-E vs. truth data (May 2002 to Mar. 2006)

(5) Relationship to organizational setup and other research projects

NASDA hopes to conduct the joint observation with GEWEX / CEOP and the AMSR-E Team and to collaborate with the AMSR Precipitation Group, the GLI Cryosphere Group, the Frontier Observational Research Program for Global Change, and CREST-JST.

2.4.2.8 Soil Moisture

(1) Outline

Algorithms that estimate soil moisture using the 6.9 GHz channel will be compared internally. Ground-based observations of soil moisture and related parameters will be conducted under various conditions of vegetation, soil, and climate.

These data will be compared with AMSR, AMSR-E and aircraft AMR data. AMR observation is necessary to detect influences of land surface heterogeneity on the satellite observation.

Although four algorithms have been currently proposed for soil moisture estimated by AMSR/AMSR-E, the algorithm comparison test shows large gaps between the results produced by each algorithm. For this reason, soil moisture has not yet been established as standard products. The two major causes are described below.

(i) Foot size truth data for validating sensors on satellites have not been acquired.
(ii) Data for validating satellite sensors has not been acquired for various land cover condition.

Consequently, a special observation plan considering these problems will be necessary to validate soil moisture.

To deal with problem (i), it is necessary to perform simultaneous satellite observation providing footprint scale data in observational areas that are as uniform as possible. It is also necessary to perform simultaneous satellite, airborne, and ground observations considering a variety of footprints. Observations planned in Mongolia will deal with the first problem. An area of 60km×60km will be observed and estimate dense soil moisture, vegetation water content, ground temperature and the moving observation on 100km will be estimated. To deal with the second problem, airborne observations measuring extensive soil moisture distributions will be performed in Iowa.

In order to deal with the problem (ii), effects of vegetation must be considered particularly important. Therefore, the observations will cover bare land in the Tibet Plateau, grassland in Mongolia, cassava fields (Manihot utilissima) as crops in Thai, and teak groves (Tectona grandis) as deciduous forests in Thai land. The observations will also cover soybean fields and cornfields in Iowa and grasslands and wheat fields in Oklahoma. Validation data for soil moisture considering the interaction with freezing and melting of permafrost will be acquired in the Tibet Plateau. Acquisition of validation data under various land cover and hydrological conditions will improve algorithm certainty and produce choices of algorithms that can be matched against all conditions.

WCRP has decided to draw up plans for a Cooperative Enhanced Observation Period (CEOP) that will focus on 2002 to 2004. Cooperation between CEOP and the AMSR-E team is necessary for validation.

(2) Product accuracy

TBD

(3) Ground-based and aircraft observation

Ground-based soil-moisture observations will be conducted in Thailand, Tibet, and Mongolia, where ground data such as soil moisture, vegetation moisture content, ground-surface temperature, ground-surface roughness, and soil texture will be collected. In addition, Aircraft observation will be conducted as well.

(i) Thailand

a. Ground-based soil moisture observation (May, Sep., Nov. 2002, May, Sep., Nov. 2003, Feb., May, Sep. 2004)
b. Ground-based automated observation (Meteorological data, soil moisture) (May 2002 to Mar. 2005)

(ii) Tibet

a. Ground-based soil moisture observation (Jun. to Oct. 2002, Aug. 2003, Jun. to Aug. 2004)
b. Ground-based automated observation (Meteorological data, soil moisture) (May 2002 to Mar. 2005)

(iii)Mongolia

a. Ground-based soil moisture observation (Jun., Aug. 2002, Jun., Aug. 2003, Jun., Aug. 2004)

b. Ground-based automated observation (Meteorological data, soil moisture) (May 2002 to Mar. 2005)

(iv) Iowa

a. Ground-based microwave radiometer observation (Jun. to Jul. 2002)

b. Aircraft observation (PSR/C & A, ACMR, Step-C, PALS, ESTAR) (Jun. to Jul. 2002)

(v) Oklahoma

a. Ground-based soil moisture observation (Jun. to Jul. 2003)

b. Aircraft observation (PSR/C & A, ACMR, Step-C, PALS, ESTAR) (Jun. to Jul. 2003)

(4) Creating match-up data

Match-up data between AMSR/AMSR-E and the above-mentioned ground-based observation data will be created.

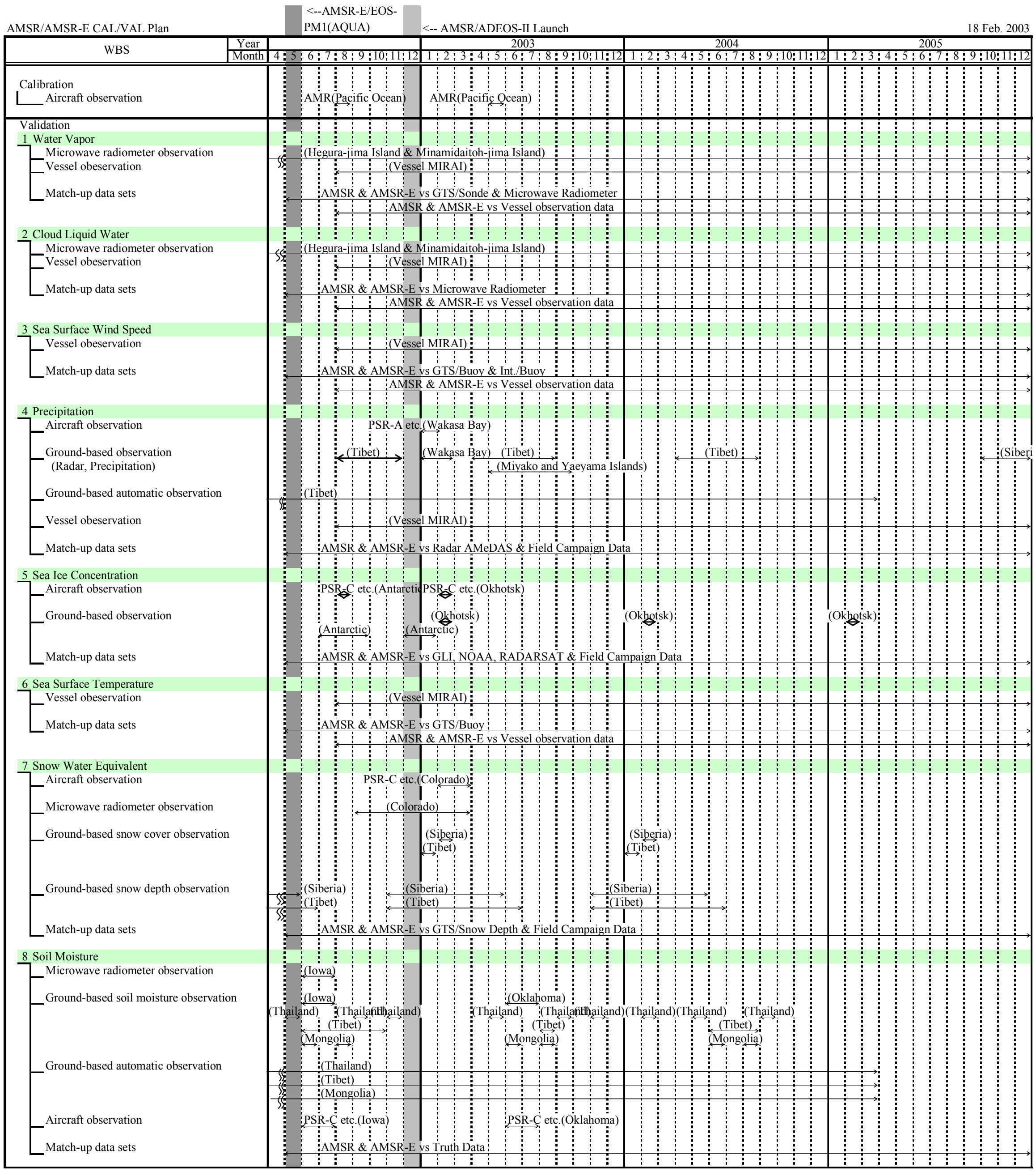
Includes matching up with China routine data, Mongolia routine data and USA (Oklahoma) soil moisture data.

· AMSR vs. truth data (Dec. 2002 to Mar. 2006)
· AMSR-E vs. truth data (May 2002 to Mar. 2006)

(5) Relationship to organizational setup and other research projects

NASDA hopes to conduct joint observation with the WCRP / CEOP and NASA / AMSR-E teams and to collaborate with the AMSR Precipitation Team, the GLI Land Team, the Frontier observational research program for global change, and CREST-JST.

2.4.3 schedule



3. SeaWinds

3.1 Scientific objectives

The SeaWinds scatterometer is a microwave radar sensor that measures ocean near-surface velocity by sending pluses to the ocean surface and receiving backscattered signals.

SeaWinds is a follow-on mission to the NSCAT scatterometer, which was aboard ADEOS. Both SeaWinds and NSCAT were provided by NASA JPL. The SeaWinds mission is to observe the global distribution of ocean near-surface velocity, with an accuracy 2m/s of for speed, an accuracy of 20 degrees for direction, and a spatial resolution of 25km. It will observe 90% of the Earth's oceans at least once in two days. Data on the ocean near-surface vector will be a rare and precious source for open ocean areas that previously were observed by vessels and other means for research on the atmosphere-ocean interaction or eolian cycle of the oceanic outer layer, which are important factors of the Earth's climate system. Particular, the ocean near-surface wind data will be collected for over a decade by the ADEOS-II SeaWinds mission. Such data is expected to understand and solve global yearly changes in phenomena such as EL Niño. Also use of near-real-time ocean weather and weather forecasting is in planning as a follow-on to the ADEOS NSCAT mission.

Within the framework of ADEOS-II as an Earth environment-observing satellite, combining SeaWinds data with GLI and AMSR data on ocean near-surface temperature and water vapor amount as well as ocean color, is expected to provide higher-order information about the ocean near-surface heat and water vapor fluxes. Also combining SeaWinds with AMSR will enable atmospheric correction and rain flagging using microwave radiometric data, which was impossible with NSCAT. Such are expected to improve the observational accuracy for ocean near-surface winds. Incorporating SeaWinds data into algorithms for obtaining ocean near-surface temperature and ocean color will improve observation accuracy.

In addition to ocean wind observations, we began to realize that information about land vegetation, snow ice, and ocean ice distribution can also be extracted from information about observed backscatter cross sections. Data use is expected to be promoted in this field in the future.

3.2 Overview of Mission Instruments

SeaWinds is a sensor developed by NASA JPL and is an advanced successor of the NASA scatterometer (NSCAT) on ADEOS. Its parabolic antenna rotates for conical scanning of the Earth's surface. It then receives microwave signals scattered by the sea surface and analyzes then to measure the direction and speed of winds on the ocean. SeaWinds observes at least 90% of the entire ocean surface once every two days. It has an accuracy of 2 m/s for wind velocity and 20 degrees for wind direction; the spatial resolution is 25 km. The observation data from SeaWinds can be used by alone, but can also be combined with data from AMSR and GLI. Such joint analysis is expected to contribute significantly to the understanding of water circulation and various ocean phenomena. Table 3.2-1 presents the main specifications of SeaWinds. Figure 3.2-1 illustrates the SeaWinds observation concept.

Table 3.2-1 Main Specifications of SeaWinds

Item	Specifications
Observation Frequency	13.402 GHz
Spatial Resolution	25 km
Observation Width	1800 km
Data Rate	35.378 Kbps (Min. 31.840 Kbps; Max. 38.208 Kbps)

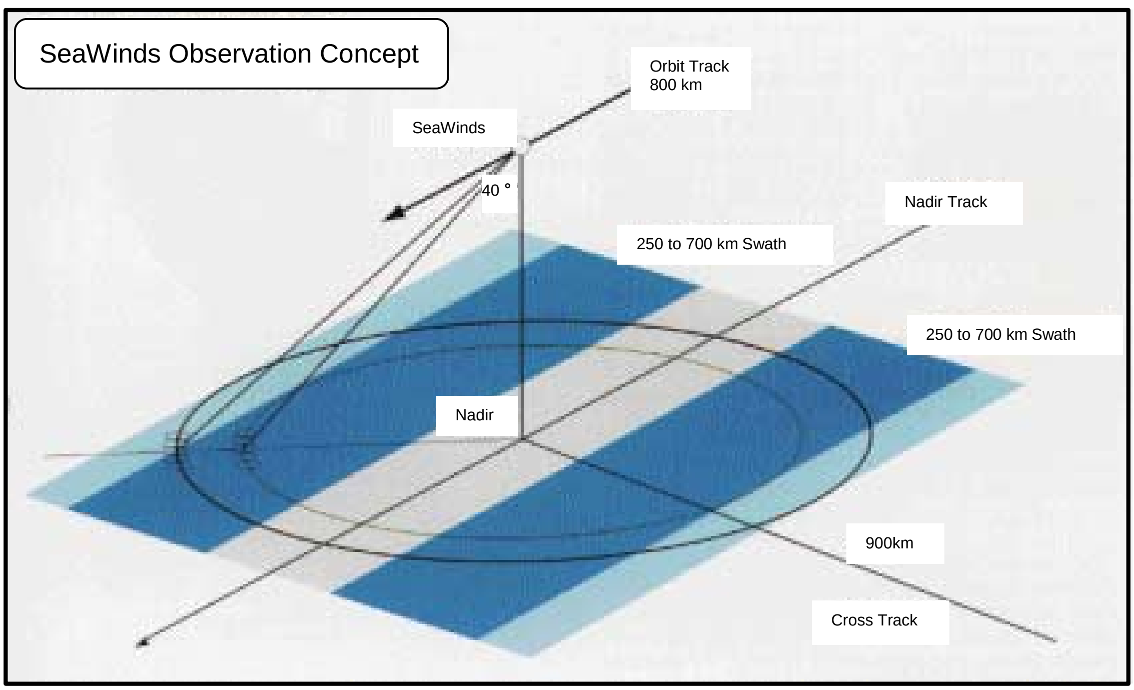


Figure 3.2-1 SeaWinds Observation Concept

3.3 Specific

3.3.1 Standard products

NASA JPL plans to provide the following three standard products, similar to those provided by NSCAT.

- Level 2: Global Backscatter Cross Sections

  Area data on backscatter cross sections of land, ocean, and ice regions
  Incidence, direction and AMSR brightness temperature data for atmospheric correction

- Level 2B: Ocean Vector Winds

  Ocean near-surface wind vector data (resolution 25km)
  Four solutions ambiguity removed are included.

- Level 3: Time-Space average Wind Vectors

  Grid data on time- and space-averaged ocean near-surface vector
  Approximately 1 degree latitude ×1 degree longitude ×1 day (average)

3.3.2 Research product

When grid data exceeding the scale of standard product level 3 data (ex. Monthly average) are produced, it is necessary to consider the problem of satellite observation samples relative to the time and space scales of changes in wind fields. It also depends on the purpose of product use, so standard creation techniques have not yet been established. These creation techniques are future research subjects and will be prepared as extensions of the ERS-1, the ERS-2, and the NSCAT missions.

SeaWinds will succeed three missions, develop the techniques, and produce continuous, long-term ocean sea-surface wind vector.

NSCAT seeks to acquire comprehensive ocean near-surface wind data of higher precision and with higher frequency, by combining its data with wind measurement sensors such as ERS-2/AMI, ERS-2/ALT, SSM/I, and TOPEX/POSEIDON ALT. The SeaWinds mission will succeed the missions of three latter sensors and will provide the same kinds of products and check changes of the data quality affected by the transition of each sensor.

4. POLDER

4.1 Scientific objectives

The Polarization and Directionally of the Earth's Reflectance (POLDER) instrument is the same sensor as flown aboard the ADEOS satellite. Since it is the only sensor to fly aboard both ADEOS and ADEOS-II, it will perform time series observations and continue the ADEOS satellite mission, thereby enabling changes in time of information acquisition to be explored.

Similar to taking a photograph (frame image), it collects reflected light ranging from the visible spectrum to the near-infrared spectrum from the Earth in a matrix CCD by rotating a filter wheel. The view zenith angle is 43 degrees along the track and 51 degrees cross track, corresponding to an image of 1580 X 2200 pixels. Since the frame images are obtained continuously satellite operation, the same target of the surface of the Earth will be observed from different points change by 11 degrees. These multi-directional observations (multi-observational angles) with polarization will produce data features.

Its instantaneous view angle is 6 degrees, and its brightness temperature resolution is 12 bits. It has eight spectral bands in the range from visible to near infrared, three of which (0.443, 0. 670, and 0.865μ) are used for polarization observations. Also, 0.765μ is used to analyze the oxygen absorption range; it sets up two types of observations regions, large region and narrow region. It is expected to estimate cloud height using the oxygen absorption range.

Using information about polarization, angle, and spectrum of the POLDER sensor, it will be possible to introduce atmospheric aerosol, cloud optic characteristic and the Earth Surface reflection characteristics. POLDER doesn't have its own calibration system, so it was designed for ADEOS to have the same bands as OCTS. Also, because POLDER doesn't have bands in infrared, infrared data of the OCTS was very good for the effective use of the POLDER. This concept of combined use of POLDER and OCTS is continued for the ADEOS-II mission. Cooperation between GLI and POLDER to produce even more abundant spectrum information than the OCTS is indispensable. ADEOS-II POLDER seeks to create, renew, and store global distribution maps of atmosphere aerosols, clouds, and the Earth's surface-reflection properties, based on compound use of not both GLI and other sensors.

4.2 Overview of Mission Instruments

POLDER is a push-broom type sensor that developed by CNES of France; it measures the polarized light, bi-directivity, and spectral characteristics of the solar rays reflected from the Earth's surface, aerosols, clouds, and the ocean. It is characterized by a large field of view (FOV), multi-band capability, and capacity to measure polarized light. Its quasi-square footprint produced by a large field-of-view angle of +/- 43 degrees times +/- 51 degrees moves along with the motion of the satellite, obtaining observation data from a variety of field-of-view angles. Further, it is capable of carrying out observation in eight bands from visible to near infrared ranges by turning its filter wheel. Data on spectra and polarized light observed by POLDER are expected to provide information useful for analyzing data obtained by other sensors. Table 4.2-1 presents the main specifications of POLDER. Figure 4.2-1 the observation principle of POLDER.

Table 4.2-1 Main Specifications of POLDER

Item		Specification
Observation Wavelength Band (nm)	No Polarized Light	443, 490, 565, 670, 763, 765, 865, 910
	Polarized Light (0, 45, 90 degrees)	443, 670, 865
Field of View		+/- 43 × +/- 51 (degrees)
Spatial Resolution		6 km × 7 km
Observation Width		1800 km × 2400 km
Data Rate		882.352 Kbps

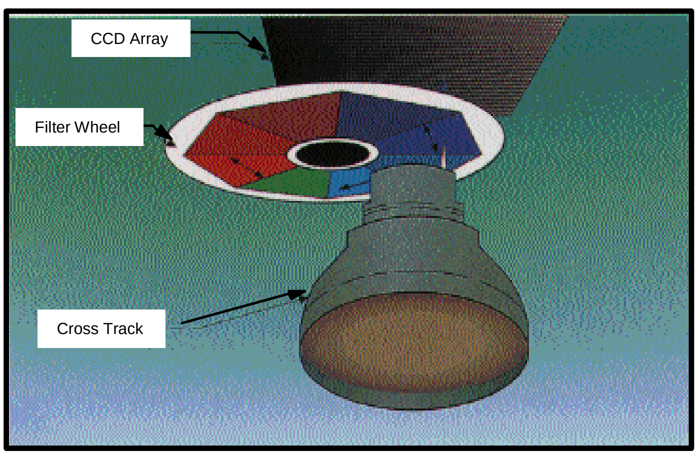


Figure 4.2-1 POLDER Observation Principle

4.3 Specific

4.3.1 Standard products

Creation of 1.1-degree-mesh Global Distribution Map

(1) Ocean aerosol optical properties
Categories: Optical thickness, grain size distribution, and reflective index

(2) Cloud over the ocean
Categories: Optical thickness, grain size distribution, and cloud top height

(3) Earth surface reflection properties

(4) Radiation Balance
Category: upper atmosphere

4.3.2 Research products

(1) Ocean near surface wind
Categories: Wind speed and direction

(2) Snow-ice surface reflectance factor

(3) Land aerosol optical properties
Categories: Optical thickness, grain size distribution, and reflective index

(4) Cloud in land region
Categories: Grain size distribution, cloud top height

(5) Cloud in ocean region
Categories: Extent, height

(6) Interaction between aerosols and clouds

(7) Distribution of ocean coloring matter concentration

5. ILAS-II

5.1 Science objectives

In the early 1970s, scientists expressed concern about the destruction of the ozone layer by chlorofluorocarbons (CFCs) and pointed out the necessity of protecting the zone layer. In the mid 1980s, the Antarctic ozone hole was discovered, and scientists revealed that CFC and other chemical components were rapidly destroying the ozone layer in the Antarctic region.

In response international controls were planed on producing and using CFCs and other chemical components. By the mid 1990s, the trend of increasing concentrations of some CFCs in the atmospheric began to slow down and seemed to even be reversing. Chlorine in the stratosphere, which destroys the ozone layer, will continue to increase over the next decade and then start to decrease. If so, and there is no change in other conditions, destruction of the ozone layer will reach its peak in the next several years and then start to decrease.

In the light of importance of the ozone depletion problem, the Environment Agency of Japan launched the improved Limb Atmospheric Spectrometer (ILAS) on ADEOS in August 1996 to monitor the ozone layer and promote investigation into the mechanism of ozone depletion. ILAS observed the altitude distribution of various ozone chemistry atmospheric trace components, temperature, air pressure, and aerosol/cloud regions in the stratosphere in the polar regions. To understand changes in the ozone layer correctly, to validate the effects of ozone layer protection to gain knowledge about physical chemistry processes in the upper layer of the atmosphere (including the ozone layer), and to contribute to predicting of atmospheric environment change on a global scale, it is necessary to conduct highly accurate observations for a long term. Although ADEOS unfortunately failed and ceased operation in July 1997, ILAS aboard ADEOS was able to acquire valuable data from the observations for about eight months. The Ministry of Environment decided to fly ILAS-II on ADEOS-II in FY2000 in order to continuously observe the ozone layer and, at the same time, to make an additional category of measurements and improve accuracy.

The scientific objectives of ILAS-II are to monitor changes in the ozone layer, and to investigate the ozone layer chemistry and physical processes, like those of ILAS. The wavelength of the spectroscope on ILAS-II and the items to be measured objects are shown in Table 5.1-1.

Table 5.1-1 Measuring wavelengths of the ILAS-II sensor and categories

Channel	Wavelength (frequency)	Item(s)
1	6.21-11.76µm (1610-850cm^{-1})	O_3, HNO_3, NO_2, N2O, CH_4, H2O, CFC-11, CFC-12, aerosol
2	3-5.7µm (3333-1754cm^{-1})	Aerosol, H_2O, CH_4, N2O, O_3, CO_2, Provided that CO_2 is for pressure measurement
3	12.78-12.85µm (782-778cm^{-1})	$ClONO_2$
4	753-784µm (13280-12755cm^{-1})	Temperature, atmospheric concentration, aerosol

“ Aerosol” includes polar stratospheric clouds (PSCs). Also, data are measured at altitudes of 10 to 60 km (sequence of measurements from cloud-top height to 250km), and the altitudinal resolution is 1km. When ADEOS-II is in orbit and passes the descending node at 10:30 AM local time, data will be measured from 57 to 73 degrees north latitude and 64 to 88 degrees south latitude. Channel 1 and 4 are basically the same as for ILAS, and channels 2 and 3 were added for ILAS-II.

ILAS observes O_3, HN_3, NO_2, N_2O, CH_4, and H_2O gas components that are important trace elements for understanding physics and chemistry involving ozone layer. CFC-11 and CFC-12 supply chlorine atoms that destroy the ozone layer, and international actions for eliminating these components have been taken. Monitoring not only enables us to know the tendency of the components destroying the ozone but also to gain knowledge on the export process from the troposphere to the stratosphere and other physical mechanisms related to material transfer in the upper atmosphere.

Temperature is an important parameter that involves the atmospheric cycle and other physical environments, the speed of chemical reaction of gaseous components, and the generation and extinction of PSCs. Moreover, since the absorption coefficient of gaseous molecules in the infrared range depends on temperature, temperature must be measured.

Measuring $ClONO_2$, which acts as a reservoir of chlorine atoms that destroy the ozone layer, is important for understanding the ozone-depletion mechanism. This new measuring category has been added to ILAS-II. Particles like aerosols and PSC_2 produce heterogeneous chemical reactions like $ClONO_2$, HCL, and H_2O and are believed to speed up ozone depletion. Since particle composition, formation, and surface area determine heterogeneous chemical reactions of particles over the surface, it is very important to extract this information. For that reason, the ILAS-II middle infrared channels include 6µm and 6µm and above to improve accuracy.

5.2 Overview of Mission Instruments

ILAS-II is an atmospheric sensor developed by the Environmental Agency to monitor and study the ozone layer in the stratosphere in high-latitude regions in both the northern and southern hemispheres. This sensor is designed for scientific research concerning physical and chemical phenomena related to the destruction of the ozone layer and for validating the effects of measures such as the specific Freon control regulation. To support such research, it will perform long-term observations of various phenomena in the stratosphere, such as ozone holes caused by Freon and other factors. ILAS-II is a spectrometer that measures (by solar obscuration) the altitude and distribution of the atmospheric content concentration, temperature, and atmospheric pressure from the top of the troposphere to the stratosphere by absorbed spectra in the atmospheric-peripheral direction with the Sun as its light source, both at sunrise and at sunset on each revolution of the satellite. Measurements use absorbed spectra in a total of four bands: three infrared bands (3.0 to 5.7 μm, 6.21 to 11.76 μm, and 12.78 to 12.85 μm) and one visible band (753 to 784 nm). As with ILAS, observation by ILAS-II is limited to the high-latitude regions on both hemispheres (56 to 70 degrees north, 63 to 88 degrees south) due to the positional relations of the satellite and the Sun with respect to the Earth in a Sun-synchronous orbit. The system is capable of measuring many parameters related to the destruction of the ozone layer through this spectral measurement: these parameters include ozone, NO_2, aerosol, water vapor, Freon (CFC-11 and CFC-12), methane, N_2O, $CIONO_2$, air temperature, atmospheric pressure, and the altitude-distribution of these elements. Table 5.2-1 presents the main specifications of ILAS-II. Figure 5.2-1 illustrates the observation concept of ILAS-II.

Table 5.2-1 Main Specifications of ILAS-II

Item	Specifications
Observation Wavelength Bands	6.2 to 11.8 μm
	3.0 to 5.7 μm
	12.78 to 12.85 μm
	753 to 784 nm
Observation Altitude	10 to 60 km
Altitude Resolution	1 km
Data Rate	453.62 Kbps

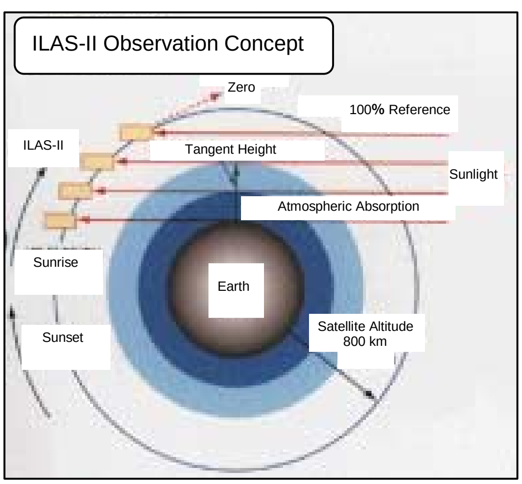


Figure 5.2-1 ILAS-II Observation Concept

5.3 Specific

5.3.1 Standard products

The principles of ILAS-II measurements are based on solar occultation, which measures the sunlight passing through the atmosphere in the regions. Since ILAS-II will be on board a sub-synchronous, sub recurrent orbit satellite, the measurements will be conducted at sunrise and sunset as viewed from the satellite. Thus, ADEOS-II will orbit the Earth 14 times a day and measurements will be conducted at 14 points in the northern and southern hemispheres each day.

The standard ILAS-II products are the altitude distribution of each observational point listed below. (Measurement errors are also provided.) For reference, the estimates of measurement accuracy we expect with ILAS-II are shown for several altitudes (Table 5.3-1).

Table 5.3-1 Expected ILAS-II measurement accuracy

Figures indicate expected ILAS-II measurement accuracy; improvement is expected.

Altitude (km)	10	20	30	40	50
O_3	5%	5%	5%	5%	5%
HNO_3	50%	10%	50%	n.d.	n.d.
NO_2	n.d.	5%	5%	20%	100%
N_2O	5%	5%	20%	100%	n.d.
CH_4	5%	5%	5%	10%	n.d.
H_2O	5%	5%	5%	10%	n.d.
CFC-11	10%	Under study			n.d.
CFC-12	Under study				
$CLONO_2$	Under study				
Aerosol extinction Coefficient (Multi-wavelength)	Under study				
Temperature	1K				
Air Pressure	1%				

Note: n.d. indicates “impossible to indicate”

5.3.2 Research products

Extinction coefficients of complex wavelength are standard aerosol products. As research products, parameters related to components of aerosols, and grain size distribution will be derived from the extinction coefficients. Also, using standard products, level 3 products will be generated as research products.

6. DCS

The Data Collection System (DCS) is a system that collects observation data (uplink messages) transmitted from buoys set up on the ocean and from observation systems on land and, at the same time, transmits control commands (downlink messages) to these buoys and observation systems (DCP: Data Collection Platform). Table 6-1 shows the main specifications of the DCS.

Table 6-1 DCS Main Specifications

Item		Specifications
Data Rate		10 Kbps
Downlink Messages	Frequency	465.9875 MHz
	Data Rate	200 bps
Uplink Messages	Frequency	401.65 MHz
	Data Rate	400 bps

7. TEDA

Technical Data Acquisition Equipment (TEDA) gathers engineering data on the relationship between the space environment on the satellite's orbit and the deterioration, malfunction, and failure of satellite parts and materials; it was also installed on other satellites such as ETS-V and ETS-VI.

The TEDA hardware consists of a technical data-collecting unit (TDU) and a pollution-monitor sensor (COM-S), with five additional sensors and monitors: a heavy-ion observation unit (HIT), a radiation dosage monitor (DOM), a pollution monitor (COM), a static electric potential monitor (POM), and a memory-malfunctioning monitor (SUM).

Using these sensors and monitors, this system will acquire data concerning the relationship between the deterioration characteristics of parts and materials and the harsh space environment. Some of the data collected will be reflected in the development of a space-environment model useful for future designs of various satellites. The data rate for TEDA data is 672 bps.

Chapter 3 System and Operation

1. System

1.1 Overview of the Satellite System

ADEOS-II is expected to be launched by H-IIA in December 2002, from Tanegashima Space Center. The satellite will be injected into a solar-synchronous sub recurrent orbit with an altitude of 802.9 km and an orbit inclination angle of 98.62 degrees. It orbits the Earth in 101 minutes. The satellite design is 3 years, but it carries five years' worth of fuel in order to maintain this orbit.

Table 1.1-1 presents the main specifications of the ADEOS-II satellite.

Table 1.1-1 Main Specifications of the ADEOS-II Satellite

Item	Specifications
Launching Rocket	H-IIA
Time of Launch	December, 2002
Orbit Altitude	802.8 km
Orbit Inclination Angle	98.62 degrees
Body dimensions (x, y, z)	5 × 4 × 4 m
Solar Battery Paddle dimensions	3 × 24 m
Weight	3,730 kg
Power Generated (at the Completion of the Mission)	5000W or more
Attitude-Control Method	Zero-Momentum 3-Axis Control
Design Life	3 years
Fuel Carried	Sufficient for 5 years

ADEOS-II consists of a mission module in the front, equipped with observation instruments, and a bus module in the rear of the satellite, where basic instruments are stored.

The mission module contains the mission instruments (observation instruments) shown in Table 1.1-2, which were developed by the NASDA and related agencies.

Table 1.1-2 Mission Instruments aboard ADEOS-II

Instrument	Developing Agency
High-Performance Microwave Radiometer (AMSR)	NASDA
Global Imager (GLI)	NASDA
Improved Atmospheric Peripheral Infrared Spectrometer II (ILAS-II)	Environmental Agency
Sea Wind Observation Instrument (SeaWinds)	NASA JPL
Land Surface Reflective Light Observation Instrument (POLDER)	CNES
Date-Collection System (DCS)	CNES
Technology Data Obtaining System (TEDA)	NASDA

The bus module contains the instruments and devices (bus instruments) shown in Table 1.1-3. There are necessary for various satellite operations, including maintaining the satellite's orbit and controlling mission instruments.

Table 1.1-3 Bus Instruments aboard ADEOS-II

Instrument	Overview
Communication and Data-Handling System (C&DH)	The communication and data-handling system (C&DH) receives and decodes command signals transmitted from the tracking control office using a frequency in the 2GHz-band and communicates them to all the ADEOS-II instruments. It is also capable of editing the temperature, voltage, and status of the interior of each instrument and transmitting the information to the ground station using telemetry signals.
Inter-Orbit Communication System (IOCS)	The inter-orbit communication system (IOCS) is a subsystem for data-relaying and tracking control through a data-relaying satellite using the S-band and Ka-band.
Mission-Data-Processing System (MDP)	The mission-data-processing system (MDP) selects the type of mission data to be transmitted, adds necessary data to mission data, edits the information into packet- or multi-format, and then transmits the information to the direct transmission system (DT) and the inter-orbit communication system (IOCS); it is also capable of transmitting the information to the mission data recorder (MDR).
Direct Transmission System (DT)	The direct transmission system (DT) sends data observed by ADEOS-II and is capable of transmitting data directly to the ground station using the X band. The DT transmits mid- to high-speed mission data at two rates in the X band (60 Mbps and 6Mbps data).
Optical Magnetic Disk (ODR)	The ODR is a high-speed, large-volume data recorder using an optical magnetic disk system, introduced in ADEOS-II for the first time. A large-scale recording experiment will be conducted with high-speed, high-volume data. The ODR is contained in the DT unit.
Electric Power System (EPS)	The electric power system (EPS) has three functions: to supply the bus power to each subsystem of the satellite; to manage charging and discharging of the battery; and to control ignition of the ordnance controller. During the night, it supplies power to the satellite by discharging the battery (BAT). During the day, excess power generated by the solar-battery paddles is used to charge the battery. During the critical phase, which is the initial stage after the launch, it provides power to ignite the ordnance controller through the explosive-tube control unit (ODC) to extend the solar-battery paddles, DCS antennae, and IOCS compartment as well as to release locks on AMSR and SeaWinds.
Paddle System (PDL)	The paddle system (PDL) converts solar energy into electric energy and transfers it to the satellite's power system. The paddle system to be installed on ADEOS-II is sufficient to satisfy demands. It has a large power-generating capacity of at least 5 kw (EOL), is highly storable, has been made lighten. The system uses an extension method wherein 50 flexible blankets with a total of 55,680 solar-battery cells are extended on a jointed mast in orbit.
Attitude-Orbit Control System (AOCS)	The attitude-orbit control system has four functions: to establish the three-axis attitude after the rocket is separated from the satellite, to maintain the satellite's attitude, to control the orbit, and to drive the solar-battery paddles. Sensors to detect the attitude include a control-standard unit (IRC), an Earth sensor (ESA), and a fine sun sensor assembly (FSSA), Actuators to control the attitude include a reaction wheel (RWA) and a magnetic torque (MTQ). This system also transmits control signals necessary for attitude control and orbit control to the RCS.
Propulsion System (RCS)	The propulsion system (RCS) generates propulsion power necessary for initial-stage attitude correction and orbit control according to the control signals from the attitude-orbit control system (AOCS), using the 1N thruster and 20N thruster.
Local User Transmission System (DTL)	The local user transmission system (DTL) is capable of modulating data extracted from four (three visible and one infrared) of the 36 observation bands of the Global Imager (GLI) (ground resolution 6 km × 6 km, data rate 23Kbps) into BPSK; it is also capable of transmitting the data to local users such as vessels on the UHF band (467.7 MHz). The water-color and water-temperature data are used to study the ocean conditions, distribution of water temperature, and basic productivity of the ocean.

1.2 Overview of the Ground System

The main components of the ground system, which carries out the mission operation of ADEOS-II, are listed below.

- Facilities and Organizations within NASDA
  - ADEOS-II Mission Operating System: Earth Observation Center
  - Earth Observation Information System (Data Comprehensive Management and Provision System): Earth Observation Center
  - Other Systems: Earth Observation Center
    - EOC Control System
    - Observation Request Enquiry System
    - Shared Information Storing System
  - Tracking and Control System (TACC)
  - Earth Observation Data Analysis Research Center (EORC)

- Facilities and Organizations outside NASDA
  - Overseas Stations
  - NASA Stations (ASF, WFF)
    - Kiruna Station
  - Sensor-Providing Organizations
  - Redu Station
  - Users
    - Principal Investigator (PI)
    - Semi-Real-Time Data Users
    - General Users

Figure 1.2-1 illustrates the overall structure of the ground system for ADEOS-II.

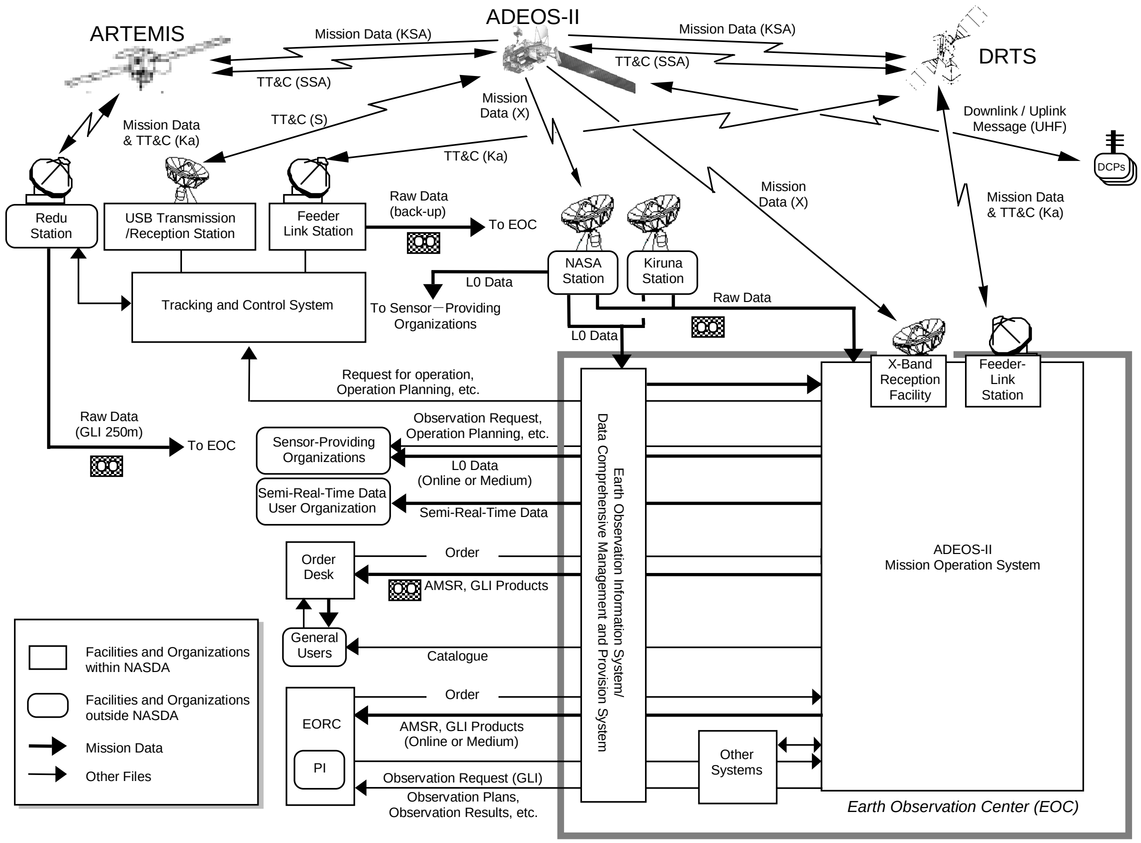


Figure 1.2-1 Overall Structure of the ADEOS-II Ground System

(1) ADEOS-II Mission Operation System

The ADEOS-II mission operation system is a central-core system for the mission operation of ADEOS-II, and is provided by NASDA for the Earth Observation Center (EOC). The ADEOS-II mission operation system establishes plans for the operation of mission instruments, recording and playing of MDR, etc., based on sensor-operation requests by sensor-providing organizations. Furthermore, it receives mission data sent via a relay satellite or directly through X band and prepares level-0 data for each mission instrument. It also prepares standard the AMSR and GLI products (level-1 products and higher-order products with level 2 and higher) and handles DCS data.[1] The level-0 data obtained by mission instruments other than AMSR and GLI that have been processed by the ADEOS-II mission operation system will be distributed to sensor-providing organizations online or through a medium.

The mission operation system of ADEOS-II also processes AMSR and GLI 1km products on a semi-real-time basis and makes them available online to semi-real-time data users.

Finally, the feeder-link station of the ADEOS-II mission operation system functions as a back-up station that transmits commands through a relay satellite and obtains telemetry data when there is trouble or some failure at the feeder-link station of the track-control system.

1 The DCS data processed by the mission operation system of ADEOS-II are limited only to data collected by the DCP managed by the NASDA.

(2) Earth Observation Information System and Data Comprehensive Management and Provision System

The Earth observation information system and data comprehensive management and provision system (EOIS-DDMS) provides a network environment in which data is exchanged online between EOC and various related organizations in and outside of Japan. In addition, these systems store and manage all ADEOS-II mission data as raw data before they are processed at level 0; the systems also store and manage the AMSR and GLI standard products.

Furthermore, the systems manage the catalog information on the AMSR and GLI products, provide it to users, and provide specific data when requested by users.

(3) Other Systems

In addition to the Earth observation information system, EOC also has the following systems related to the operation of the mission operation system of ADEOS-II.

(i) EOC Control System

This system calculates information on several competing satellites (including ADEOS-II) that collect data which EOC receives and coordinates the antenna competition of the X-band direct-receiving station within the EOC. Based on these coordination results, this system provides the mission operation system with antenna information that can be used to receive the mission data of ADEOS-II. In addition, the EOC control system manages the operates the X-band receiving equipment based on the X-band reception plan provided by the mission operation system.

(ii) Observation Request Enquiry System

This system receives GLI observation requests from EORC, prepares observation request files, and provides them to the ADEOS-II mission operation system. It also discloses results of observation planning as well as the observation results to EORC through its WWW server.

(iii)Shared Information Storing System

This system stores and manages information shared and used jointly by a number of facilities (such as the orbit information of ADEOS-II) in its data server and provides this information as it is required by various facilities.

(4) Tracking and Control System

The tracking and control system checks mission-instrument operation requests established by the ADEOS-II mission operation system with respect to the restrictions on the number of satellite commands, power restriction, and other restrictions and then prepares commands to be uplinked to the satellite. The commands prepared are transmitted directly from the USB transmission and reception station or through a relay satellite to ADEOS-II.

The tracking and control system also obtains HK telemetry data and measuring-distance data of the satellite, either through a relay satellite or by direct reception at the USB transmission and reception station. It then monitors the satellite status as well as that of the instruments installed on board and decides the orbit of the satellite.

The feeder-link station of the tracking and control system is able to serve as a back-up station that collects mission data through a relay satellite if the feeder-link station of the ADEOS-II mission operation system suffers an outage. In such cases, the acquired mission data are recorded in a medium and transmitted to the ADEOS-II mission operation system.

(5) Earth Observation Data Analysis Research Center (EORC)

At EORC, the Earth observation information system (EOIS) and the data analysis research system (DAS) are used to make prototypes of research products and data sets other than standard products. At this center, observation requests from PIs for the GLI tilt changes and the GLI 250 m data collection region are organized and provided to the observation request enquiry system at the EOC.

(6) Overseas Stations

Two classes of X-band direct reception stations overseas support the ADEOS-II mission operation: NASA stations and the Kiruna station. These stations collect ADEOS-II mission data for paths that cannot be acquired by the X-band reception station of the EOC. The NASA stations include the Alaska SAR Facility (ASF) located in Fairbanks, Alaska, and the Wallops Flight Facility (WFF) located in Wallops, Virginia.

At overseas stations, mission data in the X band are collected according to the operation plan provided by the ADEOS-II mission operation system; all level-0 data on mission instruments, except the GLI250m and POLDER data, are prepared there. The level-0 data prepared at NASA stations are provided online to sensor-providing organizations, the EOC, and other organizations. The level-0 data prepared at the Kiruna station are provided online to the EOC.

The MDR data and the GLI 250m data, included in mission data obtained at overseas stations, are regularly recorded on a medium as raw data before they are processed at level 0 and transported to EOC.

(7) Sensor-Providing Organizations

Sensor-providing organizations are related organizations and agencies—both in and outside the Japan—that develop mission instruments besides the AMSR and GLI. They include the Environmental Agency of Japan (ILAS-II), the NASDA Space Environment Measuring Group (TEDA) of Japan, NASA JPL (SeaWinds) and CNES (POLDER and DCS).

A sensor-providing organization collects level-0 data obtained by its own sensor, prepared by the mission operation system of ADEOS-II or by an overseas station, either online or through a medium; it then prepares higher-order products at level 1, level 2, or higher.

A sensor-providing organization prepares observation requests for its own sensor and provides them to the ADEOS-II mission operation system. However, the TEDA and DCS instruments require constant operation, so no observation requests are necessary except in emergencies such as sensor failures.

(8) Redu Station

Redu station is an ESA ground station located in Belgium and serving as a feeder link station for ARTEMIS. ARTEMIS is expected to collect GLI 250m data not visible by DRTS, transmit commands, and receive telemetry. The GLI 250m data obtained at the Redu station are recorded on a medium, transferred to EOC, and processed at level 0 and as standard products by the ADEOS-II mission operation system.

However, the regular GLI 250m data will not be acquired using until the ARTEMIS line quality is confirmed to be satisfactory.

(9) Data Users

(i) PI

The term “PI” represents a researcher or a representative of a research organization that has responded with a proposal to a NASDA-originated research proposal advertisement and has been selected to carry out research. A PI can place a product order online and has the right to obtain, free of charge, AMSR and GLI products online or through a medium. Requests for GLI tilt angle change and GLI 250m data-obtaining regions can be submitted by a PI to the EORC, where these GLI observation requests are organized.

(ii) Semi-Real-Time Data Users

A semi-real-time data user is an organization that has signed an agreement with NASDA on the use of semi-real-time AMSR and GLI data. Currently, the NOAA of the United States, the Meteorological Agency of Japan, and the Fishery Information Service Center (corporation) are these users.

(iii)General Users

A general user is anyone other than PIs and semi-real-time data users who uses ADEOS-II data. Standard AMSR and GLI products can be data-searched online by these users; however, the must use off-line services through the order desk to order and get products.

2. User Services

2.1 Data Policy

TBD.

2.2 Operation Phase

The operation phase for AMSR, and GLI, and AMSR-E is subdivided into three phases as shown in Figure 2.2-1. Note that the operation phases for the AMSR/GLI and the AMSR-E occur at different times.

(1) Initial Checkout Phase

The initial checkout phase is approximately the first four months after the satellite launch. Checkout is performed to confirm that the sensor hardware on the satellite functions properly in orbit and to evaluate the ground system. There is no user service during this period.

AMSR-E	May 4 to early September 2002
AMSR/GLI	December 2002 to March 2003

(2) Calibration and Validation Phase

The calibration and validation phase is the period of approximately one year after the initial checkout phase after the launch of the satellite. Sensors will be calibrated and the products validated. Data necessary for calibration and validation will be provided only to Cal/Val PIs and standard algorithm PIs.

AMSR-E	Early September 2002 to early May 2003
AMSR/GLI	March 2003 to December 2003

(3) Regular-Use Phase

The regular-use phase begins approximately a year after the launch. Standard products will be provided to all users including general users.

AMSR-E	Early September 2002 to early May 2003
AMSR/GLI	March 2003 to December 2003

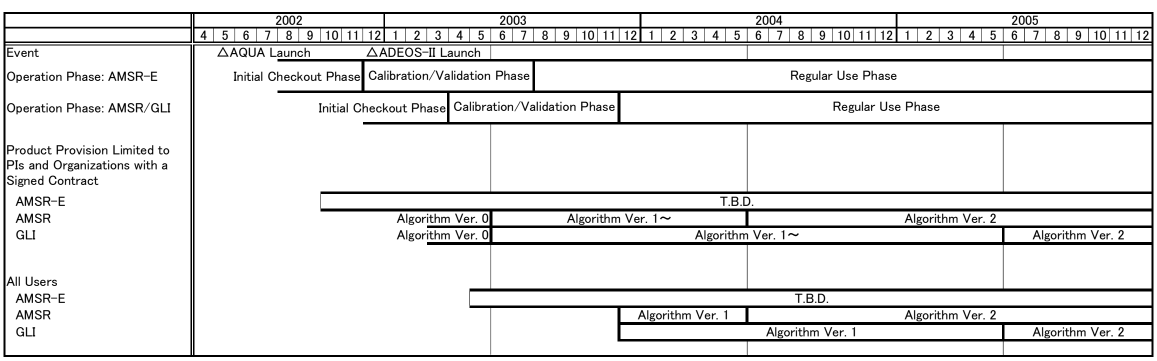


Figure 2.2-1 Operation and Product-Provision Schedule

2.3 User Definition

User service policies differ depending on the purpose of their usage. The following five definitions are used to classify all users.

- Cal/Val PIs and Standard Algorithm PIs
- Research Algorithm PIs
- Earth Science PIs
- Organizations with a Signed Contract
- General Users

Details are TBD.

2.4 User Services

2.4.1 Overview of Services

The term “user services” refers to the provision of Earth-observation data according to the users’ requests so that they can do their research or carry out their business efficiently and smoothly. The services can be classified into two groups: observation-request service and data-request service. Figure 2.4-1 present an overview of the flow of user services. Users can receive observation-request service and data-request service through the GLI and data-request service of AMSR.

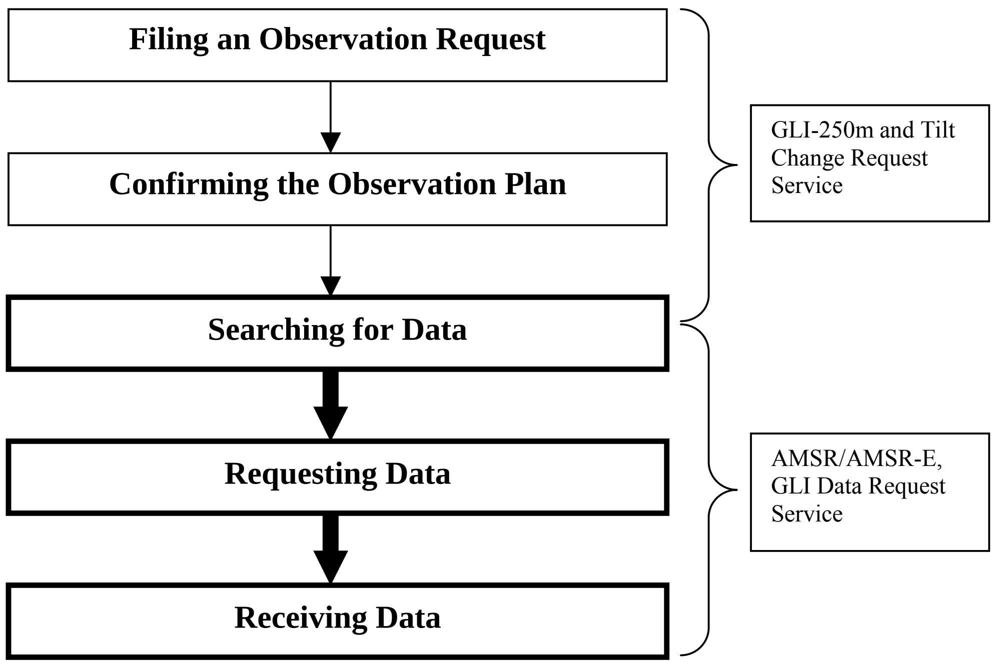


Figure 2.4-1 An Overview of the Flow of User Services

These services differ in policies and procedures, depending on the operation phases defined in Section 2.2 and on the types of users defined in Section 2.3.

In the following pages, user services are described for each operation phase and, within each operation, the service provided to each type of user will be explained.

2.4.2 Services According to Operation Phase

2.4.2.1 Calibration and Validation Phase

(Details of services are currently being determined.)

User services during the calibration and validation phase consist of providing (1) through (4) below; Table 2.4-1 identifies the services provided to each type of user.

(1) GLI Observation Requests

A request is necessary when a user wishes to schedule GLI 250m observation or to change the tilt from the default tilt pattern. GLI 1km observation does not require a request. Service details for each observation request are discussed below.

(i) Reception of Requests for GLI 250m Observation and Tilt Change

A user may request GLI 250m observation and a tilt change for a particular observation day during or after the calibration and validation phase. The user goes to the EORC web site (the URL is TBD), fills out necessary information on the observation request form online, and submits it by a deadline TBD, $(9 + \alpha)$ weeks before the observation date. If, however, new emergency observation is required or an observation request is changed, the request can be accepted up to five weeks before the observation date.

For those requests mentioned in the NASDA official document "ADEOS-II/GLI Observation Request Plans," an email will be sent from the ADEOS-II Mission Operation Office (a tentative name) to verify the requests details. The party making the request is to verify the request content and reply to the email by the date specified in the email text.

(ii) Coordination of Requests for GLI 250m Observation and Tilt Change

Each request for GLI 250m observation or a tilt change that has been received is given an observation priority ranking. If there is time before the deadline, an observation request simulation is carried out beforehand. If requests are clearly not possible, the ADEOS-II Mission Operation Office (a tentative name) will send an email stating that. The requester can then coordinate the request with the ADEOS-II Mission Operation Office (a tentative name) and, if necessary, submit a new observation request through the Web site.

(2) Observation Plan Confirmation

The user can verify the observation planning results for GLI 250m observation and GLI 1km observation after the tilt change about two weeks prior to the observation date through the EORC's web site (the URL is TBD). (Contents to be displayed are TBD.) At the same time, the URL will be given to the requester through an email (TBD).

The entire observation plan for the AMSR-E, AMSR, GLI 250m, and GLI 1km can be verified beginning two weeks prior to the observation date (this is yet to be confirmed) on the EOC's home page http://eus.eoc.nasda.go.jp. For details, see "Earth Observation Data Usage Handbook—ADEOS-II."

Users must understand that sometimes data may not be made available according to the observation plan due to reasons such as data loss during observation data reception.

(3) Data Requests for AMSR-E, AMSR, and GLI

EORC will provide invalidated level-1B products, invalidated standard products, match-up data, and research products.

Services that can be used vary according to the data type. See Table 2.4-1 and "Earth Observation Data Usage Handbook—ADEOS-II" for details concerning data types, services used, and how to use various services.

(4) User Support

User support is provided through the ADEOS-II Mission Operation Office (a tentative name).

Address: TBD (NASDA or RESTEC?)
Phone:
Fax:
Email: ad2help@restec.or.jp
URL: http://www.eorc.nasda.go.jp/

2.4.2.2 Regular Use Phase

(Details of service are currently being coordinated.)

Here, user services (1) through (4) below during the calibration and validation phase are discussed; Table 2.4-2 presents the types of services provided to each user type.

(1) GLI Observation Requests

A request is necessary when a user wishes to carry out GLI 250m observation or to change the tilt from the default tilt pattern. GLI 1km observation does not require a request. Service details for each observation request are discussed below.

(i) Reception of Requests for GLI 250m Observation and Tilt Change

A user may request GLI 250m observation and a tilt change for a particular observation day during or after the calibration and validation phase. The user goes to the EORC web site (the URL is TBD), fills out necessary information on the observation request form online, and submits it by the TBD deadline, $(9 + \alpha)$ weeks before the observation date. If, however, new emergency observation is required or an observation request is changed, the request can be accepted until five weeks prior to the observation date.

For requests mentioned in the NASDA official document “ADEOS-II/GLI Observation Request Plans,” an email will be sent from the ADEOS-II Mission Operation Office (a tentative name) to verify the details requests. The party making the request is to verify the request details and reply to the email by the date specified in the email text.

(ii) Coordination of Requests for GLI 250m Observation and Tilt Change

Each request for GLI 250m observation or a tilt change that has been received is given an observation priority ranking. If there is time before the deadline, an observation request simulation is performed beforehand. For requests that are clearly not possible, the ADEOS-II Mission Operation Office (a tentative name) will send an email stating the fact. The requester can then coordinate the request with the ADEOS-II Mission Operation Office (a tentative name) and, if necessary, submits a new observation request through the Web site.

(2) Observation Plan Confirmation

The user can verify the observation planning results for GLI 250m observation and GLI 1km observation after the tilt change about two weeks before to the observation date through EORC's web site (the URL is TBD). (Displayed contents are TBD.) At the same time, the URL will be given to the requester through an email (TBD).

The entire observation plan for the AMSR-E, AMSR, GLI 250m, and GLI 1km can be verified beginning two weeks before to the observation date (to be confirmed) on the EOC's home page http://eus.eoc.nasda.go.jp. For details, see "Earth-Observation Data Usage Handbook—ADEOS-II."

Users must understand that sometimes data may not be made available according to the observation plan due to reasons such as data loss during observation data reception.

(3) Data Requests for AMSR-E, AMSR, and GLI

The EORC will provide the following data: invalidated level-1B products invalidated standard products, match-up data, and research products.

EOC will provide level-1 products and standard products.

Services that can be used vary according to the data type. See Table 2.4-1 and "Earth Observation Data Usage Handbook—ADEOS-II" for details concerning data types, services provided, and how to use the various services.

(4) User Support

User support is provided through the ADEOS-II Mission Operation Office (a tentative name).

Address: TBD (NASDA or RESTEC?)
Phone:
Fax:
Email: ad2help@restec.or.jp
URL: http://www.eorc.nasda.go.jp/

Table 2.4-1 Overview of User Service in the Calibration and Validation Phase

Initial Checkout Phase No Service
Calibration and Validation Phase

Users	GLI 250m Observation Requests, Coordination		Observation Plan Confirmation		AMSR-E, AMSR, GLI Data Requests [*4]				
	Received at:	I/F	Received at:	I/F	Data Provided	Scene Orders[*5]	Standing Orders[*6]	Received at:	I/F
Cal/Val PIs and Standard Algorithm PIs	EORC	WWW, email	EORC	WWW, email	Invalidated Level 1Products, Invalidated Standard Products, Invalidated Research Products	Available	Not Available	EORC	ODD (WWW), FTP[*2]
Research Algorithm PIs	Not Available		EOC	EUS/OREQ (WWW, GUI)[*3]					
Earth Science PIs					Match-Up Data				Disclosure System for Data for Validation (WWW)
Users with Signed Contract	*1		*1		*1				
General Users	Not Available		Not Available		Not Available				

1. For organizations with a signed contract, the available data depend on the contract.
2. Making AMSR-E/ AMSR data available through FTP is being discussed currently (to be confirmed).
3. Details concerning which EUS/OREQ observation plans are to be confirmed are currently being discussed.
4. PI production requests necessary for calibration and validation will not be honored.
5. A scene order is an order that uniquely specifies a scene or a product among processed data.
6. A standing order is a pre-order of data that are to be obtained and/or prepared in the future.

Table 2.4-2 Overview of User Service in the Regular Use Phase

Regular Use Phase

<table>
<tr><th rowspan="2">Users</th><th colspan="2">GLI 250m Observation Requests, Coordination</th><th colspan="2">Observation Plan Confirmation</th></tr>
<tr><th>Received at:</th><th>I/F</th><th>Received at:</th><th>I/F</th></tr>
<tr><td>Cal/Val PIs and Standard Algorithm PIs</td><td rowspan="3">EORC</td><td rowspan="3">WWW, email</td><td>EORC</td><td>WWW, email</td></tr>
<tr><td>Research Algorithm PIs</td><td rowspan="3">EOC</td><td rowspan="3">EUS/OREQ (WWW, GUI)[*2]</td></tr>
<tr><td>Earth Science PIs</td></tr>
<tr><td>General Users</td><td colspan="2">Not Available</td></tr>
<tr><td>Users with Signed Contract</td><td colspan="2">[1]</td><td colspan="2">[1]</td></tr>
</table>

(EOC Window)

<table>
<tr><th rowspan="2">Users</th><th colspan="5">AMSR-E, AMSR, GLI Data Requests [4]</th></tr>
<tr><th>Data Provided</th><th>Scene Orders[5]</th><th>Standing Orders[6]</th><th>Received at:</th><th>I/F</th></tr>
<tr><td>Cal/Val PIs and Standard Algorithm PIs</td><td rowspan="5">Level-1 Products, Standard Products</td><td rowspan="4">Available</td><td rowspan="4">Available</td><td rowspan="4">EOC</td><td rowspan="3">EUS (GUI, WWW)</td></tr>
<tr><td>Research Algorithm PIs</td></tr>
<tr><td>Earth Science PIs</td></tr>
<tr><td>General Users</td><td>EUS (WWW)</td></tr>
<tr><td>Users with Signed Contract</td><td colspan="4">[1]</td></tr>
</table>

(EOC Window)

<table>
<tr><td>Cal/Val PIs and Standard Algorithm PIs</td><td rowspan="4">Invalidated Level-1 Products, Invalidated Standard Products, Research Products</td><td rowspan="3">Available</td><td rowspan="3">Not Available</td><td rowspan="3">EOC</td><td rowspan="2">ODD (WWW), FTP[3]</td></tr>
<tr><td>Research Algorithm PIs</td></tr>
<tr><td>Earth Science PIs</td><td>Disclosure System for Data for Validation (WWW)</td></tr>
<tr><td>Users with Signed Contract</td><td colspan="4">[1]</td></tr>
<tr><td>General Users</td><td colspan="5">Not Available</td></tr>
</table>

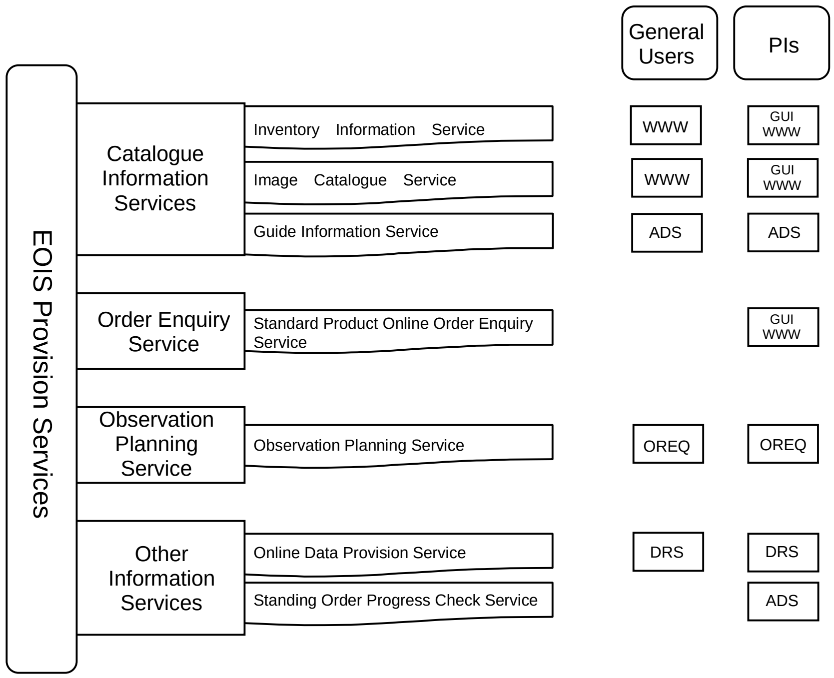
[*1] For an organization with a signed contract, the available data depend on the contract.
[*2] Details are being discussed currently concerning which EUS/OREQ observation plans are to be confirmed.
[*3] The data referred to here are AMSR-E/ AMSR data (being confirmed currently).
[*4] As a rule, production requests from PIs necessary for calibration and validation will not be honored.
[*5] A scene order is an order that uniquely specifies a scene or a product among processed data.
[*6] A standing order is a pre-order of data that are to be obtained and/or prepared in the future.

2.5 Data Comprehensive Management and Provision Services

The Earth observation information system (EOIS) is a user front-end system that provides catalogue information service and on Earth-observation data products, for promoting the use of Earth-observation data. Users can receive various services provided by the EOIS online through the Internet.

2.5.1 Overview of Data Provision Service

An overview of services provided by the EOIS is presented here. The types of services available vary depending on the tools. Section 2.5.4 discusses an overview of various tools and methods for accessing the EOIS.



WWW can be used through EUS/WWW service sites
(* Order services are available only to PIs.)
GUI can be used through EUS/GUI service sites
ADS can be used through Guide Information service sites
OREQ can be used through observation plan service sites
DRS can be used through online data-provision service sites

Figure 2.5.1-1 Overview of EOIS Provision Service

As shown in Figure 2.5.1-1, various services will be provided through various systems and servers such as EUS/WWW, ADS, OREQ, and DRS, but users do not need to be aware of this. Users can simply visit the respective URL addresses and access these services. The EUS/GUI is available only to PIs.

2.5.2 Catalog Information Service

2.5.2.1 Inventory Information

Catalog data on AMSR and GLI standard products processed by the ADEOS-II mission operation system are prepared and made available to users. The inventory information on AMSR and GLI data managed and provided by the EOIS is shown in Table 2.5.2-1.

Catalog information is also called inventory information. It consists of characters indicating the satellite name, name of the sensor used, observation date and time, observation region, dataset name, and other information concerning the standard products of the Earth observation data.

Table 2.5.2-1 Inventory Information of the AMSR and GLI Managed and Provided by EOIS

Level		Geophysical Parameters	Projection Method[*1]			Remarks
			EQR	PS	PN	
AMSR						
1A, 1B			-	-	-	
2		Amount of vapor, cloud liquid water, precipitation, ocean wind velocity, ocean surface temperature, ocean ice, snow accumulation	-	-	-	
3	Days, months	Radiance temperature (all 14 ch.)	Y	Y	Y	Ascending / Descending nodes
		Amount of vapor, cloud liquid water, precipitation, ocean wind velocity, ocean surface temperature	Y	-	-	Ascending / Descending nodes
		Ocean ice	-	Y	Y	Ascending / Descending nodes
		Snow accumulation	Y	-	Y	Ascending / Descending nodes
GLI 1km						
1A		VNIR, SWIR, MTIR observation data, calibration data	-	-	-	
1B		VNIR, SWIR, MTIR observation data, SLPT	-	-	-	
2A		Common in atmosphere and ocean regions	-	-	-	
		Common in land and cryosphere	Y	Y	Y	
2		Aerosol Angstrom exponent, aerosol optical thickness, cloud amount, optical thickness of cloud (p/wr/ir/ie)[*2], cloud equivalent grain size (wr/ie)[*2], cloud top temperature (wr/ie)[*2], cloud top altitude, cloud liquid water	Y	-	-	
		Cloud flag	-	-	-	
		Atmospheric correction, ocean color, ocean surface temperature	-	-	-	4 km resolution
		Vegetation index, global data after atmospheric correction, snow grain size and impurity	Y	Y	Y	
		Precise gasification correction parameter	-	-	-	
3 binned	16th, months	Aerosol Angstrom exponent, aerosol optical thickness, cloud amount, cloud optical thickness (p/wr/ir/ie), cloud equivalent grain size (wr/ie), cloud top temperature (wr/ie), cloud top altitude, cloud liquid water	Y	-	-	
		Snow grain size, snow impurity	Y	Y	Y	
	1st, 8th, months	Radiance leaving the ocean water, aerosol, water color, ocean surface temperature	-	-	-	
3 STA MAP	16th, months	Aerosol Angstrom exponent, aerosol optical thickness, cloud amount, cloud optical thickness (p/wr/ir/ie), cloud equivalent grain size (wr/ie), cloud top temperature (wr/ie), cloud top altitude, cloud liquid water	Y	-	-	
		Snow grain size, snow impurity	Y	Y	Y	
	1st, 8th, months	Radiance leaving the ocean water, aerosol, chlorophyll a, suspended substance, ocean color, K490 dissipation coefficient, ocean surface temperature (day and night), ocean surface temperature	Y	-	-	
	16th	Vegetation index	Y	-	-	
GLI 250m						
L1A		Observation data, calibration data	-	-	-	
L1B		Observation data	-	-	-	

1. EQR…Equi-rectangular, PS…polar stereographic (southern hemisphere), PN…polar stereographic (northern hemisphere)
2. p…analysis for each pixel, wr…water cloud (reflection method), ir…ice cloud (reflection method), ie…ice cloud (emission method)

2.5.2.2 Image Catalog

Image catalog data are first extracted and processed for browsing by the ADEOS-II mission operation system and then made visible by the image catalog data transport subsystem at the EOIS. This service can be used via EUS/WWW or EUS/GUI. The image catalog data of AMSR and GLI standard processed products made available to users are as follows.

Table 2.5.2-2 Overview of ADEOS-II Image Catalog Data

<table>
<tr><th colspan="2" rowspan="2">Level</th><th rowspan="2">Geophysical Parameters</th><th colspan="3">Projection Method</th><th rowspan="2">Remarks</th></tr>
<tr><th>EQR</th><th>PS</th><th>PN</th></tr>
<tr><td colspan="7">AMSR</td></tr>
<tr><td rowspan="4">3</td><td>Days</td><td>Radiance temperature (6.9, 36.5, 89 GHz band, vertical polarization)</td><td>Y</td><td>Y</td><td>Y</td><td>Ascending / Descending nodes</td></tr>
<tr><td rowspan="3">Days, months</td><td>Amount of vapor, cloud liquid water, precipitation, ocean wind velocity, ocean surface temperature</td><td>Y</td><td></td><td></td><td>Ascending / Descending nodes</td></tr>
<tr><td>Ocean ice</td><td></td><td>Y</td><td>Y</td><td>Ascending / Descending nodes</td></tr>
<tr><td>Snow accumulation</td><td>Y</td><td></td><td>Y</td><td>Ascending / Descending nodes</td></tr>
<tr><td colspan="7">GLI 1km</td></tr>
<tr><td colspan="2">1B</td><td>VNIR (ch. 13, 8, 5: RGB), SWIR (ch. 26), MTIR (ch. 35)</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="3">2</td><td>Aerosol Angstrom exponent, aerosol optical thickness, cloud amount, optical thickness of cloud (p/wr/ir/ie), cloud equivalent grain size (wr/ie), cloud top temperature (wr/ie), cloud top altitude, cloud liquid water</td><td>Y</td><td></td><td></td><td></td></tr>
<tr><td>Atmospheric correction, ocean color, ocean surface temperature</td><td></td><td></td><td></td><td>4 km resolution</td></tr>
<tr><td>Vegetation index, global data after atmospheric correction, snow grain size and impurity</td><td>Y</td><td>Y</td><td>Y</td><td></td></tr>
<tr><td rowspan="4">3 STA MAP</td><td rowspan="2">16th months</td><td>Aerosol Angstrom exponent, aerosol optical thickness, cloud amount, cloud optical thickness (p/wr/ir/ie), cloud equivalent grain size (wr/ie), cloud top temperature (wr/ie), cloud top altitude, cloud liquid water</td><td>Y</td><td></td><td></td><td></td></tr>
<tr><td>Snow grain size, snow impurity</td><td>Y</td><td>Y</td><td>Y</td><td></td></tr>
<tr><td>1st, 8th months</td><td>Radiance leaving the ocean water, aerosol, chlorophyll a, suspended substance, ocean color, K490 diffusion coefficient, ocean surface temperature (day and night), ocean surface temperature</td><td>Y</td><td></td><td></td><td></td></tr>
<tr><td>16th</td><td>Vegetation index</td><td>Y</td><td></td><td></td><td></td></tr>
<tr><td colspan="7">GLI 250m</td></tr>
<tr><td colspan="2">L1B</td><td>Observation data (ch. 22, 21, 20: RGB)</td><td></td><td></td><td></td><td></td></tr>
</table>

1. EQR…Equi-rectangular, PS…polar stereographic (southern hemisphere), PN…polar stereographic (northern hemisphere)
2. p…analysis for each pixel, wr…water cloud (reflection method), ir…ice cloud (reflection method), ie…ice cloud (emission method)

2.5.2.3 Guide Information

General users can access the AMSR and GLI guide information (visible images) shown in Table 2.5.2-3 on the Internet via a WWW browser.

Guide information is a part of the image catalog of Earth-observation satellite data belonging to EOC and processed so that the information can be viewed on the Internet. It is available on EOC's homepage.

Table 2.5.2-3 Guide Information

Level		Geophysical Parameters	Projection Method EQR	PS	PN	Remarks
AMSR						
3	Days	Radiance temperature (6.9, 36.5, 89 GHz band, vertical polarization)	Y	Y	Y	Ascending / descending nodes
	Days, months	Amount of vapor, cloud liquid water, precipitation, ocean wind velocity, ocean surface temperature	Y			Ascending / descending nodes
		Ocean ice		Y	Y	Ascending / descending nodes
		Snow accumulation	Y		Y	Ascending / descending nodes
GLI 1km						
3 STA MAP	16th months	Aerosol Angstrom exponent, aerosol optical thickness, cloud optical thickness (p/wr/ir/ie), cloud equivalent grain size (wr/ie), cloud top temperature (wr/ie), cloud liquid water	Y			
		Snow grain size, snow impurity	Y	Y	Y	
	8th months	Chlorophyll a, suspended substance, ocean color, ocean surface temperature (day and night)	Y			
	16th	Vegetation index	Y			

1. EQR…Equi-rectangular, PS…polar stereographic (southern hemisphere), PN…polar stereographic (northern hemisphere)
2. p…analysis for each pixel, wr…water cloud (reflection method), ir…ice cloud (reflection method), ie…ice cloud (emission method)

2.5.3 Data Provision

2.5.3.1 Ordering Data

(1) Scene Orders
(2) Standing Orders
(3) Order-Specific Items

2.5.3.2 Data provision flow

T.B.D.

2.5.3.3 Provision Media

Table 2.5.3-1 shows the media for providing ADEOS-II images

Order Type	Medium	Remarks
Scene orders	8 mm, CD-ROM	For all users (provided on DLT to EORC)
Standing orders	8 mm, DLT	Only to specified users such as PIs and EORC

2.5.3.4 Online Data Provision

Table 2.5.3-2 shows the services provided on the Internet whereby registered users can obtain AMSR and GLI low-capacity data (downloadable through FTP).

The data provided here cover the most recent one-month period; data older than a month are automatically deleted.

Specified users who can order data using either EUS/GUI or EUS/WWW may obtain requested data online through this data-provision service.

Table 2.5.3-2 Low-Capacity Data Provided via the Internet

Level		Geophysical Parameters	Projection Method[1]			Remarks
			EQR	PS	PN	
AMSR						
3	Days, months	Radiance temperature (all 14 ch.)	Y	Y	Y	Ascending / descending nodes
		Amount of vapor, cloud liquid water, precipitation, ocean wind velocity, ocean surface temperature	Y			Ascending / descending nodes
		Ocean ice		Y	Y	Ascending / descending nodes
		Snow accumulation	Y		Y	Ascending / descending nodes
GLI 1km						
3 STA MAP	16th months	Aerosol Angstrom exponent, aerosol optical thickness, cloud amount, cloud optical thickness (p/wr/ir/ie), cloud equivalent grain size (wr/ie), cloud top temperature (wr/ie), cloud top altitude, cloud liquid water	Y			
		Snow grain size, snow impurity	Y	Y	Y	
	1st, 8th months	Chlorophyll a, suspended substance, ocean color, ocean surface temperature	Y			
	16th	Vegetation index	Y			

1. EQR…Equi-rectangular, PS…polar stereographic (southern hemisphere), PN…polar stereographic (northern hemisphere)
2. p…analysis for each pixel, wr…water cloud (reflection method), ir…ice cloud (reflection method), ie…ice cloud (emission method)

2.5.4 Uses of On-Line Services

The services provided by the EOIS, described in Section 2.5.1, can be used through the following tools.

2.5.4.1 WWW Browser

Below is an overview of the services that can be used via the Internet using a WWW browser.

(1) EUS/WWW-Based Services

By accessing the following address on the Internet using a WWW browser, a user can use services such as catalog search and image catalog search. Data-ordering service on EUS/WWW is provided only to PIs.

[URL for EUS/WWW: http://eus.eoc.nasda.go.jp/]

Figure 2.5.4-1 EUS/WWW Screen Display

(2) Guide Information Service

All users can look at the guide information (visible images) by accessing the following address on the Internet using a WWW browser.

[URL for Guide Information Service:
http://www.eoc.nasda.go.jp/www/index_j.html]

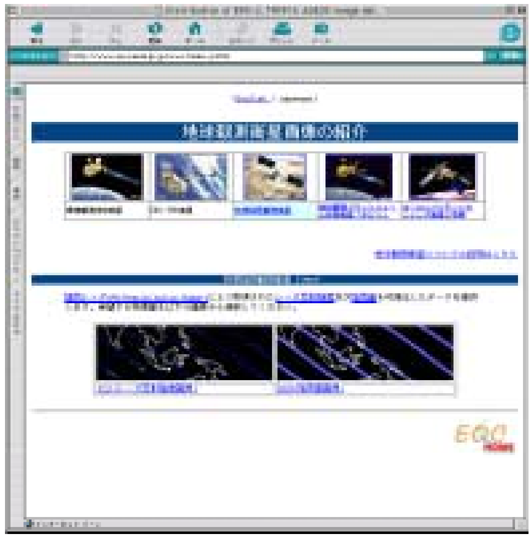


Figure 2.5.4-2 Screen Display of the Guide Information Service Page

(3) Online Data Provision Service

Registered users can obtain low-capacity data (downloadable through FTP) by accessing the following address on the Internet using a WWW browser.

Even unregistered users can register as users at this Web page.

[URL for Online Data Provision Service: http://drs.eoc.nasda.go.jp/]

Figure 2.5.4-3 Screen Display of the Online Data Provision Service Page

PIs who have placed orders using EUS/GUI can also obtain the data ordered through this Web page.

(4) Observation Plan Service

All users can view the observation plan at the site "WWW Service at the Observation Request Enquiry System (OREQ)" (observation plan) on the Internet using a WWW browser. More precisely, after a user logs in at the EUS/WWW site mentioned above (whose URL is stated under (1) above), the browser takes the user to the observation plan site.

Figure 2.5.4-4 Screen Display of the Observation Plan Service Page

(5) Standing-Order Status Checking Service

All users can check the production status of a particular product from their standing orders by accessing the following address on the Internet using a WWW browser.

[URL for the Standing-Order Status Checking Service:
http://www.eoc.nasda.go.jp/www/guide/status_j.html]

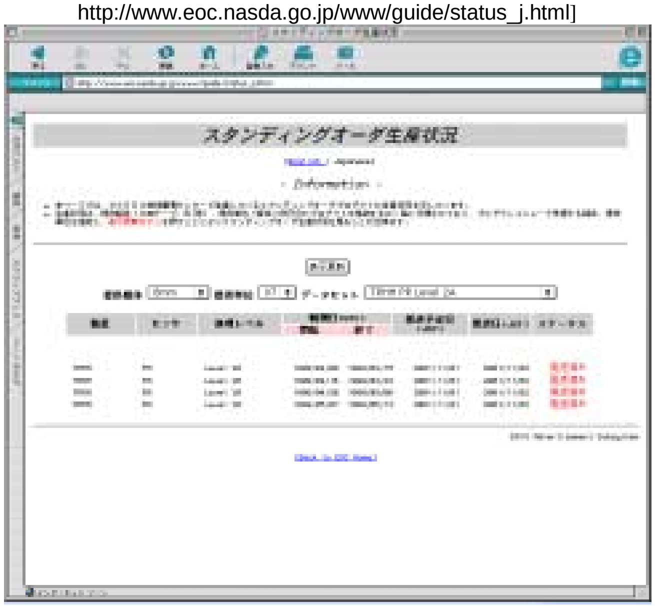


Figure 2.5.4-5 Screen Display of the Standing-Order Status Checking Service

2.5.4.2 EUS/GUI

EUS/GUI is a comprehensive online information service program that enables various services provided by the EOC server to be used in a GUI control environment. Enquiries concerning how to obtain EUS/GUI should be addressed to the RESTEC order desk.

The user selects a desired service on EUS/GUI, enters parameters such as search conditions, and sends the search request; the search results will be returned from each server and displayed (see Figure 2.5.4-6).

Users with special permission such as PIs can also send order requests.

Currently, the functioning EUS/GUI software is EUS/PC Ver. 3.x (Windows 95, Windows 98, Windows NT4.0 compatible). EUS/PC Ver. 2.x must first be upgraded.

EUS/GUI provides following functions.

(1) Catalog Information Search

The catalog information can be searched for standard products. Search key items include the date (period) of observation, latitude and longitude, name of the dataset, name of the satellite, name of the sensors used, and other options. Search keys are provided for these options.

(2) Image Catalog Data Search

The image catalog data can be searched for standard products, and the images can be displayed. The following can be displayed.

- Enlargement, reduction, and moving displays
- Enhanced display
- Pseudo-color display
- Band-switching display
- Longitude and latitude overlay
- Multiple-data display
- Level-slicing display
- Image-position information display
- Layer display (superimposed display)

By customizing options, to be discussed later, it is also possible to use user-defined viewers and to print the image catalog.

(3) Map Displays

The system can display maps of the world and maps of Japan and show search results on the coverage of various scenes. Projection methods for these maps include cylindrical projection and the polar stereographic projection. The following information can be shown on the maps.

- Inventory Search Results
- Observation Requested Locations
- Specified Regions on Maps

(4) Order Requests (available only to users with permissions to request orders)

Authorized users can place orders for standard products based on the catalog information search results. These orders can be submitted to the server online and printed out as order request forms.

(5) Request Status Search

Users can search for status information that shows the reception status and/or work progress for the orders they have placed.

(6) Customizing

Users can customize EUS/GUI settings such as the selection of gateway used for access, image viewer, and color printer used.

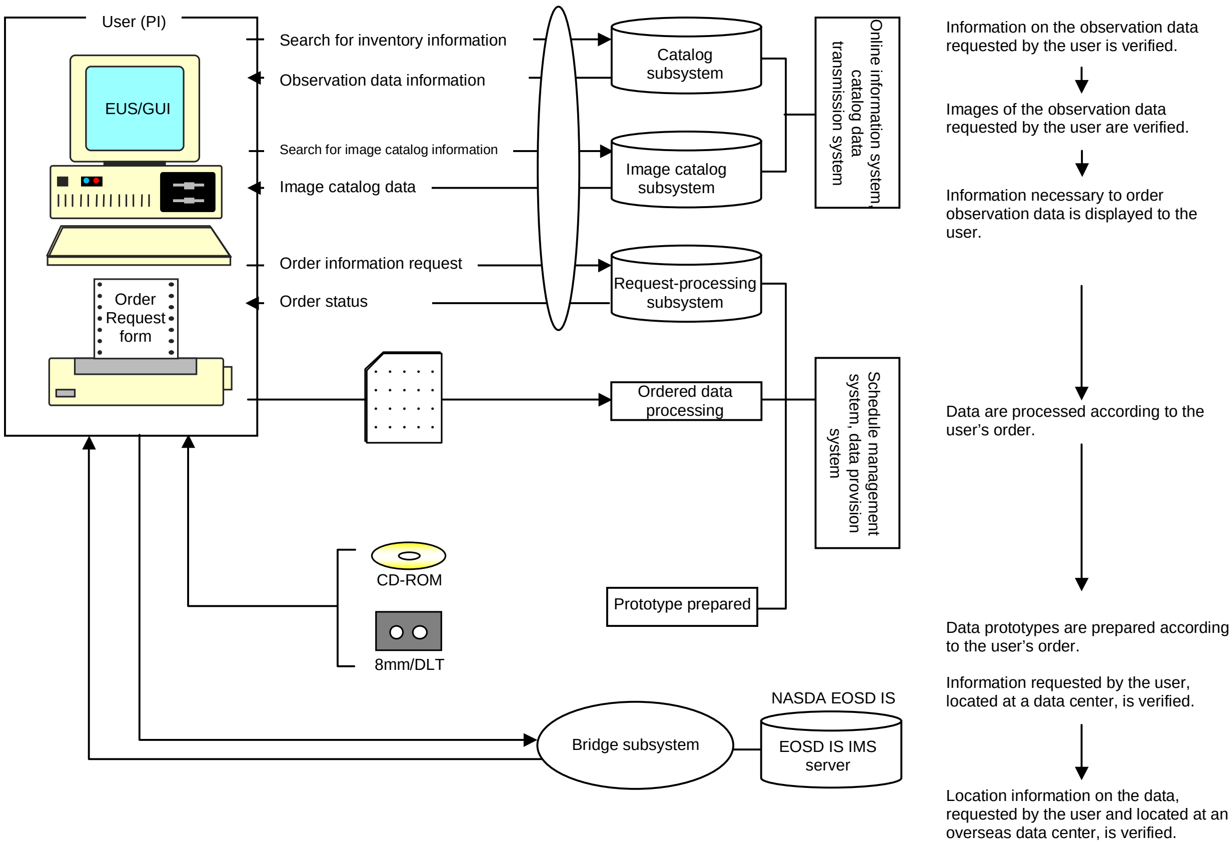


Figure 2.5.4-6 Overview of EUS/GUI

2.5.4.3 Service Limitations

The following restrictions apply when various online services provided by the EOC are used,

- EUS/GUI performance restrictions
- Service restrictions due to the server

(1) EUS/GUI performance restrictions

EUS/GUI performs a "masking" task, i.e., it displays only those services available to the particular user by identifying the user through a verification process when the program is started up. Hence, only those services available to the user can be accessed.

(2) Service restrictions due to the server

Services provided by EOC may have disclosure restrictions for certain types of information.

Such service restrictions differ depending on the service type, so the restrictions are placed on the server system providing each service.

In order to restrict service disclosure for individual users, the request message transmitted from EUS/GUI to the server contains the username.

The services that vary depending on the user are as follows.

- Inventory Information Service
- Standard Product Order Enquiry Service
- Image Catalog Service

2.6 Data Analysis Research System (EORC)

2.6.1 Overview of the System

Figure 2.6.1-1 presents an overview of the Data Analysis Research System at EORC.

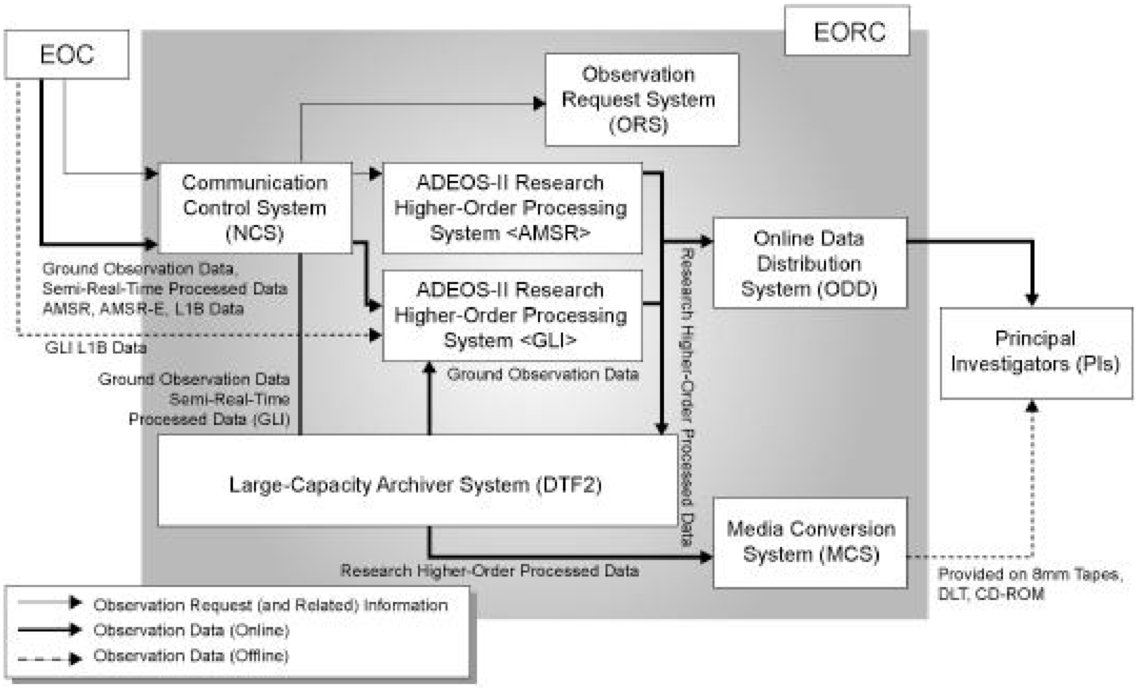


Figure 2.6.1-1 Structure of the Data Analysis Research System

Details of each of these systems are presented beginning in Section 2.6.1.1.

2.6.1.1 System Details

(1) ADEOS-II Research Higher-Order Processing System (AMSR/AMSR-E)

The ADEOS-II Research Higher-Order Processing System (AMSR/AMSR-E) processes AMSR data and AMSR-E data obtained by ADEOS-II and AQUA.

(2) ADEOS-II Research Higher-Order Processing System (GLI)

The ADEOS-II Research Higher-Order Processing System (GLI) processes GLI data obtained by ADEOS-II.

(3) Observation Request System (ORS)

The Observation Request System (ORS) requests ADEOS-II/GLI 250m mode observation to the EOC. The main functions of the ORS are as follows.

- In preparing a GLI 250m observation planning document, ORS prepares a file requesting observation for simulation in order to perform the simulation at the EOC/MMO.
- ORS prepares a file requesting GLI 250m observation based on the GLI 250m observation planning document.

(4) Online Data Distribution System (ODD)

The ODD provides data processed by the ADEOS-II research higher-order processing system through the ADEOS-II/EOS-PM1 disclosure system online (FTP).

(5) Media Conversion System (MCS)

The MCS converts the medium of data processed by the ADEOS-II research higher-order processing system as requested by users such as PIs and provides the data offline.

(6) On-Demand Data Server System (ODS)

The ODS transfers existing processed data that have been produced and stored offline at EOC offline to EORC based on requests from the EORC.

Appendix

1. Abbreviation

A

ACE-ASIA : Aerosol Characterization Experiments-ASIA
A/D : Analog to Digital
ADEOS : Advanced Earth Observing Satellite
ADEOS-II : Advanced Earth Observing Satellite-II
ADS : Advertisement Subsystem
AGC : Auto Gain Control
AGSID : ADEOS-II to Ground Stations Interface Document
ALT : Altimeter
AMI : Active Microwave Instrument
AMR : Airborne Microwave Radiometer
AMSR : Advanced Microwave Scanning Radiometer
AMSR-E : Advanced Microwave Scanning Radiometer-EOS
ANSI : American National Standard Institute
AOD : ADEOS-II Operational Document
AOS : Acquisition Of Signal
APAR : Absorbed Photosythetically Active Radiation
API : Application Programming Interface
APID : Application Process Identification
AQUA : N/A
ARCH : Archive Subsystem
ARM : Atmospheric Radiation Measurement program
ASCII : American Standard for Computer and Information Interchange
ASF : Alaska SAR Facility (University of Alaska)
AVHRR : Advanced Very High Resolution Radiometer

B

BDS : Browse data Distribution Subsystem
BRDF : Bidirectional Reflection Distribution Function
BPSK : Biphase shift keying

C

C&DH : Command and Data Handling (Subsystem)
CADS : Catalogue data Distribution System
CATS : Catalogue Subsystem
CCD : Charge Coupled Device
CCITT : International Telegraph and Telephone Consultative Committee
CCSDS : Consultative Committee for Space Data Systems
CCT : Computer Compatible Tape
CD : Compact Disc
CDR : Critical Design Review
CEOP : Coordinated Enhanced Observing Period
CEOS : Committee on Earth Observation Satellites
CEOS-IDN : Committee on Earth Observations Satellites-International Directory Network
CFC : Chloro Fluorocarbon
CIS : Catalogue Interoperability Subsystem
CLIVAR : Climate Variability Research Program
CLS : Collect Localization Satellites
CMDL : Climate Monitoring and Diagnostics Laboratory
CNES : Centre National d'Etudes Spatiales
COM-S : COntamination Monitor Sensor
COMETS : Communications and Broadcast Engineering Test Satellite
CRC : Cyclic Redundancy Code
CREST : Core Research for Evolutional Science and Technology
CRL : Communications Research Laboratory
CTLG : Catalogue data file

D

DCS : Data Collection System
DDMS : Data Distribution and Management System
DDS : Data Distribution Subsystem
DES : Data Editing Subsystem
DGS : Data Generation System
DMMC : Downlink Messages Management Center
DMSP : Defense Meteorological Satellite Program
DOM : Dose Monitor
DRS : Data Retrieval Subsystem
DRTS : Data Relay and Tracking Satellite
DSS : Data Storage System
DT : Direct Transmission
DTL : Direct Transmission subsystem for Local Users

E

EA : Environment Agency of Japan
ECI : Earth Center Inertial coordinates
ECMWF : European Center for Medium-Range Weather Forecast
ED : Definitive orbital Element
ENVISAT : Environmental Satellite
EOC : Earth Observation Center
EOIS : Earth Observation Data and Information System
EOL : End Of Life
EOM : End Of Mission
EORC : Earth Observation Research Center
EOS : Earth Observing System
EOS-PM1 : Earth Observing System-PM1 (Aqua)

EOSD : Earth Observations System Engineering Department (NASDA)
EOSDIS : EOS Data and Information System
EP : Predictive orbital Element
EPIC : Equatorial Pacific Information Collection
ERS-1/AMI : European Remote Sensing Satellite-1
ERS-2/ALT : European Remote Sensing Satellite-2
ESA : Earth Sensor Assembly
ESA : European Space Agency
ESDIS : Earth Science Data and Information System
ETS-V : Engineering Test Satellite-V
EUS : EOIS User interface Software

F

FAO : Food and Agriculture Organization of the United Nations
FAX : Facsimile Message
FCMWF : Fuci no MOS Receiving Station
FD : Floppy Disk
FDDI : Fiber-optic Data Distribution Interface
FGGE : First GARP Global Experiment (GARP: Global Atmospheric Research Program)
FGS : Foreign Ground Station
FIFE : First ISLSCP Field Experiment (ISLSC:Internationa Satellite Land Surface Climatology Project)
FOV : Field of View
FRR : Flight Readiness Review
FTAM : File Transfer Access and Management
FTIR : Fourier Transform Infrared Radiometer
FTP : File Transfer Protocol

G

GAIT : GLI Algorithm Integration Team
GCI : Geocentric Celestial Inertial
GCM : General Circulation Model
GCOM : Global Change Observation Mission
GCP : Ground Control Point
GDR : Ground segment Design Report Meeting
GEO : Geostationary
GEWEX : Global Energy and Water Cycling Research Experiment
GLI : Global Imager
GN : Ground Network
GOES : Geostationary Operational Environment Satellite
GOOS : Global Ocean Observing System
GOSAT : Geodetic Satellite
GPCP : Global Precipitation Climatology Project
GPM : Global Precipitation Mission
GPS : Global Positioning Satellite System
GRS : Global Reference System
GSFC : Goddard Space Flight Center
GSWP : Global Soil Wetness Project
GTS : Global Telecommunications System
GUI : Graphical User Interface

H

HDDT : High Density Digital Tape
HDF : Hierarchical Data Format
HIT : Heavy Ion Telescope
HK : Housekeeping
HK TLM : Housekeeping Telemetry
HKMU : House Keeping Memory Unit

I

IEOS : International Earth Observing System
IF : Intermediate Frequency
IFOV : Instantaneous FOV
IGAC : International Global Atmospheric Chemistry
IGBP : International Geosphere and Biosphere Research Program
IGOS-P : Integrated Global Observation Strategy Partnership
IIP : Instrument Implementation Plan
ILAS : Improved Limb Atmospheric Spectrometer
ILAS-II : Improved Limb Atmospheric Spectrometer-II
IOCS : Inter-Orbit Communication Subsystem
IP : Implementation Plan
IP : Internet Protocol
IPCC : Intergovernmental Panel on Climate Change
IPCN : Implementation Plan Change Notice
IPCP : Implementation Plan Change Proposal
IR : Infrared
IRD : Interface Requirements Document

J

JAFIC : Japan Fisheries Information Center
JAMSTEC : Japan Marine Science and Technology Center
Jason-1 : N/A
JFIF : JPEG File Interchange Format
JGOFS : Joint Global Ocean Flux Study
JMA : Japan Meteorological Agency
JPEG : Joint Photographic Coding Experts Group
JPL : Jet Propulsion Laboratory (California Institute of Technology)
JPRD : Joint Program Requirement Document
JST : Japan Science and Technology Corporation

L		
LAN	:	Local Area Network
LANDSAT /TM	:	Land Satellite
LLM	:	Low Light Mode
LNA	:	Low Noise Amplifier
LOICZ	:	Land-Ocean Interactions in the Coastal Zone
LOS	:	Loss of Signal
LOWTRAN	:	Low Resolution Transmission

M		
MCS	:	Media Conversion Subsystem
MDR	:	Mission Data Recorder
MERIS	:	Medium Resolution Imaging Spectrometer Instrument
MMO	:	Mission operation Management Organization
MMOFE	:	Mission operation Management Organization Front-End (Directory)
MOA	:	Memorandum of Agreement
MOBY	:	Marine Optical Buoy
MOIP	:	Mission Operations Implementation Plan
MOIS	:	Mission Operations Interface Specification
MOM	:	Mission Operations Meeting
MOU	:	Memorandum of Understanding
MRT	:	Mission Real Time
MTIR	:	Middle wavelength Thermal Infrared Radiometer

N		
N/A	:	Not Applicable
NASA	:	National Aeronautics and Space Administration
NASDA	:	National Space Development Agency of Japan
NDVI	:	Normalized Difference Vegetation Index Maps
NE Δ T	:	Noise Equivalent Differential Temperature
NESDIS	:	National Environmental Satellite Data and Information Service
NGN	:	NASA/NOAA Ground Network
NIES	:	National Institute for Environmental Studies
NOAA	:	National Oceanic and Atmospheric Administration
NRT	:	Near Real Time Data (Directory)
NSCAT	:	NASA Scatterometer
NTSK	:	NASDA Transportable Station-Kiruna
NWP	:	Numerical Weather Prediction

O		
OCTS	:	Ocean Color and Temperature Scanner
OCL	:	Operations Coordination Letter
ODD	:	Online Data Distribution Service
ODR	:	Optical Data Recorder
ODS	:	On-demand Data Server System
Opr.	:	Operational
OPLN	:	Operation Plan (between EOC and an agency)
OPL1	:	Operation Plan (between EOC and CNES / POLDER)
OREQ	:	Observation Requests handling System
ORR	:	Operational Readiness Review
ORS	:	Observation Requests Subsystem
ORST	:	Operation Result Status
OS	:	Operating System
OSDPD	:	NOAA/NESDIS Office of Satellite Data Processing and Distribution

P		
PC	:	Personal Computer
PCD	:	Payload Correction Data
PCM	:	Pulse Coded Modulation
PDR	:	Preliminary Design Review
PFM	:	Proto-Flight Model
PI	:	Principal Investigator
PO.DAAC	:	Physical Oceanography Distributed Active Archive Center
POLDER	:	Polarization and Directionality of the Earth's Reflectances
POM	:	Potential Monitor
PR	:	Precipitation Radar
PROC	:	Processing Subsystem
PSC	:	Polar Stratospheric Clouds

Q		
Q/L	:	Quick Look
QQC	:	Quality, Quantity and Continuity
QuickScat	:	Quick Scatterometer Satellite

R		
RADARSAT	:	N/A
RAM	:	Random Access Memory
RASS	:	Radio Acoustic Sounding System
RCV	:	Receiving Subsystem
RCD	:	Recording Subsystem
RDRD	:	Readability report of Raw Data
RDZD	:	Readability report of level Zero Data
REAC	:	Result of Acquisition
REQ	:	Request for Operation (between TACC and EOC)
REQA	:	Reply on 4 week Request (particular)
REQQ	:	Request for 4 week period
REQR	:	Request for Raw data record
RESTEC	:	Remote Sensing Technology Center of Japan
RF	:	Radio Frequency
RGS	:	Receiving Ground Station
ROM	:	Read Only Memory
RORR	:	Routine Operation Readiness Report meeting
RS	:	Reed Solomon
RSP	:	Reference System for Planning

RSTAR	:	R- System for Transfer Atmospheric Radiation
RTIG	:	Real Time processing Information for GLI data

S

SAR	:	Synthetic Aperture Radar
S/C	:	Spacecraft
SCID	:	Spacecraft Identifier
SeaPAC	:	SeaWinds Processing and Analysis Center
SeaWiFS	:	Sea-viewing Wide Field-of-view Sensor
SeaWinds	:	NASA-JPL Scatterometer On ADEOS-II
SIMBIOS	:	Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies
SITE	:	System Integration and Test Building
SMMR	:	Scanning Multichannel Microwave Radiometer
SMS	:	Schedule Management System
SMSS	:	Schedule Management Subsystem
SN	:	Space Network
S/N	:	Signal to Noise
SOOH	:	Spacecraft Orbital Operations Handbook
SOP	:	Spacecraft Operation Procedure
SRRD	:	Shipment Report of Raw Data
SRZD	:	Shipment Report of level Zero Data
SSM/I	:	Special Sensor Microwave/Imager DMSP
STA	:	Science and Technology Agency
STAD	:	Status information on ADEOS
STGS	:	Status of Ground Station
SUM	:	Single Event Upset Monitor
SWIR	:	Short Wavelength Infrared Radiometer

T

TACC	:	Tracking and Control Center
TACS	:	Tracking And Control Station (NASDA)
TAO array	:	Tropical Atmosphere Ocean array
TBD	:	To Be Determined
TCP	:	Transmission Control Protocol
TCP/IP	:	Transmission Control Protocol/Internet Protocol
TD	:	Time Difference file
TDU	:	TEDA Unit
TEDA	:	Technical Data Acquisition Equipment
Terra	:	Earth Observing System AM1(EOS-AM1)
TKSC	:	Tsukuba Space Center (NASDA)
TL	:	Time of Launch
TLM	:	Telemetry
TMI	:	TRMM Microwave Imager
TOMS	:	Total zone Mapping Spectrometer
TOPEX /POSEIDON	:	The Ocean Topography Experiment
TRMM	:	Tropical Rainfall Measuring Mission
TRR	:	Technical Readiness Review
TTY	:	Teletype
TX	:	Transmitter

U

UHF	:	Ultra High Frequency
URL	:	Universal Resource Locator
URS	:	User Request Management Subsystem
USB	:	Unified S-Band
UTC	:	Universal Time Coordinate
UTCF	:	Universal Time Correlation Factor

V

VCID	:	Virtual Channel Identification
VNIR	:	Visible and Near Infrared Radiometer

W

WCRP	:	World Climate Research Program
WFF	:	Wallops Flight Facility
WGS	:	World Geometric System
WRS	:	World Reference System
WS	:	Workstation
WWW	:	World Wide Web

X

Y

Z