The ADEOS-II Science Plan

Vol.1 Science Research Project Document

Ver. 2

November 15, 1999

National Space Development Agency of Japan

Earth Observation Research Center

Preface

---About the revised edition of The ADEOS-II Science Plan

This technical material is the revised edition of “The ADEOS-II Science Plan Vol. 1 Science Research Project Document Ver. 1”.

We will properly draft a revised edition of “The ADEOS-II Science Plan Vol. 2 /Implement plan ”, however, we would like ask you to refer to the AMSR/ GLI Calibration and Validation Plan to obtain the implementation.

This document is written and proofread by each of the program scientists introduced below. We greatly appreciate their cooperation for creating this document.

Note This material was written and completed just before the decision to postpone the ADEOS-II launch one year. For this reason, The ADEOS-II launch is scheduled as November 2000 in this document. The revised edition of this material will be reflect the appropriate launch time.

ADEOS-II Science Plan Ver. 2

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Content

1. INTRODUCTION

The Advanced Earth Observing Satellite-II (ADEOS-II) is a follow-on satellite and continues the ADEOS mission; it is scheduled to be launched on November 11, 2000. The ADEOS was launched in August 1996 and ceased operation in June 1997. The ADEOS-II satellite is also related to GCOM. The mission of ADEOS-II is to build on the ADEOS heritage and to perform Earth-observation missions that Japan could not develop using ADEOS. ADEOS-II will also build a foundation for research use for the Earth's environmental problems, applying Japan's satellite observations.

The ADEOS-II is the next satellite project that National Space Development Agency of Japan (NASDA) is supposed to summarize "success and failure" of the ADEOS and earnestly tackle problems. We consequently must show the concrete aspects of the Japan's Earth-observation satellite program through the ADEOS-II program.

At the same time, we must pay attention to the fact that ADEOS-II will be launched in the same period as the EOS-AM/PM (NASA, USA), the NVISAT (ESA, Europe), and other large-scale Earth-observation systems. It is necessary to carry out the research internationally and to work together with the satellite data acquired by other countries.

It doesn't make any sense to continue Earth observation work until scientific and practical successes are achieved. Scientific and practical successes, however, will never occur naturally. Although the National Space Development Agency (NASDA) established the Earth Observation Research Center (EORC) and has positively promoted satellite data applications, it is still necessary to develop a more broadly cooperative system involving the researchers of universities and national or public research centers. NASDA now faces important fluctuations in an era in which the Ministry of Education (Science and Culture) and the Science and Technology Agency are combined, and that National Research Centers and National Universities are being incorporated in to the agencies. Considering these circumstance, the ADEOS-II science plan is defined as a composition of the international financial plan, the research promotions involved in preparing the research system, and the planning and coordination involving the ministries, national agencies, universities, and organizations of foreign countries. For NASDA it is a plan to archive the scientific successes accompanying the Earth-observation projects.

2. SCIENTIFIC OBJECTIVES AND EXPECTED OUTCOMES OF ADEOS-II

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.

In particularly, the investigation into “(1) water-energy cycle” is a distinguishing characteristic of the ADEOS-II mission. It is thought that GLI estimates clouds, water vapor, and aerosols; AMSR estimates hydrology parameters like water vapor, precipitation, soil moisture, and snow runoff; Sea Winds estimates ocean stress; POLDER estimates aerosols; and ILAS-II estimates ozone and the vertical distribution of very small amounts of gaseous components in the polar regions will be useful in understanding fixed quantity of water-energy cycle on global scale. Continuous observations of ocean stress by the SeaWinds following 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 the long-term preparation and international coordination. In this sense, we are planning to take over the ground validation sites developed for ADEOS and GEWEX/GAME, expand them, and prepare and implement a comprehensive validation program. Fortunately it was been proposed at an international program called the Coordinated Enhanced Observing Period (CEOP) held in 2001 and 2002 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 the multiple channels for receiving data and a high resolution of 250 meters. GLI takes over from the successful OCTS and will work effectively to estimate ocean biomass, ocean primary productivity, land biomass, land primary productivity, and fluctuations in them. ILAS-II, a follow-on satellite of ILAS, is capable of observing ozone in the polar regions and the vertical distribution of very small amount of gaseous components and 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 the global warming predictions.

3. OBSERVATION PURPOSES AND PRODUCTS OF SENSORS ON BOARD ADEOS-II

3.1 GLI

3.1.1 Scientific objectives

One of NASDA's two sensors aboard ADEOS-II, the Global Imager (GLI), is Japan's the 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 meters resolution that are based on LANDSAT/TM; these will perform global surface observations with middle resolutions.

(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; these were hardly ever before. 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 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 s 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 under to 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 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 Seasonally 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 the simulations of the global warming caused by clouds, water vapor, and aerosols and other indefinite factors. It especially seems to investigate the quantity of lower layer and upper layer clouds, very small physical characteristics of clouds, water vapor distribution, and strength of interaction between clouds and tropospheric aerosol.

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

Monitoring the lower layer of the atmosphere and the surface of the Earth are important GLI tasks to facilitate understanding of Earth surface process. It is especially important to monitor the Polar Regions since these areas are very sensitive to greenhouse effects. The 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 adapted to detailed monitoring of the surface of the Earth will be generated.

3.1.2 Standard products, research products and algorithm development

3.1.2.1 Standard products and research products

Products provided by the all-purpose sensor GLI encompass various fields of atmosphere, ocean, land and snow runoff ice. Standard products with interesting research aspects will be grouped as research products. Here is a summary of the algorithms needed to provide these products.

(1) Atmosphere

a. Products

Standard Products

	Regional Coverage (1km)		Global Coverage (0.25equal-lon/lat)		
Geophysical Parameter	Scene	Scene (Map Projection)	4 days	16 days	Monthly
Aerosol Angstrom Exponent	---	---	■	■	■
Aerosol Optical Thickness	---	---	■	■	■
Cloud Flag	■	---	---	---	---
Cloud Type	□	□	---	---	---
Cloud Fraction	---	---	■	■	■
Cloud Optical Thickness	□	□	---	---	---
Cloud Top Temperature	□	□	---	---	---
Cloud Effective Particles Radius (W_refl)	---	---	■	■	■
Cloud Effective Particles Radius (I_emit)	---	---	■	■	■
Cloud Optical Thickness (w_refl)	---	---	■	■	■
Cloud Optical Thickness (I_refl)	---	---	■	■	■
Cloud Optical Thickness (I_emit)	---	---	■	■	■
Cloud Top Temperature (w_refl)	---	---	■	■	■
Cloud Top Temperature (I_emit)	---	---	■	■	■
Cloud Top Height (w_refl)	---	---	■	■	■
Cloud Liquid/Water Path (w_refl)	---	---	■	■	■

Note: □ Produced on order. ■ Planned production

w_refl water cloud reflectance I_refl ice cloud reflectance

I_emit denotes ice cloud emission

Research Products

Cloud fraction (pixel), Cloud top temperature, Cloud effective particle radius, Cloud top height, Cloud geometric thickness, Clear sky short wave radiometer, Column water vapor amount (pixel), Aerosol effective particle radius, Aerosol type, Precipitation, Surface solar short wave quantity, atmospheric upper short wave radiation, PAR

b. Algorithm Development

- Clear sky irradiance extraction algorithm
- Cloud irradiance extraction algorithm
- Algorithm for estimating cloud parameters
- Algorithm for classifying water cloud and ice cloud
- Algorithm for estimating aerosol parameters
- Algorithm for estimating irradiation balance

c. Basic Research for the Algorithm Development and Research for Validation

- Revising optical parameters of water vapor, water, and others
- Ground-based observations to obtain cloud parameters and aerosol parameters
- Observations to maintain the precise brightness temperature measured by the satellite
- Research on non-spherical scattering theory

(2) Ocean

a. Products

Standard Products

	Regional Coverage (1km)		Regional Coverage (4km)	Global Coverage (9km Binned)			Global Coverage (9km Binned)		
Geophysical parameters	Scene	Scene (Map Projection)	Path	Daily	8 days	Monthly	Daily	8 days	Monthly
Normalized Water-Leaving Radiance	□	□	■	■	■	■	□	□	□
Aerosol Chlorophyll a	□	□	■	■	■	■	□	□	□
Chlorophyll-a	□	□	■	■	■	■	■	■	■
Weight of Suspended Minerals	□	□	■	■	■	■	■	■	■
Dissolved Organic Material	□	□	■	■	■	■	■	■	■
Extinction Coefficient at 490nm	□	□	■	■	■	■	□	□	□
Sea Surface Temperature	□	□	■	■	■	■	■	■	■

Note: □ Production by order ■ Planned product

Research Products

Carotenoid, Phycobilin, Primary Productivity (chlorophyll a method /fluorescent method), amount of Chlorophyll a (fluorescent method)/concentration of Coccolith, concentration of Trichodesmium, PAR, Sea surface temperature (Skin), and pCO_2

b. Algorithm Development

- Atmospheric correction algorithm for ocean color
- Algorithm for estimating chlorophyll a concentration
- Algorithm for estimating weight of suspended minerals or dissolved organic material
- Algorithm for estimating phycobilin, carotenoid and other coloring matter concentration except chlorophyll a
- Algorithm for estimating coccolith concentration or trichodesmium concentration
- Algorithm for estimating primary productivity (chlorophyll a method /fluorescent method)
- Algorithm for estimating sea surface temperature
- Flux algorithm for estimating pCO_2 and CO_2 between atmosphere and ocean

c. Basic Research for algorithm development and research for validation

- Observations using vessels to obtain ocean irradiance
- Observations using mooring buoys to obtain ocean irradiance
- Obtaining parameters such as absorption or primary productivity related to phytoplankton
- Measuring atmospheric parameter for atmospheric correction
- Observations using drifting buoys and mooring buoys to measure sea surface temperature

(3) Land

a. Products

Standard Products

Geophysical Parameter	Path	Zone (Map Projection) Once/16 days	Area (Map Projection) Once/16 days
Vegetation Index	---	■	---
Precise Geometric Corrected Parameter	■	---	---
Atmospheric Corrected Global Data	---	---	■

Note: □ Production by order ■ Planned production

Zone: Polar Regions at 60 degrees North/South latitude and higher will be mapped by the polar stereographic projection. Middle latitude regions 60 degrees North/South latitude and lower (divided into three parts every 40 degrees latitude) will be mapped by equidistant cylindrical projection at every 0.5-minuti intervals.

Area: Polar Regions at 60 degrees North/South latitude and higher will be mapped for four divided parts of Polar

Stereographic projection. Middle regions will be mapped by 48 divided parts of equidistant cylindrical projection every 39 degrees

Research Products

Land cover type/Biomass carbon amount/Vegetation change index/Biomass burning index/APAR/Net primary production/Precise Biomass/Land surface temperature/Albedo

b. Algorithm Development

- Algorithm for creating products of 250m mesh and 1km mesh (Including cloud elimination, viewed incident, sun incident correction and geometric correction)
- Algorithm for estimating vegetation type map and biomass carbon amount using vegetation type map
- Algorithm for creating global land cover type map
- Algorithm for detecting vegetation/land cover change
- Algorithm for estimating net primary production (chlorophyll a method and fluorescent method)
- Algorithm for calculating vegetation parameter (APAR, Net primary production, and monthly production and precise Biomass map creation)
- Over land Atmospheric correcting Algorithm

c. Basic Research for Algorithm Development and Research for Validation

- Analysis of bi-directional reflectance of vegetation
- Development of standard spectrum emmisivity measuring method on the ground
- Development of biomass estimations method in large area for every vegetation type

(4) Cryology

a. Products

Analysis Category	Global Coverage	Regional Coverage	Every Certain Period	Monthly	Season	Yearly	Irregularly	Product type	Accuracy
Snow Grain Size	☐		☐					Standard	10%
Snow Impurities	☐		☐					Standard	10%
Cloud Detection Over Snow Ice Surface	☐		☐					Standard	10%
Snow Cover / Sea Ice Discrimination	☐		☐					Standard	10%
Snow Cover Distribution	☐		☐					Research	1km
Sea Ice Distribution	☐		☐					Research	1km
PAR		☐			☐			Research	10%
Snow Ice Surface Temperature		☐			☐			Research	10%
Atmospheric Top Irradiance Balance		☐			☐			Research	10%
Aerosol Characteristics Over Snow Ice Surface		☐					☐	Research	10%
Cloud Properties Over Snow Ice Surface		☐					☐	Research	10%
Sea Ice Distance		☐	☐					Research	10%
Ice Sheet Surface Pattern		☐		☐				Research	10%
Proglacial Location		☐		☐				Research	250m
Iceberg Location		☐				☐		Research	250m

b. Algorithm Development

- Algorithm for extracting snow grain size and impurities
- Algorithm for detecting clouds over snow ice surface
- Algorithm for discriminating snow runoff or sea ice
- Algorithm for estimating snow runoff and sea ice distribution
- Algorithm for extracting PAR
- Algorithm for calculating snow ice surface temperature
- Algorithm for calculating atmospheric top irradiance balance
- Algorithm for extracting aerosol properties over snow ice surface
- Algorithm for extracting cloud properties over snow ice surface
- Algorithm for extracting sea ice distance
- Algorithm for extracting ice sheet surface pattern
- Algorithm for monitoring proglacial and iceberg locations

c. Basic Research for Algorithm Development and Research for Validation

● Development of bi-directional reflectance over snow ice surface
● Development of non-spherical snow particles scattering model
● Development of snow ice algorithm using existing satellite data
● Development of radiation transmission of atmosphere and cryosphere
● Observations to validate effect produced by snow grain size and impurities on snow reflectance
● Observations to validate snow ice algorithm using aircraft
● Observations to validate sea ice algorithm using vessel

Common Products for All Spheres

Analysis Category	Global Coverage	Regional Coverage	Every Defined Period	Monthly	Yearly	Daily	Irregularly	Product Type	Accuracy
250m Mesh Data		√		√				Standard	0.5 pixels
1km Mesh Data	√			√				Standard	0.5 pixels
PAR	√			√				Standard	10%
Albedo		√		√				Standard	5% global energy
Surface Temperature (1km)		√		√				Standard	0.5% global energy

3.1.2.2 Algorithm development

Algorithms for extracting each kind of product will be programmed by each responsible PI, then handed over to the GLI Algorithm Integration Team (GAIT), which is a part of EORC, and converted into system friendly modules. GAIT is not a management system but is personnel of GAIT positively taking a part in the research development. GAIT supports developing effective algorithms by using four modules; GSS (the GLI Signal Simulator), which predicts conservative brightness of the GLI; GSD (the GLI Synthetic Data), which simulates observation images created by GSS; GRS (the GLI Retrieval System), which is an algorithm for calculating products; and GMD (the GLI Measurement Data), which is in situ data and data of other satellites. GSS, one of those four modules, will incorporate research results from the GLI project, and expansion of each kind has been continuously planned. In recent years, strong inverse problem solvers like neural networks have developed remarkably, and it has become possible to educate clients about neural network systems by order problem solvers like GSS. Investments of the order problem solvers like GSS will be a great driving power for those remote sensing.

GAIT is made up of NASDA researchers and guest researchers. The method of algorithm development with GAIT will make a good use of educating the remote sensing researchers and finding new users.

The person in charge of each algorithm development task is summarized as the following.

Work Category	PI	GAIT	EORC System G	Contractor
Program Creation	■			
ATBD Creation	■	□		
Program Implementation		■		□
Separated Tests		■	□	□
Overall System Tests		□	■	□

3.1.3 Validation and calibration

3.1.3.1 Calibration

Calibration of the sensors is very significant in order to provide good quality for level 2 products since the GLI has 36 channels of different wavelengths. For that, it is necessary to perform relative geometry correction between the sensors, absolute geometric correction, relative irradiance calibration between the sensors, and absolute irradiance calibration, and each of correction has to maintain high accuracy by calibration program carried out before and after the launch. Even though calibration will be performed before the launch through proto flight model testing to be reflected in the level 1 processing algorithm, parameters might change after the launch due to the geometry radio metric performance of the sensors or faulty sensors. Therefore, for the GLI operation, geometric calibration and irradiance calibration must be performed at all times during the flights. Absolute geometric correction and absolute irradiance calibration during the flights is especially strongly related to the science plan. In other words, these calibrations are inverse problems of the Earth and the atmospheric remote sensing, and the best calibrated parameters might be determined during ground validation of level 2 products described below. From such a point of view, the GLI project will perform calibration before the launch, in close cooperation with the validation efforts.

For geometric correction, an automatic correction algorithm corresponding to a point of ground calibration selected in advance will be implemented. As a result, the GLI level 1 products will maintain 1km pixels of TBD pixel and 250m pixels of TBD pixel during the sensor operations.

For radiation calibration, reflectance factors of deserts and clouds, targets with stable wavelength dependence, and clear ocean surfaces will be used. In this case, two methods will be used together with consideration that the GLI has a very large observational spectral range and a very dynamic range to radiant intensity. One method is based on the reflectance factor and radiant brightness (definition of EOS CAL Panel); the other is the direct method. The former reproduces sensor pulses by using estimated values of upward spectrum radiant brightness on the surface of the Earth and the atmospheric models. The latter estimates radiant quantities directly using well-calibrated radiometers aboard aircraft flying at high altitude, and it is used for sensor signal estimates. It is necessary for the success of those calibration programs to establish a proper validation system in relation to the surface of the Earth and the atmosphere.

3.1.3.2 Validation of atmosphere algorithms

(1) Outline

To provide good quality of GLI products, it is essential to perform validation and vicarious calibration. The progress in atmospheric physics and studies in atmospheric radiation in recent years has enables to receive signals of the GLI from the ground observation data with high accuracy. For that reason, the quality of products has begun to be very high glades due to performing validation of products and vicarious calibration of radiant. Thus, to generate GLI atmospheric products, it is important to obtain the ground support data for validation and vicarious calibration suitable for the satellite data. The details of the validation plan are described in the GLI-ATMOS Validation Plan. The following is a summary of validation based on the plan.

Table 1 shows observation quantities and accuracies needed for validation and vicarious calibration. A system for tuning ground validation data will be needed to provide the expected highly precise and accurate observation quantities. To obtain such parameters, it will be necessary to investigate new validation instrument development.

To perform such validation tests, regular observations by surface instruments, special observations using aircraft and common observations in all spheres will be required. Table 2 outlines the schedule in relation to GLI-ATMOS. It will be necessary to start developing the network of ground observations at least six months before obtaining data from the GLI sensor, i.e., starting the network in August 2000 if the GLI sensor is launched in November 2000. Intensive observations with cooperation of all spheres must be performed twice a year for the first year after acquisition of the data and then yearly from the second year. It is necessary to hold the evaluation meetings about a test constant in all spheres. The meetings should be held three months after intensive observations.

(2) Ground Observation Tests

The basic strategy for GLI-ATMOS is to acquire validation /vicarious calibration data by using the network sites for regular observations in large regions and for a long term. Of course, it is difficult for just one organization to maintain such a network, so international joint research will be carried out. Table 3 shows the sites to be established by GLI-ATMOS. As shown in the validation plan, some of those sites are in the operation stage, and some are in the planning stage. It is necessary to carefully adjust equipment investments for every site. Sites are established considering geographic distribution and ease of management. Table 3 also shows needed equipment investments. It is still necessity to check equipment in order of priority as it comes in.

(3) Intensive Observations

Detailed calibration and validation of the sensor will be accomplished by performing comprehensive detailed observations approximately every six months for the first year, then once a year, combining ground observations and aircraft observations. It is also necessary to determine how to conduct the research to achieve scientific objectives.

Table 1. Parameters for validation/vicarious calibration

S denotes Standard products, R denotes Research Products, and V denotes observation quantities for validation/vicarious calibration

Geophysical Parameter	Product Type	Accuracy	Method (note)
CLFR, CLFG	S	5%	Surface Observations, Lidar, CPR, GEO, AVHRR
CLOP	S	10%	Aircraft, AWSR, POLDER, MODIS, AVHRR
CLWT	S	20%	Aircraft, MCWR, AMSR, SSM/I
CLRE	S	20%	Aircraft MODIS, AVHRR
CLTP	S	0.5K	Sonde, Lidar
CLHT	S	1km	Sonde, Lidar
CLBH	R	1km	Sonde, Lidar
WTVA	R	0.2g/cm2	Sonde, GPS. Sun Photometer, AMSR, SSM/I
AROP	S	10%	Sky Radiometer/Sun Photometer, POLDER, MODIS, AVHRR
FSSRF	R	5W/m2	BSRN, GLI-ATMOS (instantaneous)
FSTOA	R	5W/m2	CERES (instantaneous)
FLTOA	R	5W/m2	CERES (instantaneous)
PRCP	R	Factor2	Radar, CPR (warm precipitation)
Sky Radiance	V	1%	Sky Radiometer (vicarious calibration)
Surface Leaving radiance	V	1%	TBD (vicarious calibration)

Sensors: GEO (Geostationary satellites), CPR (Cloud Profiling Radar), SWSR (Short Wave Spectral Radiometer), MCWR (Microwave Radiometer)

Products: CLFR (Cloud fraction), CLOP (Cloud optical thickness), CLWT (Cloud water path), CLRE (Effective cloud particle radius), CLHT (Cloud top height), CLBH (Cloud bottom height), WTVA (Column water vapor amount), AROP (Aerosol optical thickness), FSSRF (Short wave surface radiation fluxes), FSTOA (Short wave TOA radiation fluxes), FLTOA (Long wave TOA radiation fluxes), PRCP (Precipitation).

Table 2. GLI-ATMOS validation tests schedule.

99 00 01 02 03 04

|-------------------|-------------------|-------------------|------------------|-------------------|-------------------|-----------------

11 Launch

2 Data checkout

8 Network initialization

6 Network data release

5. 1st LFE

11. 2nd IFE

9. 3rd IFE

8. 4th IFE

2. 1st cal meeting

8. 2nd cal meeting

2. 3rd meeting

8. 4th cal meeting

8. 5th meeting

8. 6th meeting

ACE-Asia 1 ACE-Asia2

----------------------------------GAME---------------------------------

CEOP

NET work); GAW (the Global Atmospheric Program); Frontier (the Frontier Program)

November 2000: The launch

Process 1.Continuous land observations in Asia

Period: From August 2000 until the operation by the GLI is suspended.

Outline: Start network sites six months before the launch and collect the validated data regularly as shown in Table 1.

Process 2. Vessel observations

Period: From August 2000 until the operation of the GLI is suspended.

Outline: Perform continuous sky radiometer observations using vessels before and after the launch and obtain aerosol parameters for vicarious calibration and validation.

Process 3. Intensive observations

Period: From May 2000 until the operation of the GLI is suspended.

Frequency: Obtain the validated data on the surface of the Earth and the data on atmosphere by simultaneous aircraft and ground observations. All spheres' cooperation is necessary.

Process 4. Maintaining test constant

Period: From check out of the GLI until the operation of the GLI is suspended.

Frequency: Every six months for the first year, then yearly after first year. Three months after the intensive observations.

Outline: Convent GLI project meetings to decide the test constants based on the validated data from all spheres.

Table 3. Validation sites proposed for the GLI-ATMOS and the measuring instruments that should be argued. OP denotes operation, PL denotes planning, and TS denotes test.

Code	Name	Status	Measuring Instrument
L1	Si Samrong	OP	SW Spectral Radiometer, Aerosol Sampler
L2	Anhui	OP	Microwave Radiometer, SW Spectral Radiometer Total Nnephelometer, Aethalometer
L3	Yinchuan	OP	-
L4	Mandalgovi	OP	-
L5	Minami Torishima, Tokyo	PL	Aerosol Module, SW Spectral Radiometer Microwave Radiometer, SW, LW Fluxes Meter, Lidar
L6	Fukuejima, Nagasaki	PL	Aerosol Module. SW Spectral Radiometer SE, LW Fluxes Meter
L7	Bukittinggi	OP	Sky Radiometer, SW Spectral Radiometer
S1	Ship-Mirai	TS	SW Radiometer, Microwave Radiometer
S2	Line-Persia	PL	SW Spectral Radiometer, Microwave Radiometer
S3	Line-Australia	PL	Shipborne Sky Radiometer, SW Spectral Radiometer
	Airborne PL	PMS	

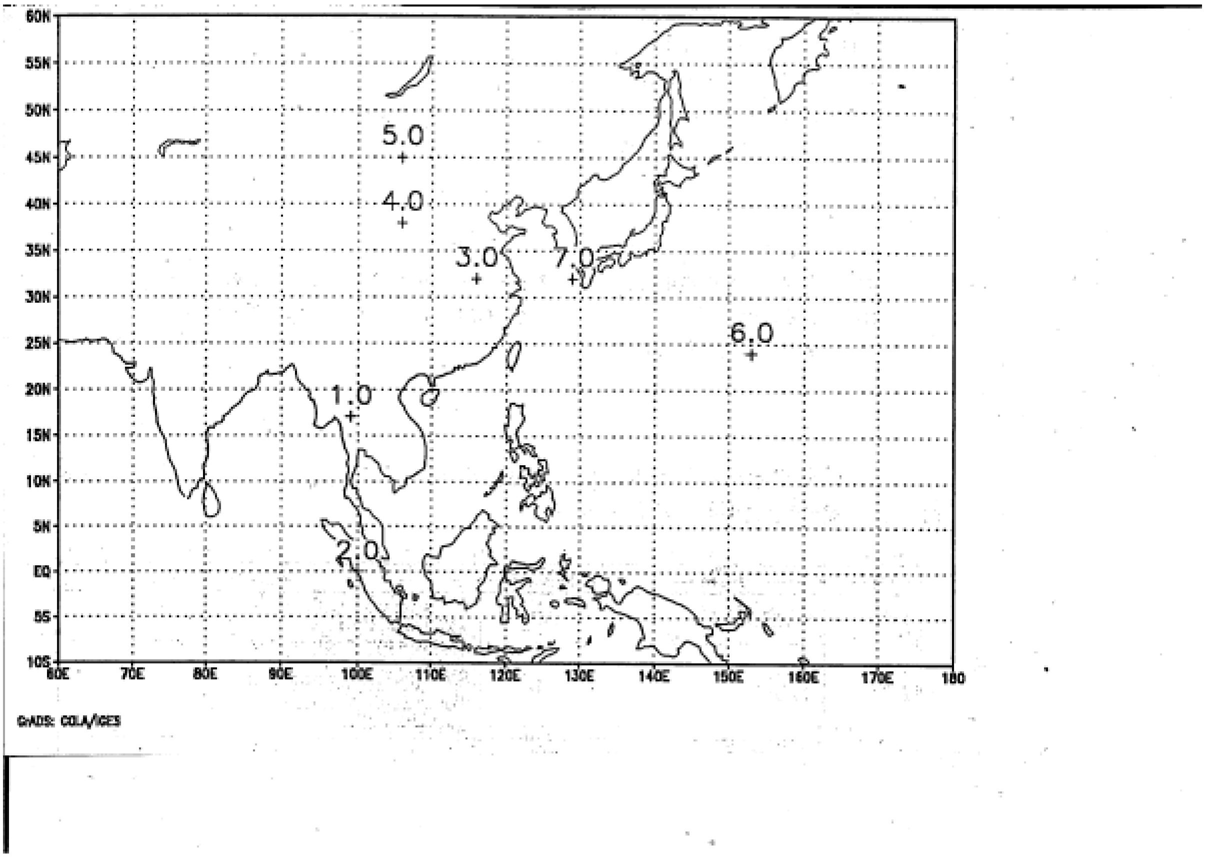

Figure 4. Validation sites for GLI-ATMOS

Table 4. Validation sites

Location	Latitude	Longitude	Site
1.0	99.87E	17.17N	Si Samrong
2.0	100.31E	0.30S	Bukittinggi
3.0	116.78E	32.55N	Anhui OP
4.0	38.48N	106.22E	Yinchuan OP
5.0	45.59N	106.19E	Mandal govi
6.0	24.17N	135.59E	Minami torishima
7.0	32.40N	129.50E	Fukueshima

3.1.3.3 Validation of ocean algorithms

(1) Outline

It is important to match GLI color information with in-situ data observed directly by ships. In order to use GLI ocean color observation as a follow-on time series to OCTS and SeaWiFS observations, it is necessary to ensure the compatibility between the sensors and to perform validation and vicarious calibration using in situ observation data.

Various attempts on calibration, vicarious calibration, and validation were made during the ADEOS/OCTS mission.

Calibration through comparison with airborne sensors, vicarious calibration using the optical buoys located in the Sea of Japan and Hawaii, and validation using vessel data with the cooperation of the Fisheries Agency and the domestic or oversea research organizations has been especially successful. GLI-OCEAN should plan to make the best use of those experiences. Primary in situ observations that will be important for validation and vicarious calibration are explained here.

Global sensors like GLI need both global-scale validation/vicarious calibration and regional scale validation. While global scale coverage requires equivalent accuracy, regional scale coverage, like for Japan, Asia, and around Asia, where the users are concentrated due to the I-LAC (Intensive LAC), requires an especially accurate geophysical parameter estimating system. Consequently, it is essential to maintain the data on global scale validation/vicarious calibration and data on and around Asia.

(2) Data Collection on a Global Scale

The important thing for data collection for vicarious calibration is to perform simultaneous observations for ocean where the brightness temperature of the atmosphere and the brightness temperature of the ocean are stable and where both the atmosphere and the ocean are reliable, and where various geophysical parameters can be collected. The data sets provided by these observations will be necessary to investigate the sensor's stability and to start calibration over for convenience not only right after the sensor's starting but also regularly. It is especially desirable in early observations to ensure exclusive vessels if the budget is secured to perform intensive observations of the ocean under good conditions. It is also desirable to validate the system for intensive observations every few months, and also the continuous observations using optical buoy systems. We consider the coast of California and the coast of Hawaii as being in good condition, so we will need to establish a joint system with the researchers from NASA and North America. We also need to perform atmospheric synchronous observations using airborne sensors.

To validate of global scale coverage, it is necessary to establish a network for validation observations with researchers in North America and Europe. Although a network like this succeeded during the ADEOS/OCTS mission, the new network for GLI-OCEAN should be expected to have more advantages for vessel data contributors than before.

(3) Data Collection in Asia

We suppose that we will be able to find many of the GLI Ocean data users in Japan and Asia. To do so, we must ensure accuracy of the algorithm and validation of the satellite data that is specialized for Asia. It is also necessary to prepare the system for data use, especially the I-LAC system that was utilized by a number of users and was very practical during the ADEOS/OCTS mission.

It is also necessary to source Cal/Val PIs and Cols in Japan and Asia, research agencies like the Fisheries Agency with whom we formed a joint system during the ADEOS/OCTS, and the cooperation of many other researchers. Table 2 shows the research organizations we are negotiating with and their vessels. Those vessels are planning many voyages around East Asia before and during the GLI observations. They are thus going to perform the chlorophyll a measurements and the optical observations for the GLI validation. In addition to the items needed for validating standard products, it is desirable to collect research products and the data with references to revitalize various types of research taking advantage of GLI-OCEAN.

Table 1. Geophysical parameters for validation/vicarious calibration, S denotes a standard product, and R denotes a research product.

Product Type	Geophysical Parameter	Method (note)
S (nLw)	Lw	Underwater spectral radiometer
S	CHL	Fluorometry, HPLC (after extraction)
S	SS	Weight measurements of filter
S	CDOM	Spectral absorption measurements of filtrate
R	Carotinoids	HPLC measurements
R	Primary Production	13C, 14C and other methods
R	New Production	15N and other methods

Table 2. Cooperating organizations

● Hokkaido University (Oshoro-maru, Hokusei-maru)
● The University of Tokyo/ Ocean Research Institute (Hakusho-maru, Tansei-maru)
● Tokyo University of Fisheries (Umitaka-maru, Shinyo-maru, Seiyo-maru
● Hiroshima University (Toyoshio-maru)
● Nagasaki University (Nagasaki-maru, Kakuyou-maru)
● Kagoshima University (Keiten-maru)
● Japan Marine Science & Technology Center (Mirai)
National Institute of Polar Research (Shirase)
● Fisheries Agency/ related research laboratories (More than one)
● Japan Fisheries Information Service Center (Cooperation with fisheries laboratories of prefectures)
● National Institute for Environmental Studies (freighter, ferry)

3.1.3.4 Land validation

(1) Outline

The resolutions of the satellite sensors used for global observations are from 500m to 1km. The MODIS sensor provided by the US and the GLI sensor on ADEOS-II have moderate resolutions. It is not difficult to obtain verification information of ocean and atmosphere with moderate resolutions. However, it is difficult to obtain verification information with moderate resolutions because the states of the surface of the Earth are very changeable on small scales. Verification information corresponding to a sensor with a resolution of 1km needs a site as large as 2km x 2km. MODIS's validation sites also need to satisfy these conditions because differences between the satellite observation scales and the ground validation scales (in-site observations) directly influence accuracy and precision of estimated geophysical parameters. Homogeneity and stability of the surface of the Earth and vegetation in the sites corresponding to the observational satellite scales are necessary conditions to attain highly precise quantification of validation. For accurate and precise validation, we must develop proper selection and new validation methods Development of direct-sampling methods and validation information that directly represents large areas.)

Over five years ago, the research group from Chiba University Center for Environmental Remote Sensing established several different validation sites where the rates of vegetation coverage are suitable for moderate-resolution sensors. They have also developed a method for collecting ground information that can represent large areas from the large validation sites. Accordingly, highly accurate and precise validation of moderate resolution sensors will be possible at the Mongolian validation site.

In the December 1998 science team meeting, CEReS was formally requested to register CEReS's Mongolian validation sites with the EOS core validation sites and to cooperate in the EOS program. The response to this request will enable us to obtain ground information from EOS core validation sites (about 20 sites) in addition to other sites the US operates for MODIS validation. It will also be useful for the GLI products validation in addition to grassy plains. For GLI and MODIS ground validation, there are three grassy plain sites with 60% to 70% coverage. For two weeks between the late July and the late August when plant life is most stable, we will perform intensive observations and cross- calibration with the U.S MODIS team at three site with high, moderate, and low rates of vegetation cover to validate the vegetation index, 3D structure of grassy plains, composite accuracy, parameters for atmospheric correction, reflectance factor and penetrate factor of individual vegetation, directional reflectance, the surface temperature, and biomass, leafs area index and to investigate vegetation (mostly seeds), and (optical information, soil moisture, soil structure, etc.), before the launch and during ADEOS-II operation. In a fiscal year when the GLI data becomes available, long-term observations covering the growing cycle of vegetation from late May to late September during the highest rate of vegetation cover among the above-mentioned will be performed, and validation information with different rates of vegetation cover under the same condition of soil will be acquired. Observations using remote-control helicopters in EOS core validation sites in North America that the US MODIS team uses during the GLI operation will be carried out by the MODIS team.

To validate global land coverage classification maps, it is necessary to collect ground truth data for various land covers of each continent. The result of land coverage validation depends on the ground truth data collection. The necessity of land ground truth data collection is not only a problem for the ADEOS-II GLI project but also for other satellite projects like MODIS and is a common concern among international land use/land cover research programs like the LUCC. However, ground truth data collection for validation or classification has been individually carried out by each project until today. Collecting ground truth data requires knowledge about land coverage of each country, so cooperation of many researchers is required. For that reason, although the purpose of the GLI land team is to validate global land cover classification maps by the GLI, the team is considering building a Global Land Cover Ground Truth Data Base (GLCGT-DB) that will be available for other land coverage classification projects, with international cooperation. Land coverage ground truth data will thus be collected through international groups such as the Committee on Earth Observation Satellites (CEOS.)

(2) Items and Methods of Validation

The major items for validating the GLI land standard products and physical parameters scientifically are described below. The ground information representing large areas will be obtained in any of the Mongolian grassy plain sites.

a. Vegetation Index (typical value in large areas)

The vegetation index is measured by an optical radiometer. It is important to complete a system to measure large areas in a short time. Ground measurements from higher altitudes using radio-control (RC) helicopters will be necessary. Moreover, equipment for an automatic observation system will be necessary to enable measurement without using personnel. An automated observation system computes the smallest areas as typical values of the Earth's surface spectrum properties from the RC helicopter measurements.

b. 3D structure of Grassy Plain Vegetation

Measurements using laser 3D scanners will enable forming the 3d structure of grassy plain vegetation. Measurements are impossible using established systems. A system must be developed to measure the 3D structure of vegetation on grassy plains. However, it will not be necessary to develop the scanner itself. It will be necessary to provide only mounts for measurements and build up an operational part that allows measurements. Also, it will allow indirect estimates of biomass without damaging conservation objects.

c. Composite Accuracy (rate of clear sky)

Measurements of daily cloud cover will clarify the shortest period for creating data sets of cloud-free composite. In practice, obtaining image data from a whole sky camera every hour will make it possible.

d. Parameters for Atmospheric Correction

Measurements of atmospheric parameters with satellite synchronization will allow highly precise comparisons between in-site observation data and synchronized observation satellite data. Aerosol and optical thickness must be measured.

e. Reflectance Factor and Penetration of Vegetation Individual

Pure measurements of the reflectance factor and penetration of plant body without the effects of soil and/or other factors are necessary to establish the scattering model. However, such a measurement system is not yet available, and it is especially difficult to measure leaves individually. Development of this measurement system is essential. The basic design of the system has been developed through research, and it is now at the implementation stage.

f. Bi-directional Reflectance

Although bi-directional reflectance (BRDF) measurements at ground observation level have been roughly completed, validation to check if high-altitude measurements match with ground measurements has not been performed. RC helicopters will make such measurements possible. The BRDF measurement system must be mounted in RC helicopters, so we must develop a remote -controlled BRDF measurement system.

g. Earth’s Surface Temperature

A system that enables numerous measurements of the surface of the Earth from RC helicopters and vehicles will be used for comparison with thermal infrared data from satellite sensors. Installing semi-automatic observation systems is also being considered.

h. Biomass

Biomass will be measured by mowing a 20 square meter area every once a week. This will enable measuring the quantity of vegetation (raw weight, dry weight, and water weight) on the ground.

i. Leaf Area Index

The leaf area index will be measured before a sample for estimating biomass gets dry. The leaf area index will be calculated so that a large area will be represented statistically.

(3) Planning Validation Activity Before and After the Launch

a. Fiscal Year before the Launch

#Intensive Observations in Mongolia from Late July to Late August

Last week of July

●Cross calibration of participating equipment

●Establishing observations sites (camp, processing system, observations system etc.)

First and second week

●Intensive observations in three sites (all validation items)

Third week

●Some continuous observations in some sites

●Data processing

●Measurement instrument cross calibration

●Closing sites

b. During GLI operation

Long-term Observations in Mongolia, from the End of May to the End of September

Third week of May (10 workers)

●Establishing observations sites

From last week of May to last week of September

(Three workers/ one-month shift)

●Start of long-term observations in high rate of vegetation sites

●Observation items

Vegetation cover condition and spectrum information using semi-automatic observations (every hour from 0900 to 1900)

Three weather factors (every 15 minutes for 24 hours)

Atmosphere observations (every 15minutes for 24 hours)

Sunlight observations (every 15 minutes for 24 hours)

Soil moisture (every 15 minutes for 24 hours)

Earth's surface temperature (every 15 minutes for 24 hours)
Biomass investigation (once a week)

First week of October (10 workers)
●Closing sites

#Intensive Observations in Mongolia from Late July to Late August

Last week of July
●Cross calibration of participating equipment
●Establish observations sites (camp, processing system, observations system etc.)

First and second week of August
●Intensive observations in three sites (all validation items)

Third week of August
●Some continuous observations in some sites
●Data processing
●Measurement instrument cross calibration
●Closing sites

#Intensive Observations by Huete Team and the Remote-Controlled Helicopter in EOS Core Validation Site in the North America for One Month (June)

Each land cover type, grassy plains, farmlands, and forestry regions will be observed using remote-controlled helicopters.

(4) Validation by Constructing Global Land Cover Ground Truth Database (GLCG-DB)

A global Land Cover Ground Truth Database (GLCG-DB) will be constructed is validation of land cover and land usage and vegetation classification. Ground truth data will be stored in one database to create land cover and land usage and vegetation classification data categorized by different projects, missions, and individual researchers. This database will then become a source of training sample data and validation data for creating the following land cover and land usage and vegetation classification data.

This database has the functions following.

It stores different kinds of ground truth geographic ranges (latitude and longitude), time, properties (land cover, land use, and vegetation classification), definition of properties (classification classes), and the source of information of the data. It is called original ground truth data.

Generalized ground truth data integrates land-cover classes of original ground truth data. To construct the GLCG-DB, it is necessary that ground truth data in use be provided from projects and missions performing land cover and land usage and vegetation classification as preconditions; this will require permission.

Schedule

From 1999 to the end of 2000
Obtaining acceptance of cooperation from the various projects and missions.

From 1999 to the end of 2000
Creating and designing GLCGT database in detail.

From 2000
Inputting ground truth data.

From 2001
Validating land cover classification maps using the GLCGT database.

3.1.3.5 Validation of cryosphere

(1) Outline

An algorithm to obtain cryosphere parameters using channels primary in the visible spectrum and near infrared regions has been developed for a remote-sensing cryosphere using the ADEOS-II GLI data. Experiments and observations in the snow ice regions like low temperature laboratory, the east side of Hokkaido, Alaska, and the Antarctic will be carried out to validate this algorithm and calibrate the sensor. Parameters related to snow, sea-ice, distribution of sea-ice, radiation, and cloud and aerosol are cryosphere parameter candidates. These parameters will be validated simultaneously by spectrum radiation observations with satellite sensors (albedo, BRDF, and infrared radiation). Snow runoff geological cross-section observations, radiation balance observations, atmospheric aerosol and cloud observations, ground weather observations, and vegetation observations (satellite direction brightness) and atmosphere observations will be performed simultaneously for vicarious calibration.

(2) Ground Observations and Experiments

Ground observations and experiments will be carried out around Lake Saroma in Hokkaido, around Fairbanks and Barrow in Alaska, on the surface of the snow ice of the inner Antarctic, and the low-temperature laboratories of participating research organizations. To understand basic properties of BRDF, measurements in the low-temperature laboratories will be carried out from FY1999 to FY2000, one year before the launch of GLI. In addition, measurements will be made around Lake Saroma in Hokkaido yearly from FY1999 to FY 2002, before and after the launch of GLI. Measurements will be made Around Fairbanks in March 2001 after the launch, around Barrows in April ever year from 2001 right after the launch, and in the Antarctic for three years from 2001 as the launch is confirmed.

a. Low-Temperature Laboratory

BRDF measurements will be made in visible spectrum and near-infrared region, controlling snow grain size, temperature, radiation amount, and the incidence by artificial snow runoff and sunlight making device.

b. Around Lake Saroma in Hokkaido

February to March, when the sea-ice of the sea of Okhotsuku begins to freeze over, will be a suitable time for optical observations because the sky is often clear for the amount of the snow runoff. There is flat sea ice on the Saroma, and flat snow runoff from the plain expands around Saroma, which is a good region to observe. Ca/Val observations relation to snow will be conduced on the surface of the snow run off, and Cal/Val in the relation to sea ice will be performed on the Lake Sarcoma and on the sea of Okhotsuku. Airborne observations and vessel observations are in planning.

c. Around Fairbanks in Alaska

Around Fairbanks, Alaska, a representive high latitude snow forest is expanding. The algorithm to detect snow run off regions where snow runoff exists grove floor from the satellite will be validated. Cooperative observations will be carried out with the University of Alaska Fairbanks (UAF). UAF can receive 250 m channels of data directly at UAF.

d. Around Barrow in Alaska

Around Barrow, Alaska, there is a flat snow runoff of several tens of centimeters on the tundra. Calibration and validation related to snow will be carried out through cooperative observations with UAF. There are also NOAA/CMDL and the UAF/ARM observation sites, and atmospheric data that supplements spectrum data obtained from CAL/Val will be obtained at the same time. Primarily snow grain sizes and impurities will be validated, and the sensor will be calibrated.

e. Antarctic

The Antarctic is the most suitable place for calibration observations because there is merely impurities and atmosphere aerosol. Also, changes in snow grain sizes are expected because the distance between the coast and inner land is 4000m. Cloud parameters, diamond dust distribution, snow-grain size, layer structure, surface frosts, seasonal and annual changes in sea ice distribution and interesting science data are expected. Plans are underway for Showa Base to directly receive the GLI/250m channels data during the GLI Cal/Val.

Table1 Schedule of ground experiences and observations.

Name of the Observations: Cal/Val Observations for Cryosphere using the ADEOS-II GLI data	
Fiscal year	FY 1999
1. Process (Month)	---4---+---5---+---6---+---7---+---8---+---9---+--10---+--11---+--12---+---1---+---2---+---3--- CC SSS
Implementation Outline	C: Low Temperature Laboratories BRDF Measurements S: Lake Saroma al Observation
Fiscal Year	FY2000
2. Process (Month)	---4---+---5---+---6---+---7---+---8---+---9---+--10---+--11---+--12---+---1---+---2---+---3--- CC *the ADEOS-II Launch SSS FFFF
Implementation Outline	C: Low Temperature Laboratories BRDF Measurements S: Lake Saroma Cal/Val F: Fairbanks Cal/Val
Fiscal Year	FY2001
3. Process (Month)	---4---+---5---+---6---+---7---+---8---+---9---+--10---+--11---+--12---+---1---+---2---+---3--- FF AAAAAAAAAAAAAAAAAAAAAAAAAAAAA BBBBBBBB SSS
Implementation Outline	B: Barrow Cal/Val A: Antarctic Cal/Val S: Lake Saroma Cal/Val
Fiscal Year	FY2002
4. Process (Month)	---4---+---5---+---6---+---7---+---8---+---9---+--10---+--11---+--12---+---1---+---2---+---3--- AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA BBBBBBBB SSS
Implementation Outline	B: Barrow Cal/Val A: Antarctic Cal/Val S: Lake Saroma Cal/Val

(3) Observation Method (table.2)

Spectrum radiate observations using the visible spectrum/near infrared spectroscope and the FTIR measure albedo in each wavelength, BRDF in each wavelength, upward and downward radiate flax radiate brightness temperature in each direction. It will investigate the relationship with cryosphere parameters. Measurements of cryosphere parameters mainly will be carried out for snow run off, layer structure, snow temperature, concentration, snow grain sizes, shapes, and microscope photography. Also sample of snow runoff will be passed through filters in a laboratory, and concentration of impurities in samples will be estimated by weight measurements. Optical properties of impurities in sample will be estimated by optical measurements (reflectance factor/penetration).

Using mainly the pyrhekiometers and the radiometers for long-term monitoring observations, measurements of balance of short wave radiation and long wave radiation and albedo in large regions will be carried out. Those results are supposed to be used for validation of cloud detection on the snow ice, upper atmosphere radiation balance, aerosol properties, and cloud properties. Also sun photometer, aerosol sampling, and other satellite data will be used for validation of those.

Airborne observations and vessel observations aim at validation of snow/sea ice, ice sheet surface patterns, Proglacial location, and ice burg locations, and will use other satellite data and instruments like AMSS, AMR, and videos. Also snow runoff distribution observations will measure leaf area index (LAI) in forests and investigate into the relationship with forest density.

Vicarious calibration will be carried out after the launch of the GLI in mainly Barrow and Antarctic. It requires visible spectrum/near infrared spectroscope, FTIR, and precise atmospheric observations, and intensive observations with the combination of above-mentioned validation will be carried out.

Short-term observations will be carried out and around Lake Saroma, around Fairbanks, and around Barrow. Long-term observations will be carried out mainly on Antarctic.

Table.2 Validation method of cryosphere Parameters

Geophysical Parameter	Method	Instrument	Accuracy	Location
Snow Grain Size	Snow Runoff Geological Cross-Section Observations	Snow Cover Cross Section Measuring Instrument, Microscope	5%	S, B, A
Snow Impurities	Snow Runoff Geological Cross-Section Observations e.t.c.	Snow Cover Cross Section Measuring Instrument, Filtering	5%	S, B, A
Cloud Detection over Snow Ice	Radiation Balance Observations	Pyrheliometer, Radiometer	5%	S, B, A
Snow Runoff /Sea Ice Discrimination	Airborne	AMSS, Video, Other Satellite Data	5%	S, B, A
Snow Runoff Distribution	Airborne, Vegetation Measurement	AMSS, Video, LAI Meter	Several Tens Meters	S, F
Sea Ice Distribution	Airborne, Vessel	AMSS, AMR, Video, Other Satellite Data	Several Tens Meters	S, A
Photosynthesis Active Radiation (PAR)	Spectrometer	Visible/ Near Infrared Spectroscope	5%	F, B, A
Snow Ice Surface Temperature	Spectrometer	FTIR, Radiation Thermometer	1 Degree	S, F, B, A
Atmospheric Upper Layer Radiation Balance	Radiation Balance Observations	Pyrhekiometer, Radiometer, Other Satellite Data, e.t.c.	10%	F, B, A
Aerosol Properties	Radiation Balance Observations	Pyrheliometer, Radiometer, Sun Photometer, e.t.c.	10%	B, A
Cloud Properties	Radiation balance observations	Phrheliometer, Radiometer, Radiozonde, e.t.c.	10%	B, A
Sea Ice Closeness	Airborne	AMSS, AMR, Video, Other Satellite Data	10%	S, A
Ice Sheet Surface Patterns	Airborne	Video, Other Satellite Data	10%	A
Proglacial Location	Airborne	Video, Other Satellite Data	Several Hundreds Meters	A
Ice Burg Location	Airborne	Video, Other Satellite Data	Several Hundreds Meters	A

3.2 AMSR

3.2.1 Scientific objectives

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

(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

The 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, geophysical parameters like the sea surface temperature and soil moisture that the conventional microwave radiometers could not observe will be obtained. The AMSR also will observe water vapor, cloud water, and precipitation as well as the conventional microwave radiometers, and improvement of the observations accuracy and precision is expected with high spatial resolutions.

The AMSR will be aboard not only the ADEOS-II but also NASA's EOS-PM1. The one aboard the EOS-PM-1 is called "AMSR-E", but both of those two sensors are meant in a term called "AMSR". Observational time of the ADEOS-II is 10:00 in local time, and of EOS-PM1 is 1:30. More observations will be performed, and those two sensors will bring the chance to observe daily changes. The 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 models of weather forecast and to enable to proof practical use of the AMSR. In the future, satellite data and numerical values will be assimilated, and this will increase higher analysis performance. Use of fixed AMSR data for this is considered as one of the future promising fields.

3.2.2 Standard products

(1) Accumulated water vapor (only over the oceans), global, accuracy of 3.5kg/m^2

Accumulated water vapor of 0 to 70kg/m^2 will be estimated with the accuracy of 3.5kg/m^2

(2) Accumulated cloud water (only over the oceans), Global, accuracy of 0.05kg/m^2

Accumulated cloud water of 0 to approximately 1.0kg/m^2 will be estimated with the accuracy of 0.05kg/m^2

(3) Precipitation (only over the oceans), global, accuracy of 10%

Precipitation of up to approximately 20mm will be estimated with the accuracy of 10%

(4) Ocean near surface wind velocity, global, accuracy of 1.5m/s

Ocean near surface wind velocity at 0 to approximately 30m/s will be estimated with the accuracy of 1.5m/s. Microwave anisotropy over sea surface is removed.

(5) Sea surface temperature, global, accuracy of 0.5 Celsius degrees

Sea surface temperature at –2 to 35 Celsius degrees will be estimated with accuracy of 0.5 Celsius degrees. Estimates seas where are 50 km or more away from the lands. Microwave anisotropy over sea surface is removed.

(6) Sea ice distribution/sea water concentration, Polar regions, errors are within 10%

Sea ice distribution and seawater concentration in the North pole and the South pole will be estimated within 10% or less of errors.

(7) Snow cover depth, accuracy of 20% or within 5cm

Information about snow cover amount in regions except forests.

(8) Soil moisture

Information about soil moisture in bare fields and grassy fields

3.2.3 Research products

(1) High accurate and precise accumulated water vapor

It will follow standard products. Depending on the circumstances, analysis values for other satellite data and weather models will be used together.

(2) High accurate accumulated cloud water

It follows standard products. Depending on the circumstances, analysis value for other satellite data and weather models will be used together.

(3) High accurate precipitation

It follows standard products. Depending on the circumstances, analysis value for other satellite data and weather models will be used together. Precipitation in lands and snowfall in the winter also are included.

(4) High accurate sea surface temperature

It follows standard products. Depending on the circumstances, analysis value for other satellite data and weather models will be used together.

(5) High accurate ocean near surface wind velocity

It follows standard products. Depending on the circumstances, analysis value for other satellite data and weather models will be used together.

(6) High accurate sea ice distribution

It follows standard products. Depending on the circumstances, analysis value for other satellite data and weather models will be used together. Other than sea ice distribution, information about the types of sea ice and snow cover depth on the sea ice are included.

(7) High accurate snow cover depth

It follows standard products. Depending on the circumstances, analysis value for other satellite data and weather models will be used together.

(8)High accurate soil moisture

It follows standard products. Depending on the circumstances, analysis value for other satellite data and weather models will be used together. Information about melting in frost regions is included.

3.2.4 Algorithm development

How difficult to develop algorithm is determined by if whether algorithm is performed by (a) only the AMSR data, (b) other satellite data together, or (c) other data like numerical model. Coding, calculation time, and size of calculator needed also depend on those. Consequently, the one must choose out of a certain standard product algorithm with 70% or more of composition of the AMSR (calculated by CPU, disc, and e.g.). For a research product, algorithm must be chosen out of those with 50% or more, and algorithm with 50% or less is categorized as complex algorithm.

The performance evaluation of algorithms must be held, and algorithms of standard products must be chosen from what has good performance among the algorithms generated by PI's, who are introduced by RA. We consider of making the strict deadline of the reports for the PI's and cooperation for algorithm installation and tuning as well. Although the same will be treated of the thing for research, it will leave few (2 to3). The performance evaluation of algorithm will be measured in the same standard both in Japan and other countries. After the launch of satellite, if the algorithm for the research product were considered as better than the algorithm for the standard product, those algorithms will be exchanged and reprocessed.

3.3 SeaWinds

3.3.1 Scientific objectives

The SeaWinds scatterometer is a microwave radar sensor used to measure ocean near-surface velocity, sending pluses to the ocean surface and receiving backscatters.

The SeaWinds is a follow-on mission and continues the NSCAT scatterometer, which was aboard the ADEOS. It was the sensor provided by NASA/JPL as well as the NSCAT. The purpose of the SeaWinds mission is to observe global distribution of ocean near-surface velocity, with the measurement of speed of 2m/s accuracy, direction with 20 degrees accuracy, and spatial resolution of 25km. 90% coverage of Earth's oceans will be observed at least once two day. Data on ocean near-surface vector will be rare precious observational source for open ocean areas, that already have been observed by vessels and other means until now, to the research on atmosphere-ocean interaction or eolian cycle of oceanic outer layer which are important factors of the Earth's climate system. Especially the ocean near-surface wind data will have being collected for more than a decade by the ADEOS-II SeaWinds mission, and it is expected to understand and solve global yearly change in phenomena such as EL Niño. Also use of near-real time ocean weather/weather forecast is in planning as follow-on the ADEOS NSCAT mission.

In the inside of the framework of the ADEOS-II as a Earth environment observing satellite, combining the SeaWinds data with the GLI and the AMSR data on ocean near-surface temperature and water vapor amount, and ocean color together, higher order information about ocean near-surface heat and water vapor fluxes are expected to be obtained. Also, Combination with the AMSR will enable atmospheric correction and rain flagging, using microwave radiometer data, which used to be impossible with the NSCAT. It is expected to improve the observational accuracy for ocean near surface winds. By taking the SeaWinds data into algorithm for obtaining ocean near-surface temperature and ocean color, each observation accuracy will be improved.

In addition to ocean winds observations, we began to know that information about land vegetation, snow ice, and ocean ice distribution can be also extracted from information about observed backscatter cross-sections. data use promotion in this field in the future is expected.

3.3.2 Standard products

Three kinds of following standard products provided by the NASA/JPL are in planning as well as the NSCAT.

●Level 2: Global Backscatter Cross-Sections

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

●Level2B:Ocean Vector Winds
Ocean near-surface wind vector data (resolution measured in 25km)
Four solutions before applying ambiguity removal are included.

●Level3: Time-Space average Wind Vectors
Grid data on time and space averaged of ocean near-surface vector
Approximately 1 degree latitude × 1 degree longitude × 1 day (in average)

3.3.3 Research product

When grid data of the scales that is longer than standard product level3 data (ex. Monthly average) is made, it is necessary to consider about the problem with the satellite observation samples relative to the time and space scales of changes in wind fields. Also since it depends on the purpose of product use, standard creation techniques have not yet established at this moment. This creation techniques are the future research subject and will be prepared with continuous the ERS-1, the ERS-2, and the NSCAT missions.
The SeaWinds mission will succeed and develop it and produce continuous ocean sea-surface wind vector in long-term.

The NSCAT is planning of making comprehensive ocean near-surface wind of higher precision and higher frequency, by combining data of wind measurement sensors not only the NSCAT but also the ERS-2/AMI, the ERS-2/ALT, the SSM/I, and the TOPEX/POSEIDON ALT. The SeaWinds mission will succeed and provide the same kinds of products and check changes of the data quality affected by transition of each sensor.

3.3.4 Algorithm development

The algorithms to obtain ocean near-surface vector from backscatter cross-section area observed by the scatterometer will be divided into mainly 4 parts, rain flagging, geophysical model function, wind retrieval, and ambiguity removal.

Atmospheric correction and rain flagging correct effects of attenuation caused by water vapor, clouds, and raindrops to the observations for scatter cross-section areas and distinguish the domains where rain intensity is strong but observations accuracy cannot be guaranteed. The ADEOS NSCAT, which didn't carry microwave radiometer, uses the OCTS's visible /infrared spectrum image and the DMSP's SSM/I data. The SeaWinds is considered to use the AMSR's brightness temperature as the information reflecting water vapor amount, cloud amount, and precipitation, however, its method has not yet established specifically. The most behind part in the SeaWinds algorithm is the research and development at this moment.

Geophysical model functions give the values of the scatter cross-section areas in advance as function of direction and wind speed relative to incidence and wind direction, and it is the database which serves as the basis to obtain wind velocity from observed scatter cross section areas. Comparing the ERS-1/AMI scatterometer data with objective analysis data, NASA/JPL experimentally developed the method to create model function. This method will be taken over for the NSCAT and the SeaWinds.

Many of investigations have been taken for wind retrieval algorithms to obtain wind velocity from scatter cross-section areas observed by the scatterometers, and now maximum likelihood estimation (MLE) has been mostly used. Algorithm, which is adopted MLE has already developed for the NSCAT data processing, and it has been applied to the ERS-1/AM I scatterometer data processing, obtaining good result. It can be adopted The SeaWinds as well.

Ambiguity removal is the algorithm that chooses the best in maximum of 4 solutions for wind vector obtained by wind retrieval. For the NSCAT data processing, algorithm using median filter for initiated wind vector fields based on objective analysis data has developed, and it has also been applied to the ERA-1/AM I data processing, obtaining good results. This algorithm will be applied to the SeaWinds too.

In addition to the general algorithms mentioned above, there is the algorithm needed only for the SeaWinds, the wind vector estimate algorithm for the inside and outside observations. Although it used to be impossible with conventional fan beam sactterometers to observe the regions directly under the satellite orbits and around them because of the incidence limitation, The SeaWinds enables to observe scatter cross section areas directly under the satellite and around it because it adopts the conical scanning. However, since the observing direction is limited for those regions, it cannot seek for wind velocity vector in the same accuracy as the regular observation areas only using the scatter cross-section areas.

Nevertheless, using scattering cross section area data and wind vector data on surrounding observations regions, it is supposed that the wind speed field of the domain with a width of about 500km called 'Nadir Gap' can be estimated in practical precision and accuracy. Also, in the outside of regular observation regions, it will be possible to expand some observation width in the same way for the regions where there is lack of scattering cross section area observations provided that the research for this method is hardly carried out.

In the above, we described the outline of the present status of algorithm development. The SeaWinds is the sensor provided by the NASA/JPL, and its algorithm development and standard data processing will be carried out by JPL. From the ERS-1/AMI achievements and the preparation situation for the NSCAT and the SeaWinds, we can expect the algorithm that achieves improvement of observational accuracy by the time the SeaWinds is launched. Thus we are going to put emphasis on the study of meteorology and oceanography using data but develop original algorithm as a basic course line. However, individual researchers, who are trying to develop and improve the algorithm for their own interests based on their new ideas, are greatly welcomed, and we will support those researchers as much as possible.

For the NSCAT algorithm, we have contributed to JPL's algorithm development and improvement through the Japan-U.S. NSCAT science team and its sub working group activities. We will continue to take in place of various working group activities and follow in the JPL's algorithm development and improvement of the SeaWinds as well as the NSCAT. Especially, the algorithm needed on the SeaWinds in the first place, that are, atmospheric correction by combining with the AMSR, rain flagging, and expansion of outside and inside of observation areas will be investigated independently, and we will make efforts to reflect its results on the JPL's standard algorithm.

The SeaWinds

Category	Coverage	Interval	Accuracy	Note
Atmospheric Correction Scattering Cross Section Area Data	Global (Land, and Ice Region included)	Path	0.5dB	
Ocean Near-surface Wind Vector Data	Global (Ocean Region)	Path	Wind Speed 2m/s Wind Direction 20 Degrees	
Ocean Near-Surface Vector Grid Data	Global (Ocean Region)	Daily	Not clear at this Moment	

3.4 POLDER

3.4.1 Scientific objectives

The POLDER (Polarization and Directionally of the Earth's Reflectance) instrument is the same sensor as the one aboard the ADEOS satellite. Taking the advantage of being the only one among sensors aboard the ADEOS-II, which is the same as the one aboard the ADEOS, it will perform time series observations and continue the ADEOS satellite mission. Thereby, change in time of information acquisition can be explored.

Just like taking the photograph (frame image), it collects reflected light in the range from visible spectrum to near infrared, from the Earth into the matrix CCD by rotating the filter wheel. The view zenith angle is 43 degrees along the track and 51 degrees cross track, which corresponding to an image made of 1580X2200 pixels. Since the frame images are obtained continuously accompany with the satellite operation, the same target of the surface of the earth will be observed from the different points of view being changed every 11 degrees. This multi directional observations (multi observational angles) of the frame images with polarization observations will bring distinctive features of data.

Its instantaneous view angle is 6 degrees, and a brightness temperature resolution is 12 bits. It has 8 spectral bands in the range from visible spectrum to near infrared, and 3 spectral bands (0.443, 0. 670, and 0.865μ) of them are used for the polarization observations. Also, 0.765μ is used for the analysis of oxygen absorption range, and it sets up two types of observations regions, large region and narrow region. It is expected to estimates cloud height using oxygen absorption range.

Using information about polarization, angle, and spectrum of the POLDER sensor, it is possible to introduce atmospheric aerosol, cloud optic characteristic and the Earth Surface reflection characteristics. Just because the POLDER doesn't have its own calibration system, it was designed for the ADEOS by the same bands as OCTS. Also, because the POLDER doesn't have bands in infrared, infrared data of the OCTS was very good for the effective use of the POLDER. This idea of combination use of the POLDER and the OCTS is taken over for ADEOS-II mission. Mutual cooperation of the GLI and the POLDER having even more abundant spectrum information than the OCTS is indispensable. The ADEOS-II POLDER aims at creation, renewal, and storage of global distribution maps of atmosphere aerosol, clouds, and Earth's surface reflection properties, based on compound use of not only the GLI but also other sensors.

3.4.2 Standard products

Creation of Global Distribution Map of 1.1-degree mesh

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

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

(3) The Earth surface reflection properties

(4) Radiation Balance
Category: upper atmosphere

3.4.3 Research products

(1) Ocean near surface wind
Category: wind sped and wind direction

(2) Snow-ice surface reflectance factor

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

(4) Cloud in land region
Category: grain size distribution, cloud top height

(5) Cloud in ocean region
Category: extent, height

(6) Interaction between Aerosol and cloud

(7) Distribution of Ocean Coloring Matter Concentration

3.4.4 Algorithm development

The POLDER abroad the ADEOS-II is the same polarization and directionally of the Earth's reflectance instrument sensor as the one aboard the ADEOS satellite. Therefore, the same standard algorithm for the POLDER is prepared. Since the POLDER did not have correcting system for itself, mutual calibration/ validation with the GLI must be carried out. Consequently, algorithm improvement will be carried out from the point of view of not only for solo use of the POLDER, but also for mutual use of the POLDER with the GLI. Effective algorithm for each category of followings will be developed.

1. Air (oxygen) molecular absorption correction
2. Atmosphere (ocean/land) aerosol optical properties derivation
3. Cloud optical properties derivation
4. Earth' surface reflective properties derivation

Even higher accurate and precise estimates about atmospheric aerosol and clouds are possible over ocean. Even more advanced atmospheric correction algorithm development of ocean color analysis is possible. Especially, algorithm development and processing system creation of not only the GLI but also other mutual cooperative compound instruments is considered.

4. ADEOS-II SCIENTIFIC RESEARCH PLAN

4.1 Purpose

This chapter describes scientific objective expected based on observed parameters provided by the sensors aboard the ADEOS-II. The scientific objectives of the ADEOS-II are to use various sensors aboard comprehensively and to contribute to solving the Earth environmental changes. Such results won't come out nor exist without the science based on each of the sensors. Thus, there might be the scientific objective that overlaps with a scientific objective of the sensors mentioned above.

Since the ADEOS-II is the Earth environment observing satellite, Aeronomy, Oceanography, Hydrology, Cryology, and Vegetation are science in the relation. In another word, it is the 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 ocean that used to be difficult to be estimated.

Next, the most important thing is to establish the point of view to make that knowledge comprehensive. For this, it is indispensable to combine numerical models or ground validation data, and it is desired to develop technique and systematization that mobilized all knowledge and information we have. In another word, as the ADEOS-II science, it can say that solving climatic mechanism of the Earth environment based on establishment of this comprehensive technique is the total goals.

4.2 Aeronomy

4.2.1 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 cased its operation in the middle of its mission, so that basic objective of ADEOS-II with Aeronomy is long-term monitoring by continuing the ADEOS observations.

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

In addition, ADEOS-II will enable microwave observations, and the hydrologic cycle will be investigated on 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 atmosphere. Hydrogical transfer among atmosphere, water, and ground involves transformation among tree states. It is thus an important phenomenon that generates short-term atmospheric changes and long-term climatic change due to interaction of sensible heat/latent heat, exchange of heat between the atmosphere and ocean, and radiation properties due to its existence. 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 make rapid progress of estimate accuracy of 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, participate in related international projects such as GEWEX and CLIVAR. In recent years, researchers have pointed out the importance 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.

4.2.2 Investigation into water cycle involving clouds

In climate models, it is difficult to qualitatively assess clouds. On the whole, ADEOS-II seeks to at 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 reduced the ice grain size of the expanding anvil cloud, causing more sun light 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 that cloud grain size distribution can significantly effect radiation properties. Fortunately, GLI has channels that can estimate cloud grain size distribution. If the global distribution of cloud grain size were known, it would contribute to the understanding of 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 satellite and aircraft. It has not been proven whether this theory is right or wrong. If is right, it would be necessary to rewrite the radiant codes for atmospheric models. Likewise, we would not able to ignore the effects on atmospheric circulation. This is a problem was should immediately resolve. The 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. Nevertheless, 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. In particular, 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 point, joint observation by TMI and AMSR is indispensable.

4.2.3 Investigation into influence on aerosols

In cloud physics, aerosols have been of scientific interest as an atmospheric component and as a factor in cloud condensation nucleus and in 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 Intergovernmental Panel on Climate Change (IPCC)). Aerosols affects and restrain global warming by reflecting solar radiation due not only to the increase of aerosols but also to the increase of lower layer clouds caused by emitted aerosols. However, aerosols do not produce a “soot-covered effect” if you take the other view. If aerosols create black clouds, they will 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 greatly contributes to solving the global warming problem.

4.2.4 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 has 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 the organized ozone layer observations from space. In addition to the ozone layer, this sensor also monitors nitrogen oxide, CFC, and other atmospherics trace elements. Those data will give us important information, particularly for understanding atmospheric chemical reaction 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.

4.3 Oceanography

4.3.1 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 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 task 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 take a leading part in the research. Together they are two pillars in oceanography research by ADEOS-II.

Frequent abnormal weather phenomenons have increased social concern about climate change problems. To solve the climate change problems like this, it is necessary to understand the climate system. In recent years, we have rapidly been bearing that the ocean plays very important roles in the global climate system. The climate system is fundamentally considered as a water-energy cycle process. The roles of ocean in the process can be categorized into two parts: water-energy transfer between oceans and atmosphere and water-energy transfer below the oceans. 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 increase of carbon dioxide gas in the atmosphere has important subjects of 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 amount of the biogeochemical cycle of carbon compounds. Strong efforts to clarify the role of the ocean in global carbon cycle processes should thus be promoted. However, we are now at 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. Human must conduct research on ocean primary productivity on a global scale from the viewpoints of both environmental and food resources concerns.

4.3.2 Marine metrology and physical oceanography

4.3.2.1 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 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. Considering that basically only information about the sea surface can be observed, 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 sensor aboard ADEOS-II. The other one is a parameter of second –order that can be estimated from the several sensor together.

(1) First-order Parameter Calculation Algorithm Development

A Parameter considered as first-order surface fluxes is the near sea surface velocity. Here we will omit the specific explanation about the near sea surface velocity since we have already explained in the chapter of the GLI. 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 even under cloudy weather that can be provided by AMSR. Estimating sea surface temperature under cloudy weather was impossible with a thermal infrared radiometer. This used to be a very major implement to the progress of oceanography. AMSR is expected to provide continuous space-time sea surface temperature observations, 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 high by 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 method. For instance, estimating latent heat fluxes require saturation specific humidity, sea surface specific humidity, wind velocity, and etc. However sea-surface specific humidity is computed empirically using 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. Although most of fluxes data were supposed to be estimated using ADEOS, this was impossible due to the failure of ADEOS. Real acquisition of flux data will thus be made possible by ADEOS-II for the first time

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

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, we will meet a limitation. 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 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

It is necessary to evaluate estimated values sea surface fluxes by using in situ data acquired by buoys or the 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 fluxes input.

4.3.2.2 Investigation into ocean circulation mechanism

What are 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 from the point of view of 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 quantity of sea-surface fluxes or ocean circulation mechanism, which involves distribution in the ocean. A number of researchers input or assimilate surface fluxes obtained from the satellite into ocean circulation models and understand and predict these phenomena. These researchers perform monitoring. We emphasize here that developing a numerical model is essential for both research endeavor.

(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 the accuracy of 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, development of data assimilation system will enable us to predict changes in the Kuroshio Current. Highly accurate observations of sea-surface height using TOPEX/POSEIDON has rapidly advanced the data assimilation of the ocean circulation models 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 characteristic are named the 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 the satellite 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 pollutant and floating wreckages

The problems of tanker oil spills and the spread of illegally dumped pollutants have raised severe public concerns. Those are very significant problems for human beings. 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 Zone

We know that the ocean circulation greatly influences the fisheries industry. Thus, it is important to forecast accurately 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.

4.3.3 Marine biophysics

4.3.3.1 Estimates of biomass and productivity

Carbon-containing material is transformed from inorganic to organic elements by photosynthesis due to the 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 by a factor of two. 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 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 with the 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 taxon 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.

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

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

ADEOS made possible 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 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 has 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, it is expected to expand our horizons with regard to the relationship of the mechanism of constituent circulation and the ecosystem.

(2) Understanding of Constituents Circulation in Continental Shelf Regions

ADEOS enable 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 have the important influences on optic 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 constituents circulation and 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 being 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 to accurate research on how much of the organic materials produced by phytoplankton are supplied to marine organism resource, 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 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 area 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.

4.4 Hydrology

4.4.1 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 directly fluxes of the Earth's surface on a global scale and to collect information of precipitation and inland water content (soil moisture and snow cover) to estimate the data 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 foe 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 for the first time to globally observe soil moisture and snow in a fixed quantity, and to improve 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 and evaluate influences of climate on human activities. Moreover, the combination of TRMM products and improved accuracy in estimating inland precipitation using combing 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 interfere 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 water-heat cycle in the Eurasian Continent in order to predict and understand fluctuations in Asian monsoons. The comprehensive observation data covering very wide area that was previous impossible have been simultaneously acquired with the satellite data, and various analysis has been conducted. The success in water-energy cycle observation research based on close cooperative relationship 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 DAEOS-II data as well as effective algorithm development and validation.

4.4.2 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 by controlling transfer of energy to or from fluxes of infraction radiate, sensible heat, latent heat and underground heat by suppressing of 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 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 installed instruments 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 has started 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, gas 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 methods based on physics. Based on # 3, E.Njoke formulizes problems as three simultaneous equations and proposes a numerical solution methods. Koike invokes method # 2, building his argument on the facts that a numerical solution methods 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 changes in snow accumulation. Hahn and Shukula have shown that there is an inverse correlation between the snow cover area and during winter on the Eurasia Continent and precipitation during Indian monsoons the following summer. It has not yet been verified with 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.

A number of algorithms have been applied to estimate snow accumulation. Most of these are basically intended fro dried snow, estimating only extinction when radiation from the ground transmits into the layer of snow cover, estimating only extinction when emission due to scatters transmits into the layer of snow cover, or adding emission to it. Most of them used 19GHz or 37GHz. If information about grain size 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 snow accumulation calculation is also important, so Cheung has 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 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. It consequently will be possible to develop more quantitative 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. Until today, although real-time quantitative observation data for land-surface classification has been acquired, 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 and preparation of ground observation systems from long-tem aspects are required.

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 real 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 gause data, infrared data from geostationary satellite, and microwave radiometer data for the Global Precipitation Climate Project (GPCP) under WCRP/GEWEX. Creating of one-degree grid data sets also has been tried. However, the relationship between precipitation in land regions as 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 with observing precipitation over land are shown below.

1) Since the land surface has 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), a soil moisture, ground temperature, and vegetation water content calculation algorithm for land surfaces using information acquired at low frequencies (6.9 to 36.5GHz) has been proposed in recent years, and accuracy of estimating radiation rate of land surface has been improved. Moreover, by combing the low-frequency band and high-frequency band (85GHz), and algorithm to calculate the state of the land surface and precipitation system simultaneously has been developed. However, in 2), the vertical profile of precipitation has great influence, so active sensor 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, 3) is the task and algorithm development area expected to receive attention in the future.

The combination of 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 is expected. However, TRMM is limited to observing area between 35 degrees north and south latitude to acquire. Improved sampling frequency is also necessary precipitation data when changes are not remarkable. To solve this, it is planned to conduct observations performed 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 improvement of daily change observations and sampling frequency. This will enable providing basic data sets for global observation by GRM.

4.4.3 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 is macro hydrology models development 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-liner property. GAME seeks to improve the GCM, and research focusing on a meso-sale grid several tens of kilometers in size has been promoted. This is on the same scale as AMSR’s spatial resolution at 6.9GHz. It is 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 fro 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 atmosphere

4.5 Cryology

4.5.1 Development of cryology with ADEOS-II

The tendency of increasing temperature since the Little Ice Age of 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 ice sheet and the increasing outflows of icebergs. For this reason, continuous, long-term observations to investigate the process 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 it understand fluctuation in the distribution of the snow-ice sphere. However, use of microwave 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, glacier and ice sheet and changes in the ice sheet edges can be mapped to monitor the snow-ice sphere change due to the greenhouse effect. Aldedo of ice sheet and change in the characteristics of surface snow cover can be observed by using SeaWinds and POLER.

Earth glaciers have 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 yet 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 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. I addition, spectrum information obtained from GLI and POLDER us useful for detecting minerals in the snow-ice surface and dirt sue to bio-bacteria activity based on changes in the albedo and spectrum. Polarization information provided by POLDER is useful for estimating atmospheric correction and changes in albedo of the snow-ice surface.

The long-wave multiple polarization information provided by AMSR helps understand the interaction of snow-ice areas 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.

Investigation of the interactions among sea ice in the polar regions, the ocean, and the biosphere are subjects for sea-ice research. Monitoring 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.

4.5.2 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 phenomenon 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 algorithm by AMSR using airborne microwave radiometer (AMR) data, for airborne observation and the microwave radiometer (SSM/I) data of DMSP. Calibration and data creation method are to be established to guarantee quality of data.

(1) Snowfall distribution, snowfall area, permafrost

Investigating the changes in snow cover distribution and area is very important for monitoring greenhouse effects. Since the rate of radiation is not well known for land, there are many research themes. 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 from water to ice or from ice to water, it will be relatively easy to detect the surface condition.

(2) Sea-ice distribution/sea ice density

Seasonal changes of sea ice regions surrounding Antarctica are significant. A vast area of 3 million 500 thousand 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 emissivity 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, emmissivity 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 the observations using AMR to truth data.

(3) Fluctuation in ice sheet distribution

Continuous microwave observations of changes in ice-sheet distribution in Greenland and Antarctica are important for determining the influences of global warming. The observations of snow accumulation on ice sheet, 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 the observations of ice sheet mass balance in the Antarctic, changes due to accumulation of ice contained in ice sheets in inland regions will contribute 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 conduct basic research algorithm 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 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.

4.5.3 Science with optical observations

(1) Snowfall distribution/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 with further improve the accuracy. Also, 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/sea-ice concentration

It will be possible to roughly estimate the overall 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, by using AMSR and GLI together, highly accurate estimates of sea-ice distribution can be expected. Knowing the surface state of sea ice (snow cover distribution and emmisivity above the sea ice) and surface temperature will be essential for determining the heat balance of the sea-ice sphere. Furthermore, such a combination will be able to categorize the thickness of sea ice and types of ice bar.

(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 area 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 for monitoring gigantic iceberg 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 heat balance on the Earth and global warming. In particular, ice-albedo/feed back 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 of models of wavelength, snow grain size, snow shapes, and snow cover depth has been advanced with albedo. It is expected to become possible to estimate snow cover distribution and snow depth by observing albedo. Since the GLI has 36 wavelength for observing snow-ice regions, it will bring important data that may reveal relationships between detailed snow ice state of the surface and albedo.

(7) 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 temperature compared to the data provided. It is additional information for analysis on combination with other wavelength ranges.

(8) 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, it is known that the albedo in the near infrared range increases when a blizzard occurs. It thus might 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, it is expected to reveal detailed relation the snow-ice state of the surface has with albedo.

4.6 Vegetation

4.6.1 Importance of observing vegetation with ADEOS-II

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

Vegetation plays an important role in energy and water budget 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 and 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 comprehensive by understand the Earth's environment.

4.6.2 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 area, and vegetation has been influenced greatly by human beings. This results in a global energy balance. The albedo of forest area is 0.11 or less. In comparison, the albedo of soil in bare land areas is 0.5 or more. Because changes vegetation influence the Earth's energy balance and cycle, it is very important to estimate vegetation change.

Vegetation significantly influences land-water behavior in the hydrologic cycle process. All vegetation have 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 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.

4.6.3 Assumption of carbon cycle and plant primary productivity

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

The global vegetation maps widely used in the most are based on the normalized difference vegetation index maps (NDVI) calculated by the NOAA/AVHRR. The AVHRR is sensible to soil colors but greatly disturbed by snow cover. It is thus necessary to develop a new method to estimate biomass by 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 carbon-fixing ability from plants and contribute to estimating carbon circulation. At same time, we can obtain important data that contributes to estimates of the maximum population that will be able to live on the Earth.

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

4.6.4 Monitoring greenhouse effects

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

It is important to estimate conditions in marshy areas of Siberia and to calculate the greenhouse gas methane discharged from marshy areas to understand the current global warming situation and to predict it in the future. Monitoring such marshy areas will be performed using global sensor AMSR and GLI.

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

4.6.5 Contribution to vegetation research and practical use

It is important to properly estimate agricultural area to determine reserves food to quickly grasp 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 the agricultural agencies and organizations in each country. However, it is now necessary to perform things more quickly and precisely, and use of Earth-observing satellite has been considered.

It is important to estimate situation of 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 area 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 the 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 forest and grasslands and regions made arable by slash-and-bum methods. We will also be able too create biomass maps. These frequent observations and moderate high resolution of GLI will enable us to estimate emergency situation, such as forest fires.

GLI will play a central role in research vegetation.

4.7 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 these 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 SeaWind 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. Estimating cloud water and cloud grain size distribution by complex analysis of AMSR and GLI data.
2. Analyzing aerosols over oceans and land by complex analysis of GLI and POLDER data.
3. Estimating snow cover and sea ice distribution by complex analysis of the AMSR and the GLI.
4. Improving the estimate accuracy of water using AMSR and GLI.
5. Improving the estimate accuracy of sea surface conditions, such as sea-surface temperature, sea near-surface wind, and surges by combining AMSR and GLI.
6. Improving the estimate accuracy of vegetation biomass by combining GLI 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 the increase of data does not simply mean improved understanding.

(1) Data are mutually 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 physical aspects. It is therefore necessary to validate the data which developing an algorithm.

Considering the above, practical approach to comprehensive 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 subject that we can understand now recognizing like #1 to #6.

(2) We should consider algorithm development for sour-dimension analysis. We can say that combined of use of satellite data and the climatic models is a key to comprehensive by using satellite data. 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 thought about it.

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

4.8 Combination of remote sensing data with numerical value model

In the previous chapter, we stated that combing 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 approximation. 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 s 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 of other projects like the Earth simulator is necessary.

Furthermore, basic parameters like wind and temperature and various other parameters like clouds and aloud water, and soil moisture needed for describing climate system tend to be observed using the same satellite. However, to estimate these new parameters over a large area from satellite data, numerical models are still necessary. 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 simultaneously all of these data 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. By using such cloud water values, the accuracy of cloud water can be improved.

Another approach is to estimate quantities like soil moisture, which is not observed by 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 retrieves 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 combing analysis, numerical models, and satellite data suitable for this new age. 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 uses a scheme considered most likely to be right, though not fully satisfactory, and it has been impossible to make 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 scheme of models by using cloud water and cloud obtained from ADEOS-II. Consequently, improving forecasting accuracy of numerical models will improve, accuracy of primary estimated values for cloud and cloud water obtained from ADEOS-II data as well. This will improve the accuracy of cloud and cloud water. Thus, combing of models and satellite data enables improving accuracy of both.

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

Satellite 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, and oceanography worldwide have been looking forward it into 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 as on the ocean surface.

4.9 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 scientific project having definite scientific objective and will conduct research by combing various data such as satellite observations, ground observation data, and numerical modeling. This scientific project must be open to researcher worldwide and must incorporate an implement 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. Since it used to be difficult it implement a global scale field campaign encompassing land, atmosphere, and ocean data, data for validation was limited. 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, has proposed a satellite launch project with research objectives. Nonetheless it is rare to implement field observations simultaneously with 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, was performed in the Tibet plateau and Thailand, and comprehensive, valuable data for energy-water cycle research was acquired. Based in this cooperative and successful research, it is even more desirable to establish as 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 observational 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 subprogram. GEWEX investigates this global energy-water cycle, modeling, and evaluating influence on water resources. On the other hand, CLIVAR seeks to pursue long-term prediction for 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 drives and modifies 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-scale mountains make this impossible. As a result, the concept of observing 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 practical group work of the WCRP and satellite organizations and to promote the research of climate and water resource.

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 spatial 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 satellite is necessary to acquire data for algorithms and data set validation and to establish global satellite technology. These experiments will contribute to research on seasonally 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 seeks to effective by use the GEWEX heritage, adjust the observation plan of the on-going LIVAR, revise the plan concept if necessary, perform intensive observations in the same time fame cooperation with satellite ground validation experiments and the weather forecast organizations that are supported by space agencies.

5. POSTSCRIPT

Here, we have summarized the ADEOS-II science plan ver. 2. Although the scientific objectives of ADEOS-II are spectacular, this document doesn't seem to be satisfactory for implementing practical work. To describe the practical aspects, the implementation plan will be revised several times in the future. We hope that we will able to achieve every scientific objective stated in this science research project by one means or another.

However, the project is human effort after all. Even though scientific objective are right and the project is well planned, the research won't progress if there are no people to participate. In the present circumstances, Japan suffers an extreme lack of researchers for this work. We earnestly hope that many people will read the ADEOS-II science plan and participate in this project.

Appendix

1.1 ILAS-II

1.1.1 Science objectives

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

Responding to this problem, the international controls on CFCs and other chemical components producing and using them have implemented. By the mid 1990s, the tendency of increasing concentration of some CFCs in the atmospheric began to slow down and seemed to even be decreasing. Chlorine in the stratosphere, which destroys the ozone layer, will continue to increase over the next decade and then start to decrease. If 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 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 atmospheric trace components, temperature, air pressure, and aerosol/cloud regions in the stratosphere in the polar regions, involving ozone chemistry. 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 acquired valuable data from the observations for about eight months. The Ministry of Environment decided to launch ILAS-II on ADEOS-II in FY2000 in order to continuously by observe the ozone layer, and at the same time, to make an additional category of measurements and improve accuracy.

The scientific objectives of the ILAS-II are (1) to monitor changes in the layer of ozone, and (2) to investigate the ozone layer chemistry and physical processes, like those of ILAS. The wavelength of the spectroscope on ILAS-II and the to measured objects are shown in Table 1.1-1.

Table 1.1-1 Measuring wavelengths of the ILAS-II sensor and categories

Channel	Wavelength (frequency)	Objects
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	12.80-12.83μm (781-779cm^{-1})	$ClONO_2$
4	753-784μm (13280-12755cm^{-1})	Temperature, atmospheric concentration, aerosol

"Aerosol" includes Polar Stratospheric Cloud (PSC.) Also, data are measured at altitudes of 10 to 60 km (sequence of measurement 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 56 to 70 degrees north latitude and 63 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 cloud observe O_3, HN_3, NO_2, N2O, CH4, H_2O gas components that ILAS are important small components for understanding physical 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, measuring temperature is indispensable.

Measuring $ClONO_2$, which act as a chlorine atom reservoir that destroys 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 H2O 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.

1.1.2 Standard products

The principles of ILAS-II measurements are based on the 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. This means that the 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 1.1-2).

Table 1.1-2 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”

1.1.3 Research products

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