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AMSR-E Data Users Handbook

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Japan Aerospace Exploration Agency

Global environment change has become a worldwide concern in recent years. In order to clarify such environmental change, in the U.S., satellites of the Earth Observing System (EOS) series have been developed for the purpose of monitor the Earth environment using remote sensing technology from space. "Aqua" is the second satellite of the EOS series. "Advanced Microwave Scanning Radiometer for EOS (AMSR-E)" of JAXA is loaded onto "Aqua" as a joint mission between Japan and the U.S.

Aqua was launched by a Delta 2 rocket in May 2002 from Vandenberg, California in the U.S, and is in a circular orbit of altitude 705 km, inclination angle 98 degree and period 99 min.

Since one month after the Aqua launch, AMSR-E observation data has been received at the NASA ground stations at Alaska in the U.S. and Svalbard Island in Norway, processed to de-packet data at NASA/GSFC and transmitted to JAXA/EOC by network.

JAXA had conducted calibration and validation of these AMSR-E observation data for about one year. As the result, the AMSR-E level 1 product was available to distribute to public users since June 2003, and higher level products were available since September 2003. After that, JAXA continues to improve product processing algorithm. As of March 2009, the latest version of AMSR-E products is version 2 for level 1 and version 6 for higher level products.

The purpose of this handbook is to provide users with necessary information for proper utilization of AMSR-E products. We hope AMSR-E products as described in this handbook contribute to studies on global environment change monitoring, preservation and so on.

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1 INTRODUCTION

It is well known that the earth environment consists of the interconnection among the ocean, the land, the atmosphere and the organism on the earth. To clarify the earth environment as a system, continuous and global observations are essential. Therefore, many countries are proceeding the project under international cooperation. As a part of the project, NASA developed the EOS Aqua satellite that was put into the orbit whose Ascending Node local time is PM. Also, JAXA developed the ADEOS-II satellite that was put into the orbit whose Descending Node local time is AM.

AMSR-E (Advanced Microwave Scanning Radiometer for EOS Aqua) was developed by JAXA and is aboard Aqua. AMSR-E was developed based on AMSR that JAXA had developed for the ADEOS-II satellite.

AMSR-E and AMSR are the radio sensors that precisely measure faint radio waves radiated from the earth surface and atmosphere by themselves with multiple frequency bands. Their purpose is to understand the global water circulation. Different from optical sensors, radio sensors can always observe regardless of the weather condition or the daylight condition. Putting AMSR and AMSR-E into AM and PM orbits respectively enable us to grasp the environment change within a day. AMSR and AMSR-E are expected to greatly contribute to better understanding of the earth environment system.

1.1 Purpose

This handbook provides the necessary information to the user to utilize AMSR-E data including information related to standard products and also introduces reference information such as the Aqua spacecraft, onboard instruments, and ground systems.

1.2 Scope

This document consists of 5 sections and 3 appendixes:

Section 1:	Describes purpose, scope, and overview of Aqua and AMSR-E mission.
Section 2:	Introduces the specifications of the Aqua satellite system and mission instruments, the outline of Aqua orbit, and its operation policy. Moreover, detail specification of AMSR-E instrument is introduced.
Section 3:	Introduces the outline of the ground systems of JAXA and NASA.

Section 4: Explains the outline of AMSR-E products provided by JAXA and their data format.

Section 5: Presents the outline of the AMSR-E product services to be provided by JAXA/EOIS.

Section 6: Present the result of AMSR-E mission after launch, including initial on-orbit checkout, calibration and validation and major observation results.

Appendix 1~3: Contain the acronym list, reference information and product format.

1.3 Mission Overview

1.3.1 Aqua Mission

Aqua is one of a series of space based platforms that are central to NASA's Earth Science Enterprise (ESE), a long-term study of the scope, dynamics and implications of global change. The Aqua program is composed of Aqua and other spacecraft[*1] and a data distribution system (ESDIS: Earth Science Data and Information System). The Aqua project is an international project with cooperation of the United States, Japan and Brazil in development of the spacecraft and ground system. Additionally, multidisciplinary teams of scientists and researchers from North and South America, Asia, Australia and Europe put the data to work.

The focus for the Aqua Project is the multi-disciplinary study of the Earth's Interrelated Processes (atmosphere, oceans, and land surface) and their relationship to earth system changes. Comprehensive measurements taken by its onboard instruments allow scientists to assess long-term change, identify its human and natural causes and advance the development of models for long-term forecasting.

Figure 1.3-1 Appearance of Aqua on Orbit

[*1] : EOS series satellite includes EOS Terra (launched in December 1999) and EOS Aura (launched in July 2004)

The major targets and purposes for Aqua observation are shown in Table 1.3-1 about each field of the atmosphere, the ocean, land area, and cryosphere.

Table 1.3-1 Major Targets and Purpose of Aqua Observation

Category		Observation Target and Reason
Atmosphere		
	Targets	Aerosol , Temperature, Humidity, Cloud, Precipitation and Radiative energy fluxes
	Reason	Atmospheric temperatures and humidities are central variables for local and global weather conditions. Aerosols are tiny particles of water and solid matter (e.g. sea salt, volcanic ash) suspended in the atmosphere. They influence weather patterns by absorbing or scattering solar energy and by attracting condensation to form clouds. Clouds are the major source of fresh water for the planet. They also impact the climate by reflecting solar energy into space (cooling) and by trapping heat emitted by the Earth (warming).
Ocean		
	Targets	Ocean Color, Sea Surface Temperature and Sea Surface Wind
	Reason	Variations within the oceans can affect fisheries around the world, and the amount of spatial distribution of heat and chemical exchanges between the ocean and atmosphere. Variations in sea surface temperatures in particular can indicate changes that can impact ocean productivity and weather on a global scale.
Land		
	Targets	Fire occurrence, Land cover and land use change, Surface temperature, Surface wetness, Vegetation dynamics, Volcanic effects
	Reason	Land cover type (e.g. vegetation, crops) and extent influence the climate regionally and globally. Variations in the climate are both affected by and contributors to land use change.
Cryosphere		
	Targets	Snow cover, Sea Ice
	Reason	Snow cover influences the climate by reflecting light away from the Earth and by keeping heat from escaping from the soil, allowing the formation of cold air masses and limiting frost penetration into the ground. The amount of snow cover may indicate forthcoming flooding or drought. Sea ice affects the climate through its ability to insulate water against heat loss and strong reflection of solar energy, reducing the amount of solar radiation absorbed at the Earth's surface.

Aqua was launched by a Delta 2 rocket at 2:55 am on May 4, 2002 (PDT) from Vandenberg, California in the U.S. After launch, Aqua was placed into an orbit, which covers the earth globally every 16 days, and continues to observe data required for an elucidation of the process which affect the earth environment over the design life (6 years). The observation data is recorded to the data recorder on the satellite, and then it is transmitted to the ground via X band approximately once an orbit and received at EOS Polar Ground Stations (EPGSs), which are located in Alaska, US and Svalbard, Norway. The received observation data undergoes fundamental preprocessing at NASA GSFC(Goddard Space Flight Center) and is then distributed to the processing organization of each sensor data including JAXA which performs data processing of AMSR-E

Moreover, Aqua mission operation planning and scheduling, tracking and control (such as monitoring satellite health, orbit determination, attitude control and so on) are also performed at GSFC. In addition operation commands are transmitted and HK telemetry data are received mainly at the EPGSs, but this is also performed as a backup operation at White Sands Complex (WSC) via the Tracking and Data Relay Satellite (TDRS).

1.3.2 AMSR-E Mission

The AMSR-E is a twelve channel, six frequency total power passive microwave radiometer system. It measures brightness temperatures at 6.925, 10.65, 18.7, 23.8, 36.5, and 89.0 GHz. Vertically and horizontally polarized measurements are taken at all channels. AMSR-E measures geophysical parameters supporting several global change sciences and monitoring efforts. Here, various physical parameters observed by AMSR-E, and their observation purposes are shown in Table 1.3-2.

Table 1.3-2 Observation Targets and Purposes of AMSR-E

Target	Purpose
Precipitation	Precipitation has extremely important roles, through provision of water to the biosphere and as an air conditioning agent that removes excess heat from the surface (through evaporation) and making the Earth habitable. The AMSR-E measures rain rates over both land and ocean. Over the ocean, the AMSR microwave frequencies can probe through smaller cloud particles to measure the microwave emission from the larger raindrops.
Sea Surface Temperature	Over the ocean, AMSR-E provides sea surface temperatures (SST) through cloud cover of no precipitation, supplementing infrared-based measurements of SST that are restricted to cloud-free areas. SST fluctuations are known to have a profound impact on weather patterns across the globe, and the AMSR's all-weather capability could provide a significant improvement in our ability to monitor SST's and the processes controlling them.
Water Vapor	The total integrated water vapor of the atmosphere is measured over the ocean, which is important for the understanding of how water is cycled through the atmosphere. Since water vapor is the Earth's primary greenhouse gas, and it contributes the most to future projections of global warming, it is critical to understand how it varies naturally in the Earth system.
Wind Speed	Ocean surface roughness is also measured by AMSR-E, which is converted into a near-surface wind speed. These winds are one important component of how much water is evaporated from the surface of the ocean.
Cloud Liquid Water	AMSR-E cloud water estimates over the ocean help studies of whether clouds, and their ability to reflect sunlight, increase or decrease under various conditions. This could be an important feedback mechanism that either enhances or mitigates global warming, depending on whether clouds increase or decrease with warming.
Sea Ice	Monitoring of sea ice parameters, such as ice type and extent, is necessary to understand how this frozen blanket over the ocean acts to change climate through its ability to insulate the water against heat loss to the frigid atmosphere above it, and through its ability to reflect sunlight that would otherwise warm the ocean.
Snow Cover	In much the same way as the AMSR can see large ice particles in the upper reaches of rain systems, it also measures the scattering effects of snow cover. These measurements are empirically related to snow cover depth and water content based upon field measurements. Like sea ice, snow cover has a large influence on how much sunlight is reflected from the Earth. It also acts as a blanket, keeping heat from escaping from the underlying soil, and allowing deep cold air masses to develop during the winter. It further provides an important storage mechanism for water during the winter months, which then affects how much surface wetness is available for vegetation and crops in the spring.
Soil Moisture	Wet soil can be identified in the AMSR observations if not too much vegetation is present. Surface Wetness is important for maintaining crop and vegetation health, and its monitoring on a global basis would allow drought-prone areas to be monitored for signs of drought.

AMSR-E always operates in the normal mode after Aqua routine operation start on orbit. AMSR-E observation data is received at EPGSs approximately once per orbit together with the other sensor data, and the data is transmitted to Earth Observation Center (EOC) of JAXA after performing fundamental pre-processing by GSFC. At JAXA/EOC, the AMSR-E observation data is processed to brightness temperature (Low level processing), and then various physical parameters are calculated (Higher level processing). And these products are delivered to users as JAXA standard products. Moreover, AMSR-E HK telemetry data is transmitted from GSFC to JAXA/EOC via network and it is used for monitoring of AMSR-E instrument operation status.

Additionally, the AMSR-E brightness temperature data processed at JAXA/EOC is delivered to NASA. These AMSR-E data is processed to various physical parameters at Marshall Space Flight Center (MSFC) of NASA and provided to users as NASA standard products.

1.4 Responsibilities of the Related Countries

As described in the section 1.3, mainly NASA promotes the Aqua project as an international project between United States, Japan and Brazil.

Table 1.4-1 shows the roles and responsibilities of US, Japan and Brazil on the development and operation of the Aqua satellite and instruments, and also shows the responsibilities on data acquisition, processing.

Table 1.4-1 Roles and Responsibilities of US, Japan and Brazil

Roles		Responsible Country		
		U.S.	Japan	Brazil
Development of Spacecraft and Instruments				
Spacecraft Bus		O		
Advanced Microwave Scanning Radiometer for EOS Aqua (AMSR-E)			O	
Atmospheric Infrared Sounder (AIRS)		O		
Advanced Microwave Sounding Unit (AMSU)		O		
Humidity Sounder for Brazil (HSB)				O
Clouds and the Earth's Radiant Energy System (CERES)		O		
Moderate Resolution Imaging Spectrometer (MODIS)		O		
Operation of Spacecraft and instruments				
Launch		O		
Satellite Operation Planning, Tracking and Controlling		O		
Satellite and Instrument Status Monitoring		O	O	O
Data Acquisition and Processing				
Data Acquisition		O		
Pre-processing of All Instruments Data		O		
AMSR-E Data Processing	Low Level		O	
	Higher Level	O	O	
AIRS Data Processing		O		
AMSU Data Processing		O		
HSB Data Processing		O		O
CERES Data Processing		O		
MODIS Data Processing		O		

1.5 Development Policy of AMSR-E Data Processing Algorithm

The AMSR-E high level product processing algorithm was contemplated and developed by the joint science team of Japan-U.S. The algorithm development by the joint science team examines an algorithm in both Japan and U.S. at first, and develops JAXA algorithm and NASA algorithm, respectively. At a certain stage, comparison and examination of these algorithms are done, and, finally they are unified as a Joint algorithm.

Before a joint algorithm is established, AMSR-E data is processed at both JAXA and NASA, based on both JAXA and NASA algorithms. The AMSR-E products processed by JAXA algorithm is delivered to users as “JAXA Standard Products”, and NASA’s one is delivered as “NASA Standard Products”.

After a joint algorithm is established, all AMSR-E data is processed at only JAXA and the products are delivered as “AMSR-E Standard Products” to not only JAXA users but also NASA users.

2 OVERVIEW OF THE AQUA SPACECRAFT

2.1 Spacecraft

The Aqua science instruments are hosted by TRW's modular, standardized spacecraft bus. It accommodates payload refinement and or replacement without impacting the design or the development schedule. Moreover, this bus system is scalable to meet the needs of future remote sensing missions (including EOS Aura). The spacecraft is built of lightweight composite materials to allow for increased payload weight and reduced launch costs. The Earth-facing side of the spacecraft is devoted solely to the Aqua instruments, maximizing fields-of-view.

Figure 2.1-1 provides a graphical description of the Aqua satellite and Table 2.1-1 shows its main characteristics.

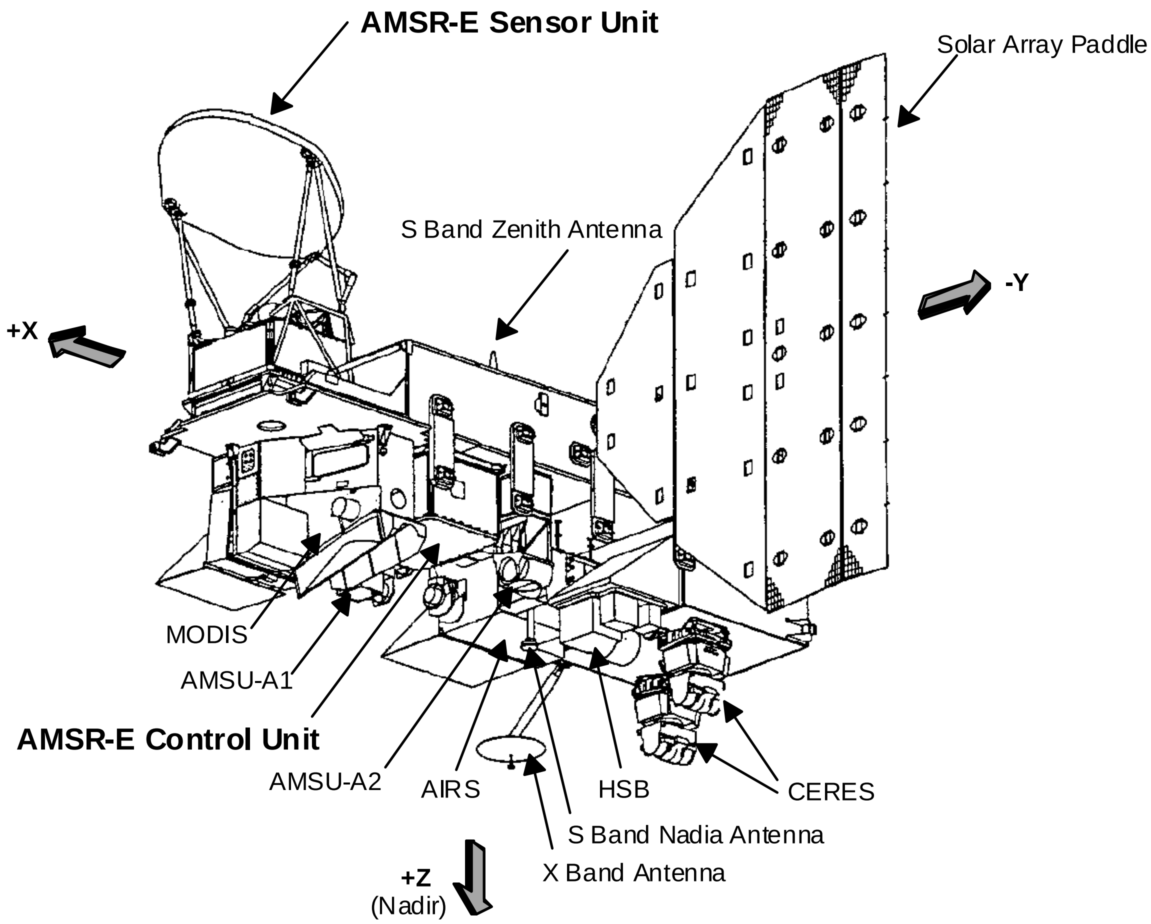


Figure 2.1-1 Aqua Spacecraft

Table 2.1-1 Aqua Main Characteristics

Item		Characteristics
Scale	Stowed (at Launch)	2.68m / 2.49m / 6.49m (X/Y/Z)
	Deployed (on Orbit)	4.81m / 16.70m / 8.04m (X/Y/Z)
Weight	Total (at Launch)	2,934 kg
	Satellite Bus	1,750 kg
	Mission Instruments	1,082 kg
	Propellant	102 kg
Electric Power	End of Mission Life	4,860 W
Life	Design Life	6 years
Orbit	Type	Sun Synchronous Sub-Recurrent
	Altitude	705 km
	Inclination	98.2˚ ±0.1˚
	Period	98.8 min.
	Recurrent Period	16 days
	Revolutions per Recurrent Period	233 rev./16 days
	Orbit Interval on Equator	Approx. 140 km
	Local sun time at descending node	PM1:30 ±15 min.
Launch	Launch Vehicle	Delta II Class
	Launch Site	Vandenberg Air Force Base
	Launch Date and Time	2:55 am May 4, 2002 (PDT)

2.2 Overview of the Onboard Instruments

The observatory on Aqua includes 6 science instruments, namely Advanced Microwave Scanning Radiometer for EOS Aqua (AMSR-E), Atmospheric Infrared Sounder (AIRS), Advanced Microwave Sounding Unit (AMSU), Humidity Sounder for Brazil (HSB), Clouds and the Earth's Radiant Energy System (CERES) and Moderate Resolution Imaging Spectrometer (MODIS)

2.2.1 Advanced Microwave Scanning Radiometer for EOS (AMSR-E)

(1) Mission Overview

AMSR-E is a microwave radiometer for six frequency bands from 6.9GHz to 89GHz. Each frequency band is monitored by vertical and horizontal polarized wave. AMSR-E scans the Earth's surface by mechanically rotating the antenna and acquires radiance data of the Earth's surface.

The aperture diameter of AMSR-E antenna is 1.6m, and its spatial resolution is about 5km in the 89GHz band and about 60km in the 6.9GHz band of the largest wavelength. It conically scans and keeps an angle of incidence on the earth surface (a nominal of 55 degrees) to be constant and minimizes the effect of sea surface wind on the sea surface temperature and accomplishes a swath width of about 1450km. Further, AMSR-E has a function to acquire radiance temperatures of deep space (about 2.7K) for calibrating observation data and high temperature calibration source.

- Development Agency: JAXA (Japan Aerospace Exploration Agency)
- Observation Target: Water Vapor, Cloud Liquid Water, Precipitation, Sea Surface Wind, Sea Surface Temperature, Sea Ice, Snow Cover, Soil Moisture

(2) Main Characteristics

Figure 2.2-1 provides the AMSR-E appearance, and Table 2.2-1 shows the main characteristics.

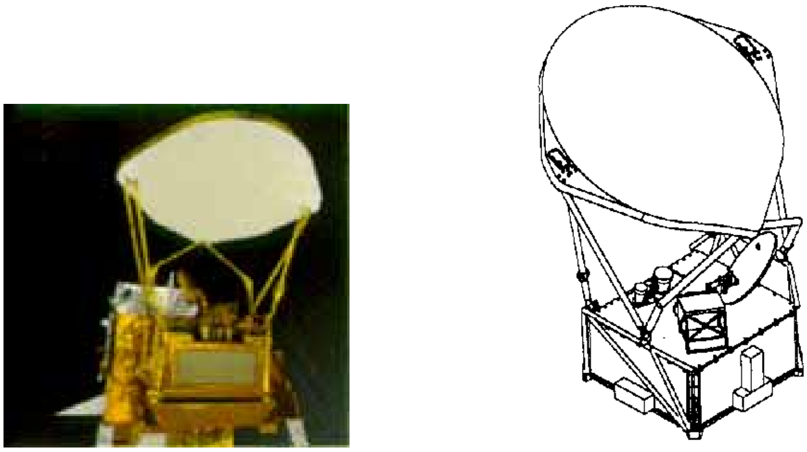


Figure 2.2-1 AMSR-E Appearance

Table 2.2-1 AMSR-E Main Characteristics

Items		Characteristics						
Observation Frequency		6.925 GHz	10.65 GHz	18.7 GHz	23.8 GHz	36.5 GHz	89.0 GHz A	89.0 GHz B
Spatial Resolution		50 km		25 km		15 km	5 km	
Band Width		350 MHz	100 MHz	200 MHz	400 MHz	1000 MHz	3000 MHz	
Polarization		Horizontal and Vertical						
Incident Angle		55˚						54.5˚
Cross polarization		less than –20 dB						
Swath Width		more than 1,450 km						
Dynamic Range		2.7-340 K						
Precision		1 K (1) as target						
Sensitivity		0.34K	0.7K	0.7K	0.6K	0.7K	1.2K	
Quantifying Bit Number		12 bit	10 bit					
Data Rate		87.392 Kbps						
Electric Power		350 ±35 W						
Weight		324 ±15 kg						
Size	Antenna Unit	1.95 x 1.7 x 2.4 m						
	Control Unit	0.8 x 1.0 x 0.6 m						

2.2.2 Atmospheric Infrared Sounder (AIRS)

(1) Mission Overview

AIRS is designed to meet the NOAA requirement of a high-resolution infrared (IR) sounder to fly on future operational weather satellites. AIRS, AMSU, and HSB measurements are analyzed jointly to filter out the effects of clouds from the infrared data in order to derive clear-column air temperature profiles and surface temperatures with high vertical resolution and accuracy.

AIRS is a high-resolution sounder which consists of the IR Spectrometer and the Visible and Near IR sensor. The IR Spectrometer covers the spectral range between 3.74 and 15.4 μm to measure simultaneously in 2,378 spectral channels (spectral resolution ($\lambda/\Delta\lambda$) is 1,200). The Visible and Near IR sensor covers the spectral range between 0.4 and 1.0 μm to measure in 4 channels. The high spectral resolution enables the separation of the contribution of unwanted spectral emissions and, in particular, provides spectrally clean "super windows," which are ideal for surface observations.

- Development Agency: NASA/JPL (Jet Propulsion Laboratory)
- Observation Targets: Atmospheric Temperature Profiles, Humidity Profile, Total Precipitable Water, Fractional Cloud Cover, Cloud Top Height, Cloud Top Temperature, Skin Surface Temperature, Day/Night Surface Temperature Difference, Outgoing Day/Night Longwave Surface Flux, Sea Surface Temperature, Precipitation Estimate, Tropopause and Stratopause Height, Outgoing Longwave Spectral Radiation, Cloud Optical Thickness, Surface Spectral Emissivity, Surface Albedo, Net Shortwave Flux

(2) Main Characteristics

Figure 2.2-2 provides the AIRS appearance, and Table 2.2-2 shows the main characteristics.

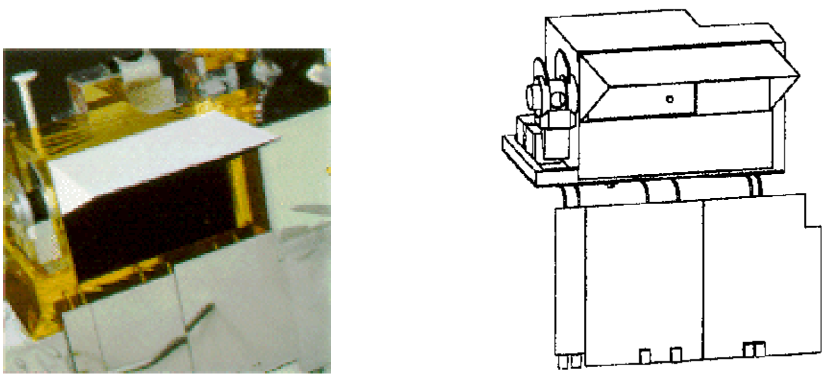


Figure 2.2-2 AIRS Appearance

Table 2.2-2 AIRS Main Characteristics

Items		Characteristics
IR Spectrometer	Observation Wave Length	3.74 - 15.4 m
	Spectral Resolution	1,200 λ/Δλ
Visible and Near IR	Wave length	0.4 - 1.0 m
Spatial Resolution		Horizontal: 13.5 km (Nadir) Vertical: 1 km
Accuracy		Temperature: 1 K Emissivity: 0.05
FOV / IFOV		±49.5˚ (Cross track) / 1.1˚
Swath Width		1650 km
Data Rate		1.30 Mbps
Electric Power		256 W
Weight		156 kg
Size		139.7 x 151.2 x 76.2 cm

2.2.3 Advanced Microwave Sounding Unit (AMSU)

(1) Mission Overview

AMSU is designed primarily to obtain profiles of stratospheric temperature and to provide a cloud-filtering capability for tropospheric observations. AMSU observes in a 23.8 – 89 GHz frequency range by 15 channels in which each has the beam width of 3.3˚. Channels 3 to 14 on AMSU are situated on the low-frequency side of the oxygen resonance band (50-60 GHz) and are used for temperature sounding. Channel 1, located on the first (weak) water vapor resonance line, is used to obtain estimates of total column water vapor in the atmosphere. Channel 2, at 31 GHz, is used to indicate the presence of rain. Channel 15 on AMSU-A, at 89 GHz, is used to indicate precipitation, using the fact that at 89 GHz ice more strongly scatters radiation than it absorbs or emits.

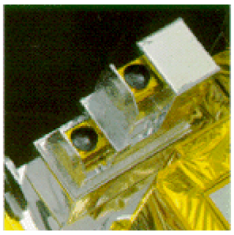
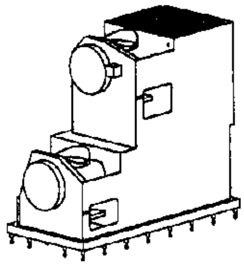
AMSU is divided into two modules, AMSU-A1 and AMSU-A2, channels 3-15 are assigned to AMSU-A1, and channels 1 and 2 are assigned to AMSU-A2.

The observation data by the channels 1 and 2 of AMSU is used for calibration of the air humidity data of AIRS.

- Development Agency: NASA/GSFC (Goddard Space Flight Center)
- Observation Target: Atmospheric Temperature, Humidity, etc.

(2) Main Characteristics

Figure 2.2-3 provides the AMSU appearance, and Table 2.2-3 shows the main characteristics.

AMSU-A1



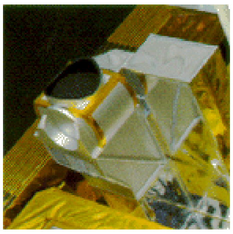
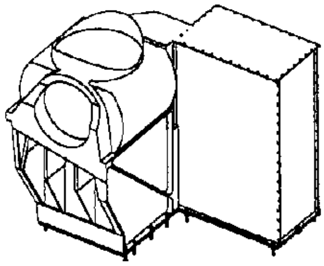
AMSU-A2



Figure 2.2-3 AMSU Appearance

Table 2.2-3 AMSU Main Characteristics

Items		Characteristics
AMSU-A1	Observation Frequency	Channel 3 - 14 : 50 - 60 GHz Channel 15 : 89 GHz
	Data Rate	1.316 Kbps
	Size	65.5 x 29.9 x 59.2 cm
AMSU-A2	Observation Frequency	Channel 1 : 23.8 GHz Channel 2 : 31 GHz
	Data Rate	0.350 Kbps
	Size	54.6 x 64.9 x 69.7 cm
Spatial Resolution		40 km (Nadir)
FOV / IFOV		±49.5˚ / 3.3˚
Swath Width		1650 km
Electric Power		125 W
Weight		100 kg

2.2.4 Clouds and Earth's Radiant Energy System (CERES)

(1) Mission Overview

CERES measures the radiative flows at the top of atmosphere (TOA). The CERES experiment attempts to provide a better understanding of how different cloud processes, such as convective activity and boundary-layer meteorology, affect the TOA fluxes. This understanding help determine the radiative flux divergence, which enters directly into physically based, extended-range weather and climate forecasting. CERES also provides information to determine the surface radiation budget, which is important in atmospheric energetics, studies of biological productivity, and air-sea energy transfer.

CERES instruments use a scanner very similar to ERBE (Earth Radiation Budget Experiment) of a NOAA satellite, and its accuracy is improved by adopting bi-axial scan mode. Moreover, the same sensors are flown on TRMM (Tropical Rainfall Measuring Mission) and Terra, which are the EOS series satellites, and are operational at this time. However, about CERES on TRMM, a fault voltage flow occurred after launch, and acquisition of the data is limited to intermittent operation.

The Terra and Aqua each carry two identical instruments: one operates in a cross-track scan mode and the other in a biaxial scan mode (TRMM carries only one instrument).

- Development Agency: NASA/LaRC (Langley Research Center)
- Observation Target: Radiation Flux, etc.

(2) Main Characteristics

Figure 2.2-4 provides the CERES appearance, and Table 2.2-4 shows the main characteristics.

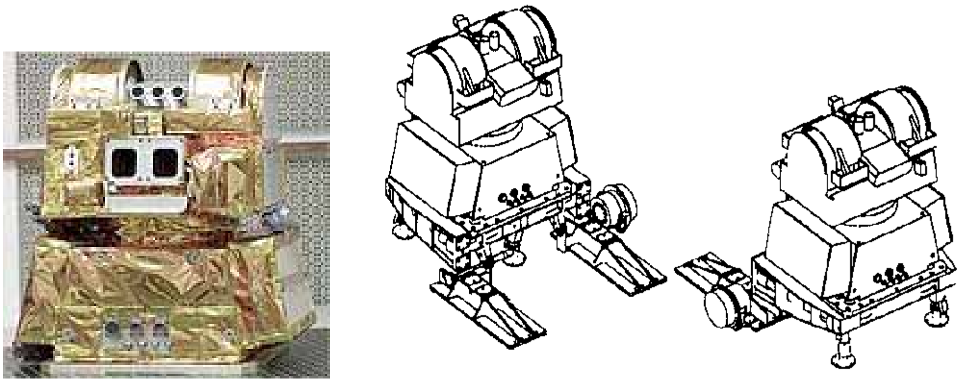


Figure 2.2-4 CERES Appearance

Table 2.2-4 CERES Main Characteristics

Items	Characteristics
Observation Wave Length	Short Wave Channel : 0.3 - 5 m Long Wave Channel : l8 - 12 m All Channel : 0.3 - >100 m
Spatial Resolution	20 km (Nadir)
FOV	Cross Track : ±78˚ Azimuth : 360˚
IFOV	14 mrad
Data Rate	9.5 Kbps
Electric Power / 1 unit	Average : 47 W Maximum :104 W (in Biaxial Scan mode)
Weight / 1 unit	50 kg
Size / 1unit	60 x 60 x 70 cm

2.2.5 Moderate Resolution Imaging Spectroradiometer (MODIS)

(1) Mission Overview

The MODIS instrument employs a conventional imaging spectroradiometer concept, consisting of a cross-track scan mirror and collecting optics, and a set of linear arrays with spectral interference filters located in four focal planes. The optical arrangement provides imagery in 36 discrete bands between 0.4 and 14.5 μm selected for diagnostic significance in Earth science. The spectral bands have spatial resolutions of 250, 500, or 1,000 m at nadir. Signal-to-noise ratios are greater than 500 at 1-km resolution (at a solar zenith angle of 70˚), and absolute irradiance accuracies are < ±5% from 0.4 to 3 μm (2% relative to the sun) and 1 percent or better in the thermal infrared (3.7 to 14.5 μm).

MODIS instruments provide daylight reflection and day/night emission spectral imaging of any point on the Earth at least every 2 days, operating continuously.

- Development Agency: NASA/GSFC
- Observation Target: Cloud, Radiation Flax, Aerosol, Land cover, Land use change, Vegetation various, Surface temperature, Sea surface temperature, Ocean Color, Snow cover, Atmospheric temperature, Humidity, Sea Ice, etc.

(2) Main Characteristics

Figure 2.2-5 provides the MODIS appearance, and Table 2.2-5 shows the main characteristics.

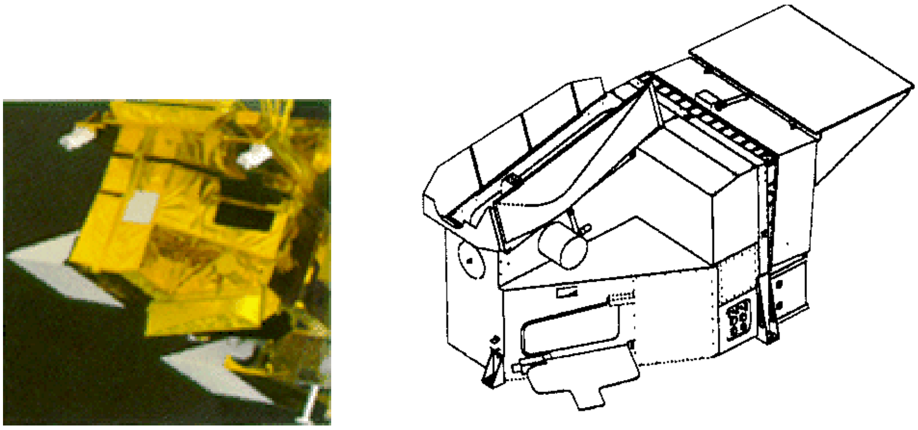


Figure 2.2-5 MODIS Appearance

Table 2.2-5 MODIS Main Characteristics

Items	Characteristics					
Observation Wave Length	Band	Wave Length	Band	Wave Length	Band	Wave Length
	1	0.620 - 0.670 µm	13	0.662 - 0.672 m	25	4.482 - 4.549 µm
	2	0.841 - 0.876 µm	14	0.673 - 0.683 m	26	1.360 - 1.390 µm
	3	0.459 - 0.479 µm	15	0.743 - 0.753 m	27	6.535 - 6.895 µm
	4	0.545 - 0.565 µm	16	0.862 - 0.877 m	28	7.175 - 7.475 µm
	5	1.23 - 1.25 µm	17	0.890 - 0.920 m	29	8.400 - 8.700 µm
	6	1.628 - 1.652 µm	18	0.931 - 0.941 m	30	9.580 - 9.880 µm
	7	2.105 - 2.155 µm	19	0.915 - 0.965 m	31	10.780 - 11.280 µm
	8	0.405 - 0.420 µm	20	3.660 - 3.840 m	32	11.770 - 12.270 µm
	9	0.438 - 0.448 µm	21	3.929 - 3.989 m	33	13.185 - 13.485 µm
	10	0.483 - 0.493 µm	22	3.929 - 3.989 m	34	13.485 - 13.785 µm
	11	0.526 - 0.536 µm	23	4.020 - 4.080 m	35	13.785 - 14.085 µm
	12	0.546 - 0.556 µm	24	4.433 - 4.496 m	36	14.085 - 14.385 µm
Spatial Resolution	Band 1, 2: 250 m Band 3 – 7: 500 m Band 8 – 36: 1000 m					
FOV	±55°					
Swath Width	Cross Track: 2330 km Along Track: 10 km (Nadir)					
Data Rate	Day area: 10.06 Mbps Night area: 3.2 Mbps Average: 6.2 Mbps					
Electric Power	225 W (Max.) 162.5 W (Min.)					
Weight	229 kg					
Size	1.044 x 1.184 x 1.638 m					

2.2.6 Humidity Sounder for Brazil (HSB)

(1) Mission Overview

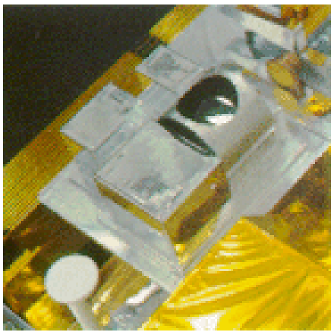
The HSB instrument is a passive 4-channel radiometer that receives and measures radiation from the atmosphere in order to obtain data on humidity profiles for weather forecasting. The HSB receiver channels are configured to operate in DSB (Double Sideband) with frequencies centered at 150 GHz (channel 17) and 183,31 GHz (channels 18, 19 and 20).

The observation data by HSB is used for the improvement in accuracy of the air humidity and precipitable water profile computed from AIRS observation data like AMSU.

- Development Agency: INPE (Instituto Nacional de Pesquisas Espaciais)
- Observation Target: Atmospheric Humidity, etc.

(2) Main Characteristics

Figure 2.2-6 provides the HSB appearance, and Table 2.2-6 shows the main characteristics.



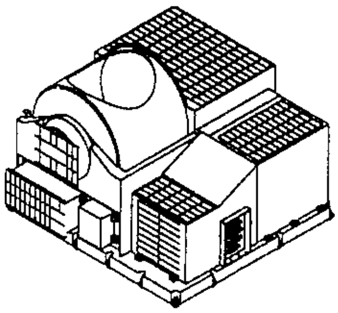


Figure 2.2-6 HSB Appearance

Table 2.2-6 HSB Main Characteristics

Items	Characteristics
Observation Frequency	Channel 17 : 150 GHz Channel 18 - 20 : 183.31 GHz
Spatial Resolution	13.5 km (Nadir)
FOV / IFOV	±49.5˚ / 1.1˚
Swath Width	1650 km
Data Rate	4.2 kbps
Electric Power	80 W
Weight	60 kg
Size	52.6 x 70 x 65 cm

2.3 AMSR-E Detailed Explanation

2.3.1 AMSR-E Operations Principle

AMSR-E is the microwave radiometer of acquiring radiance data about the surface of the earth respectively by vertical and horizontal polarized wave as antenna equivalent noise temperature of six frequency bands from 6.9GHz to 89GHz.

An operation principle of AMSR-E in orbit is shown in the Figure 2.3-1. The AMSR-E sensor unit is carried in the satellite flight direction tip part, and surface incidence projection of an antenna beam serves as the conical scan which moves forward while drawing the circle of diameter about 1660 km by flying, rotating to a Z-axis counterclockwise rotation.

The antenna beam direction has the angle of off-nadir of 47.5˚ toward the Z-axis, and it becomes 55˚ as incidence angle on the surface of the earth by the effect on a globular form of the earth.

The dependence on the incidence angle of the radiometric character of the microwave radiation meter is strong, but by using the conical scanning form whose incidence angle on the surface is constant, it secures a good character without depending on observation points. The influence of the sea surface wind to an incidence angle of 55˚ is small, and it sets up as an angle that the difference in the vertical and the horizontal polarized wave is big. As for the signal processing component, it is the design which takes in the surface of the earth observation data beyond ±75˚ around the X axis direction. On the other hand, about the interference of low or high temperature calibration source to a main beam, it is the design which does not have any interference in the range of -61˚ to 58˚ for 6.9 GHz, and ±61˚ for the other frequencies. Therefore, as the effective earth observation data, the data acquired around the X axis direction in the scanning angle range beyond ±61˚ are decided to be adopted, and this angle is corresponding to observation swath width of 1450 km.

In order to carry out 10km sampling interval for the satellite flight direction, in consideration of the ground speed of Aqua which flies at the altitude of 705km, the cycle of a conical scan is made into 1.5 sec nominal so that a sensor unit may rotate one time about in 10km of earth surface distance. This rotation speed is equivalent to 40 rpm, and secures a sample interval in the scanning direction with 10 km by setting up a sample period in the scanning direction with 2.6msec.

In addition, since the additional beam about 89 GHz sets up about 15km inter-channel offsets to the satellite flight direction, the sampling interval of the satellite flight direction of the data for 3 scan serves as 5km nominal. A sampling period in the scanning direction is set up with 1.3 msec, and it is being made a sample interval in the scanning direction is 5 km nominal.

The IFOV (footprint, specified in half value) of each antenna beam is the oval form which major axis is the satellite flight direction, and the IFOV is about 6.5km x 4km (satellite flight direction x scanning direction at 89GHz) in the condition of 1.6m aperture diameter of the antenna. The observation data of the area, which length is about 10km corresponding to the integral time of 2.6 msec (with 89GHz, 1.3 msec) in the scanning direction, become the equivalent data on 1 pixel (spatial resolution). The underlap is what has no overlap between pixels of the scan lines or the scan direction. AMSR-E is designed for no underlap.

In order to observe six frequency bands, six primary radiometers are taken in the antenna unit in the side-by-side. Beam center of each radiometer points to different portion of main reflector. For this reason, the angles of the beam, which points to earth surface simultaneously from the main reflector, differ on each frequency. Then, each frequency and the beam center of each polarization wave are designed so that it may pass along the same scanning line, by shifting and arranging the primary radiometer of each frequency in the satellite flight direction. It is designed the footprint of each frequency observes the same point on the surface of the earth by changing the observation timing of each frequency to compensate for a deviation in the scanning direction. A relative position deviation of the footprint for every frequency is frequency registration.

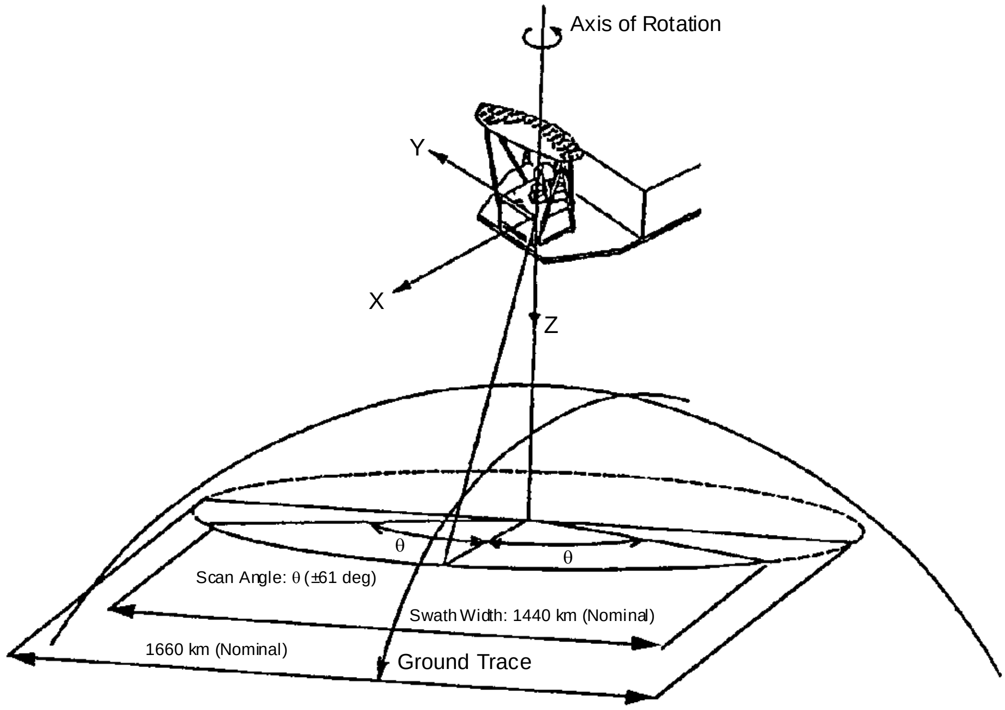


Figure 2.3-1 Operation Principle of AMSR-E

2.3.2 Elements and Appearance

AMSR-E is composed by two units, which are Sensor Unit and Control Unit. The system configuration of AMSR-E and its appearance are shown below.

(1) System Configuration

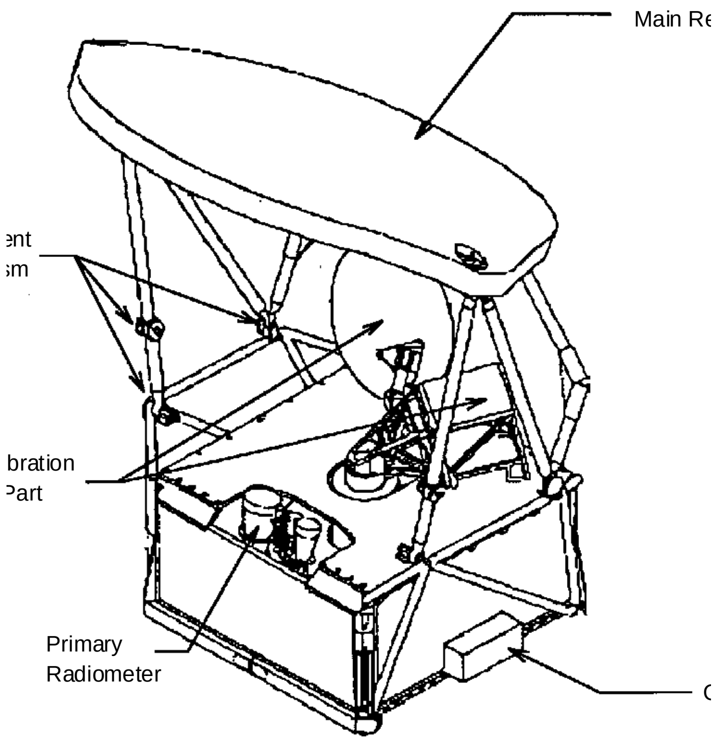
Several units and components shown in Table 2.3-1 compose AMSR-E.

Table 2.3-1 AMSR-E System Configuration

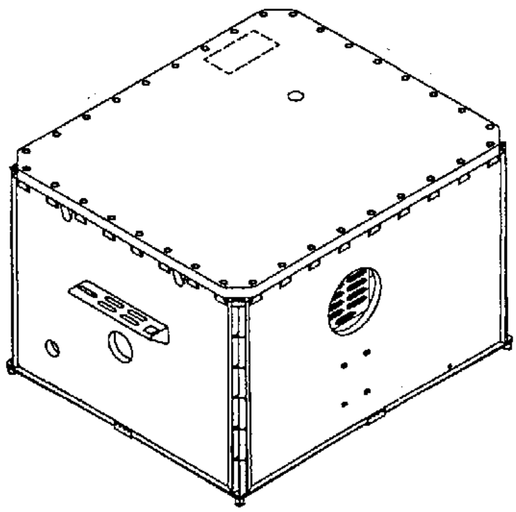
Unit	Components	Code	Main Function
Sensor Units (SENS UNIT)	Antenna Part	ANT	Introduce the micro radiation wave of the earth to a receiver.
	Calibration Part	CAL	It consists of low and high temperature source for calibration of observation data.
	Receiver	RX	After carrying out low noise amplification of the microwave inputted from the antenna part, band restriction is carried out at observation band width, and then, the data is amplified, detected and integrated, and output to a signal processing part. Moreover, a required temperature monitor is performed for calibration of the observation data.
	Antenna Drive Assembly (Antenna Drive Mechanism)	ADA (ADM)	It rotates the antenna, receiver, etc. of AMSR-E at a fixed rotation speed.
	Signal Processor (Sensor Unit)	SPS	It performs A/D conversion of the observation data from a receiving part, calibration control of a receiving part, each part control in the sensor unit by the command received from SPC, telemetry data acquisition of sensor unit, and output of the telemetry data to SPC.
	Thermal Controller (Sensor Unit)	TCS	It performs heater control in a sensor by the command from SPS.
	Power Distribution Unit (Sensor Unit)	PDUS	It receives electric power from PDUC and distributes it to each component in the sensor unit.
	Orbital Balancing Mechanism / Orbital Balancing Electronics	OBM /OBE	It performs weight balance adjustment of rotation part of sensor unit on orbit.
	Structure (Sensor Unit)	STRS	It supports and fixes each component of sensor unit.
	Deployment Mechanism	DEP	At the time of a launch, it stows the main reflector, and deploys it on orbit.
	Integration Parts	-	It unifies each component electrically and mechanically.
Control Unit (CONT UNIT)	Antenna Drive Assembly (Antenna Drive Electronics)	ADA (ADE)	Driving assembly is composed in the sensor unit, and electronic part is composed in the control unit.
	Signal Processor (Control Unit)	SPC	It receives observation data and telemetry data from SPS, adds the other telemetry data such as spacecraft telemetry, edits it to the designated format and outputs it to spacecraft. Moreover, it receives command commands from spacecraft, controls each component in the control unit and forwards necessary commands to the sensor unit. Additionally, it performs rotation and momentum control of ADA and MWA.
	Thermal Controller (Control Unit)	TCC	It performs heater control in a sensor by the command from SPC.
	Power Distribution Unit (Control Unit)	PDUC	It receives electric power from spacecraft and distributes it to PDUS and each component in the control unit.
	Momentum Wheel Assembly	MWA	In order to compensate the momentum by antenna rotation for scanning, it consists of a momentum wheel, which rotates to opposite direction by the same momentum energy as antenna rotation.
	Structure (Control Unit)	STRC	It supports and fixes each component of control unit.
	Integration Parts	-	It unifies each component electrically and mechanically.

(2) Appearance

Figure 2.3-2 shows the appearance of AMSR-E.



Appearance of Sensor Unit and Each Part Name



Appearance of Control Unit

Figure 2.3-2 Appearance of AMSR-E

(3) System Block Diagram

Figure 2.3-3 shows the system block diagram of AMSR-E.

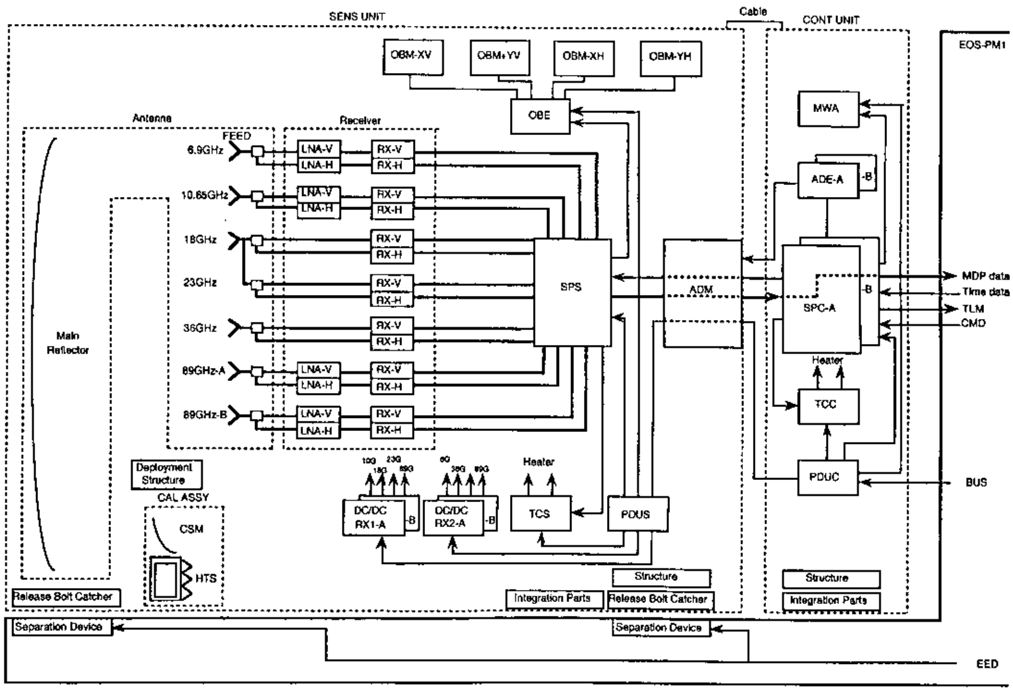


Figure 2.3-3 AMSR-E System Block Diagram

2.3.3 Explanation of the Components

Composition, main function, and performance are explained about each component of AMSR-E. However, the performance shown below is specification value and may be improved through verification of the instrument after launch.

2.3.3.1 Antenna Part

(1) Structure

The AMSR-E antenna part consists of a main reflector and a primary radiometer. Moreover, the primary radiometer is constituted by the horn antennas for each 6GHz, 10GHz, 18/23GHz (common use), 36GHz and 89GHz (two units), and the separating unit for vertical and horizontal polarization wave. Additionally, a band rejection filter and high pass filter is equipped to the separating unit of 18/23 GHz common use primary radiometer to separate each observation frequency.

(2) Function

Main functions of the Antenna part are shown in below.

- Introduce the micro radiation wave of the earth to a receiver.
- It has enough beam width to guarantee necessary spatial resolution.
- It has enough beam efficiency to guarantee necessary observation accuracy.
- Separate vertical and horizontal polarization wave and introduce them to receiver.

(3) Performance

Main performance of the Antenna part is shown below.

Table 2.3-2 Main Performance of the Antenna Part

Item	Performance						
Frequency [GHz] (Nominal)	6.925	10.65	18.7	23.8	36.5	89.0A	89.0B
Band Width [MHz] (Nominal)	350	100	200	400	1000	3000	3000
Beam Width [deg] (Nominal)	2.2	1.5	0.80	0.92	0.42	0.19	0.18
Cross Polarization	Less than -20 dB						
Main Beam Efficiency	More than 90%						
Polarization	Horizontal and Vertical						
Number of Primary Radiometer	1	1	1		1	1	1

2.3.3.2 Calibration Part

(1) Structure

AMSR-E Calibration part consists of the CSM (Cold Sky Mirror) which acquires the brightness temperature (about 2.7 K) of deep space and the HTS (High Temperature Source) by which temperature control was carried out near normal temperature, in order to calibrate observation data.

(2) Function

Main functions of the Calibration part are shown in below.

- HTS is the electric wave absorber which controlled temperature uniformly, emits the microwave used as the standard of calibration, and inputs it into a primary radiometer.
- CSM introduces the microwave background radiation (2.7K) from deep space to a primary radiometer.

(3) Performance

Main performance of the Calibration part is shown below.

Table 2.3-3 Main Performance of the HTS

Item	Performance					
Frequency [GHz] (Nominal)	6.925	10.65	18.7	23.8	36.5	89.0
Band Width [MHz] (Nominal)	350	100	200	400	1000	3000
Reflective characteristic	Less than -35 dB					
Temperature Control Range	27 ˚C ± 10 ˚C					
Temperature measurement accuracy	Within 0.3 ˚C (0.1˚C as target)					
Polarization	Horizontal and Vertical					

Table 2.3-4 Main Performance of the CSM

Item	Performance					
Frequency [GHz] (Nominal)	6.925	10.65	18.7	23.8	36.5	89.0
Band Width [MHz] (Nominal)	350	100	200	400	1000	3000
Mirror Type	Offset parabola					
Beam Width (Nominal)	Less than 10 deg					
Polarization	Horizontal and Vertical					

2.3.3.3 Receiver

(1) Structure

The receiver is independent to horizontal and vertical polarization wave for every frequency, respectively.

(2) Function

Main functions of the Receiver are shown in below.

- After carrying out low noise amplification of the microwave input from the antenna part, band restriction is carried out at observation band width, and then, the data is amplified, detected and integrated, and output to a signal processing part.
- Temperature monitor is performed necessary for calibration of the observation data.
- It has AGC (Auto Gain Control) function controlled by the command from the signal processor.
- It has a DC/DC converter and supplies the electric power in the voltage that is stabilized primary power.

(3) Performance

Main performance of the Receiver is shown below.

Table 2.3-5 Main Performance of the Receiver

Item	Performance					
Frequency [GHz] (Nominal)	6.925	10.65	18.7	23.8	36.5	89.0
IF Center Frequency [GHz] (Nominal)	-	2.5	2.5	2.2	2.5	4.5
Band Width [MHz] (Nominal)	350	100	200	400	1000	3000
Noise Factor [dB] (The value on lower line is target)	1.25 1.16	1.52 1.5	2.3 2.01	2.7 2.48	4.4 4.1	6.7 6.0
Integration Time [ms] (Nominal)	2.5					1.2

2.3.3.4 Antenna Drive Assembly

(1) Structure

The Antenna Drive Assembly consists of an antenna drive mechanism and antenna drive electronics. The antenna drive mechanism mainly consists of the following parts. In addition, the antenna drive electronics is contained in the control unit.

- Motor
- Bearing
- Slip ring
- Encoder
- Commutator

(2) Function

Main functions of the Antenna Drive Assembly are shown in below.

- It rotates the antenna, receiver, etc. of AMSR-E at a fixed rotation speed.
- Earth surface is conically scanned by rotating the antenna part, the receiver, etc. of AMSR-E at a fixed rotation speed.
- With a fixing shaft, a rotation portion is held through bearing.
- Electric power and signal are exchanged between fixed part and rotating part through the slip ring.
- The encoder monitors rotation position and speed.

(3) Performance

Main performances of the Antenna Drive Assembly are shown in below.

Table 2.3-6 Main Performance of the Antenna Drive Assembly

Item	Performance
Rotation Speed	40 rpm ± 1% RMS
Rotation Direction	Counterclockwise rotation to the Z-axis

2.3.3.5 Signal Processor

(1) Structure

The Signal Processor consists of the Signal Processor of the Sensor unit (SPS) and Signal Processor of the Control unit (SPC). SPC contains the electronics of the Orbital Balance Mechanism (OBM). Moreover, SPC and its interface part have a redundant system.

(2) Function

Main functions of the Signal Processor are shown below.

- It carries out A/D conversion of the observation data from receiver, and edits the data into the specified format with calibration data and telemetry data, and sends it to a satellite system.
- Gain and offset control of the Receiver is performed.
- Electric discharge timing from the integration equipment of the Receiver and hold timing control are performed.
- Temperature measurement of the Sensor Unit and the Control Unit is performed.
- The command from a satellite system is processed and it provides for other components of AMSR-E. Moreover, telemetry data from other components of AMSR-E is edited, and it sends out to a satellite system.
- It has a DC/DC converter and supplies the electric power in the voltage that is stabilized primary power.

(3) Performance

Main performance of the Signal Processor is shown below.

Table 2.3-7 Main Performance of the Signal Processor

Item	Performance
A/D Conversion Resolution	6.9 GHz : 12 bits Others : 10 bits
Number of Channels of Temperature Sensor	SPS : 32 channels SPC : 22 channels
Frequency of Temperature Measurement	1.5 sec. (in Normal Observation)

2.3.3.6 Thermal Controller

(1) Structure

The Thermal Controller consists of the Thermal Controller of Sensor Unit (TCS) and the Thermal Controller of Control Unit (TCC).

(2) Function

Main functions of the Thermal Controller are shown below.

- The TCS receives a command from the SPS, and performs heater control in the sensor unit with ON/OFF control system.
- The TCC receives a command from the SPC, and performs heater control in the Control Unit and Sensor Unit with ON/OFF control system.

2.3.3.7 Power Distribution Unit

(1) Structure

The Power Distribution Unit is consists of the Power Distribution Unit of Sensor Unit (PDUS) and the Power Distribution Unit of Control Unit (PDUC).

(2) Function

Main functions of the Power Distribution Unit are shown in below.

- The PDUS receives electric power from the PDUC, and distributes it to each component of the Sensor Unit. Moreover, it has a capacitor bank.
- The PDUC receives electric power from the Aqua spacecraft, and distributes it to the PDUS and each component of the Control Unit. Moreover, it has a capacitor bank.

(3) Performance

Main performance of the Power Distribution Unit is shown below.

Table 2.3-8 Main Performance of the Power Distribution Unit

Item	Performance
Maximum Electric Power	Sensor Unit : more than 533 W Control Unit : more than 900 W

2.3.3.8 Disturbance Control Mechanism

(1) Structure

The Disturbance Control Mechanism consists of the Disturbance Control Mechanism of sensor unit and the Disturbance Control Mechanism of control unit. The Disturbance Control Mechanism of sensor unit consists of the Orbital Balancing Mechanism (OBM) and the Orbital Balancing

Electronics (OBE), and the Disturbance Control Mechanism of control unit consists of the Momentum Wheel Assembly (MWA) and the wheel control electronics. Moreover, the electronics of Disturbance Control Mechanism is contained in the Signal Processor of control unit.

(2) Function

Main functions of the Disturbance Control Mechanism are shown below.

- In order to compensate moment energy caused by antenna rotation for scan, it has the Momentum Wheel Assembly (WMA), which rotates to an opposite direction with the equivalent energy to antenna rotation.
- It has the OBM for performing mass balance adjustment of a sensor unit rotation on orbit.
- WMA and OBM are controlled by the command received from Aqua spacecraft.
- It runs up and down of antenna rotation so that attitude of a satellite may not be affected as much as possible.

2.3.3.9 Deployment Mechanism

(1) Structure

The Deployment Mechanism mainly consists of the following parts.

- Holding Structure
- Hinge
- Joint
- Dumper
- Latch

(2) Function

Main function of the Deployment Mechanism is shown below.

- It stows the main reflector of antenna at the time of launch, and deploys it on orbit.

(3) Performance

Main performance of the Deployment Mechanism is shown below.

- It has sufficient torque to deploy the main reflector of antenna on orbit.
- After deployment of the main reflector of antenna, it secures it for keeping necessary alignment accuracy.

2.3.4 Operation Mode

2.3.4.1 Definition of Operation Mode

There are six operation modes shown below for AMSR-E. The relationship between the Aqua satellite operation status and the AMSR-E operation mode is shown in Table 2.3-9. Moreover, ON / OFF of the component to each mode of AMSR-E, and the output data in those cases are shown in Table 2.3-10.

(1) Normal Mode

It is the mode to acquire and edit the observation data and to output as the mission data to the Aqua spacecraft. All components including receiver are turned on in this mode. In the observation mode, mission data and HK telemetry data are output to the spacecraft. Moreover, this mode includes a standby status until starting of observation after turning on a receiving part and the heater for HTS.

(2) Sleep Mode

In this mode, the observation is stopped. ADM and MWA are rotating at normal speed. A receiver power supply is turned off and a sleep mode heater setup for controlling each apparatus to permissible temperature within the limits is carried out. AMSR-E moves from the normal mode to this mode corresponding to the safe mode of the Aqua spacecraft.

(3) Survival Mode

In this mode, each equipment is kept in the temperature range that it can work. Rotation of ADM and MWA is stopped and a survival heater setup for controlling each apparatus to permissible temperature within the limits is carried out. And, as for this mode, only telemetry and command processing are being carried out in the signal processor.

(4) All Off Mode

In this mode, all equipments are tuned off. AMSR-E is in this mode at the time of the launch, antenna deployment, and sensor unit release.

(5) Run Up

The mode until it carries out the run up of the ADM and the MWA and they carry out stable rotation from a stopping to normal speed. As acceleration preparation, a series of operation or status are included, such as ON of the heater for ADM to acceleration operation, a heater setting change, etc.

In order to suppress the influence on the satellite side of turbulence in permissible value, rotation speed is increased through several steps. Moreover, rotation speed correction of MWA and balance adjustment of the sensor unit by OBM is performed if needed. Here, normal rotation speed of ADM and MWA is 40 rpm and 3400 rpm respectively.

(6) Run Down

It is the mode, which runs down the ADM and the MWA from normal rotation to stop. A series of operation or states are included, such as slowdown operation and a heater setting change, etc. This mode isn't used on orbit as nominal operation of AMSR-E.

Table 2.3-9 Relationship between Aqua Spacecraft Status and AMSR-E Operation Mode

Status of Aqua Spacecraft		AMSR-E Operation Mode					
Mode	Status	All off	Survival	Run up	Run down	Sleep	Normal
Launch	At the launch.	O	X	X	X	X	X
Propulsion	During Orbit Maneuver.	O	O	O	O	O	X
Standby	Preparation period of Routine operation.	O	O	X	X	O	X
Science	Routine Operation.	O	O	O	O	O	O
Safe	Anomaly verification and measurement.	O	O	X	O	O	X
Survival	Power supply is restricted to the minimum.	O	O	X	O	O	X

O: Available X: Not Available

Table 2.3-10 On/Off of AMSR-E Component in each Mode and Output Data

Mode	Component								Output Data
	Sensor Unit				Control Unit				
	RX	OBM/OBE	SPS	TCS	ADE	MWA	SPC	TCC	
All off	X	X	X	X	X	X	X	X	PA, PB
Survival	X	O*1	O	O	X	X	O	O	HK
Run up	X	O*1	O	O	O	O	O	O	HK
Run down	X	O*1	O	O	O	O	O	O	HK
Sleep	X	O*1	O	O	O	O	O	O	HK
Normal	O	O*1	O	O	O	O	O	O	Mission data, HK

O: On X: Off
*1: It turns on, only when a sensor unit needs to be balance adjusted.

RX: Receiver
OBM/OBE: Orbital Balance Mechanism/Electronics
SPS: Signal Processor of Sensor Unit
TCS: Thermal Controller of Sensor Unit
ADE: Antenna Drive Electronics
MWA: Momentum Wheel Assembly
SPC: Signal Processor of Control Unit
TCC: Thermal Controller of Control Unit
PA: Passive Analog Telemetry
PB: Passive Bi-level Telemetry

2.3.4.2 Transition of Operation Mode

AMSR-E is launched in the all off mode and then, performs temperature control of equipment in the survival mode until starting of antenna deployment and sensor unit release. At the time of antenna deployment and sensor unit release, operation mode is changed to the all-off mode which once turns off all equipments, and then, deployment/release are performed by ordnances etc. The operation mode is changed to the survival mode after antenna deployment / sensor unit release. And then the antenna run-up operation is started at the designated timing. During the run up of antenna, balance adjustment of the sensor unit is carried out by OBM if needed. When ADM and MWA rotation reach normal speed, the operation mode is shifted to a sleep mode, and finally is shifted to the normal mode by performing power supply ON of the receiver, and a heater setup. Figure 2.3.4 shows the mode transition of AMSR-E after the antenna deployment and the sensor unit release.

In addition, although AMSR-E usually operates in the normal mode, which always observes, it can be shifted to a sleep mode, a run down, and the survival mode if needed.

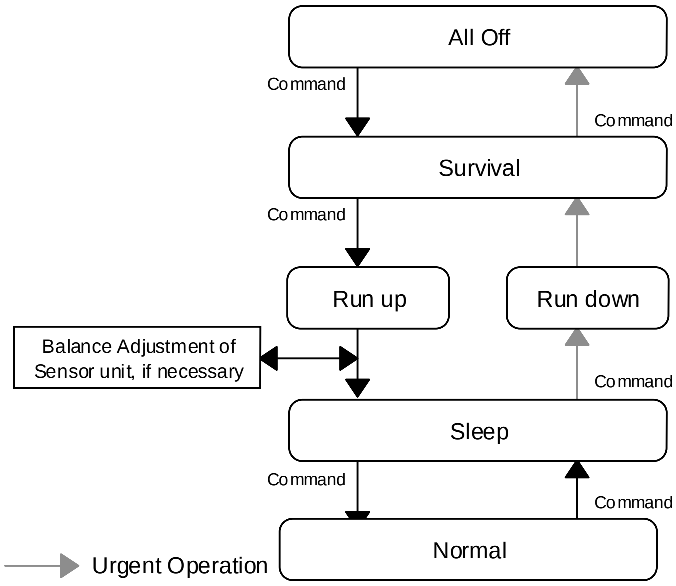


Figure 2.3-4 AMSR-E Mode Transition

2.3.5 Radiometric Characteristics

2.3.5.1 Observation Frequency and Polarization

As for the observation frequency and polarized wave of AMSR-E, it is the same specifications in comparison with ADEOS-II /AMSR except for a 50GHz band (50.3GHz and 52.8GHz) that was removed.

2.3.5.2 Main Beam Efficiency

Main beam efficiency is prescribed in the mean inside the observation range, which is the rate of the polarized wave toward all the receiving electric power contained in the angle range of 2.5 times of the beam width. More than 90% is required to the main beam efficiency of each observation frequency of AMSR-E.

2.3.5.3 Temperature Resolution

A temperature resolution of each observation frequency of AMSR-E is shown in the following.

Table 2.3-11 Temperature Resolution of AMSR-E

Frequency	Polarization	Temperature Resolution		
		Specification	Target	Actual Performance (rms)
6 GHz	Horizontal	0.34 K	0.30 K	0.33 K
	Vertical	0.34 K	0.30 K	0.30 K
10 GHz	Horizontal	0.70 K	0.60 K	0.54 K
	Vertical	0.70 K	0.60 K	0.47 K
18 GHz	Horizontal	0.70 K	0.60 K	0.46 K
	Vertical	0.70 K	0.60 K	0.48 K
23 GHz	Horizontal	0.60 K	0.55 K	0.44 K
	Vertical	0.60 K	0.55 K	0.45 K
36 GHz	Horizontal	0.70 K	0.65 K	0.40 K
	Vertical	0.70 K	0.65 K	0.45 K
89 GHz-A	Horizontal	1.20 K	1.10 K	0.98 K
	Vertical	1.20 K	1.10 K	0.78 K
89 GHz-B	Horizontal	1.40 K	1.10 K	0.79 K
	Vertical	1.20 K	1.10 K	1.12 K

2.3.5.4 Dynamic Range

The dynamic range of AMSR-E is 2.7K～340K. Necessary dynamic range is kept by adjusting the gain/offset of a receiver so that high temperature and a low-temperature calibration output may be settled in a predetermined output range.

2.3.5.5 Linearity

The linearity of AMSR-E is ±1% (rms). (Spec. value)

2.3.6 Calibration

AMSR-E acquires a low temperature and high temperature calibration data during the scanning period for 1.5 second to calibrate the influence of a change in gain of the receiver. Figure 2.3-5 shows the position of HTS and CSM.

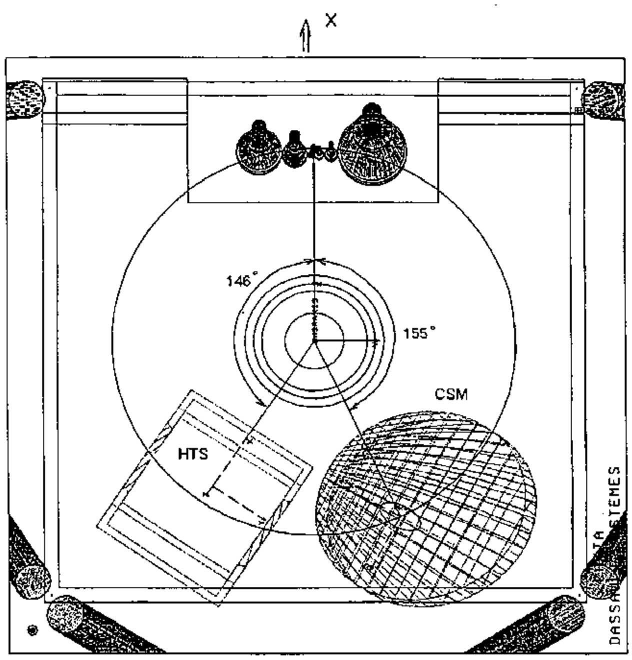


Figure 2.3-5 Position of HTS and CSM

2.3.6.1 Low Temperature Calibration

Low temperature calibration is carried out by observing deep space (brightness temperature 2.7K) using CSM. However, calibration brightness temperature shifts from 2.7K under the influence of satellite structure, strut and so on.

For brightness temperature of the low temperature calibration source, radiation of the Earth, radiation of the Moon, radio interferometry from GEO satellite, stray light from the Sun, the satellite structure, and the Earth reflected in the main reflector affects as an error factor. Among these error factors, especially, influence of the Earth and Moon radiation, radio interferometry and stray light from the Sun is relatively large, and is corrected through level 1A processing (see the section 4.2.2).

2.3.6.2 High Temperature Calibration

High temperature calibration data is acquired by observing HTS, which is the wave absorber by which temperature is controlled to 300K.

For brightness temperature of the high temperature calibration source, non-uniformity of the HTS and difference of temperature measured by the Pt sensor have been detected as an error factor. These errors are corrected through level 1A processing (see the section 4.2.2).

2.3.7 Geometric Characteristics

In order to grasp the geometric characteristic of AMSR-E, it is necessary to grasp synthetically off nadir angle, incidence angle, scanning angle, swath width, beam width concerning IFOV, foot print considering IFOV and integration time, pointing and so on.

2.3.7.1 Off Nadir Angle and Incidence Angle

Off nadir angle and incidence angle are the geometric parameters related to earth form and a satellite’s altitude, and depend for the hardware design of AMSR-E on the direction of a beam to an AMSR-E coordination system. The relations of these parameters are shown in the Figure 2.3-6.

In AMSR-E, when the satellite orbit altitude is set to 705km and an earth radius is set to 6373km, the off nadir angle is set up so that the incidence angle may become 55˚. Consequently, the off nadir angle is designed so that it may become 47.5˚ nominal.

As for 89GHz, 2 beams of 89GHzA and 89GHzB whose offset on each of the satellite flight directions is 15km nominal are being used, and the surface of the earth surface distance of the 89GHzA-B is 1498km nominal by setting off nadir angle of 89GHzB at 47.0˚. In this case, the s incidence angle of 89GHzBs is set at 54.5 degree nominal.

Additionally, six primary radiometers use the main reflector simultaneously, as shown in Figure 2.3-7. Consequently, arrangement and direction of each radiometer is offset geometrically, to realize 47.5˚ of sensor off nadir angles.

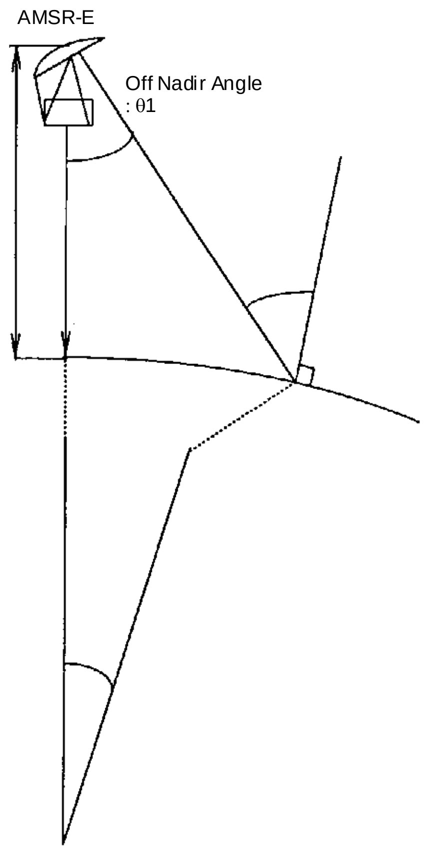


Figure 2.3-6 AMSR-E Geometric Characteristics Model (Off Nadir Angle & Incidence Angle)

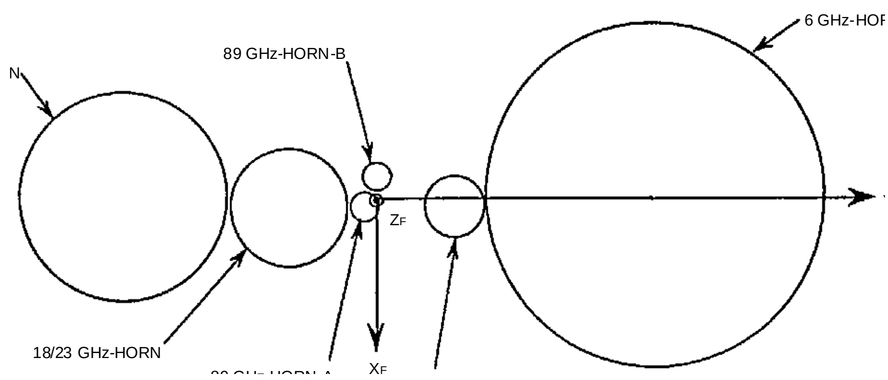


Figure 2.3-7 Alignment of Primary Radiometer

2.3.7.2 Scan Angle and Swath Width

The off nadir angle of AMSR-E is set as 47.5˚, and when the movable part containing the antenna carries out counterclockwise conical scan centering around the earth center direction (the direction of the Z-axis), the earth surface projection of the beam center on the basis of an AMSR-E fixed part draws the circumference with a diameter of 1660km.

Furthermore, when a ±61˚ scanning angle is secured to the satellite flight direction (the direction of the X-axis), the earth surface projection width of the scanning angle range secures the nominal swath width of 1450km.

The precondition for securing the scanning angle in H/W design of AMSR-E is that there is no interference into the course of the main beam from the primary radiometer to main reflector, and from main reflector to earth surface, within the predetermined scanning angle. Moreover, it is also a precondition that the acquisition and processing of data that include an effective scan are performed in the signal processor.

As for interference of the main beam, it is the design that there is no interference within the range of ±61˚ for 6.9 GHz, or within the range of –61˚ ~ +58˚ for the other frequency.

Moreover, in the signal processor, since data ±75˚ or more is taken in as observation data, the scanning angle is secured enough.

Moreover, about 6.9GHz, the interference to the view in the range of +58˚ – +61˚ does not influence to a gain, beam efficiency, cross polarization, and the amount of generating. For this reason, as a design, scanning angle of ±61˚ and the swath width of 1450km or more are substantially securable in all observation frequencies.

2.3.7.3 Rotation Speed, Scan Cycle and Sampling Interval

As geometrical principle of AMSR-E, The sampling interval of the satellite flight direction corresponds to the ground distance of the satellite flight direction which is set by the time an AMSR-E rotation part carries out data acquisition at arbitrary rotation angles, makes one revolution after that and acquires data again at the same rotation angle (scanning cycle). The geometric model is shown in the Figure 2.3-8.

When the satellite altitude is set to 705 km and an earth radius is set to 6373 km, the ground speed of Aqua is 6.76 km/sec. When an AMSR-E rotation part rotates by 40rpm nominal, it rotates one time exactly by scanning cycle 1.5sec. In this case, the sampling interval of the satellite flight direction is 10.14km nominal.

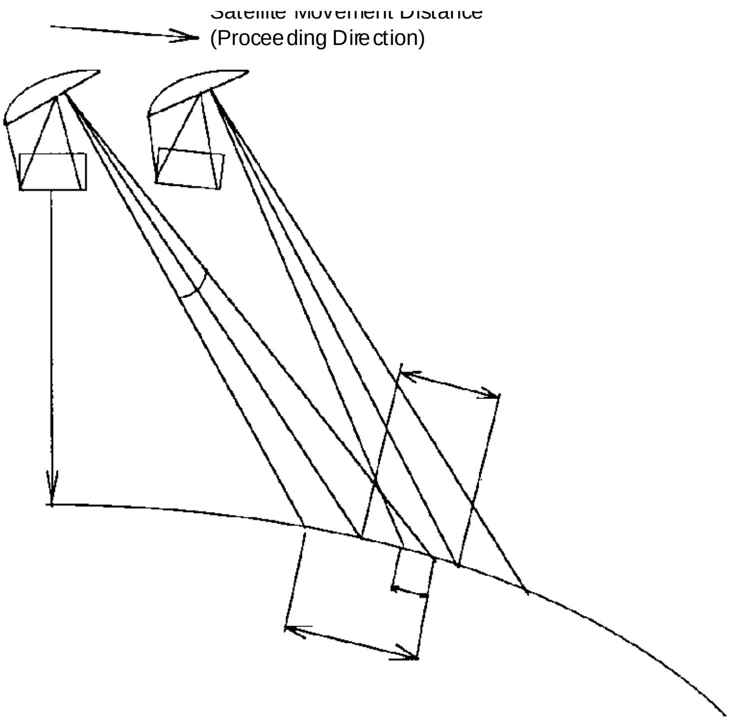


Figure 2.3-8 AMSR-E Geometric Characteristics Model

(Sampling Interval, Beam width, Footprint and Overlap)

2.3.7.4 Sampling Period, Integrated Time and Sampling Interval

Earth surface projection of AMSR-E beam center is drawing the circle with a diameter of 1660km. When the rotation speed of an AMSR-E rotation part is 40rpm nominal, if a sampling cycle is set as 2.6msec, the scanning direction sampling interval is 8.87km nominal.

Since a sampling cycle is 1.3msec in the case of 89GHz, the scanning direction sampling interval is 4.44km nominal. Moreover, the integration time of frequency other than 89GHz is 2.488msec nominal, and it is 1.1875msec nominal for 89GHz.

2.3.7.5 Beam Width and Footprint

The beam width is designed so that it may be realized as a character of the antenna part. The beam width design value of the antenna part is shown in the Table 2.3-12.

On the other hand, the projection form on the surface of the earth and the distance of the surface of the earth (hereinafter referred as “footprint”) of the main beam depends on satellite altitude, the off nadir angle and beam width, and it is decided corresponding to the earth form.

As shown in Figure 2.3-8, the footprint of the satellite flight direction is geometrically determined considering a maximum to the minimum of the beam width to the satellite flight direction as an earth surface incidence range. The footprint corresponding to the nominal beam width of each frequency band is also shown in Table 2.3-12 about the case where the satellite altitude was set to 705km and an earth radius is set to 6373km.

Table 2.3-12 Beam Width and Footprint

Frequency	Beam Width (Nominal)	Footprint (Scanning×Proceeding)	Remarks
6.925 GHz	2.2°	43.2 x 75.4 km	In case of; Satellite Altitude: 705 km Earth Radius: 6378 km
10.65 GHz	1.5°	29.4 x 51.4 km	
18.7 GHz	0.8°	15.7 x 27.4 km	
23.8 GHz	0.9°	18.1 x 31.5 km	
36.5 GHz	0.4°	8.2 x 14.4 km	
89 GHz A	0.2°	3.7 x 6.5 km	
89 GHz B	0.2°	3.5 x 5.9 km	

2.3.7.6 Overlap and Underlap

The overlap of the satellite flight direction is the ratio of the length of the portion, which the footprint in the following scan overlaps. Conversely, the condition where overlap was lost is called underlap.

Similarly, the overlap of the scanning direction is the ratio of the scanning direction length of the portion that the footprint of the next integration section overlaps. Conversely, the condition where overlap was lost is called underlap.

The overlap ratio of every observation frequency is shown in the Table 2.3-13 about both in the flight direction/scanning direction as the nominal condition.

Table 2.3-13 Overlap Ratio (Nominal)

Frequency	Overlap Ratio	
	Scanning	Flight
6.925 GHz	82.6%	86.6%
10.65 GHz	76.3%	80.3%
18.7 GHz	62.9%	63.0%
23.8 GHz	66.2%	67.8%
36.5 GHz	46.5%	29.5%
89 GHz A/B	42.5%	22.6%

2.3.7.7 Frequency Registration

About frequency registration, the following error factors are taken into consideration about each of the satellite flight direction and the scanning direction.

< Scanning direction >

- Antenna beam direction error
- Observation timing gap
  (Time correction gap for every frequency until it acquires the data of same point on the earth surface.)

< satellite flight direction >

- Antenna beam direction error
- Effect on satellite progress
  (Time gap for every frequency until it acquires the data of same point on the earth surface.)

In the above factors, the factors that may be generated in the stage of design or manufacture are the antenna beam direction error and the observation timing gap. Moreover, the factors that may occur after a launch are the effect on satellite progress and the antenna beam direction error caused by its heat deformation, etc.

The influence of the satellite flight direction influences both directions of the flight direction and the scanning direction strictly. Since the influence is maximized when AMSR-E is observing at nadir (at the crossing time of X-Z face), the influence is evaluated under this condition. On the other hand, it is negligible quantitatively about the scanning direction.

From the result of the design with consideration to each error factor, the beam center of each frequency and each polarization wave passes along the same scanning line except for an 89GHz B, and the error is less than ±0.16˚ in the satellite proceeding direction.

Moreover, the center of a sampling of the scanning direction is less than ±0.26 degrees from the sampling start position of 89GHzA.

2.3.7.8 Pointing

The inclination gap of the antenna beam bore site of an AMSR-E sensor is based on the AMSR-E coordination system defined as a center of ADM attachment side. Furthermore, at the position which the antenna beam sets to the satellite advance direction (scanning angle center), error factor of the inclination angle to the scanning direction and the advance direction is evaluated respectively. The error factor could be divided into two elements; the change error element that depends on time and the fixed error element that does not depend on time. Among these, since the fixed error ingredient is fixed, it can be corrected by improving of the angle error recognition accuracy also including evaluation by observation data. However, about a variable error, an observation data error is affected as it is.

3 OUTLINE OF THE GROUND SYSTEMS

3.1 Overall System

The main components of the ground segment of Japan and the U.S. that carry out mission operation of Aqua and AMSR-E are listed below. An overview of the ground segment is shown in Figure 3.1-1.

3.1.1 JAXA System

(1) Earth Observation Center (EOC)

Earth Observation Center (EOC) of JAXA is the central organization for AMSR-E mission operation. In EOC, the following systems perform AMSR-E data processing, archiving and providing data services to users. The outline of AMSR-E Data Processing System and the Earth Observation Data and Information System (EOIS) are described in sections 3.2 and section 3.3, respectively.

- AMSR-E data processing system
- EOIS / Data Distribution and Management System (EOIS/DDMS)
  - MCS : Media Conversion Subsystem
  - DSS : Data Storage Subsystem
  - SMSS : Schedule Management Subsystem
  - BDS : Browse data Distribution Subsystem
  - ADS : Advertisement Subsystem
  - DDS : Data Distribution Subsystem
  - ISS : Information Service System

In addition to the above, the following two systems are used for AMSR-E mission operation in JAXA/EOC.

- MIFS: Mission Information File Server

  Irrespective of the kind of satellite, or the contents of processing, the common information used by two or more systems is stored, and provided to the system of EOC if needed.

- Order desk

  The order to process data is received off-line (Fax etc.) from general users, and is input into the SMSS. Moreover, it becomes the contact point to provide the user with the processed data recorded on the designated media by the MCS.

(2) Earth Observation Research Center (EORC)

EORC of JAXA is the organization responsible to verify the higher level standard products (level 2 and level 3) and to develop and improve the higher level standard product processing algorithm. Additionally, in EORC, research product and data set, other than the standard product, are processed experimentally.

3.1.2 NASA Side Equipment

Mission operation of Aqua is carried out by NASA/EOSDIS (Earth Observation System Data and Information System). EOSDIS components related to the AMSR-E mission operations are listed below. In addition please see descriptions of other programs in section 3.4.

- NASA EOS Polar Ground Stations (EPGS)
- EOS Data and Operation System (EDOS)
  - Ground Station Interface Facilities (GSIFs)
  - Level Zero Processing Facility (LZPF)
  - NASA Server
- EOS Operation Center (EOC)
- Flight Dynamics System (FDS)
- Science Investigator-led Processing Systems (SIPS) for AMSR-E
- Distributed Active Archive Centers (DAACs)
  - National Snow and Ice Data Center (NSIDC) DAAC
  - Physical Oceanography DAAC (PO.DAAC)
- EOS Data Gateway
- White Sands Complex (WSC)

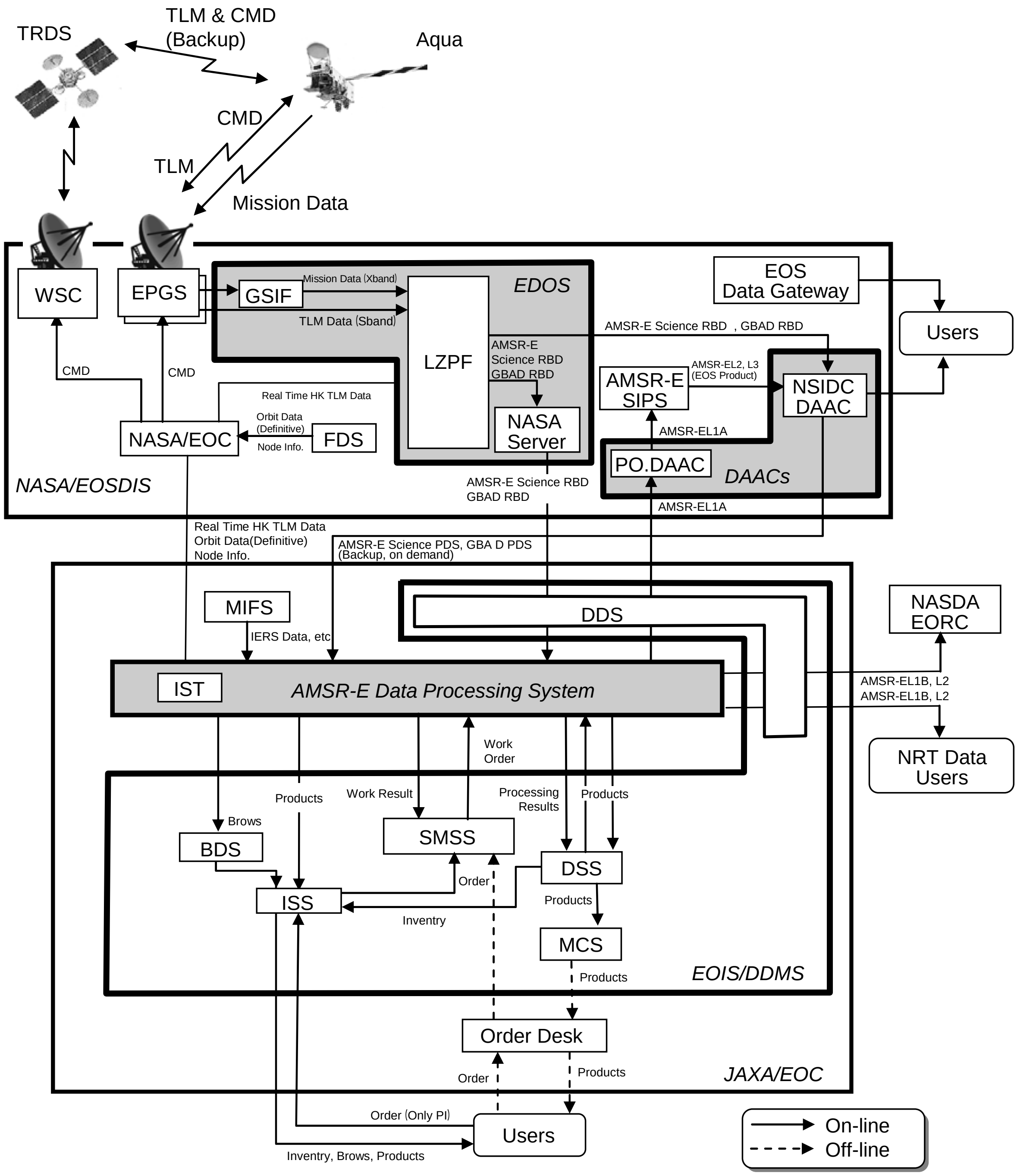


Figure 3.1-1 Aqua Ground Segment Overview (AMSR-E Related Parts)

3.2 AMSR-E Data Processing System

AMSR-E data processing system consists of the level 1 processing system and the higher level processing system. The level 1 processing system is exclusive use for AMSR-E data processing, but the higher level processing system is jointly used with the higher level processing of ADEOS-II/AMSR data. Here, conceptual Figure of AMSR-E data processing system is shown in Figure 3.2-1. The functions of the AMSR-E data processing system are listed in Table 3.2-1.

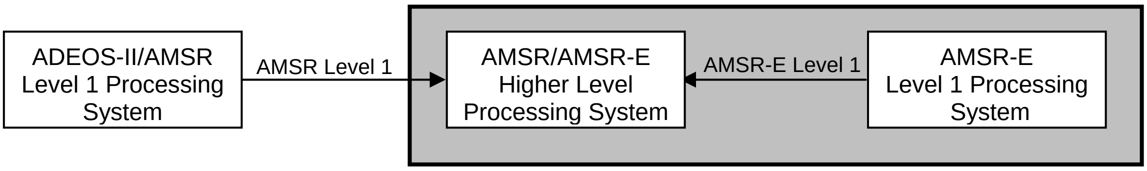


Figure 3.2-1 AMSR-E Data Processing System

Table 3.2-1 Function of AMSR-E Processing System

Items	Function	Related System	
		Level 1	Higher
Operation management	Processing control of AMSR-E data is performed. It is possible to be able to check the status of data processing and to control data processing stop and re-start manually by operator.	O	O
Operation Planning and Scheduling	The processing plan (work order) is generated to perform data processing (for both planned and ordered processing).	O	O
Data processing	Level 1 processing and higher level processing is carried out (JAXA algorithm or joint algorithm is used for Higher level processing). Moreover, browse data is created from the level 3 product. Here, details of the AMSR-E data processing are described in chapter 4.	O	O
I/O Management	Data exchange between the AMSR-E data processing system and the other systems is controlled in accordance with the interface protocol specified by JAXA.	O	O
Algorithm Management	Version management of various software and parameters used in level 1 and higher level processing is performed.	O	O
Product Check	Mainly during the initial checkout period after launch, detailed quality evaluation is performed for all level 1 products.	O	
Product Inspection	During routine operation phase, the quality of the level 1 and higher level product is picked up at random and inspected by the operator. In addition, if anomalous data is found by the random inspection, the data is inspected in detail.	O	O
Instrument Support Toolkit (IST)	Aqua definitive orbit data, orbital event information (node information: north and south pole crossing time of satellite on orbit), and AMSR-E real time telemetry data are acquired from NASA/EOC via network. The IST software is created by NASA to supply organizations of all Aqua sensor providers.	O	

3.3 Earth Observation Data and Information System

The Earth Observation Data and Information System (EOIS) Data Distribution and Management System (DDMS) is a user front-end system that offers the Earth Observation Satellite Data Catalogue Information Service as well as the related products to help you to utilize the earth observation satellite data. This system manages the various information necessary to select the earth observation data by using a database and distributes it online as well as provides the standard processed data through a variety of media and formats. Table 3.3-1 shows the function of subsystems of EOIS/DDMS related to AMSR-E mission operations.

Table 3.3-1 Function of EOIS/DDMS

System	Subsystem	Function
Data Generation System	Media Conversion Subsystem (MCS)	The MCS is the system to copy processed data from the Data Storage Subsystem onto distribution media for users. The subsystem also has the format conversion function.
	Data Storage Subsystem (DSS)	The Data Storage Subsystem is the system to store and manage satellite data, including AMSR-E data, in a readable form, and to register and manage information related to earth observation data, such as processing information, scene information, etc., and provide response to query from other subsystems to its requestor.
Schedule Management System	Schedule Management Subsystem (SMSS)	The Schedule Management Subsystem is the system to input and edit order information, grasp production status, manage transport of deliverables, and manage stock and order of distribution media.
	User Request Management Subsystem (URS)	The User Request Management Subsystem is the system to receive data orders through the EUS. The system informs its status for each order based on the user request to the users by online.
Catalogue data Distribution System	Browse data Distribution Subsystem (BDS)	The Browse Data Distribution Subsystem is the system to generate and manage sampling data and compression data as the image catalog data, and to distribute the data to users by a network or media.
On-Line Information System	Data Distribution Subsystem (DDS)	The Data Distribution Subsystem is the system to exchange data by network with JAXA/EOC external facilities, such as NASA.
	Network Management Subsystem (NMS)	The Network Management Subsystem is the system to monitor network load within JAXA/EOC and manage the network security, the log information, and the network users.
Information Service System (ISS)		ISS is the client system for receiving requests of the catalog information, reference demand of image catalog data and order demand of earth observation data from the on-line users.

3.4 EOSDIS

EOSDIS (EOS Data and Information System) is the ground system of the U.S./NASA, which carries out mission operation planning, status monitoring, etc. of all the satellites and sensors of EOS series including Aqua, and also carries out data acquisition, processing, preservation, etc. The main facility of EOSDIS is installed in NASA/GSFC (Goddard Space Flight Center). Here, the outline of EOSDIS components is described in Table 3.4-1, especially for parts related to AMSR-E mission operations.

Table 3.4-1 The Outline of EOSDIS Components Related to AMSR-E

System		Function outline
EPGS		EPGS is the ground station located at Alaska in the U.S., and Svalbard of Norway, and receives observation data via X band, and telemetry data reception via S band. Moreover, EPGS receives operation command from NASA/EOC and transmit it to the satellite via S band. Acquired observation data and telemetry data is once stored at GSIF, and transmitted to LZPF via network.
EDOS	GSIF	GSIF is installed in EPGS of both Alaska and Svalbard, respectively. The observation data acquired via X band is stored during short time until the data transmission to the LZPF is confirmed.
	LZPF	LZPF creates RBD and PDS of the AMSR-E observation data and orbit, and attitude data (GBAD data) from observation data and telemetry data that is acquired by EPGS and transmitted via GSIF. Moreover, AMSR-E and GBAD RBD are transmitted to JAXA/EOC via network. Here, transmission to JAXA/EOC of RBD is carried out based on the protocol that JAXA specifies. For this reason, the server for data transmission (NASA server) is installed in EDOS. Moreover, PDS is transmitted to NSIDC DAAC. Furthermore, telemetry data is processed and transmitted to NASA/EOC.
DAAC[*1]	PO.DAAC	PO.DAAC receives AMSR-E level 1A data from JAXA/EOC via network, and transmits it to AMSR-E SIPS.
	NSIDC DAAC	NSIDC DAAC receives AMSR-E PDS and GBAD PDS from LZPF via network, and archives them. The archived PDS is provided to JAXA/EOC by using physical media (8mm tape), when JAXA/EOC requires it. Furthermore, NSIDC DAAC receives the AMSR-E higher level product that AMSR-E SIPS creates (EOS product) via network and archive it, and provides it to users on demand.
AMSR-E SIPS[*2]		AMSR-E SIPS receives AMSR-E level 1A data from JAXA/EOC via PODAAC, and processes it to the higher level product by using NASA algorithm. The created higher level product is transmitted to NSIDC DAAC via network for archiving.
FDS		FDS has responsibility to control Aqua orbit and performs orbit maneuver if needed. Moreover, FDS generates definitive orbit data and orbital event information (node information: north and south pole crossing time of satellite on orbit), and transmits it to NASA/EOC.
NASA/EOC		NASA/EOC performs mission operations planning of Aqua satellite and sensors, and generate command. (Basically any commands are not generated for AMSR-E mission operation during routine operation phase, because AMSR-E always operates in normal mode.) Moreover, the definitive orbit data and orbital event information acquired from FDS are transmitted to IST installed in JAXA/EOC.
EOS Data Gateway		EOS Data Gateway is the catalogue system of NASA and provides interoperability among major catalogue systems of earth observation data of the world[*3].
WSC		WSC is the transmission and receiving station for the NASA's data relay satellite (TDRS), and performs command transmission and telemetry reception as backup for Aqua mission operations.

*1: Currently, seven DAACs are existing in the U.S.
*2: SIPS is a data processing system for which NASA provides funding, and it is directly managed by PI.
*3: The U.S., Canada, Germany, Australia, Russia, Israel.

3.5 Outline of AMSR-E Ground System Operation

3.5.1 Data Acquisition

The observation data of AMSR-E is packetized in CCSDS format together with the other sensor data on orbit, is transmitted to the ground station via X band, and is received at the high latitude ground station of NASA located at Alaska and Svalbard (EPGSs).

The AMSR-E observation data is transmitted to the ground stations once per each orbit. That is, about 100 minutes observation data recorded on the onboard recorder is transmitted to the ground by one downlink. In addition, as routine operating, an AMSR-E sensor operates only in the normal mode, and there is no mode to obtain calibration data, so observation data is always acquired when operating.

All the data acquired at the ground stations including AMSR-E observation data is transmitted to EDOS/LZPF through GSIF.

3.5.2 RBD / PDS Data Processing

In EDOS/LZPF, RBD (Rate Buffered Data) and PDS (Production Data Set) are created from the acquired packet data. RBD is created for the operational purpose of the near real time data users (weather forecasting, etc.). For this reason, RBD processing is carried out in the unit of a downlink, without data editing (no deleting overlapped data, fill data gap, etc. and quality check). On the other hand, for PDS data processing, overlapped data is deleted, data gap is filled, and the quality is checked. The result of quality check is added to the PDS data as quality information.

The RBD and PDS delivered from NASA to JAXA/EOC as necessary data for AMSR-E data processing is listed in the Table 3.5-1.

Table 3.5-1 RBD and PDS Delivered from NASA to JAXA/EOC

Item		Contents
RBD	AMSR-E Science Data	AMSR-E observation data
	GBAD Data	Definitive orbit data and attitude data of Aqua
PDS	AMSR-E Science Data	AMSR-E observation data
	GBAD Data	Definitive orbit data and attitude data of Aqua

GBAD: Ground Based Attitude Determination

3.5.3 Data Reception from NASA

At JAXA/EOC, RBD and orbital event information created by NASA is received and processed to level 1 and higher level products. In this section, the outline of data reception from NASA is described.

(1) Observation Data, Orbit Data and Attitude Data

As for AMSR-E observation data (AMSR-E Science Data), and orbit and attitude data (GBAD Data), RBD is usually delivered to JAXA/EOC. These RBD is transmitted from LZPF through NASA server via network, is received by using EOIS/DDS of JAXA/EOC, and is automatically inputted into the AMSR-E Data Processing System. RBD transmission to JAXA/EOC is basically completed within 160 minutes after the data is acquired at EPGS.

If RBD file is still not delivered within the limit time, JAXA requests re-sending of the concerned RBD by Web interface, or requests NASA/NSIDC DAAC to send the corresponding PDS. In accordance with the request from JAXA/EOC, PDS is transmitted from NSIDC/DAAC to JAXA/EOC via network, and is inputted into AMSR-E Data Processing System. However, at NSIDC/DAAC, PDS delivery is available 24 – 48 hours after data receipt at EPGS.

RBD receipt or non-receipt is judged by operator of the AMSR-E Data Processing System in accordance with monitoring of the level 1 processing plan (work order), or the orbital event information described in the following.

(2) Orbital Event Information

The orbital event information (node information) created by NASA/FDS is transmitted from NASA/EOC to IST of AMSR-E processing system once per day. The orbital event information consists of the orbit number and satellite crossing time of south/north pole, as necessary information for extracting and editing of AMSR-E data in scene unit (half orbit from pole to pole). The AMSR-E data processing plan (work order) is created from this orbital event information.

(3) Definitive Orbit Data

In AMSR-E data processing, the predictive orbit data included in GBAD data is usually used. However, when higher accuracy of data processing is required in the future, definitive orbit data is needed. This definitive orbit data is created by NASA/FDS, and is transmitted from NASA/EOC to IST of AMSR-E data processing systems by 1 time per day.

3.5.4 Standard Product Processing

In the AMSR-E data processing system, the following kinds of automatic processing (partially operator is working) are carried out in accordance with the previously defined parameters, etc.

- Standard processing
  - Planned processing
  - Order processing
- Near real time data processing
- Re-processing
- Catalog processing

The outline of each processing is shown below.

(1) Standard processing

Standard processing is the routinely performed level 1 – 3 data processing by using RBD or PDS, and divided to two kinds of processing, planned processing and order processing.

a) Planned Processing

Planned processing is to routinely produce the products, which are previously decided, in accordance with the processing plan created from orbital event information, whether the products are ordered or not. For planned processing, the fixed parameters previously specified are used.

The AMSR-E level 1A created in the planned processing is provided to the NASA/PO.DAAC.

b) Order processing

Order processing is to produce the product in accordance with the work order that is prepared based on the demand from users by EOIS/SMSS. For order processing, fixed kinds of processing are performed in accordance with a menu (parameter) previously specified by EOIS. In addition, two kinds of processing priority are defined, one is urgent processing and the other is normal processing, and these processing priorities are informed from EOIS/SMSS by using work order. The urgent processing is performed prior to any other processing.

(2) Near real time data processing

Near real time data processing is to produce the product of previously defined contents (extracting of the interest region, etc.) and to provide it to users (Near real time data users) until the specified due time for the purpose of operational use, such as weather forecasting.

(3) Re-processing

When parameters or algorithm of processing is updated, the products (level 1 - 3) and browse that have already been generated as standard processing are processed again by using updated parameters or algorithm. Product reprocessing depends on which parameter or algorithm is updated.

(4) Catalogue processing

Catalogue processing is to produce browse data by sampling the Level 3 products (daily) generated routinely as standard processing.

AMSR-E data processing described in the above is performed in accordance with the following priority.

1: Order Processing (Priority: “Urgent”)
2: Near real time data processing
3: Standard Processing and Catalogue Processing
4: Order Processing (Priority: “Normal”)
5: Re-processing

4 OUTLINE OF THE AMSR-E PRODUCTS

4.1 Product Definitions

4.1.1 Product Level Definitions

AMSR-E product level is defined as shown in the Table 4.1-1.

Table 4.1-1 AMSR-E Product Level Definitions

Level	Definition	Processing Type
Level 0	Quality of AMSR-E RBD or PDS is inspected and the result is attached as a quality flag.	Not Deliverable
Level 1A	Radiometric and geometric correction is carried out for the level 0 data, conversion coefficient of antenna temperature and count value of antenna temperature is calculated, and 1 scene data is extracted.	Planned
Level 1B	Brightness temperature is calculated from observed count value by using conversion coefficient included in level 1A product.	Planned
Level 1B Map	Level 1B product re-sampled on map projection.	Order
Level 2	Geophysical parameters concerning to water are calculated from level 1B product.	Planned
Level 2 Map	Level 2 product re-sampled on map projection.	Order
Level 3	Level 1B product and level 2 product is averaged daily and monthly, and spatially re-sampled on grid, which globally covers the world.	Planned

4.1.2 Scene Definitions

(1) Level 1A / Level 1B / Level 2

- The scene of AMSR-E level 1A, level 1B and level 2 products is defined as a half orbit from center of scanning at southernmost point to northernmost point. These products contain 10 scan overlapping at the beginning and end of each scene, as shown in figure 4.1-1. Level 2 product covers from the scan including the northernmost point or the southernmost point in the scanning central point to the scan just before the one including the next northernmost point or the next southernmost point.

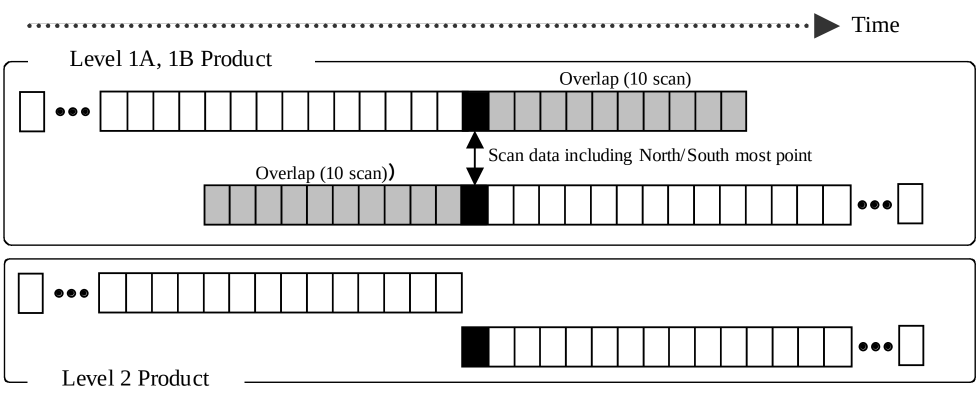


Figure 4.1-1 Scene Definition of Level1, 1B and 2 Product

(2) Level 1B Map / Level 2 Map

- Product size is 300 x 300 pixel, and each pixel is defined as approximately 10 km x 10 km. That is, scene size of a map is approximately 3000 km x 3000 km.
- The map projection method is selected from Equi-rectangular (EQR), Mercator (MER) or Polar Stereographic (PS). (see table 4.1-1 and figure 4.1-2)
- As the earth model, WGS 84 is adopted.
- Referential latitude for scene extracting is selected from the following 3 types. Here, the definition of referential latitude is the latitude of the point of contact at which the earth (sphere) is projected onto the map (plane).

  - Standard Latitude : For EQR and MER, the standard latitude is set onto the 0˚ (equator). For PS, the standard latitude is set onto the ±90˚ (pole)
  - Scene Center : Latitude of scene center by which users specify for map extracting.
  - Specified Latitude : Latitude specially specified by users. User can specify latitude every 5˚.

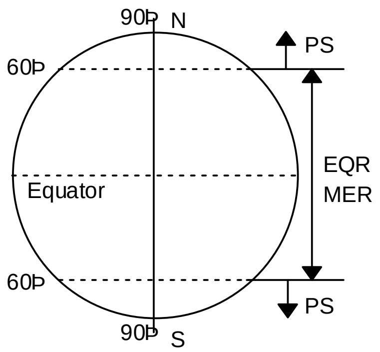


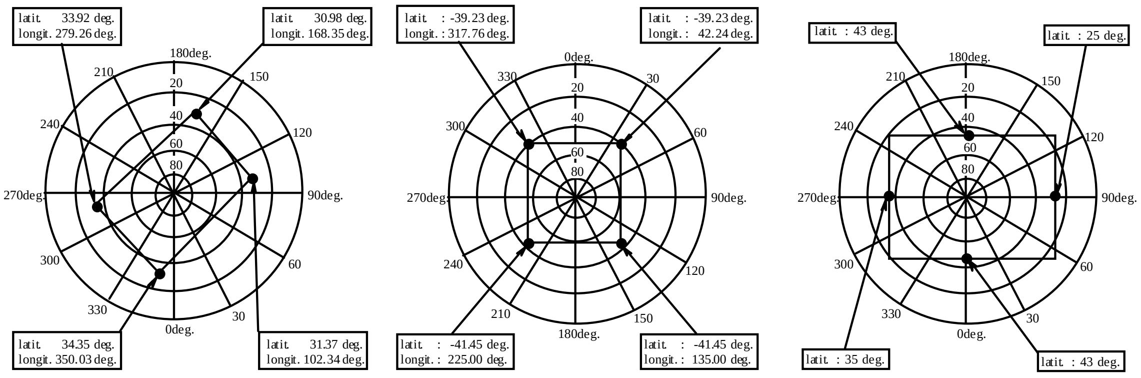
Figure 4.1-2 Map Projection Method

Table 4.1-2 Map Projection Method

Latitude (N and S)	Projection Method		
	EQR	MER	PS
0˚ - 60˚	O	O	x
60˚ - 90˚	x	x	O

(3) Level 3

- Level 3 is global map product
- There are 2 kinds of map projection method, one is EQR and the other is PS.
- Grid interval of EQR is 0.25˚ and PS is 25 km.
- The definition of the target area for PS map is shown in Figure 4.1-3 (a) – (c).



(a) Brightness Temp. & Sea Ice Concentration (North Hemisphere) (b) Brightness Temp. & Sea Ice Concentration (South Hemisphere) (c) Snow Depth (North Hemisphere)

Figure 4.1-3 Definition of Target Area of Level 3 Product for PS

4.1.3 Standard Product Definition

4.1.3.1 Level 1 Product

(1) Level 1A Product

- Dummy data is filled for the missing packets in level 0 data.
- Extracted to scene of half orbit from pole to pole.
- Bit array of the observation data (10 or 12 bits) is converted to 16 bits.
- Influence of the Earth radiation on low temperature calibration source (CSM: Cold Sky Mirror) for 6 GHz is corrected.
- Influence of the Moon radiation on CSM is corrected.
- Radio interferometry from GEO satellite at 10 GHz is corrected.
- Stray light from the Sun to CSM for 6 GHz is corrected.
- Temperature of high temperature calibration source (HTS: High Temperature noise Source) is corrected.
- Longitude and latitude, incidence angle, sun azimuth and sun elevation are calculated for corresponding observation data.
- Amount of the missing packets is checked and quality information is appended.
- Land/Ocean flag is appended.

(2) Level 1B Product

- Antenna temperature is calculated from digital count value in level 1A product.
- Scanning bias is corrected for 6 GHz.
- Calibration curve is applied for antenna temperature.
- Antenna temperature is converted to brightness temperature
- Observation data within ±61˚ of antenna angle is extracted.

(3) Level 1B Map Product

- Level 1B data projected onto map (EQR, MER or PS).

Table 4.1-3 AMSR-E Level 1 Products

Products	Data Unit	Frequency	Data Volume*1
Level 1A	Scene (Half orbit)	29/day*2	38 MB
Level 1B	Scene (Half orbit)	29/ day *2	32 MB
Level 1B Map	Scene (EQR, MER or PS)	Order	5 MB*3

*1: Estimated data volume per data unit

*2: Revolutions per day = 14.5rev./day

*3: The data volume depends on the map projection method and standard latitude.

4.1.3.2 Higher Level Product

(1) Level 2 Product

- Geophysical parameters are calculated from level 1B data.
- As same as level 1B product, geometric information, quality information and ancillary information (time tag of each scan based on TAI93, and orbit number) are appended.

Table 4.1-4 AMSR-E Level 2 Products

Product	Code	Data Unit	Frequency*1	Data Volume*2
Water Vapor	WV	Scene (Half orbit)	29/day	2.6 MB
Cloud Liquid Water	CLW	Scene (Half orbit)	29/day	2.6 MB
Amount of Precipitation	AP	Scene (Half orbit)	29/day	2.6 MB
Sea Surface Wind	SSW	Scene (Half orbit)	29/day	2.6 MB
Sea Surface Temperature	SST	Scene (Half orbit)	29/day	2.6 MB
Snow Depth	SWE	Scene (Half orbit)	29/day	2.6 MB
Sea Ice Concentration	IC	Scene (Half orbit)	29/day	2.6 MB
Soil Moisture*3	SM	Scene (Half orbit)	29/day	2.6 MB

*1: Revolutions per day = 14.5rev./day

*2: Estimated data volume per data unit

*3: Addition to standard product from processing algorithm ver. 2

(2) Level 2 Map Product

- Level 2 data projected onto map (EQR, MER or PS).
- Each pixel data is re-sampled to 10 km interval by using nearest neighbor method.

Table 4.1-5 AMSR-E Level 2Map Products

Product	Code	Data Unit	Frequency	Data Volume*1	Map	Referential Latitude		
						Standard	Scene Center	Specified
Water Vapor	WV	Scene	Order	5.5 MB	EQR	O	O	O
					MER	O	O	O
					PS	O		O
Cloud Liquid Water	CLW	Scene	Order	5.5 MB	EQR	O	O	O
					MER	O	O	O
					PS	O		O
Amount of Precipitation	AP	Scene	Order	5.5 MB	EQR	O	O	O
					MER	O	O	O
					PS	O		O
Sea Surface Wind	SSW	Scene	Order	5.5 MB	EQR	O	O	O
					MER	O	O	O
					PS	O		O
Sea Surface Temperature	SST	Scene	Order	5.5 MB	EQR	O	O	O
					MER	O	O	O
					PS	O		O
Snow Depth	SWE	Scene	Order	5.5 MB	EQR	O	O	O
					MER	O	O	O
					PS	O		O
Sea Ice Concentration	IC	Scene	Order	5.5 MB	EQR	O	O	O
					MER	O	O	O
					PS	O		O
Soil Moisture*2	SM	Scene	Order	5.5 MB	EQR	O	O	O
					MER	O	O	O
					PS	O		O

*1: Estimated data volume per data unit
*2: Addition to standard product from processing algorithm ver. 2

(3) Level 3 Product

- Level 1B data (Brightness Temperature) and level 2 data (Geophysical Parameters) are averaged temporarily and spatially. 2 kinds of temporarily averaged data are produced, one is for daily data and the other is for monthly data. The averaged data is projected onto global map of EQR or PS.
- Data unit is specified as global data for each product, however these are divided to the ascending path data and the descending path data. Here, the ascending path data and descending path data is defined as follows.

  - Ascending : Observation data from the South Pole to the North Pole.
  - Descending : Observation data from the North Pole to the South Pole.

Table 4.1-6 AMSR-E Level 3 Product

Product	Code	Data Unit	Frequency	Map	Data Volume*1
Brightness Temperature	TB	Global (A/D)	1/day, month	EQR	1.98 MB*2
				PS (North)	0.26 MB*2
				PS (South)	0.20 MB*2
Water Vapor	WV	Global (A/D)	1/day, month	EQR	1.98 MB
Cloud Liquid Water	CLW	Global (A/D)	1/day, month	EQR	1.98 MB
Amount of Precipitation	AP	Global (A/D)	1/day, month	EQR	1.98 MB
Sea Surface Wind	SSW	Global (A/D)	1/day, month	EQR	1.98 MB
Sea Surface Temperature	SST	Global (A/D)	1/day, month	EQR	1.98 MB
Snow Depth	SWE	Global (A/D)	1/day, month	EQR	1.98 MB
				PS (North)*3	0.47 MB
Sea Ice Concentration	IC	Global (A/D)	1/day, month	PS (North)	0.26 MB
				PS (South)	0.20 MB
Soil Moisture*4	SM	Global (A/D)	1/day, month	EQR	1.98 MB

A: Ascending D: Descending

*1: Estimated data volume per data unit

*2: There are 12 channels data of brightness temperature, and the data volume of 1 file correspond to 1 channel data.

- Horizontal polarization (6 ch.): 6.9, 10.65, 18.7, 23.8, 36.5, 89.0 GHz
- Vertical polarization (6 ch.): 6.9, 10.65, 18.7, 23.8, 36.5, 89.0 GHz

*3: SWE projected onto PS of south hemisphere is not produced.

*4: Addition to standard product from processing algorithm ver. 2

4.2 Level 1 Processing Algorithm

4.2.1 Editing

Processing flow of AMSR-E data editing is shown in Figure 4.2-1.

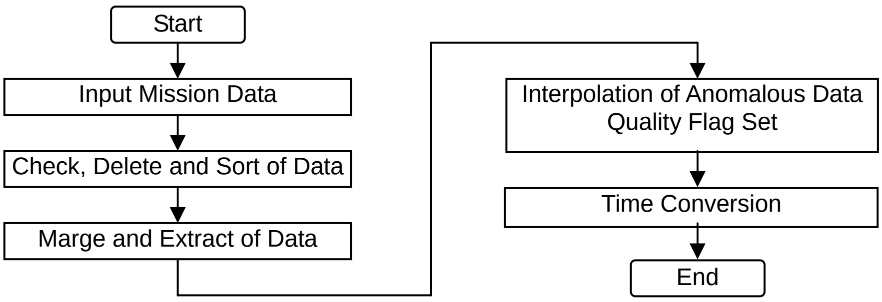


Figure 4.2-1 Processing Flow of Data Editing

For AMSR-E de-packet RBD, quality check (missing data, duplicate data and so on), deleting of unnecessary data (direct broadcast data) and sorting by packet sequence counter and time is carried out.

Next the RBD (or PDS) is divided to processing unit, which is scene of half orbit (southernmost point ~ northernmost point) and includes overlapping for data processing. When several files are existing as input data for this data editing, these files are merged. Format conversion of the edited data of scene unit is carried out and engineering data is calculated. Additionally, the parity bit and missing data of this converted data is checked. The missing and anomalous data is interpolated, or filled by dummy data. And, quality flags of these data are set up.

In the editing process, time system of input data (Science/GBAD) is converted from TAI time based on 1958 to TAI time of 1993. And then, trigger time of 1 cycle corresponding to each scan is calculated.

Here, concept of data editing is shown in Figure 4.2-2.

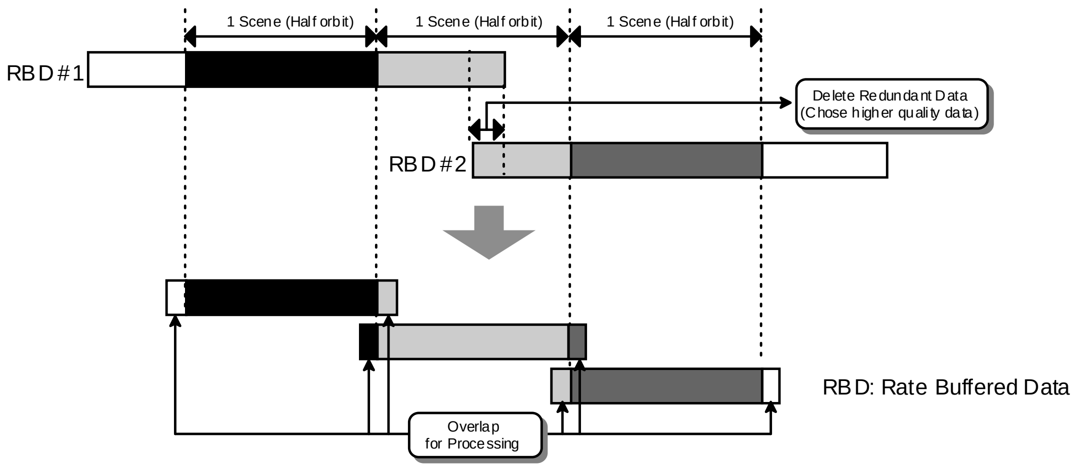


Figure 4.2-2 Concept of Data Editing (Example: Input data is RBD.)

4.2.2 Level 1A Processing

Level 1A processing is carried out to derive geometric and radiometric information from edited AMSR-E data, as shown in Figure 4.2-3.

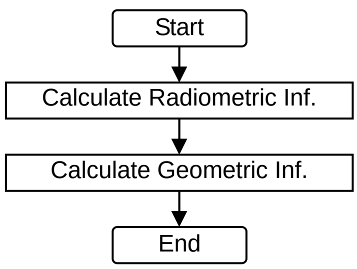


Figure 4.2-3 Level 1A Product Processing Flow

(1) Calculation of the Radiometric Information

Processing flow for calculation of radiometric information is shown in Figure 4.2-4.

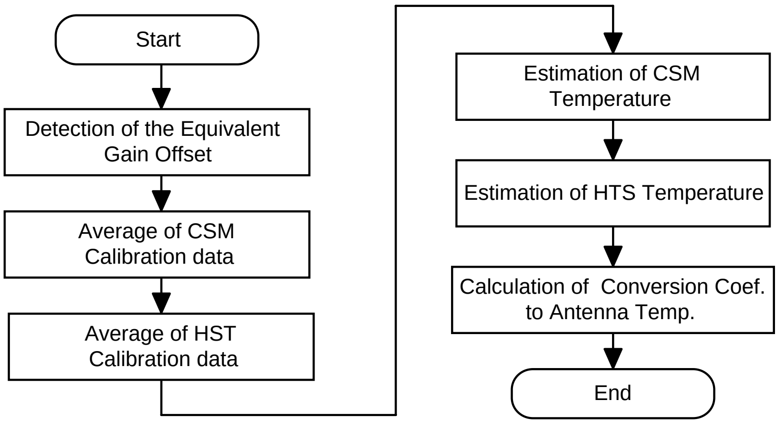


Figure 4.2-4 Processing Flow for Calculation of Conversion Coefficient to Antenna Temperature

a) Detection and Equation of the Equivalent Gain Offset

The range from which low and high temperature calibration data was acquired on the same AGC (Antenna Gain Control) level (gain and offset) is specified. And then, the calibration data of same AGC level is averaged. Data of different gain and offset is not averaged.

b) Correction of CSM and HTS Calibration Data

Observation count value of the low and high temperature calibration source (CSM and HTS) is corrected, as shown in below.

- Correction of HTS calibration data: Correction algorithm is applied.
- Correction of CSM calibration data: Radiation from the Moon and the Earth, radio interferometry from GEO satellite, and stray light from the Sun are removed.

c) Calculation of Conversion Coefficients to Antenna Temperature for all Frequencies

The coefficients of linear equation (A, B) converting observation count value (C_a) to antenna temperature (T_a) are calculated from expected temperature of HTS (T_h), average of high temperature calibration data (C_h), expected temperature of CSM and average of low temperature calibration data (C_c). (See Figure 4.2-5)

$$T_a = A \times C_a + B$$

$$A = \frac{T_h - T_c}{C_h - C_c} \qquad B = \frac{T_h - T_c}{C_h - C_c} \times (-C_c) + T_c$$

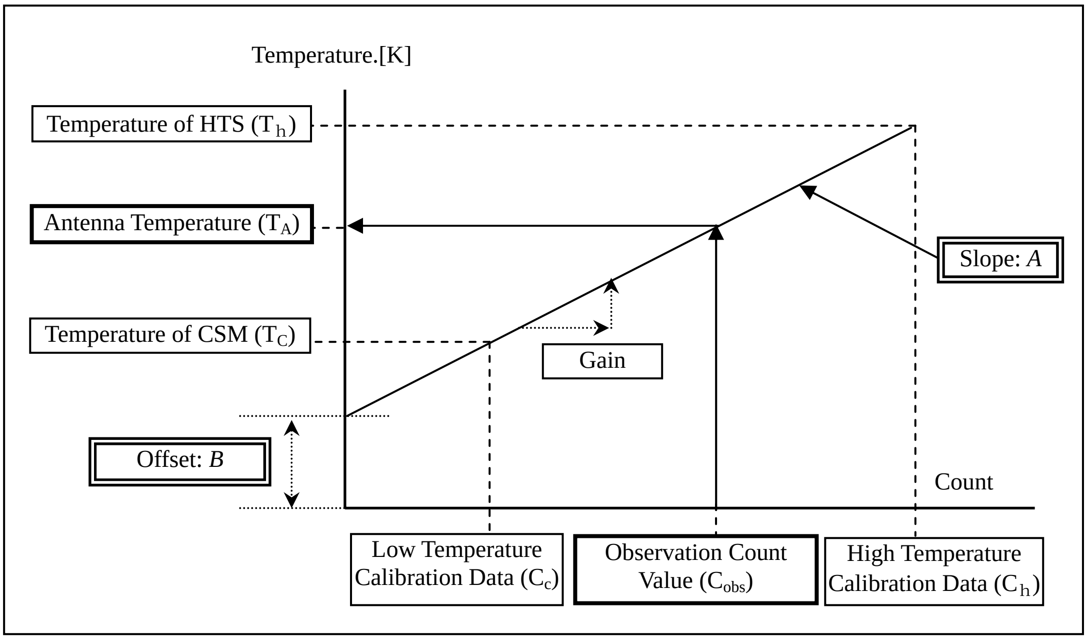


Figure 4.2-5 Conceptual Diagram of Radiometric Information Calculation

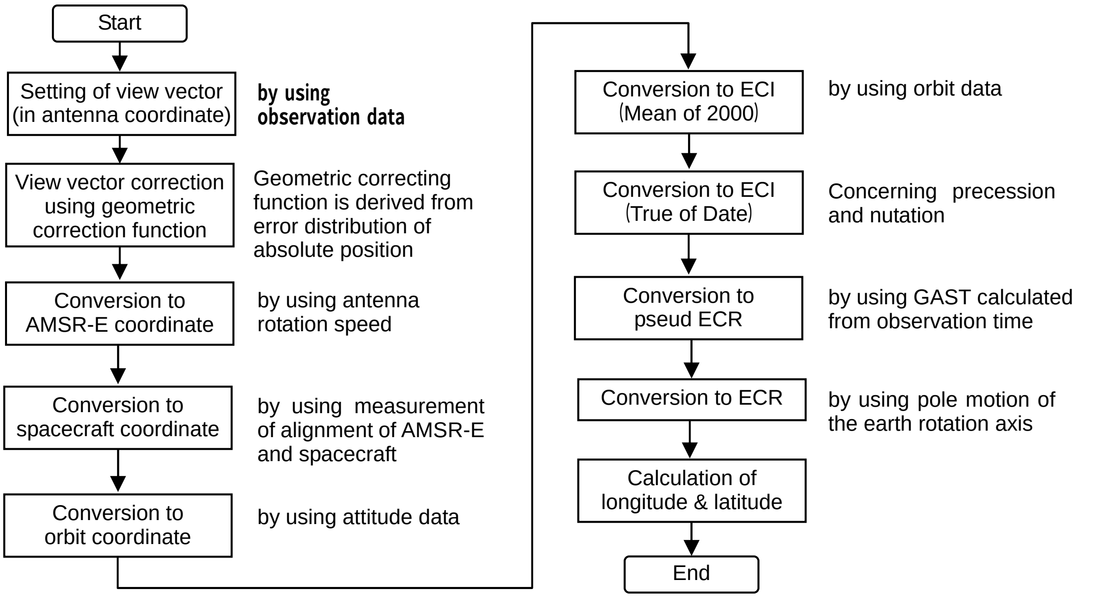
(2) Calculation of the Geometric Information

The following calculation is carried out in this process.

- Calculate the following information.
  - Latitude and longitude of the observation point.
  - Calculate elevation angle and direction angle of the Sun, and incident angle and direction angle of land surface.
- Set Land/Ocean flag for all observation frequency

a) Latitude and Longitude of the observation point

The processing flow is shown in Figure 4.2-6, about calculation of latitude and longitude of the observation point on the earth.



ECI: Earth-Centered Inertial Coordinate System ECR: Earth-Centered Rotating Coordinate System
GAST: Greenwich Apparent Sidereal Time

Figure 4.2-6 Processing Flow of Calculation of Longitude and Latitude

- View vector correction

Elevation angle and direction angle of view vector is corrected in accordance with position error in satellite progressive direction (Δ Line) and scanning direction (Δ Pixel). Δ Pixel is corrected by adjusting of direction angle. Δ Line is corrected by adjusting of both elevation and direction angle. Figure 4.2-7 shows the relationship between view vector and the corrected observation point.

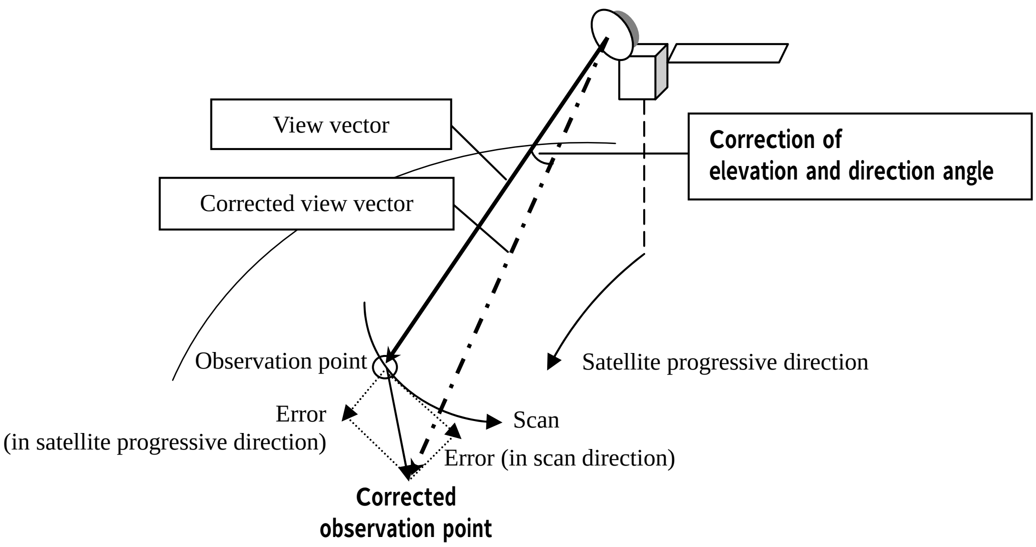


Figure 4.2-7 Relationship between View Vector and the Corrected Observation Point

- Coordinate Conversion

Latitude and longitude information is the position corresponding to observation data of 89 GHz, and calculated from observation time and satellite position for each observation point through coordination system conversion of vector. Earth model is the WGS 84 and the calculated latitude is geodetic latitude. Geometric information for observation frequency other than 89 GHz is not included in Level 1A product. But this information can be converted from geometric information of 89 GHz using relative registration parameter, which is one of core metadata. On the other hand, when geometric information of 89 GHz is substituted for the other observation frequency, its position error on the Earth surface is expected about 5 through 10 km.

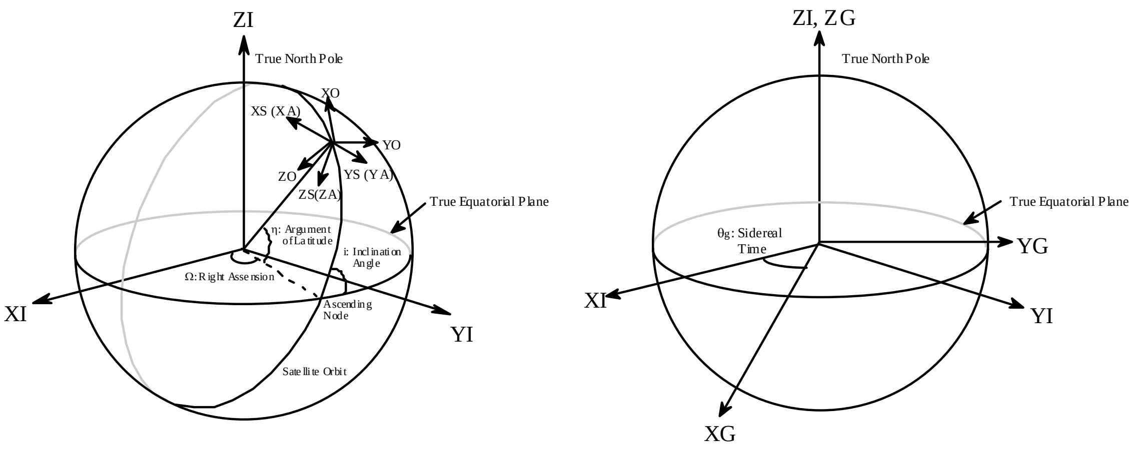
Conversion method of geometric information using the relative registration parameter is described in the "Format Description of Level-1A Product", which is attached to this handbook as appendix 3.

Here, the definitions of coordinate systems are shown in Table 4.2-1 and Figure 4.2-7, for calculation of longitude and latitude of observation point.

Table 4.2-1 Definitions of Coordinate System

Coordinate System	Symbol	Origin/Axis	Definitions
Antenna Coordinate System	R	Origin (OR)	Center of antenna rotation axis
		XR	Same as XA, in case of rotation angle 0°*1
		YR	Same as YA, in case of rotation angle 0°*1
		ZR	Same as ZA
AMSR-E Coordinate System	A	Origin (OA)	Center of rotation
		XA	Same direction as spacecraft roll axis
		YA	ZA x XA
		ZA	Same direction as spacecraft yaw axis
Spacecraft Coordinate System	S	Origin (OS)	Gravity point of spacecraft
		XS	Spacecraft roll axis
		YS	Spacecraft pitch axis
		ZS	Spacecraft yaw axis
Orbit Coordinate System	O	Origin (OO)	Gravity point of spacecraft
		XO	YO x ZO
		YO	Opposite direction of orbit angular momentum vector
		ZO	Earth center direction
ECI (Mean of 2000)	I_{2000}	Origin (O I_{2000})	Earth center
		X I_{2000}	Mean equinox direction
		Y I_{2000}	Z I_{2000} x X I_{2000}
		Z I_{2000}	Vertical direction to mean equatorial plane
ECI (True of Date)	I_{True}	Origin (O I_{True})	Earth center
		X I_{True}	True equinox direction
		Y I_{True}	Z I_{True} x X I_{True}
		Z I_{True}	Vertical direction to true equatorial plane
Pseudo ECR		Origin (OG)	Earth center
		XG	Prime meridian direction
		YG	ZG x XG
		ZG	True earth rotation axis
ECR	G	Origin (OG)	Earth center
		XG	Prime meridian direction on equatorial plane
		YG	ZG x XG
		ZG	Based on the IERS Referential Point (IRP)

*1: "Rotation angle 0" is defined as the moment in which rotation start is triggered. Position error of antenna rotation is corrected when conversion to antenna coordinate system is carried out.



(a) Relationship between Coordinate System of AMSR-E, Spacecraft and ECI

(b) Relationship between Coordinate System ECI and ECR

Figure 4.2-7 Definition of Coordinate System

b) Solar elevation angle and a direction angle at observing point

Solar elevation angle and the solar direction angle corresponding to the observation position of 89GHz are calculated from the latitude and longitude of the observing point, and the position information of the Sun.

c) Land surface incidence angle and direction angle of observing view vector

Land surface incidence angle and direction angle of observation view direction vector are calculated from the latitude and longitude of the observing point, and the position information of the Sun.

d) Land/Ocean Flag

Land/Ocean flag information is retrieved from the existing database using latitude and longitude information, and is set up.

4.2.3 Level 1B Processing

Input data of level 1B processing is level 1A product and the processing flow is shown in Figure 4.2-8.

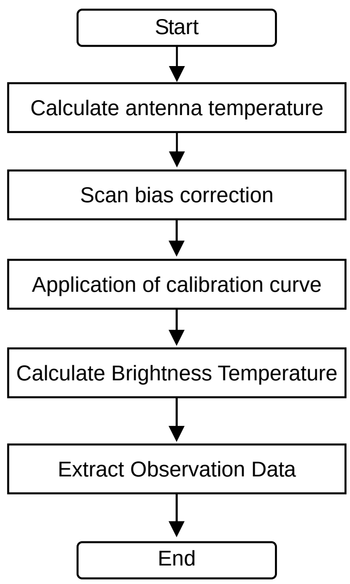


Figure 4.2-8 Level 1B Product Processing Flow

(1) Calculate Antenna Temperature

Observation count value C_{obs} is converted to antenna temperature T_A by using the antenna conversion coefficients A and B derived from level 1A product processing.

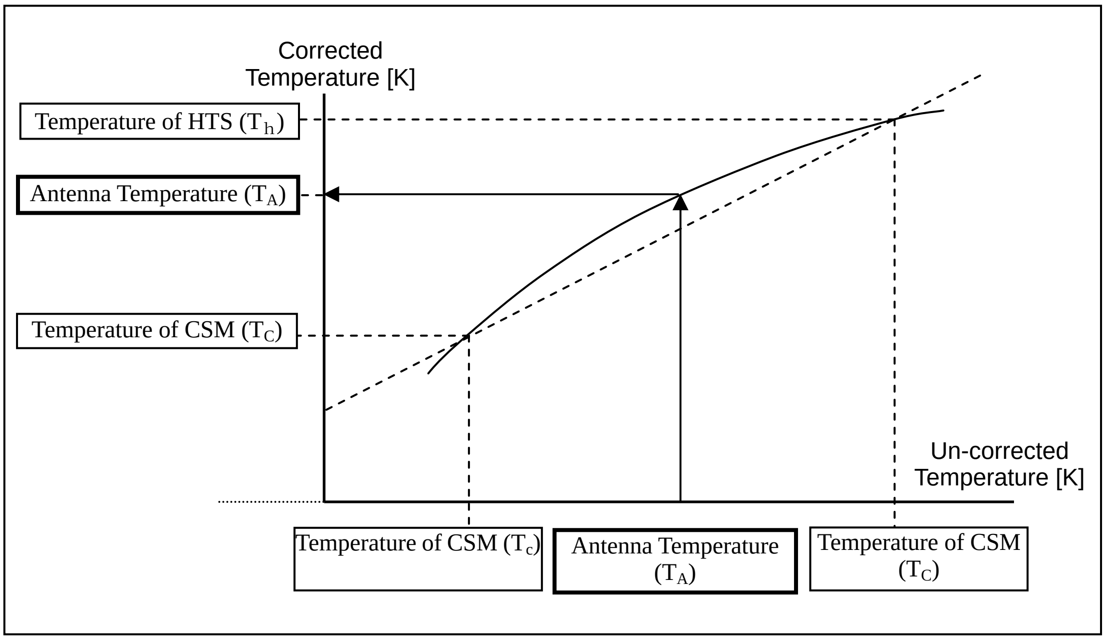
(2) Scan Bias Correction

Scan-bias of 30 points at the first part of a scan data (total 196 points) in level 1B product are corrected by using conversion coefficients.

(3) Application of Calibration Curve

Antenna temperature T_A is converted to the corrected antenna temperature T_A’ by using calibration coefficients C_1, C_2, C_2, C_4 and C_5.

$$T_A{}' = C_1 + C_2 \cdot T_A + C_3 \cdot T_A{}^2 + C_4 \cdot T_A{}^3 + C_5 \cdot T_A{}^4$$



(4) Calculation of Brightness Temperature

Brightness temperature (V polarization: TBvb and V polarization: TBhb) is calculated from the antenna temperature TA of each V and H polarized wave.

$$T_{Bvb} = A_{vv}T_{Av} + A_{hv}T_{Ah} + 2.7A_{ov}$$
$$T_{Bhb} = A_{hh}T_{Ah} + A_{vh}T_{Av} + 2.7A_{oh}$$

(5) Extraction of Observation Data

The observation data within the range of ±61 degrees in which the data is not influenced by CSL and HTS is extracted from the observation data acquired within the range of ±75 degrees in the level 1A product.

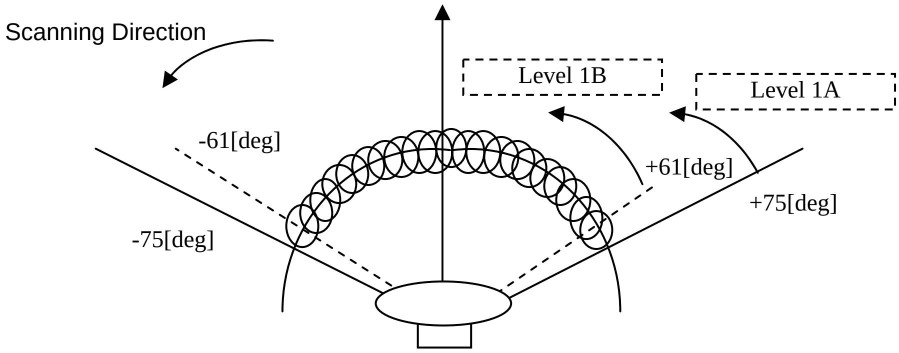


Figure 4.2-9 Observation Image and Product Storing Range

4.2.4 Level 1B Map Processing

Level 1B Map product processing is to extract level 1B product in accordance with specified center latitude and standard latitude, and to project it onto map using the specified projection method (Equi-Rectangular, Mercator or Polar Stereographic).

- Data of the area, which is projected onto map, is extracted from a level 1B product based on the specified center latitude.
- The extracted level 1B data is divided to blocks and corresponds based on center positions of output fixed area (3000 km x 3000 km) and the extracted level 1B.
- 4 corner positions of each block extracted from level 1B product are converted according to the specified map projection method.
- Position of each pixel is previously known, because output area of level 1B Map product is fixed. And so, coefficients from coordinate system of output area to level-1B area are calculated from the known position and mapped position of the extracted level 1B.
- Level 1B data block corresponding to the pixel of output area is extracted by using the conversion coefficients of coordinate system. And observation brightness temperature is calculated using Nearest Neighbor technique.
- When there is no level-1B data corresponding to the output area, 0 is set as brightness temperature.

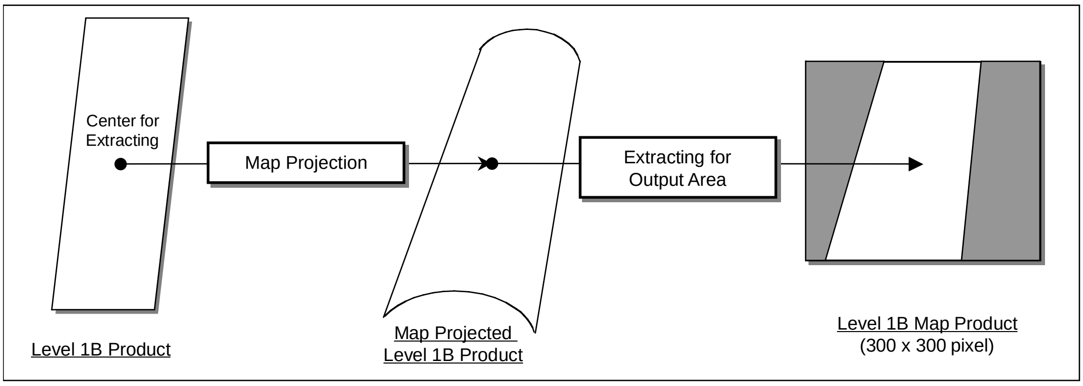


Figure 4.2-10 Concept of Map Projection

4.3 Higher Level Processing Algorithm

4.3.1 Level 2 Processing

Seven kinds of the geophysical parameters are calculated from AMSR-E level 1B data. The calculated geophysical parameters are Water Vapor, Cloud Liquid Water, Amount of Precipitation, Sea Surface Wind, Sea Surface Temperature, Sea Ice Concentration and Snow Water Equivalent.

4.3.1.1 Water Vapor

(1) Input Data

For water vapor processing, the following information is necessary as input data.

- AMSR-E Level 1 Product
  - 18.7, 23.8, 36.5 GHz Brightness Temperature (V/H Polarization)
  - Longitude / Latitude
  - Incidence Angle
  - Observation Time
- Land / Ocean Flag
- Sea Ice Map (AMSR / AMSR-E Level 3 Product, etc.)
- Sea Surface Temperature
- Sea Surface Wind
- Temperature at 850 hPa

(2) Algorithm Overview

a) Land and Sea ice Mask

Land and sea ice is masked by using land/ocean flag and sea ice data. Sea ice data is revised once a day by using the latest data such as AMSR/AMSR-E sea ice level 3 products. If a FOV of

AMSR-E is judged as land or sea ice, then the flag ‘land/sea ice' is set and the retrieval is terminated.

b) Quality Check of AMSR-E Brightness Temperature Data

If below conditions are false, then the flag bad 'TBB' is added and the retrieval is terminated.

- Brightness temperatures T19V, T19H, T24V, T24H, T37V and T37H are within the range from 90 K to 300 K,
- T19V - T19H is positive,
- T24V - T24H is positive,
- T37V - T37H is positive, and
- T24V - T19V is less than TBD K.

c) Quality Check of Ancillary Data

- If sea surface wind speed (Vs) of ancillary data set is out of the range from 0 to 60 m/s, a default value Vs = 5 m/s is set.
- If sea surface temperature (SST) of ancillary data set is out of the range from 0 to 35 ˚C, the flag 'others ' is added and the retrieval is terminated.
- If temperature at 850 hPa (T85) of ancillary data set is out of the range from 200 K to 300 K, a default value T85 = SST - 10 K is set. .

d) Calculation of Index of Cloudiness & Quality Check

Sea surface emissivities at 19 GHz V/H, 24 GHz V/H, and 37 GHz V/H are calculated from frequency, Sea Surface Temperature (SST), and incidence angle, and the derived emissivities are corrected with SST and Sea Surface Wind Speed. And then, the index of cloudiness (CCI) is calculated. If the CCI is less than -0.05, the flag 'bad TBB' is added and the retrieval is quit.

e) Decision of Clear, Cloudy, or Rain Category

- If T19V is larger than 240 K, it is assumed to be rainy condition.
- If T19V is less than 240 K and CCI is larger than 0.2, it is assumed to be cloudy condition.
- If T19V is less than 240 K and CCL is less than 0.2, it is assumed to be clear condition.

f) Calculation of Vertical Mean Temperature of Atmosphere and Square of Atmospheric Transmittance & Quality Check

For each channel, i.e. 18.7 GHz V/H, 23.8 GHz V/H, 36.5 GHz V/H, square of atmospheric transmittance (Tr) and vertical mean temperature of atmosphere (Ta) are calculated from temperature at 850hPa (T85), sea surface emissivity, sea surface temperature (SST) and brightness temperature iteratively. In the case that Ta cannot be obtained or vertical mean temperature of atmosphere-sea surface system is less than TBB, the flag 'bad TBB', is added and the retrieval is terminated.

g) Calculations of Water Vapor Content Iindex and Cloud Liquid Water Index

Cloud liquid water index (CWI) is derived from brightness temperature V/H, atmospheric transmittance (Tr) and vertical mean temperature of atmosphere (Ta) at 18.7 GHz and 36.5 GHz. And then, water vapor index (PWI) is calculated from the CWI, atmospheric transmittance (Tr) at 18.7 GHz and 23.8 GHz and the coefficients obtained from the specified look up table. The coefficients are determined so that we can get the maximum correlation between PWI and PWA from radio sonde.

h) Conversion PWI to Water Vapor Content

PWI is converted to total water vapor content (PWA, kg/m^2) using a look-up table, which is designed as the provability of PWA with AMSR retrievals is equivalent to that of PWA with radio sonde. If PWI is out of range of look-up table, the flag 'low accuracy' is added.

i) Heavy rain Correction to Water Vapor Content

In the case of rainy category, PWA is corrected by T19H/19V.

- If T19/T19V is less than 0.884
  → PWA = PWA-1.51.
- If T19H/T19V is more than 0.884
  → PWA = PWA+(T19H/T19V-0.884)/(0.960-0.884)* 16.5- 1.51.

4.3.1.2 Cloud Liquid Water

(1) Input Data

For cloud liquid water processing, the following information is necessary as input data.

- AMSR-E Level 1 Product
  - 6.925, 10.65, 18.7, 23.8, 36.5 GHz Brightness Temperature (V/H Polarization)
  - Longitude / Latitude
  - Incidence Angle
- Land Map (1/12˚ Resolution)

(2) Algorithm Overview

a) Quality Check of AMSR-E Brightness Temperature Data

This process checks whether the Brightness Temperature input of 5 frequencies fall into the range of possible ocean observations. Lower and upper bound for each channel and for the difference between vertical polarization and horizontal polarization are preset. The subroutine returns a flag of 1 if the brightness temperature values fall outside these bounds.

b) Normalization of Brightness Temperature Data

This is a utility procedure that normalizes the brightness temperature observations by adjusting the brightness temperature to a constant incidence angle of 55˚. This routine also adds the geophysical offsets to remove the absolute calibration error. There is one offset number for each channel.

c) Land and Sea ice Mask

This process takes as input the latitude and the longitude of a cell and determines whether it is close to land or coast by comparing the input with an l/12 degree resolution land bit map. The subroutine then returns 1 to indicate land or 0 otherwise.

Moreover, total ice concentration is calculated from the latitude and the brightness temperatures by using AMSR team ice algorithm.

An error flag is set if any check returns true and the corresponding cell is excluded from the calculation of cloud liquid water.

d) Calculation of Cloud Liquid Water

Integrated cloud liquid water is calculated from brightness temperature of 10 channels (5 frequencies X 2 polarization) by using a Linear Statistical Regression (LSR) algorithm. In this processing, a combination of coefficients is utilized and these are specified in accordance with a simulation in which brightness temperatures for a wide variety of ocean scenes (sea surface temperature, wind speed, water vapor and cloud liquid water) are computed by the Radiative Transfer Model (RTM). These coefficients were found such that the rms difference between estimated value and the true value for the specified environmental scene was minimized

If the value of cloud liquid water is above 0.18 mm, it flags the observation as having rain.

4.3.1.3 Precipitation

(1) Input Data

For precipitation (rain rate) processing, the following information is necessary as input data.

- AMSR Level 1 Product
  - 18.7, 36.5, 89.0 GHz Brightness Temperature (V/H Polarization)
  - Longitude / Latitude
  - Incidence Angle
- Sea Surface Temperature (AMSR level 3 product)
- Sea Ice Concentration (AMSR level 3 product)

(2) Algorithm Overview

Combinations of both emission and scattering signatures are used in retrieval algorithm. The algorithm retrieves rainfall over ocean and land areas except for the following surfaces: coastal (~25 km from coastal line), sea ice, snow-covered land, and desert areas. Separate algorithms are applied for over ocean and over land regions. Generally, retrievals over ocean have better quality than those over land. The sea ice flag is based on sea ice concentration retrievals from AMSR provided by the EOC integrated retrieval system. Snow-covered land and desert surface detection is based on AMSR brightness temperatures and embedded in the precipitation retrieval algorithm.

a) Precipitation Retrieval Algorithm (Ocean)

A combination of emission and scattering signature is used as the key parameter for rainfall determination.

$$f = (1 - \frac{D}{D_0}) + 2(1 - \frac{PCT}{PCT_0})$$

where D is the depolarization of 18.7 GHz (D = T_{B19V} - T_{B19H}), and D_0 is D at the threshold of rain onset; PCT is the polarization corrected brightness temperature defined PCT = 1.818T_{B89V} - 0.818T_{B89H}, and PCT_0 is PCT at the threshold of rain onset.

D_0 and PCT_0 are determined monthly for every 3° (latitude) x 6° (longitude) box based on 37 GHz depolarization and sea surface temperature, and are saved in a file as a look-up table. The relationship between f and rainfall rate is determined by radiative transfer calculation result with consideration of beam-filling effect, and can be expressed by the following equation.

$$R = \alpha f^{\beta}$$

where α and β are spatial scale-dependent coefficients. The dependence of α and β on spatial scale is due to the spatial dependence of beam-filling effect.

b) Precipitation Retrieval Algorithm (Land)

The land portion of precipitation retrieval algorithm uses 18.7 and 89 GHz brightness temperatures. It is expressed by the following equation.

$$R = a(DT_B - DT_{B0})$$

where a=0.2 is a coefficient derived from radiative transfer model simulations; D_{TB} =$T_{B18.7}$ - T_{B89}. DT_{B0} is DT_B at the threshold of rain onset that is determined monthly for every 3° (latitude) x 6° (longitude) box and is saved in a file as a look-up table.

4.3.1.4 Sea Surface Wind Speed

(1) Input Data

For sea surface wind speed processing, the following information is necessary as input data.

- AMSR-E Level 1 Product
  - 10.65, 36.5 GHz Brightness Temperature (V/H Polarization)

- 6.925 GHz Brightness Temperature (H Polarization)

(2) Algorithm Overview

Sea surface wind speed (SSW) is retrieved mainly from 36.5 GHz vertical (V) and horizontal (H) brightness temperature of AMSR by a graphical method. The retrieval is restricted to no rain condition since the brightness temperature of 36.5 GHz is saturated under rainy condition, SSW obtained only from 36.5 GHz has a large anisotropic feature depending on an angle between antenna direction and wind direction. Its anisotropic feature is corrected by using two data from 36.5 and 10.65 GHz, since 10.65 GHz data are less anisotropic. Even under rainy condition, 10.65 and 6.925 GHZ data are not saturated, so wind speed is retrieved by using those H data. Retrieval accuracy of wind speed using 10.65 and 6.925 GHz becomes worse than using 36.5 GHz, since a sensitivity of 10.65 and 6.925 GHz to wind speed is not so strong.

36.5 GHz data is used for the algorithm of standard products processing. 6.925 GHz and 10.65 GHz data is used for research product, which is provided from EORC.

4.3.1.5 Sea Surface Temperature

(1) Input Data

For cloud liquid water processing, the following information is necessary as input data.

- AMSR-E Level 1 Product
  - 6.925, 10.65 GHz Brightness Temperature (V/H Polarization)
  - 23.8, 36.5 GHz Brightness Temperature (H Polarization)
  - Incidence angle

(2) Algorithm Overview

a) Incident angle correction

Corrections for the brightness temperature due to incident 'angle variation are given by the following equations;

dA = -2.9 x (A-55.0) .... 6(V)

dA = -2.7 x (A-55.0) .... 10(V)

Where A is the incident angle. The horizontal polarization data are also corrected by similar equations.

b) Atmospheric correction

A correction for atmospheric opaque is obtained from a pair of two temperatures of 23 GHz and 37 GHz (V polarization). Because brightness temperatures of 23 V and 37 V are changed with SST, the table is made with 5 ˚C interval of SST from 0 to 35 ˚C. It is necessary to omit data contaminated by rain, since SST accuracy becomes worse in rain areas. Its judge is made by counting the number of pixels within 6 GHz or 10 GHz spatial resolution. If the number of pixels with out of range is larger than a threshold, SST is missing.

c) Surface wind correction

Brightness temperature of V polarization is constant under condition of sea surface wind speed less than 7-8 m/s. But, the one with H polarization increases uniformly. Above 7 - 8 m/s, both brightness temperature of V and H polarization increase with wind speed. Based on this correlation, corrections for sea surface wind are calculated independently from two frequencies; 6 V and 6 H, and 10 V and 10 H, which are already corrected for atmospheric opaque.

d) Land contamination correction

Contamination by land emission increases drastically when the pixel approaches a shoreline, or the pixel includes an island. Here, land contamination is removed for cases that it is less than 2 K For pixels of contamination larger than 2 K, SST is missing.

e) Sun glitter removal

Sun glitter is checked by using a relative angle between the antenna beam and sun direction, which is given by LIB. SST is missing for pixels with the relative angle larger than 30˚.

f) Salinity correction

Salinity effect cannot be neglected when SST is high as 30 ˚C, and an amount of correction is an order of 0.1 or 0.3 K. Its effect is calculated in advance by using the climate salinity, and data set of correcting salinity effect is prepared with spatial resolution of 1 degree. This data set is not modified even after the launch.

g) Sea ice removal

Sea ice is checked by using the same table as atmospheric correction. If the value exceeds 5.5 K in the latitude larger than 65˚, the pixel is contaminated. SST is missing when the number of pixels with sea ice contamination exceeds a specified value.

h) Conversion to SST

The relationship between 6V (or 10V) and SST is calculated by using the complex relative dielectric constant.

i) Spatial running mean

The temperature resolution at 6 GHz is about 0.3 K for one pixel, which is corresponding to about 0.6 ˚C of SST. It is necessary to reduce its noise. A current method is a spatial running mean with 5 pixels by 5 pixels (50 km by 50 km area). The simulation indicates the reduced noise becomes less than 0.1 K after applying 5 by 5 running mean.

4.3.1.6 Snow Depth

(1) Input Data

For snow water equivalence processing, the following information is necessary as input data.

- AMSR Level 1 Product
  - 18.7 and 89 GHz Brightness Temperature (V Polarization)
  - 36.5 GHz Brightness Temperature (V/H Polarization)
  - Longitude / Latitude
  - Incidence Angle
- Land/sea/ice
- Topography

- Snow class (Strum *et al*, 1995)
- Snow (im)possible

(2) Algorithm Overview

a) Detection of the Snow Region

The first step is to determine the kind of surface present (flat land, water body on land, ice, ocean, mountainous terrain, snow climatologically (im)possible, forest cover). Unless the surface is flat land without heavy forest cover, the procedure flags the surface type and does not attempt to compute the snow depth. For flat land without heavy forest cover, the algorithm proceeds to the next step, which reads, in AMSR channel brightness temperatures.

Next a rough surface temperature (either snow covered or snow free) will be calculated. These estimated temperatures would also be used to determine whether snow cover is possible for this pixel. A threshold (275K) is used as the threshold for the present time.

When there is raining or wet snow, no accurate snow parameter estimates can be produced. The rain and wet snow tests will then be applied.

Liquid precipitation can affect the microwave signatures over land. Thus, when it is raining, snow parameters may not be retrieved. A multi frequency procedure to filter the rain cases is adopted to remove the pixels affected by the rain signal.

Wet snow can confound snow depth retrievals by depressing the scattering behaviour of the snow. Ultimately, this leads to underestimation of the pack. Unfortunately, at present there is little that can be done to overcome this problem directly although at least the detection of wet snow is possible by using a combination of information about the surface temperature, polarization difference at 36.5 GHz.

b) Calculation of Snow Depth

Compared with non-snow surfaces, therefore, a snowpack has a distinctive electromagnetic signature at frequencies above 25 GHz. When viewed using passive microwave radiometers from above the snowpack, the scattering of upwelling radiation depresses the brightness temperature of the snow at increasingly high frequencies. This scattering behavior of snow can be exploited to detect the presence of snow on the ground. Having detected the snow, it is then possible to estimate the snow depth of the pack using the degree of scattering.

Wet soil snow depth is estimated by the following equation.

$SD = 1.66 \text{ x } \Delta Tb$

Otherwise, dry soil snow depth is estimated by the following equation.

$SD = a \times \Delta Tb / (1 - ff)$

The D_{TB} term is the difference in brightness temperature between 18.7 GHz and 36.5 GHz channels (vertical polarization). The a coefficient should, therefore, be varied both spatially and temporally and so we have computed a set of coefficients for each month of the year. The spatial distribution of the coefficients is achieved using the seasonal snow pack classification of Sturm et al. (1995) which divides the northern hemisphere into 6 dominant regional snow types. ff is the forest fraction in percent.

4.3.1.7 Sea Ice Concentration

(1) Input Data

For sea ice concentration processing, the following information is necessary as input data.

- AMSR-E Level 1 Product
  - 6.925, 18.7 GHz Brightness Temperature (V Polarization)
  - 36.5 GHz Brightness Temperature (V/H Polarization)
  - Longitude / Latitude
  - Incidence Angle

(2) Algorithm Overview

The technique uses data from the 6 GHz and 37 GHz channels at vertical polarization to obtain an initial estimate of sea ice concentration and ice temperature. The derived ice temperature is then utilized to estimate the emissivities for the corresponding observations at all the other channels. Ice concentrations are derived mainly from 37 GHz and 19 GHz channels, as in the Bootstrap technique, but makes use of emissivities instead of brightness temperatures to minimizes errors associated with spatial changes in sea ice temperatures.

The ice temperature is in the end normalized using the derived ice concentration value, for it to represent temperature only of the sea ice part of the satellite observational area.

4.3.1.8 Soil Moisture

(1) Input Data

For soil moisture processing, the following information is necessary as input data.

- AMSR Level 1 Product
  - 6.925, 10.6, 18.7, 36.5, 89.0 GHz Brightness Temperature (V/H Polarization)
  - Longitude / Latitude
  - Incidence Angle

(2) Algorithm Oveview

In general, at a smooth interface between two semi-infinite media, the emissivity is equal to one minus the Fresnel power reflectivity, which is calculated by using dielectric constant of the media and incident angle. Among the water surface emissivities at AMSR observing frequencies, 6.9; l0.6, 18.7, 36.5 and 89 GHz, the emissivity is larger at the higher frequency than at the lower one for both polarizations.

The following index, the discrepancy between the brightness temperatures at two frequencies divided by one at lower frequency, can be used as an index for surface wetness.

$$ISW = \frac{(T_{bhigh} - T_{blow})}{T_{blow}}$$

ISW :Index of Surface Wetness
T_{bhigh} :Brightness Temperature (High Frequency)
T_{blow} : Brightness Temperature (Low Frequency)

The temperature dependency of ISW is negligible. Figure 4.3-1 shows the relationship between observed surface soil moisture and are ISW calculated by the combination of the brightness temperatures at 36.5 GHz and 6.9 GHZ obtained through the AMR experiments. This combination shows the best performance.

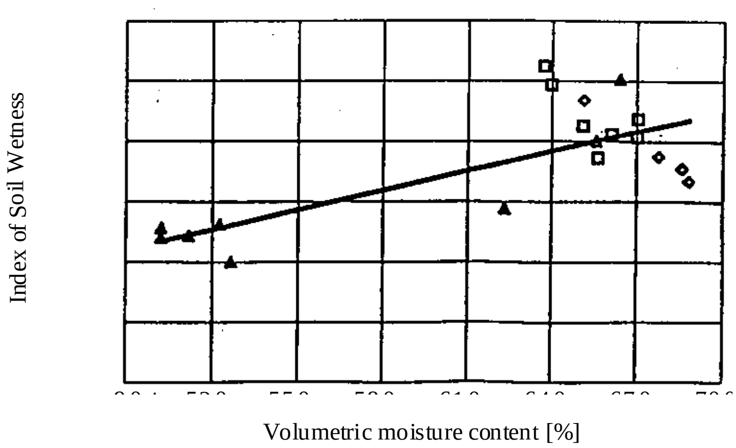


Figure 4.3-1 Soil Moisture – ISW Relationship

Vegetation canopy reduces the signal of land surface wetness, that is, the dependency of ISW on surface soil moisture. Figure 4.3-2 shows the relationship between Global Vegetation Index (GVI) and ISW using 19 GHz and 37 GHz channels of SSM/I. The maximum value of ISW decreases as GVI increases. The liner regression equation for soil moisture estimation is shifted with keeping its slope angle as the equation satisfies a maximum surface soil wetness and its corresponding ISW identified empirically under each vegetation condition.

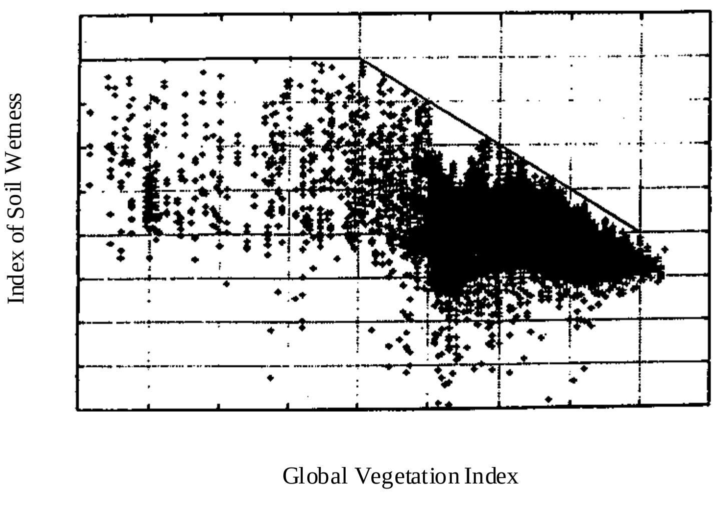


Figure 4.3-2 GVI – ISW Relationship derived from SSM/I

4.3.2 Level 2 Map Processing

Level 2 product is projected onto the map in accordance with specified reference latitude and map projection method (Equi-Rectangular, Mercator or Polar Stereographic), as described in the section 4.1.2. Here, level 2 map processing method is the same as level 1B Map product.

Moreover, When packet is missed caused by any reasons, the observation data corresponding to the portion into which the missing packet is filled by dummy data. Dummy data value is always -9999.

4.3.3 Level 3 Processing

The level 1B and level 2 data of 1 day is projected to the map in accordance with the specified projection technique (Equi-Rectangular or Polar Stereographic) as described in the section 4.2.2, and then the arithmetic average of 1 day is computed on each grid. Moreover, level 3 data for 1 day of each geophysical parameter is inputted for 1 month, arithmetic average of 1 month is computed on each grid, as the same way as 1 day average calculation. These statistical values are computed for observation data on ascending orbit and descending orbit respectively.

When packet is missed caused by any reasons, the observation data corresponding to the portion into which the missing packet is filled by dummy data. Dummy data value is always -9999.Additionally, when there is no data in a grid, -8888 is set to the grid as dummy data.

4.4 Product Format

As a format which stores AMSR-E level 1 - 3 products, HDF is applied by the following reasons.

- Various toolkits are available
- It is easy to access from a user, HDF does not depend on computer environment, for example
- It is easy to adapt to system, because ECS of NASA also applies this as standard format.

The detailed format of AMSR-E level 1 ~ 3 products is specified in the documents, which are listed in below and attached to this handbook as the appendix 3.

- AMSR-E Level 1 Product Specifications (including level 1A, 1B and 1B Map)
- AMSR-E Level 2 Product Specifications
- AMSR-E Level 2 Map Product Specifications
- AMSR-E Level 3 Product Specifications

5 EOIS Data Service

The Earth Observation Data and Information System (EOIS) provides comprehensive on-line information services. In using the EOIS, users are able to implement searches against the earth observation data and view the related information and its browse as well.

5.1 Outline of EOIS Services

EOIS provides data services to users categorized into Principle Investigator (PI), General Researcher and General User, as shown in table 5.1-1. The outline of EOIS services are listed in the table 5.1-1.

Table 5.1-1 User Definition

User Category	Definition
Principle Investigator （PI）	Data is offered to PI from JAXA free of charge to achieve a common research purpose in cooperation with JAXA at the research.
General Researcher	General researchers need user registration. They can obtain earth observation satellite data from EOIS free of charge via internet. (Available data is limited)
General User	General users need neither a special qualification nor application to obtain data at catalogue price. General users can obtain only sample data from EOIS via internet.

Table 5.1-2 EOIS Data Services

Services		Users			Reference*
		PI	General Researcher	General User	
Scene Order					
	Scene Search	O	O	O	5.3.1(1)
	Product Order	O			5.3.1(2)
	Sample Data Download	O	O	O	5.4.3
Data Set Order					
	Data Set Search	O			5.3.2(1)
	Data Set Order	O			5.3.2(2)
Standing Order					
	Product Order	O			5.3.3(1)
Image Catalog					
	Display of Image Catalog	O	O	O	5.3.4(1)
	Editing of Image Catalog	O	O	O	5.3.4(1)
Map					
	Observation Area Indicate	O	O	O	5.3.4(2)
Status Search					
	Status Search	O	O		5.3.4(3)
	Product Download	O	O		5.4.2

*: Corresponding section in this document.

Users can use EOIS data services, shown in the table 5.1-2, by accessing to “Data Distribution Service” menu in the EORC web site (www.eorc.jaxa.jp/en/index.html).

The outline of EOIS services are explained in the following sections of this document. For more detail, “EOIS User’s Manual” is available for PIs, general researchers and general users respectively. Users can obtain the “EOIS User’s Manual” from the web site of EOIS data services.

EORCWebpage:
http://www.eorc.jaxa.jp/en/index.html

Figure 5.1-1 EOIS Login Page

5.2 Data Distribution Method

There are three kinds of method for data distribution to users (scene order, data set order and standing order).

(1) Scene Order

Each scene can be specified by satellite, sensor, observation date and location (latitude/longitude or GRS/WRS). Users order on a scene-by-scene basis. This service is available to all users including PIs, general researchers and general users. Both scheduled products and ordered products are available.

(2) Dataset Order

Users can order a specified multiple-kinds or multiple-days products of a specified sensor as a single dataset. This service is available only to PIs. Because the purpose of this data set order is to deliver large number of the products of planned processing to users at a time, the ordered products cannot be selected by using this method.

(3) Standing Order

Users specify conditions (i.e., sensor, processing level, products, period or latitude/longitude) for JAXA to process data in advance. Data are stored in media and delivered to users at the requested frequency (e.g., 16 days, one month). This service is available only to PIs. When latitude/longitude is specified as one of the conditions, EOC will deliver data, the scene center of which falls in the specified latitude/longitude range.

5.3 Product Search and Order

5.3.1 Scene Order

(1) Scene Search

Scene search is a function to allow users to search catalog information of the Earth observation data that are archived in the EOC. Users can search data that meet search conditions such as satellite, sensor, observation date and location (latitude/longitude or GRS/WRS). This service is available to all users. For AMSR-E all scheduled products, listed in Table 5.3-1, are available for scene search.

Table 5.3-1 AMSR-E Products (Available to Scene Search)

Level		Physical Parameters	Map Projection*1			Note
			EQR	PS	PN	
1A、1B			-	-	-	
2		WV, CLW, AP, SSW, SST, IC, SM*3	-	-	-	
3	Day Month	TB (for 12 channels)	O	O	O	A/D*2
		WV, CLW, AP, SSW, SST, SM*3	O	-	-	A/D*2
		IC	-	O	O	A/D*2
		SWE	O	-	O	A/D*2

*1: EQR → Equi-rectangular PS → Polar Stereo (South hemisphere) PN → Polar Stereo (North hemisphere)
*2: A → Ascending orbit data), D → Descending orbit data)
*3: Addition to standard product from processing algorithm ver. 2

Search results are displayed as a list with detailed descriptions. If processed products for ordered production are archived in the EOC, information on the processed products is displayed as part of the detailed information on scheduled products, which is the information that was used to generate requested products.

If a user wishes to specify the location by latitude/longitude, the user can do so by graphically selecting the area on the map that is displayed on the monitor. Observation area (coverage), which is included in a search result, can be graphically displayed on the map that is displayed on the monitor.

(2) Product Order

PIs and general researchers can submit a request for a scene order for any scheduled product and ordered product via the scene search results screen (on-line).

For AMSR-E, processing information of scheduled products is displayed as a search result. All users need to do is choose products from the search result and specify media. For ordered products, users need to do a catalog search of scheduled products (refer to Table 5.3-2) and choose scenes from the search result. Based on the inventory information of the selected scenes, users need to create order information by specifying order parameters such as processing level and map projection parameters.

Table 5.3-2 Source Information for Requesting Ordered Products

	Ordered Products		Source Information for Requesting	
AMSR-E	Level 1B Map	-	L1B	-
	Level 2 Map	WV, CLW, AP, SSW, SST, IC, SWE, SM*1	L2	WV, CLW, AP, SSW, SST, IC, SWE, SM*1

*1: Addition to standard product from processing algorithm ver. 2

General users should request products via the data distribution agent* specified by JAXA.

*: In FY2008, the Remote Sensing Technology Center (RESTEC) is the data distribution agent. General users can get detailed information to order products by accessing to Customer-oriented RESTEC Online Service System (CROSS) on RESTEC Web page (www.restec.or.jp/top_e.html).

(3) Product Version

a) Scheduled Products

Scheduled products data are processed using the current and previous versions of product processing algorithm (As of March 2009, version 6 and 5 is available for the higher level products, but only version 2 for level 1 product), and are archived in the EOC and available for users. If a user uses the EOIS online services, the user can search data that were generated using a specified version of processing algorithm by specifying Product Version Number for the search.

b) Ordered Products

For ordered products, only data which are processed using the current version of processing algorithm are available for users.

5.3.2 Data Set Order

(1) Data Set Search

Data set search is a function to allow users to search data set, which includes specified multiple kinds or multiple-days products of a specified sensor. Users can search data set by using observation date and data set name. This service is available only to PIs. For AMSR-E data set, listed in Table 5.3-3, are available for data set search.

Table 5.3-3 AMSR-E Products (Available to Data Set Search)

Data Set	Contents
AMSR-E	
Level 1A, 1B	
Level 2+3 (Day)	WV, CLW, AP, SSW, SST, SWE, IC, SM[*2]
Level 3 (Day, Month)	TB (for 12 channels), WV, CLW, AP, SSW, SST, SWE, IC, SM[*2]

*1: Addition to standard product from processing algorithm ver. 2

(2) Data Set Order

PIs can submit a request for a data set via the data set search results screen (on-line).

5.3.3 Standing Order

(1) Product Order

Users are requested to complete the order form (paper sheet). If a total processing volume requested by PIs exceeds the EOC processing capability, the PC (Project Coordinator) of JAXA/EORC will coordinate with the registered users to maintain the proper processing load.

(2) Product Versions

For Standing Order, users can choose from options of “Current version” or “Version not specified”. When “Current version” is chosen, data which are produced using the current version of processing software at the time of media production, are delivered, e.g., Ver. 6 in Figure 5.3-1. When “Version not specified” is chosen, the most recent version of data for the requested period are delivered, e.g., if Ver. 5 and Ver.6 are archived, Ver. 6 data are delivered.

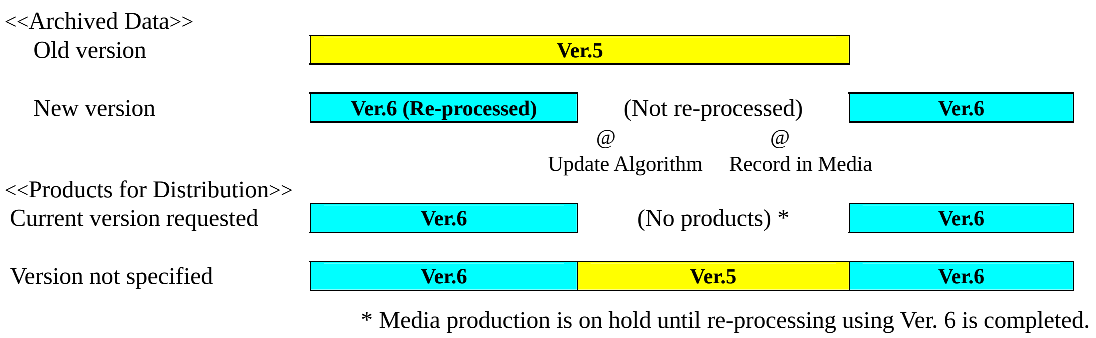


Figure 5.3-1 Product Versions for Standing Order

5.3.4 Support Information for Product Search and Order

EOIS provides users with support information for product search and order.

(1) Display of Image Catalog

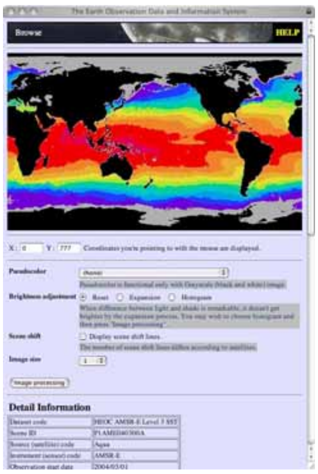
For products shown in Table 5.3-4, image catalog can be displayed for the products which are extracted as the result of scene search or data set search, and it helps users to confirm observation areas and cloud coverage, among other things.

Table 5.3-4 AMSR and GLI Image Catalog Data

Level		Physical Parameters	Map Projection*1			Note
			EQR	PS	PN	
3	Day	TB (6.9, 36.5, 89 GHz Vertical Polarization)	O	O	O	A/D*2
	Day Month	WV, CLW, AP, SSW, SST, SM*3	O	-	-	A/D*2
		IC	-	O	O	A/D*2
		SWE	O	-	O	A/D*2

*1: EQR → Equi-rectangular PS → Polar Stereo (South hemisphere) PN → Polar Stereo (North hemisphere)
*2: A → Ascending orbit data), D → Descending orbit data)
*3: Addition to standard product from processing algorithm ver. 2

Products with multiple band data are displayed in RGB color. A single band data can be displayed in pseudo-color using pre-defined pallet information. Brightness and size of image catalog can be adjusted, and scene shift line can be displayed.



AMSR-E Level3 (SST)

Figure 5.3-2 Screen Image (Image Catalog)

(2) Display of Map

For the products which are extracted as the result of scene search or data set search, observation area can be displayed on the coverage map screen.

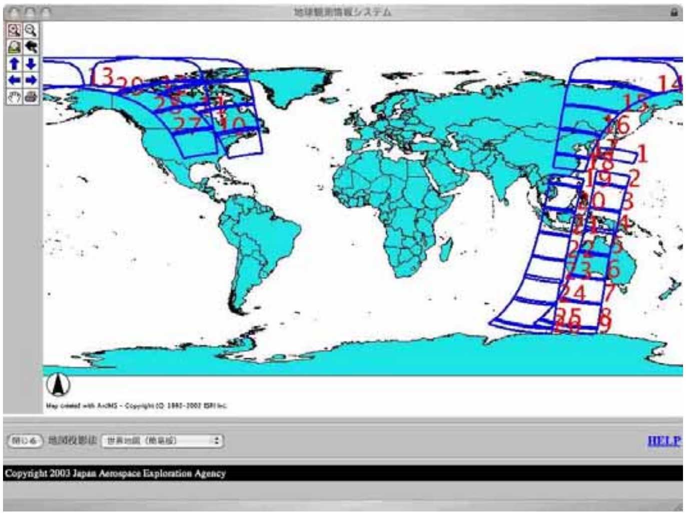


Figure 5.3-3 Screen Image (Display of Scene in Map)

(3) Status Search

PIs and general researchers can confirm the preparation status of the product that was ordered via scene order or data set order. If a registered user selects "Online data download" for ordered product, the product can be downloaded from EOIS online. (see 5.4.1 (2))

5.4 Product Distribution

5.4.1 Distribution Media

For scene order, CD-ROM, DVD-R and on-line are available as media for data distribution. Basically, a physical medium contains a single product. However, if a multi-file option is specified, multiple-products can be stored on a physical medium.

For datasets, CD-ROM, DVD-R and on-line are available.

On-line data distribution is available only to registered users.

For standing order, DVD-R and USB-HDD are available. Basically a physical medium contains a series of specified products. However, for some products, a combination of different products can be recorded in one medium. EOC will determine available combinations of products, from which users choose what meets their needs.

Data distribution methods for the scene order, data set order and standing order are summarized in Table 5.4-1.

Table 5.4-1 Data Distribution Method

Service	Media			
	CD-ROM	DVD-R	Online	USB-HDD
Scene Order	A	A	R	X
Data Set Order	P	P	P	X
Standing Order	X	P	X	P

A: Available to all users R: Available to PIs and general researchers
P: Available to PIX: Not available

The format of product in distribution media is NCSA-HDF

5.4.2 Online Product Distribution

PIs and general researchers can obtain processed data via the Internet by specifying "On-line" delivery when the user submits an order, with the scene ordering or data set ordering option. This service is not available to general users.

Registered user can confirm whether or not the product is ready to download on the "Order status result screen". If "On-line" button is displayed on the record, the product can be downloaded.

Product for download are compressed. Download file includes a shipping list (text file), and is archived by tar.

5.4.3 Sample Data Distribution

Pre-selected products are staged on a server for a pre-defined period, allowing downloading via the Internet. This service is available to all users including general users.

Sample data can be downloaded by clicking "Sample data button" in the scene search result screen. If sample data is not ready, user can apply for acquiring sample data.

In consideration of ordinary Internet environments, the file size of products available through this service is around 10 Mbytes (max. 50 MB). To meet this constraint, Level 3 products of AMSR-E are available and staged in the server for about 6 months. For specific product names, refer to Table 5.4-2.

Table 5.4-2 Sample Data Provided though the Internet

Level		Physical Parameters	Map Projection*1			Note
			EQR	PS	PN	
3	Day Month	TB (for 12 channels)	O	O	O	A/D*2
		WV, CLW, AP, SSW, SST, SM*3	O	-	-	A/D*2
		IC	-	O	O	A/D*2
		SWE	O	-	O	A/D*2

*1: EQR → Equi-rectangular PS → Polar Stereo (South hemisphere) PN → Polar Stereo (North hemisphere)

*2: A → Ascending orbit data), D → Descending orbit data)

*3: Addition to standard product from processing algorithm ver. 2

Files for download are compressed with an extension “Z”. When download of multiple files is requested, the files are archived by tar and their file names have an extension “tar.”

5.5 User Services from EORC

Earth Observation Research Center (EORC) also provides PIs with the other services than EOIS. For AMSR-E, basically services from EORC are same as for ADEOS-II/AMSR, and the services are described in the document “ADEOS-II Users Handbook” in detail. Users can get this document from EORC website. The URL is as follows.

- http://sharaku.eorc.jaxa.jp/ADEOS2/doc/document.html

6 AMSR-E Operation Status and Results

In this chapter, it is introduced around the information related to the AMSR-E about the results of initial check-out on orbit, calibration and validation, observation results, etc. AMSR-E on Aqua was launched on May 4, 2002 (PDT), and AMSR-E is operating continuously with no major trouble as of March 2006.

Main events after launch of ADEOS-II are shown as follows:

Table 6-1 Main Events after Launch of AMSR-E

Date (JST)		Event
2002	May 4	Launched by a Delta 2 rocket from Vandenberg, California in the U.S
	May 5 ~ 24	AMSR-E run-up (Increase antenna rotation to normal operation speed (40 rpm))
	May 18	AMSR-E mission data transmission is started
	May 24 ~ 30	Content of the observational data becomes 0 intermittently.
	May 30	It is confirmed that the content of the observational data is not 0
	June 2 ~ 4	AMSR-E first image acquisition (press release: June 12)
	June 28	No data due to LLM (Light Load Mode)
	July 29 ~ August 8	
	September 12 ~ September 20	
2003	June 18	AMSR-E level 1 products were released.
	September 19	AMSR-E higher level products (algorithm version 1)were released.
	October 29 ~ November 6	No Data due to Sleep mode to avoid electro-magnetic storm caused by high solar activities.
2004	March 12	AMSR-E higher level products (algorithm version 2) were released.
	June 4	AMSR-E "Kuroshio Monitor" Web site was opened.
	November 4	Data Deficit of AMSR-E 89GHz receiver A.(Not available yet)
	December 2	AMSR-E "El Niño Watch" Webpage was opened.
	December 8	AMSR/AMSR-E "Tropical Cyclones Database" Webpage was opened.
	December 27	AMSR-E and MODIS "Sea Ice Distribution" Webpage was opened.
2005	March 1	AMSR-E level 1 product (algorithm version 2) and higher level products (algorithm version 3) were released.
	June 8	AMSR/AMSR-E and TRMM " Tropical Cyclones Database" Webpage was opened.
	October 18	AMSR/AMSR-E " All Weather Ocean Wind Speed" Webpage was opened
2006	March 5	AMSR-E higher level products (algorithm version 4) were released.
	September 14	AMSR-E " SST Anomaly in the arctic" Webpage was opened.
2007	March 12	AMSR-E higher level products (algorithm version 5) were released.
	June 18	AMSR-E " Arctic Sea-Ice Monitor" Webpage was opened.
2008	March 25	AMSR-E higher level products (algorithm version 6) were released
2009	August	AMSR/AMSR-E Webpage will be redesigned.
		AMSR-E higher level products (algorithm version 7) will be released

JAXA has modified the production codes of Level 2 precipitation and snow products to accommodate the data deficit of the AMSR-E 89GHz receiver A. Each 89GHz receiver A (89A) and receiver B (89B) brightness temperatures (Tb) was separately used in the previous codes. After the modification, both 89A and 89B Tb in a circle with radius 12.5km are averaged and used for retrieving geophysical parameters. Although retrievals were not performed in the previous codes when the 89A Tb were missing, modified codes can retrieve geophysical parameters even with only 89B Tb.

The latest operation status of AMSR-E sensor and ground system is announced from “Aqua Related Information” on EORC Data Distribution webpage (see 5.1). On the other hand, AMSR-E Cal/Val information is placed on AMSR-E Webpage (see 6.3).

Aqua Related Information :
http://www.eorc.jaxa.jp/en/about/distribution/info/aqua.html

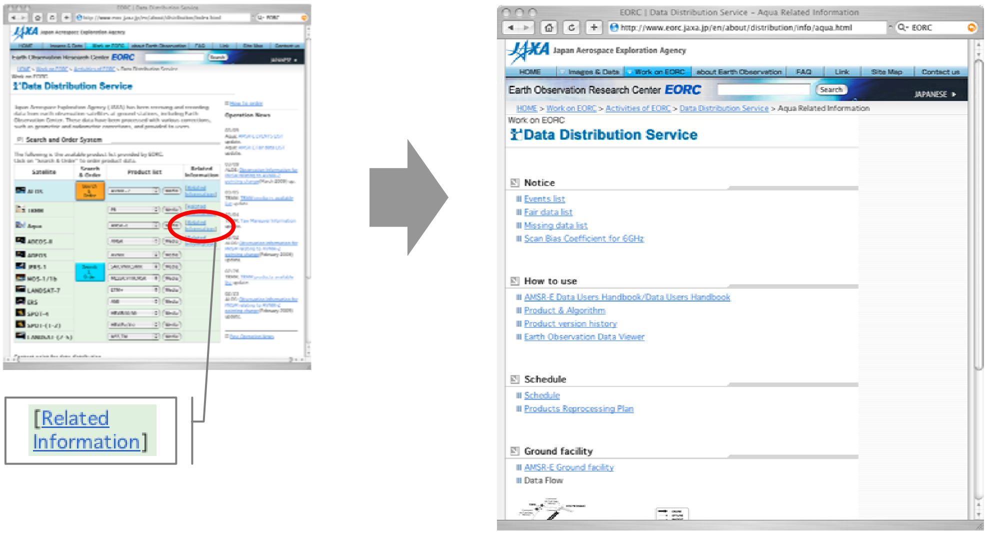


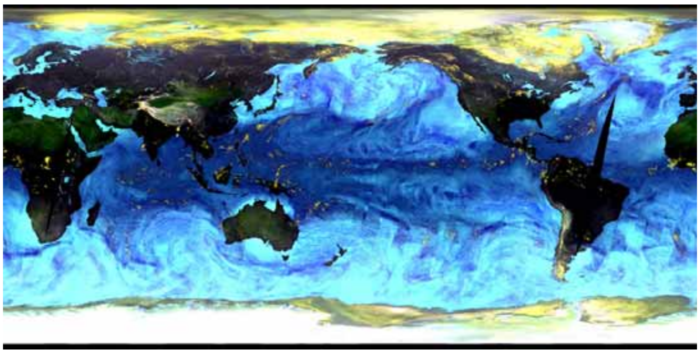
Figure 6-1　Aqua Related Information Webpage

6.1　Initial Check-out on Orbit

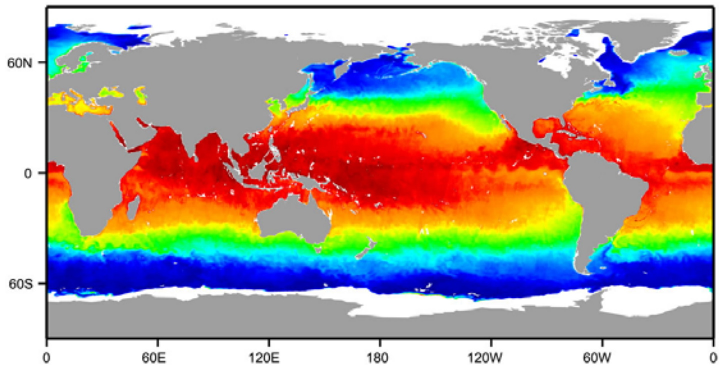
Aqua was successfully launched by a Delta II rocket at 2:54:58 (PDT) on May 4, 2002, from the Vandenberg Launch Site in California. As scheduled, the Aqua spacecraft successfully separated from the Delta II rocket on its first orbit at 3:54 (PDT), and AMSR-E was powered on at 4:50 (PDT) on May 4.

AMSR antenna run-up was completed during the period from May 5 to 24. Successful completion of these operations were confirmed by analyzing of telemetry data from satellite. After that, initial checkout was performed on orbit during three months, to check functions of bus instruments and mission instrument.

During initial checkout phase, AMSR acquired observation data from June 2 to 4, 2002. These observation data were released as the first image of AMSR-E on June 12.



Images are from three-day averaged data (June 2-4 UTC, 2002) of AMSR-E descending paths. Brightness temperatures of 89.0-GHz (both vertical and horizontal polarization) and 23.8-GHz (vertical polarization) channels were used. Black indicates missing data. Areas around the north and south poles are black since AMSR-E is not able to acquire data in those areas. The upper image is the global map. Over the oceans, cold temperatures, which usually correspond to strong precipitation areas, are highlighted by bright yellow; colors varying from aqua to dark blue correspond to increases of water vapor and clouds. Snow coverage, dry and cold land surfaces, and sea-ice distribution in both polar regions are also indicated by bright yellow.



Three-day average data (June 2-4 UTC, 2002) of sea-surface temperature (SST) was acquired. SST was estimated by using the 6.925-GHz vertical polarization channel, with atmospheric and sea-surface wind corrections by other frequency channels. The greatest advantage of microwave observation is the capability to estimate SST through clouds. In addition, the 6.925-GHz channels enable us to observe SST over the global oceans including cold SST regions, while the TRMM/TMI 10-GHz channels are only appropriate for warmer SST regions. Land areas are masked in gray, and white indicates areas with missing data due to the presence of sea ice and strong precipitation. Many of the higher SST values along coastlines are not real but result from microwave emission from land areas. This effect will be improved by algorithm validation.

Figure 6.1-1 AMSR First Image (Observation date: June 2 ~ 4, 2002)

6.2 Calibration and Validation

(1) Calibration Overview

AMSR calibration is defined as the task for evaluation and adjustment of Brightness Temperature (TB) data. Outline of AMSR data calibration after launch is described as in below.

a) Brightness Temperature Calibration

TB data was evaluated, it is called as radiometric calibration that includes absolute evaluation of TB value and relative evaluation of scan bias. Radiometric noise, physical temperature of components of GLI sensor are monitored regularly.

b) Geometric Calibration

Evaluation includes rough beam patterns, inter-channel co-registration and absolute position accuracy. Antenna rotation speed, attitude notation and the like was monitored regularly.

c) Data Quality Evaluation

Includes evaluations of the quality of initial data, the soundness of all engineering values and deductive algorithms.

(2) Validation Overview

Major objectives of the AMSR validation is to define accuracy of products quantitatively, to generate the products with required accuracy and to improve the algorithms if necessary. Outline of AMSR data validation after launch is described as in below.

a) Evaluation of Accuracy of Physical Quantities

Accuracy of physical quantities is evaluated. Although the method differs with each quantity, comparing the physical quantities will generally do evaluation estimated from AMSR data with independently measured quantities (survey data, aircraft data and other similar satellite data).

b) Evaluation of Data Quality

Initial quality is evaluated, the same as for Level 1. Data insufficiencies resulting from algorithm malfunction and the like and image quality when viewed as images is evaluated.

6.3 Calibration and Validation Plan and Result

Such as accuracy of the data included in AMSR-E product obtained by calibration and validation are open to the public on the AMSR/AMSR-E webpage as notes to handle the product. URL of AMSR/AMSR-E webpage is as follows.

AMSR/AMSR-E：
http://sharaku.eorc.jaxa.jp/AMSR/index.html

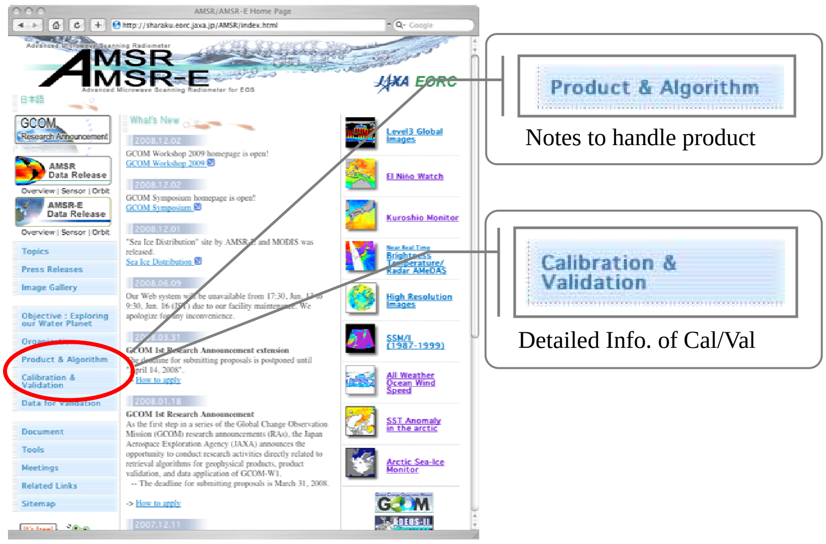


Figure 6.2-1　AMSR/AMSR-E Webpage

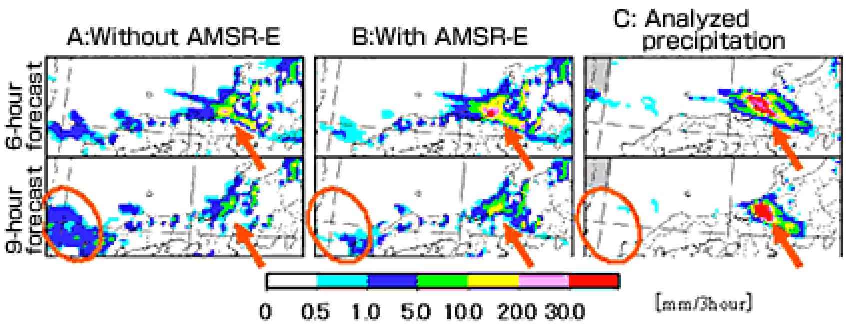
Details of calibration and validation of AMSR-E, such as a plan and validation data, can be obtained from these homepages. However, access to a certain part of information is limited, and only PIs of AMSR-E have accesses to the data.

6.3 Utilization of AMSR and GLI Data

(1) AMSR-E data for weather forecasts

The Japan Meteorological Agency (JMA) started using data from AMSR-E for its weather forecasting operations on November 17, 2004. In recent years, the most commonly used forecasting method is numerical weather predictions by reproducing the atmospheric movements on a computer. The accuracy of the numerical weather prediction heavily depends on the quality and quantity of observation data and numerical models. Data from a satellite is very important input information for the predictions because a satellite can acquire homogenous data from the vast ocean areas which are otherwise very difficult to observe.

Since November 17, water vapor volume and precipitation strength information estimations based on AMSR-E data have been inputted into the numerical weather predictions. With the additional information, water vapor distribution on the ocean can be more precisely input, and that contributes to improving the accuracy of the predictions. The following images show an example of the improvement in forecasting accuracy at the time of localized heavy rain in Fukui Prefecture.



The above images are six- and nine-hour forecasts at 3:00 p.m. on July 18, 2004 (Japan time). A and B are forecast results with and without AMSR-E respectively, and C shows actual precipitation. With AMSR-E, estimated rain strength (indicated by an orange arrow) is closer to actual precipitation, thus forecast accuracy is obviously improved. Without AMSR-E, the forecasted area of precipitation is extended to the offshore of Yamaguchi Prefecture (indicated by an orange oblong), but the area gets smaller with AMSR-E. Analysis and forecast results were provided by the Japan Meteorological Agency.

Figure 6.3-1　AMSR-E Data for Weather Forecasts

(2) Publication of AMSR-E Data

AMSR-E data is published through AMSR/AMSR-E webpage shown in figure 6.2-1. AMSR-E data publication services from AMSR/AMSR-E webpage are shown in below

- El Nino Watch : Daily states of El Nino observed by AMSR-E
- Kuroshio Monitor : Daily states of Japan current observed by AMSR-E
- Tropical Cyclones Database : Tropical Cyclones observed by AMSR and AMSR-E
- Sea Ice Distribution : Sea ice distribution maps observed by AMSR-E and MODIS over the Sea of Okhotsk
- All Weather Ocean Wind Speed : Daily ocean wind speed observed by AMSR-E
- SST Anomaly in the arctic : Monthly sea surface temperature observed by AMSR-E
- Arctic Sea-Ice Monitor : Daily sea ice distribution observed by AMSR-E

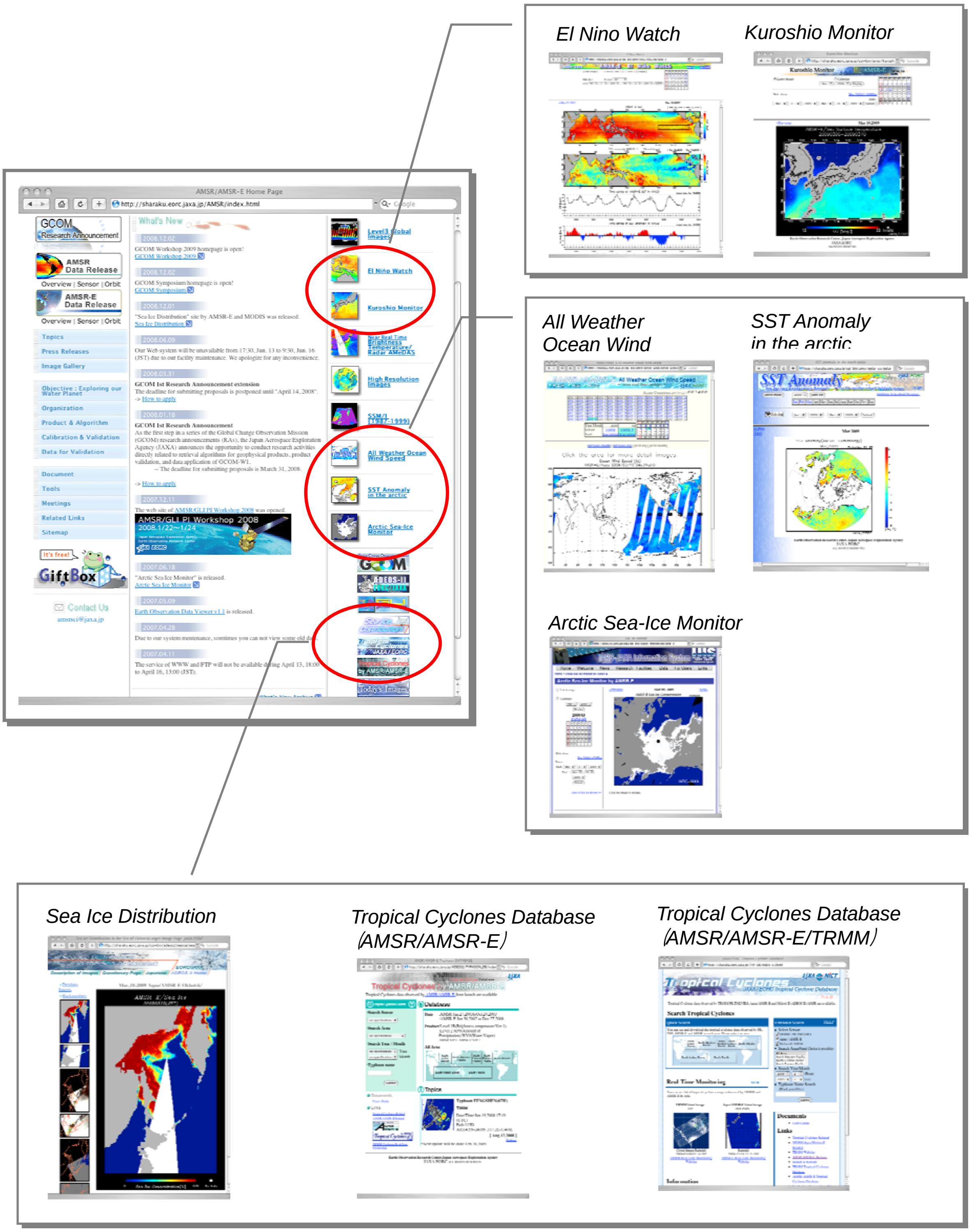


Figure 6.3-2 AMSR-E Data Publication Services

Appendix 1 ACRONYMS and ABBREVIATIONS

A

ADA : Antenna Drive Assembly
ADE : Antenna Drive Electronics
ADEOS-II : ADvanced Earth Observing Satellite-II
ADM : Antenna Drive Mechanism
ADS : Advertisement Subsystem (JAXA)
AIRS : Atmospheric Infrared Sounder
AMR : Airborne Microwave Radiometer
AMSR : Advanced Microwave Scanning Radiometer
AMSR-E : Advanced Microwave Scanning Radiometer for EOS
AMSU : Advanced Microwave Sounding Unit
ANT : ANTenna part
AP : Amount of Precipitation

B

BDS : Browse data Distribution Subsystem (JAXA)

C

CAL : CALibration part
CATS : Catalogue Subsystem (JAXA)
CCI : Cloudiness Index
CCSDS : Consultative Committee for Space Data Systems
CCT : Computer Compatible Tape
CD-ROM : Compact Disk Read Only Memory
CEOS : Committee on Earth Observation Satellites
CERES : Clouds and the Earth's Radiant Energy System
CLW : Cloud Liquid Water
CSM : Cold Sky Mirror
CWI : Cloud Water Index

D

DAAC : Distributed Active Archive Center (NASA)
DAS : Data Analysis System (JAXA)
DAT : Digital Audio Tape
DEP : DEPloyment mechanism
DDMS : Data Distribution and Management System (JAXA)
DDS : Data Distribution Subsystem
DRS : Data Retrieval Subsystem (JAXA)
DSS : Data Storage System (JAXA)

E

ECS : EOSDIS Core System
EDOS : EOS Data and Operation System
EOC : Earth Observation Center (JAXA)
EOC : EOS Operation Center (NASA)
EOIS : Earth Observation Data and Information System (JAXA)
EORC : Earth Observation Research Center (JAXA)
EOS : Earth Observing System (NASA)
EOSDIS : EOS Data and Information System
EPGS : EOS Polar Ground Station (NASA)
EQR : Equi-Rectangular Map Projection
ERBE : Earth Radiation Budget Experiment
ESDIS : Earth Science Data and Information System (NASA)
ESE : Earth Science Enterprise

F

FD : Floppy Disk
FDS : Flight Dynamics System (NASA)
FTP : File Transfer Protocol

G

GSFC : Goddard Space Flight Center (NASA)
GSIF : Ground Station Interface Facility (NASA)
GUI : Graphical User Interface
GVI : Global Vegetation Index

H

HDF : Hierarchical Data Format
HK : Housekeeping
HSB : Humidity Sounder for Brazil
HTS : High Temperature Source

I

IC : Sea Ice Concentration
INPE : Instituto Nacional de Pesquisas Espaciais
ISW : Index of Surface Wetness

J

JAXA : Japan Aerospace Exploration Agency
JPEG : Joint Photographic Coding Experts Group
JPL : Jet Propulsion Laboratory (California Institute of Technology)

L

LAN : Local Area Network
LaRC : Langley Research Center (NASA)
LSR : Linear Statistical Regression
LZPF : Level Zero Processing Facility (NASA)

M

MCS : Media Conversion Subsystem (JAXA)
MIFS : Mission Information File Server (JAXA)
MLP : Multi-layer Perception
MO : Magneto Optical disk
MODIS : MODerate resolution Imaging Spectrometer
MSFC : Marshall Space Flight Center (NASA)
MWA : Momentum Wheel Assembly

N

NASA : National Aeronautics and Space Administration
NASDA : National Space Development Agency of Japan
NCSA : The National Center for Supercomputing Applications
NOAA : National Oceanic and Atmospheric Administration
NRT : Near Real Time Data (Directory)

NSIDC	:	National Snow and Ice Data Center (University of Colorado at Boulder)
	O	
OBE	:	Orbital Balancing Electronics
OBM	:	Orbital Balancing Mechanism
	P	
PA	:	Passive Analog telemetry
PB	:	Passive Bilevel telemetry
PC	:	Personal Computer
PDS	:	Production Data Set
PDUC	:	Power Distribution Unit Control unit
PDUS	:	Power Distribution Unit Sensor unit
PI	:	Principal Investigator
PN	:	Polar Stereo Map Projection (North)
PO.DAAC	:	Physical Oceanography Distributed Active Archive Center
PS	:	Polar Stereo Map Projection (South)
	R	
RBD	:	Rate Buffered Data
RX	:	Receiver
RESTEC	:	Remote Sensing Technology Center of Japan
	S	
SDS	:	Scientific Data Sets
SIPS	:	Science Investigator-led Processing System (NASA)
SMSS	:	Schedule Management Subsystem (JAXA)
SPC	:	Signal processor Control unit
SPS	:	Signal processor Sensor unit
STRC	:	Structure (Control unit)
STRS	:	Structure (Sensor unit)
SSM/I		Special Sensor Microwave/Imager
SST	:	Sea Surface Temperature
SSW	:	Sea Surface Winds
SWE	:	Snow Water Equivalent
	T	
TAI	:	International Atomic Time
TB	:	Brightness Temperature
TBD	:	To Be Determined
TCC	:	Thermal Controller (Control unit)
TCS	:	Thermal Controller (Sensor unit)
TDRS	:	Tracking and Data Relay Satellite
TMI	:	TRMM Microwave Imager
TOA	:	Top of the Atmosphere
TRMM	:	Tropical Rainfall Measuring Mission
	U	
URL	:	Universal Resource Locator
URS	:	User Request Management Subsystem (JAXA)
USGS	:	United States Geological Survey
	W	
WV	:	Water Vapor
WSC	:	White Sands Complex (NASA)
WWW	:	World Wide Web

Appendix 2 RELATED INFORMATION

A2.1 Reference Documents

The titles, provider, and contents of the reference documents are shown below:

(1) "EOIS User Manual"

- Prepared by: JAXA
- Contents: Utilization manual of the EOIS which is an online product search and provision service of JAXA.

A2.2 Related Sites over Internet

URLs of the homepages related to Aqua or AMSR-E are listed below.

■ Japanese Sites

(1) JAXA Homepage

- http://www.jaxa.jp/index_e.html

(2) JAXA/EORC Homepage

- http://www.eorc.jaxa.jp/eorctop.htm

a) AMSR/AMSR-E Homepage (JAXA/EORC)

- http://sharaku.eorc.jaxa.jp/AMSR/index_e.htm

b) AMSR/AMSR-E Related Information

- http://www.eorc.jaxa.jp/en/about/distribution/info/aqua.html

c) EOIS

- https://www.eoc.jaxa.jp/iss/jsp/indexEn.html

(4) Restec Homepage

- http://www.restec.or.jp/restec_e.html

■ Overseas Sites

(1) NASA Homepage

- http://www.nasa.gov/

a) Aqua Homepage

- http://aqua.nasa.gov/

b) ESDIS Homepege

- http://esdis.eosdis.nasa.gov/

(2) GSFC Homepage

- http://www.gsfc.nasa.gov/

(3) AMSR-E Homepage (NASA/MSFC)

- http://wwwghcc.msfc.nasa.gov/AMSR/

(4) MODIS Homepage (NASA/GSFC)

- http://ltpwww.gsfc.nasa.gov/MODIS/

(5) AMSU Homepage (NOAA/NESDIS)

- http://orbit-net.nesdis.noaa.gov/crad/st/amsuclimate/amsu.html

(6) AIRS Homepage (NASA/JPL)

- http://www-airs.jpl.nasa.gov/

(7) CERES Homepage (NASA/LaRC)

- http://asd-www.larc.nasa.gov/ceres/ASDceres.html

(8) HDF Homepage

- http://www.hdfgroup.org/

A2.3 Contact Points

- Data Distribution Service

(1) General Users

Application and Service Dept.
Remote Sensing Technology Center of Japan
Roppongi First Bldg.
1-9-9, Roppongi, Minato-ku,
Tokyo 106-0032, Japan
TEL: +81-3-5561-9777 FAX: +81-3-5574-8515
E-mail: data@restec.or.jp URL: http://www.restec.or.jp/top_e.html

(2) Specific Users (PI, RA)

Order Desk
JAXA Earth Observation Research Center (EORC)
2-1-1, Sengen, Tsukuba-city, Ibaraki 305-8505 Japan
TEL: +81-29-859-5571 FAX：+81-29-859-5574
E-mail: orderdesk@jaxa.jp URL: http://www.eorc.jaxa.jp/en/

- Contact point related to EOIS

Order Desk
Earth Observation Division Earth Observation Department
Remote Sensing Technology Center of Japan (RESTEC)

JAXA Earth Observation Center
1401 Numanoue, Ohashi, Hatoyama-machi,
Hiki-gun, Saitama, Japan, 350-0302
TEL: 81-49-298-1307 FAX: 81-49-298-1398
E-mail: eusadmin@nsaeoc.eoc.jaxa.jp

- Contact point related to This Document

Order Desk
JAXA Earth Observation Research Center (EORC)
2-1-1, Sengen, Tsukuba-city, Ibaraki 305-8505 Japan
TEL: +81-29-859-5571 FAX：+81-29-859-5574
E-mail: orderdesk@jaxa.jp URL: http://www.eorc.jaxa.jp/en/

Appendix 3 AMSR-E Product Format

The following documents, which specify the detailed format of AMSR-E level 1 ~ 3 products, are attached to this handbook.

- AMSR-E Level 1 Product Specifications (including level 1A, 1B and 1B Map)
- AMSR-E Level 2 Product Specifications
- AMSR-E Level 2 Map Product Specifications
- AMSR-E Level 3 Product Specifications

The latest version of these product format specification documents are available to get from AMSR-E Related Information Webpage.

- http://www.eorc.jaxa.jp/en/about/distribution/info/aqua/handbook_format.html