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Advanced Microwave Scanning Radiometer 3 (AMSR3)
onboard Global Observing Satellite for
Greenhouse Gases and Water Cycle (GOSAT-GW)

Data Users Handbook

First Edition

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Japan Aerospace Exploration Agency

Preface

Our blue planet is facing environmental changes of an unprecedented scale in recent years. Rising air and sea surface temperatures driven by global warming, extreme weather events, floods, and droughts—concerns about these global environmental transformations continue to grow year by year.

The Japan Aerospace Exploration Agency (JAXA) conducts the Water Cycle Observation Mission to obtain long-term, stable observations of the entire Earth, with the aim of elucidating global climate change and the mechanisms of the water cycle. The data obtained from this mission are utilized across a wide range of fields, including climate change research, weather forecasting, fisheries, and navigation support.

The Advanced Microwave Scanning Radiometer 3 (AMSR3), onboard the Greenhouse Gases and Water Cycle Observatory “Ibuki-GW” (GOSAT-GW: Global Observing SATellite for Greenhouse Gases and Water Cycle), is a successor sensor designed to inherit and further advance the more than 23 years of observations related to Earth’s water cycle. These observations were established by its predecessors—the Advanced Microwave Scanning Radiometer for EOS-PM (AMSR-E), which began operation in 2002, AMSR, and AMSR2, which has been in operation since 2012.

GOSAT-GW was launched on June 29, 2025 aboard the final H-IIA launch vehicle (No. 50) from the Tanegashima Space Center and was placed into a sun-synchronous orbit at an altitude of approximately 666 km, with an inclination of about 98 degrees and an orbital period of roughly 98 minutes. AMSR3 observes the weak microwave emissions radiated from the Earth’s surface and atmosphere to estimate various water-related geophysical parameters. It observes 99.9% of the Earth’s surface within three days and, like AMSR2, operates in an orbit with a mean local solar time of approximately 13:30 at the ascending node. After being received by domestic ground stations and the Svalbard ground station, the observation data are transmitted online to JAXA’s Tsukuba Space Center, where they are processed and distributed.

AMSR3 continues the observations of AMSR2 while enabling more detailed global precipitation (both rainfall and snowfall) estimates—including in high-latitude regions—through newly added high-frequency channels and enhanced multi-frequency observations. This capability supports the development of highly reliable and long-term geophysical datasets related to water, such as total precipitable water, precipitation, sea surface temperature, and snow depth, all of which contribute to the understanding, monitoring, and prediction of climate variability.

JAXA has conducted initial calibration of the AMSR3 observation data acquired after the launch of GOSAT-GW. The Level-1 products (brightness temperatures) and higher-level products (geophysical parameters) will be made publicly available from June 2026 through the Earth observation data distribution system “G-Portal” (https://gportal.jaxa.jp/gpr/?lang=en/).

This document is intended to provide essential information for users of the GOSAT-GW/AMSR3 products. We hope that the data will be widely utilized by many users and will contribute to demonstrating its effectiveness in fields such as weather forecasting, fisheries, and navigation support. Furthermore, it is our aspiration that these data will aid in advancing the understanding of global environmental change mechanisms, assessing the impacts of climate variability, and supporting the monitoring and preservation of the Earth's environment.

June 2026
Japan Aerospace Exploration Agency
GOSAT-GW Project Team

－Earth Observation User Handbook －　AMSR3　－
Contents

List of Tables and Figures

Chapter 1. Introduction

To maintain a healthy global environment, we must accurately understand the current state of the Earth's environment and the mechanisms that govern it to effectively implement conservation measures while anticipating future changes.

There are two primary methods for observing and measuring the planet's environment. The first involves the direct measurement of observable phenomena on land and at sea. The second involves remote sensing from satellites and other remote platforms using visible and infrared light, microwaves, and other electromagnetic waves. Although the latter method requires advanced processing to derive observables, it is essential for capturing phenomena on a global scale.

The Japan Aerospace Exploration Agency (JAXA) manages a hydrological cycle observation mission that uses satellites to observe the global environment. The mission's main role is to observe global hydrological mechanisms and climate change over a long period, acting as a health check for Earth.

"Ibuki GW" (GOSAT-GW: Global Observing SATellite for Greenhouse-gases and Water cycle) carries the Advanced Microwave Scanning Radiometer 3 (AMSR3). This device is capable of broad-area and continuous observation of various components related to the hydrological cycle, including precipitation, water vapor, sea surface wind speeds, sea surface temperatures, sea ice distribution, soil moisture content, and snow depth.

1.1 Purpose of this Document

This document provides users who obtain AMSR3 datasets publicly released by JAXA with the information required to effectively use them. We also aim to provide information related to both standard and other products, AMSR3, and the ground system.

1.2 Scope of this Document

This document provides the information needed by AMSR3 data users as well as brief descriptions of the satellite, its sensor, ground system, products, and data-providing service. The document includes information that users need to access the data-providing service to obtain datasets. The document's overall structure is as follows:

Chapter 1 - Introduction
Chapter 2 - Overview of GOSAT-GW and AMSR3
Chapter 3 - Overview of GOSAT-GW/AMSR3 Ground System
Chapter 4 - AMSR3 Products
Chapter 5 - Data-Providing Service
Chapter 6 - How to use AMSR3 data Usage Instruction
Appendix - List of Acronyms, Related Information

1.3 Overview of the AMSR3 Mission

AMSR3 is the advanced microwave-scanning radiometer onboard the GOSAT-GW. This sensor system is the successor to AMSR-E (AMSR for EOS-PM) launched in 2002 aboard the US EOS-Aqua satellite, AMSR onboard the “Midori-II” (ADEOS-II: Advanced Earth Observing Satellite-II), and AMSR2 launched in 2012 aboard the “SHIZUKU” (GCOM-W: Global Change Observation Mission-Water) (Figure 1-1). This section provides an overview of the AMSR3 mission to observe the water cycle, which advances and continues the AMSR series observations.

Figure 1-1 AMSR series

1.3.1 Importance of hydrological observation

Water on Earth plays a crucial role in the redistribution of the solar energy that reaches the Earth's surface and is closely linked to weather phenomena and climate change. Surface water in liquid and solid forms over oceans and land absorbs solar energy, causing it to evaporate or sublimate and be transported into the atmosphere as water vapor, which returns to liquid or solid form such as clouds and precipitation as it cools. During this process, the energy retained by the water vapor is released into the atmosphere, driving various meteorological phenomena. Water that transforms into a liquid or solid form in the atmosphere returns to the surface as rain or snow. This water can return to the ocean through rivers or is stored on land as soil moisture, snow cover, and frozen ground. These reservoirs function as a form of ‘climate memory,’ retaining their states over extended periods, and together with the oceans, which store vast amounts of water, serve as key factors influencing medium- to long-term variations in the complex Earth system.

Water circulating through the Earth’s systems is indispensable for our daily lives. Rainfall plays a vital role in sustaining ecosystems and provides numerous benefits for human society. However, typhoons and heavy rainfall can severely damage human infrastructure and even result in the loss of life. Droughts can inflict serious harm on ecosystems and directly affect agricultural production. The increase in global temperatures in recent years has raised concerns that the occurrence of such extreme weather events, including typhoons, intense rainfall, and droughts, will continue to increase. Under such environmental changes, minimizing the impacts of natural disasters while effectively utilizing precipitation as a water resource requires monitoring the current state of the Earth’s hydrological cycle using accumulated observational data to understand its mechanisms and predict variations over short, medium, and long timescales.

1.3.2 Objectives of the AMSR3 Mission

The objective of the AMSR3 mission is to sustain and advance the AMSR series, which has been utilized worldwide, while meeting emerging needs through higher-resolution products enabled by the addition of high-frequency channels and enhanced ground processing. Table 1-1 lists the objectives of AMSR3.

Table 1-1 Objectives of the AMSR3 mission

Mission objectives	Field	Objectives of the AMSR3 mission
Monitoring and predicting variations in the hydrological cycle	Climate change	To monitor hydrological cycle variability associated with climate change and contribute to predicting its impact on society and developing appropriate countermeasures.
Social implementation in practical application	Weather	At the Japan Meteorological Agency and meteorological organizations worldwide, AMSR observation data—such as sea surface temperature, sea ice concentration, soil moisture, surface wind speed over the ocean, snow depth, and all-weather ocean surface wind speed—are routinely utilized in forecasting operations, contributing to improved prediction accuracy for typhoons, heavy rainfall events, and other severe weather phenomena.
	Fisheries	To provide sea surface temperature information and contribute to activities such as fishing ground exploration.
	Maritime navigation support	To provide information on sea-ice concentration and sea surface temperature, thereby contributing to the development of sea-state and sea-ice information for safe vessel operations and to the selection of optimal navigation routes.

The AMSR3 is equipped with 21 channels spanning frequencies from 6.9 to 183.3 GHz, with both vertical (V) and horizontal (H) polarizations (Figure 1-2). This sensor observes weak microwave emissions and scattering naturally originating from the Earth’s surface and atmosphere.

Polarization describes the direction in which an electromagnetic wave oscillates. For Earth-observing satellites, vertical polarization (V-pol) corresponds to oscillations perpendicular to the Earth’s surface, whereas horizontal polarization (H-pol) corresponds to oscillations parallel to the surface. The distinctive differences in microwave intensities between these polarizations enable the retrieval of a wide range of geophysical parameters.

Furthermore, as different geophysical parameters are highly sensitive to different frequency bands, AMSR3 is expected to contribute to a wide range of research and operational applications, including meteorology, oceanography, land studies, and cryospheric science.

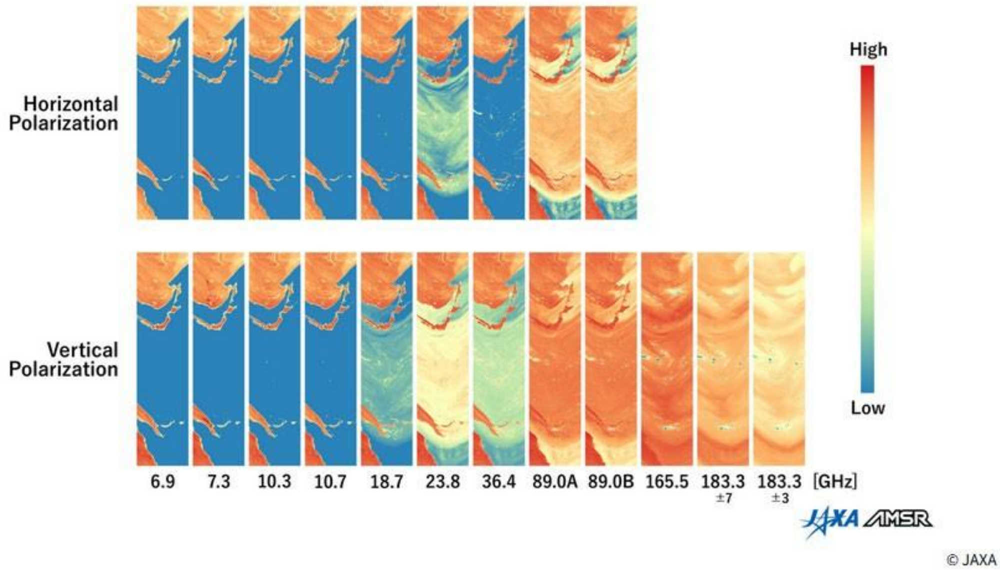


Figure 1-2 Observation images around Japan obtained from the 21 channels of AMSR3 Extracted portion of the ascending orbit on August 16, 2025

The newly added high-frequency channels on AMSR3 (165.5, 183.3 ± 3, and 183.3 ± 7 GHz) provide higher sensitivity to ice particles within clouds, falling snow reaching the surface, and mid- to upper-tropospheric water vapor compared with the channels carried by the previous-generation AMSR2. Figure 1-3 shows an observational image of the Arctic region obtained during the ascending path on August 16, 2025.

For precipitation estimation, analytical data from meteorological models, such as temperature and water vapor, are referenced. The precipitation occurring inside the yellow dotted line is classified as snow, whereas the precipitation occurring outside this line is classified as rain. Indeed, in the RGB image in Figure 1-3, which includes high-frequency channels, the appearance of clouds and precipitation differ between the inside and outside of the yellow dotted line. The light purple region observed inside the yellow dotted line represents ice clouds composed mainly of ice particles (ice crystals and snow), whereas the bright green areas outside the line are rain clouds containing abundant liquid water particles (cloud droplets and rain). However, over Greenland, the surface appears bright cyan in this RGB composite owing to environmental conditions that differ from those over sea ice, such as elevation and surface temperature. Consequently, distinguishing clouds in this region has become increasingly challenging.

In this way, by utilizing high-frequency channel observations of AMSR3, it becomes possible to capture differences in cloud properties, such as between liquid and ice clouds, and obtain information on snowfall occurring beneath clouds, which is difficult to observe with AMSR2.

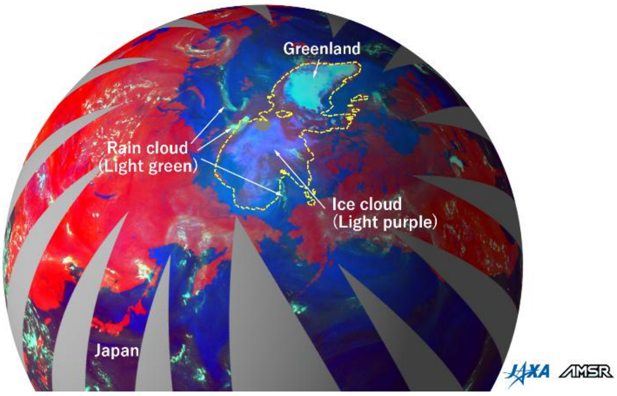


Figure 1-3 AMSR3 observation image highlighting cloud and precipitation areas in bright green over the Arctic region
(RGB composite created using brightness temperature data from the 18.7, 89.0, and 165.5 GHz V-polarization channels on the ascending path of August 16, 2025).

1.3.3 AMSR3 Observations and Data Applications

The AMSR3 observes various forms of water related to the global hydrological cycle at a high temporal frequency using a microwave radiometer. As microwaves at certain frequencies exhibit high sensitivity to water, a microwave radiometer can measure the microwave energy that contains information about water. Microwave radiation originates from the Earth’s surface and atmospheric constituents. Therefore, observations can even be made when sunlight is absent at night or in polar regions during winter. In microwave observations, the appearance of the target objects varies depending on the frequency band used. Higher frequency bands with shorter wavelengths are more sensitive to clouds and precipitation, whereas lower frequency bands with longer wavelengths can penetrate clouds and observe the Earth’s surface. To quantitatively observe water-cycle-related geophysical parameters by leveraging these characteristics, AMSR3 employs frequency bands from 6.9 to 89.0 GHz and the 165.5 and 183.3 GHz bands. Ultimately, observations are conducted in the eight frequency bands shown in Figure 1-2 (with 6.9 and 7.3 GHz, 10.3 and 10.7 GHz, and 183.3 ± 3 GHz and 183.3 ± 7 GHz each treated as single frequencies).

Table 1-2 shows the relationship between AMSR3 physical parameter products and the observation frequencies used. In this way, the AMSR series can observe multiple water-cycle-related variables almost simultaneously on a global scale.

Table 1-2 AMSR3 observation frequencies and related geophysical quantities

Field	Product	Frequency [GHz] (●purpose of use, ○secondary use)								Purpose of use
		6.9/7.3	**10.3/10.7**	**18.7**	**23.8**	**36.5**	**89.0**	**166**	**183**	
Atmosphere	Total precipitable water over ocean			○	●	○				Numerical weather prediction, climate change research
	Total precipitable water over land			●	●	○				Numerical weather prediction, climate change research
	Cloud liquid water content			○	○	●				Climate change research
	Precipitation		○	●	○	○	●			Global precipitation mapping, climate change research, heavy rainfall monitoring, flood and drought prediction, and crop yield prediction
	Snow precipitate			○	○	○	●	●	●	
Ocean	Sea surface temperature	●	●		○	○				Numerical weather prediction, climate change research, oceanographic information, fisheries, polar navigation
	Sea surface wind speed	○	○		○	●				Climate change research, oceanographic information
	All-weather sea surface wind speed	●	●	○						Climate change research, oceanographic information, typhoon analysis
Cryosphere	Sea ice concentration	○		●	○	●				Numerical weather prediction, climate change research, polar navigation
	High-resolution sea ice concentration			○	○	○	●			
Land	Snow depth		○	●	○	●	○			Numerical weather prediction, climate change research
	Soil moisture content	●	●	○	○	○	○			Numerical weather prediction, climate change research, drought prediction, crop yield prediction

Figure 1-4 shows an RGB composite image created by assigning the AMSR3 observation data acquired from August 15 to 17, 2025 (18.7, 89.0, and 165.5 GHz, all in vertical polarization) to the red (R), green (G), and blue (B) color channels, respectively, to enhance visual interpretability. The cloud and precipitation areas are highlighted in bright green.

The newly introduced AMSR3 channel used in this composite (165.5 GHz) provides high sensitivity to ice particles in the upper layers of clouds, enabling more detailed observations of cloud and precipitation regions. As AMSR3 has an observation swath of approximately 1,500 km, 99.9% of the Earth's surface can be observed within 3 days (Figure 1-4). Thus, with its wide observation swath enabling rapid global coverage, high spatial resolution achieved through a large antenna, and numerous observation channels ranging from low to high frequencies, AMSR3 can be regarded as the world's highest-performance microwave radiometer developed by Japan.

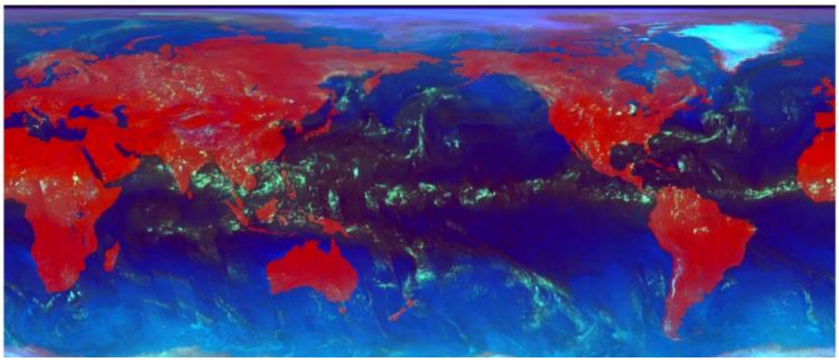


Figure 1-4 Global AMSR3 Observation Image Highlighting Cloud and Precipitation Areas in Bright Green (RGB composite image of the average brightness temperatures at 18.7, 89.0, and 165.5 GHz (V-polarization) from the ascending orbits on 15–17 August 2025.)

Observational data are widely provided as various geophysical parameters, including precipitation and atmospheric water vapor—both major components of the atmosphere, as well as sea ice extent in polar regions, which has been declining in recent years. They also include soil moisture, which is useful for monitoring droughts and floods and has potential applications in agriculture, and sea surface temperature, which is an essential parameter for ocean monitoring, including the Kuroshio Current. These observational data are indispensable for operational services such as numerical weather predictions, fisheries, and maritime navigation support. They are routinely used by organizations, including the Japan Meteorological Agency and Fisheries Information Service Center, particularly for improving precipitation forecasts related to typhoons and heavy rainfall, and for producing oceanographic information used to identify fishing grounds.

Building on the knowledge gained from AMSR-E, AMSR, and AMSR2, AMSR3 incorporates numerous improvements and is expected to provide data with even higher utility.

1.3.3.1 Example of data utilization (1): Observation of polar sea-ice distribution

Satellite-based microwave radiometer observations of sea ice have been conducted continuously since 1978, and the AMSR series has made significant contributions to high-resolution and long-term monitoring of sea ice regions since 2002. Sea ice covering the polar oceans is a key indicator of climate change. Figure 1-5 shows the sea ice distribution in the Arctic and Antarctic observed by AMSR3 during its ascending orbit on August 15, 2025, in which the white areas represent the extent of sea ice. In the Arctic summer as in Japan, the sea ice extent approaches its annual minimum. In contrast, the Antarctic is in mid-winter, and the sea ice cover is greatly expanded.

In recent years, the Arctic sea ice extent has decreased substantially owing to global warming, with summer sea ice areas declining by approximately 40% over the past 46 years. Meanwhile, Antarctic sea ice in contrast to the Arctic, had showed an increasing trend until around 2015 but experienced a sharp decline since 2016. In 2025, the total global sea ice extent reached its lowest level in the history of satellite observations (Figure 1-6), drawing significant attention to its ongoing changes. Information on polar sea ice distribution is utilized for monitoring climate change and for polar navigation support services in Japan and abroad, and continued long-term observations will remain essential.

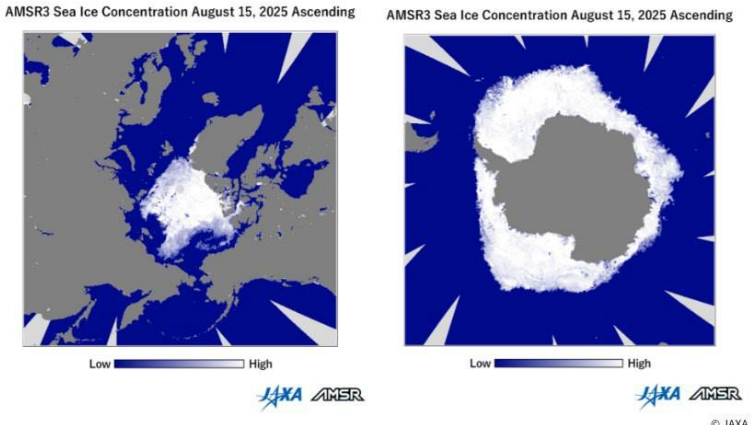


Figure 1-5 Sea-ice distribution in the Arctic (left) and Antarctic (right) observed by AMSR3.
(Ascending orbit on 15 August 2025)

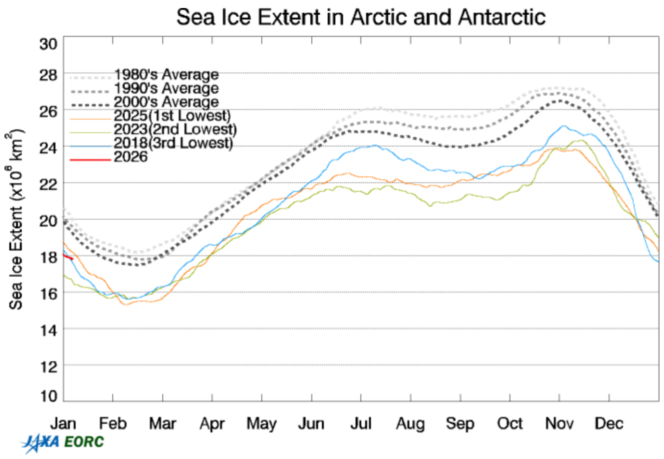


Figure 1-6 Variations in minimum global sea-ice extent observed by AMSR2

1.3.3.2 Example of data utilization (2): Observation of El Niño and La Niña conditions

The AMSR series is widely used in the oceanographic field because it can observe information beneath clouds during both day and night. Figure 1-7 shows the sea surface temperature distribution over the western and eastern Pacific, including the area surrounding Japan, as observed by AMSR3 from descending orbits on August 15–17, 2025. The figure demonstrates that stable observations are achieved even over the tropical Pacific, where cloud cover is extensive. The light gray areas over the ocean represent regions where data are missing owing to the effects of heavy rain or strong winds. In particular, the area off the coast of Peru (indicated by the black box in Figure 1-7) is a key region where El Niño and La Niña events originate, influencing weather patterns in Japan and worldwide. Figure 1-7 captures a characteristic feature of non-El Niño periods in this region, where lower-than-normal temperatures (shown in yellow to orange) extend in an east–west direction.

Figure 1-8 presents examples of El Niño and La Niña tendencies observed in the AMSR series. This figure shows the time series of sea surface temperature anomalies relative to the climatological mean in the El Niño monitoring region (black box in Figure 1-7). Negative anomalies indicate La Niña tendencies, whereas positive anomalies indicate El Niño tendencies. AMSR2 clearly captured the largest El Niño event that occurred between March 2014 and June 2016, as well as the longest La Niña event, which persisted from April 2020 to January 2023.

AMSR3 features enhanced channels with higher sensitivity to sea surface temperature and improved spatial resolution. As it continues the observations of AMSR2, further expansion of its applications is expected in fields such as extreme weather prediction and fisheries.

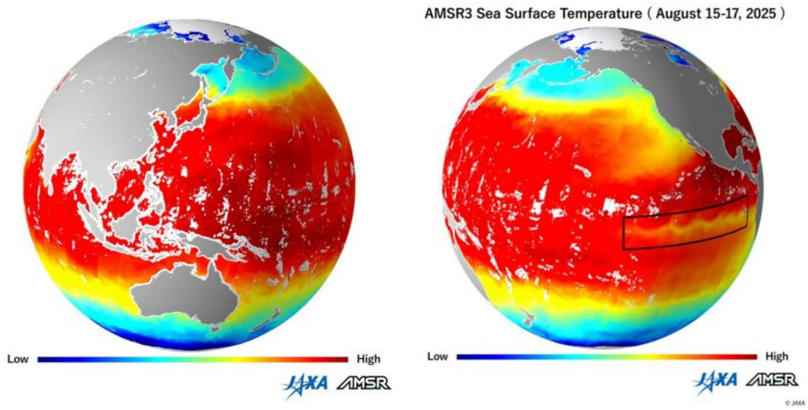


Figure 1-7 Sea surface temperature observed by AMSR3
(Average of the descending orbits on 15–17 August 2025)
Note: The light gray areas over the ocean indicate data gaps caused by heavy rain or strong winds.

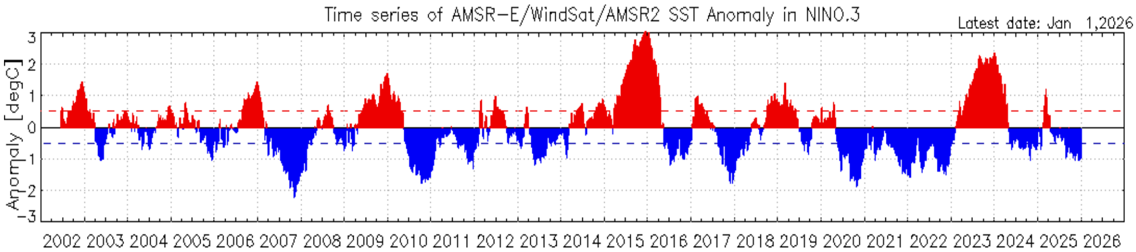


Figure 1-8 Examples of El Niño and La Niña conditions observed by AMSR-E, WindSat and AMSR2.

Chapter 2. Overview of GOSAT-GW and AMSR3

GOSAT-GW was launched on June 29, 2025 (JST) and was subsequently inserted into its observation orbit on July 20. The onboard sensor, AMSR3, conducts observations while rotating its antenna at 40 rpm. This chapter provides an overview of GOSAT-GW and AMSR3.

2.1 Overview of GOSAT-GW

The GOSAT-GW is an Earth observation satellite that simultaneously conducts greenhouse gas (led by the Ministry of the Environment and National Institute for Environmental Studies) and water cycle (led by JAXA) observation missions. The purpose of the satellite is to continue and advance the water cycle observation mission conducted by “Shizuku” (GCOM-W), launched in 2012, and greenhouse gas observation missions conducted by “Ibuki” (GOSAT), launched in 2009, and “Ibuki-2” (GOSAT-2), launched in 2018.

To achieve this, the satellite is equipped with the successor instruments the Advanced Microwave Scanning Radiometer 3 (AMSR3) and Greenhouse Gas Observing Sensor Type 3 (TANSO-3), developed by the Ministry of the Environment.

Figure 2-1 shows the exterior view of the GOSAT-GW, and Figure 2-2 shows its satellite coordinate system. Table 2-1 presents the satellite specifications of the GOSAT-GW, and Table 2-2 provides a comparison of satellites equipped with the AMSR series sensors.

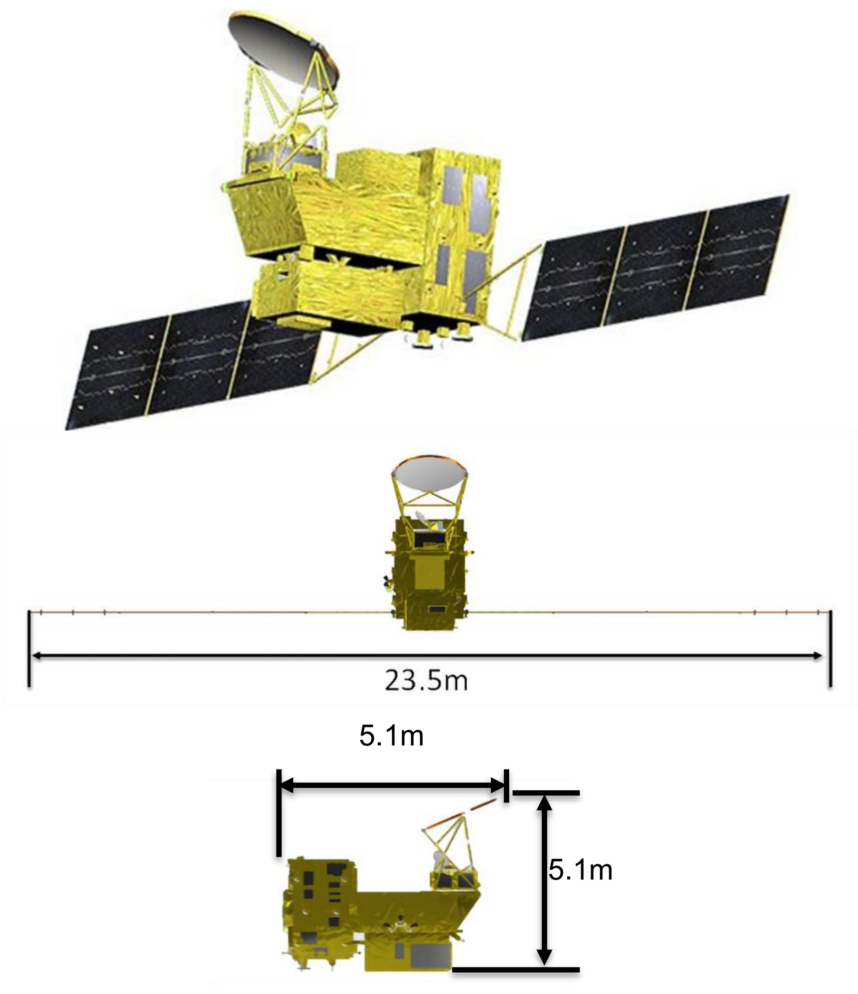


Figure 2-1 Exterior views of GOSAT-GW

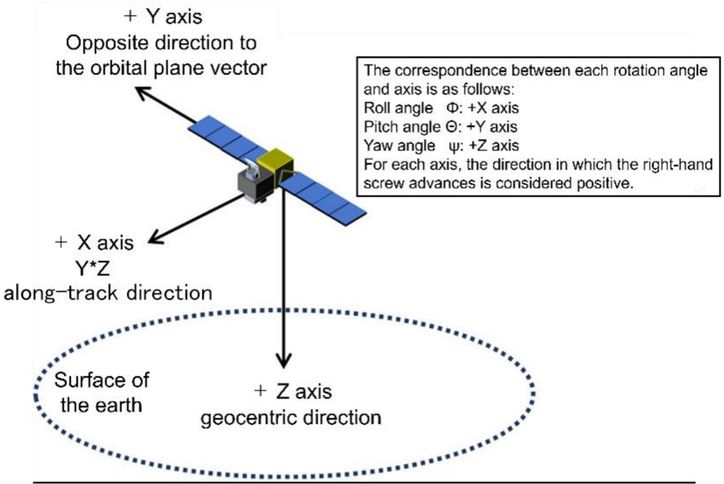


Figure 2-2 GOSAT-GW coordinate system

Table 2-1 Specifications of GOSAT-GW

Launch timing		June 29, 2025 (Japan Time)
Launch site		Tanegashima Space Center
Launch vehicle		H-IIA
Launch mass		Approximately 2600 kg (including 300 kg of propellant)
Power generated		Approximately 5300 W
Shape		Equipped with two solar array wings 5.1 m (X) × 23.5 m (Y) × 5.1 m (Z) (deployed configuration in orbit)
Life		7 years (or more)
Orbit	Type	Sun-synchronous quasi-repeating orbit (Frozen Orbit*)
	Altitude	Approximately 666 km (at the equator) - same as GOSAT
	Inclination	98.1°
	Orbital period	98.18 minutes
	Repeat cycle	3 days - same as GOSAT
	Number of revolutions per day	14 + 2/3
	Number of revolutions per repeat cycle	44
	Orbit repeat accuracy	±2.5 km
	Local time at ascending node	13:30 ± 15 minutes - same as GCOM-W

* Orbit that does not require orbit control to maintain its eccentricity.

Table 2-2 Comparison of satellites equipped with AMSR series sensors

Satellite	Aqua	ADEOS-II	GCOM-W	GOSAT-GW
Operating agency	NASA	JAXA	JAXA	JAXA
Onboard instruments	AMSR-E AIRS AMSU HSB CERES MODIS	AMSR GLI ILAS-II SeaWinds POLDER	AMSR2	AMSR3 TANSO-3
Orbit	Sun-synchronous quasi-repeating orbit	Sun-synchronous quasi-repeating orbit	Sun-synchronous quasi-repeating orbit	Sun-synchronous quasi-repeating orbit
Altitude (at equator)	705 km	803 km	699.6 km	666 km
Local solar time	13:30 (ascending node)	10:30 (descending node)	13:30 (ascending node)	13:30 (ascending node)
Launch	May 4, 2002	December 14, 2002	May 18, 2012	June 29, 2025
Design lifetime	6 years	3 years	5 years	7 years
Status	Operational (AMSR-E was decommissioned in October 2011)	Decommissioned (October 2003)	Operational	Operational

2.2 Overview of AMSR3

AMSR3 was developed as a successor to AMSR2 within the AMSR series, which began with the AMSR-E. Compared with AMSR-E, both AMSR2 and AMSR3 feature a larger antenna aperture (expanded from 1.6 m to 2.0 m) resulting in improved spatial resolution.

An antenna aperture of 2.0 m is among the largest apertures for satellite-borne microwave radiometers, enabling high-resolution observation of water-related geophysical parameters. As the AMSR3 uses microwave frequencies, observations can be made even at night and under cloudy conditions. Low-frequency channels penetrate clouds, allowing sensors to observe the Earth's surface and oceans.

AMSR3 observes radiation emitted from the Earth's surface and atmosphere. The data obtained by the sensor can be converted into brightness temperatures using the calibration data from the cold-sky mirror (CSM) as the low-temperature reference and the high-temperature source (HTS) as the high-temperature reference.

These brightness temperatures are used to derive various water-related geophysical parameters, including total precipitable water, cloud liquid water, precipitation, snow depth, soil moisture content, sea surface temperature, sea surface wind speed, all-weather sea surface wind speed, sea ice concentration, high-resolution sea ice concentration, and sea ice motion vectors.

To reduce the effects of radio-frequency interference, AMSR3 is equipped with a new 10.25 GHz channel in addition to the 7.3 GHz channel on AMSR2, enabling more accurate observations. The exterior view of the AMSR3 is shown in Figure 2-3, the main specifications of the AMSR3 are presented in Table 2-3, the list of channels is provided in Table 2-4, a comparison of major specifications among the AMSR series is given in Table 2-5, and a comparison of spatial resolution by observation frequency is shown in Table 2-6.

The AMSR3 consists of two units: a sensor unit that includes a rotating scanning mechanism and a fixed control unit. The antenna section, which receives microwaves from the Earth’s surface, rotates once every 1.5 s while scanning the surface in an arc, observing a swath approximately 1,535 km wide per scan (nominal value at 666 km altitude and 55.0° incidence angle). With this scanning method, AMSR3 can observe more than 99.9% of the Earth’s surface once during the day and once during the night over a 3-day period. Earth-viewing data are acquired within a scanning range of ±75° centered on the satellite’s flight direction, while calibration data from the high- and low-temperature calibration sources are obtained outside this range. The high-temperature calibration source is a microwave absorber whose temperature is controlled at approximately 300 K, and the low-temperature calibration source is a reflector that points toward deep space. Using the calibration data, a two-point calibration can be performed. To sequentially acquire low-temperature calibration, earth-viewing, and high-temperature calibration data at the correct rotation angles, the scanning rotation speed is maintained at a constant level through feedback control based on the speed signal from the rotation drive mechanism.

A momentum wheel is installed to compensate for the large angular momentum generated by the rotating–scanning mechanism. The momentum wheel adjusts its rotational speed in response to the angular momentum of the scanning unit, thus preventing adverse effects on the overall satellite system.

Figure 2-3 Exterior views of AMSR3

Table 2-3 Main specifications of AMSR3

Frequency (GHz)	6 GHz band		10 GHz band		18.7	23.8	36.5	89	165.5	183 GHz band	
	6.925	7.3	10.25	10.65						183.3 ±3	183.3 ±7
Swath width	Approximately 1,535 km at 666 km altitude and 55.0° incidence angle (nominal)										
Scan rate	Conical scan system (40 rpm)										
Antenna	Offset parabolic antenna (2.0 m diameter)										
Dynamic range	2.7 K - 340 K										
Quantization bits	12 bits										

Table 2-4 List of AMSR3 channels

Center frequency	Bandwidth (nominal)	Polarization	Temperature resolution (at 150 K)	Beamwidth (nominal)	Spatial resolution (nominal)	Sampling interval (scan direction)	Incidence angle
6.925 GHz	350 MHz	H/V	< 0.34 K	1.8°	33 km x 57 km	8 km	approx. 55°
7.3 GHz	350 MHz	H/V	< 0.43 K	1.8°	33 km x 57 km	8 km	approx. 55°
10.25 GHz	500 MHz	H/V	< 0.33 K	1.2°	22 km x 38 km	8 km	approx. 55°
10.65 GHz	100 MHz	H/V	< 0.70 K	1.2°	22 km x 38 km	8 km	approx. 55°
18.7 GHz	200 MHz	H/V	< 0.70 K	0.65°	12 km x 21 km	8 km	approx. 55°
23.8 GHz	400 MHz	H/V	< 0.60 K	0.75°	14 km x 24 km	8 km	approx. 55°
36.42 GHz	840 MHz	H/V	< 0.70 K	0.35°	6 km x 11 km	8 km	approx. 55°
89.0 GHz A/B	3000 MHz	H/V	< 1.20 K	0.15°	3 km x 5 km	4 km	approx. 55° / approx. 54.5°
165.5 GHz	3200 MHz*1	V	< 1.50 K	Az: 0.23° El: 0.30°	4 km x 9 km	8 km	approx. 52° (reference)
183.3±3 GHz	1470 x 2 MHz	V	< 1.50 K	Az: 0.23° El: 0.27°	4 km x 8 km	8 km	approx. 52° (reference)
183.3±7 GHz	1700 x 2 MHz	V	< 1.50 K	Az: 0.23° El: 0.27°	4 km x 8 km	8 km	approx. 52° (reference)

*1 Due to the use of the DSB (Double Sideband) scheme, the 165.5 GHz ± 300 MHz portion is excluded.

Table 2-5 Comparison of major specifications of the AMSR series

Sensor	AMSR-E	AMSR	AMSR2	AMSR3
Satellite	Aqua	ADEOS-II	GCOM-W	GOSAT-GW
Swath Width	1450 km	1600 km	1617 km	1535 km
Frequency (GHz)	6.9, 10, 18, 23, 36, 89	6.9, 10, 18, 23, 36, 50, 52, 89	6.9/7.3, 10.65, 18, 23, 36, 89	6.9/7.3, 10.25/10.65, 18, 23, 36, 89, 165.5, 183 ± 3 [180 & 186] 183 ± 7 [176 & 190]
Antenna Diameter	1.6 m	2.0 m	2.0 m	2.0 m
Spatial Resolution	43 x 75 km @ 6.9 GHz 8 x 14 km @ 36 GHz	40 x 70 km @ 6.9 GHz 8 x 14 km @ 36 GHz	35 x 62 km @ 6.9 GHz 7 x 12 km @ 36 GHz	34 x 58 km @ 6.9 GHz 7 x 11 km @ 36 GHz

Table 2-6 Comparison of spatial resolution by observation frequency for the AMSR series

		Spatial resolution (km)			
		AMSR-E	**AMSR**	**AMSR2**	**AMSR3**
Frequency (GHz)	6.925	43x75 (HV)	40x70 (HV)	35x62 (HV)	33x57 (HV)
	7.3	―	―	35x62 (HV)	33x57 (HV)
	10.25	―	―	―	22x38 (HV)
	10.65	29x51 (HV)	27x46 (HV)	24x42 (HV)	22x38 (HV)
	18.7	16x27 (HV)	14x25 (HV)	14x22 (HV)	12x21 (HV)
	23.8	18x32 (HV)	17x29 (HV)	15x26 (HV)	14x24 (HV)
	36.5	8.2x14.4 (HV)	8x14 (HV)	7x12 (HV)	6x11 (HV)
	50.3	―	6x10 (V)	―	―
	52.8	―	6x10 (V)	―	―
	89 (A series)	3.7x6.5 (HV)	3x6 (HV)	3x5 (HV)	3x5 (HV)
	89 (B series)	3.5x5.9 (HV)	3x6 (HV)	3x5 (HV)	3x5 (HV)
	165.5	―	―	―	4x9 (V)
	183.3±3	―	―	―	4x8 (V)
	183.3±7	―	―	―	4x8 (V)

*HV：Horizontal and vertical polarization, V：Vertical polarization

2.2.1 Observation Principles of AMSR3

The AMSR3 scans the Earth's surface by mechanically rotating the main reflector of its antenna section in synchronization with the satellite's motion, thereby observing the microwaves emitted from the surface and atmosphere. The microwaves collected by the main reflector are guided into horns corresponding to eight frequency bands, where they are separated into vertical (V) and horizontal (H) polarizations before being sent to the receiver unit (pairs 6.9 and 7.3 GHz, 10.25 and 10.65 GHz, and 183.3 ± 3 and 183.3 ± 7 GHz are each treated as a single frequency band). The signals input to the receiver are amplified, detected, integrated, and then digitized by the signal processing unit through A/D conversion. The resulting signals are recorded as count values and used in level 1 (L1) processing performed on the ground.

Each horn also collects microwaves from high- and low-temperature calibration sources. These data are used to calibrate the observational data.

Figure 2-4 shows the operational principle of AMSR3 in orbit. AMSR3 employs a conical scanning system in which the main reflector rotates while observing the Earth's surface. The observation range spans approximately ±75° centered on the satellite's flight direction, and the swath width is about 1,535 km at 666 km altitude and 55.0° incidence angle. The scan interval is approximately 1.5 s, and data sampling is performed at fixed intervals triggered by each antenna rotation: 2.6 m/s for the 6.9–36 GHz channels,1.3 m/s for the 89 GHz channel, and 2.6 m/s for the 165.5 and 183.3 GHz channels. In each scan, 243 samples are acquired for the 6.9–36 GHz channels, 486 samples for the 89 GHz channel, and 243 samples for the 165.5 and 183.3 GHz channels.

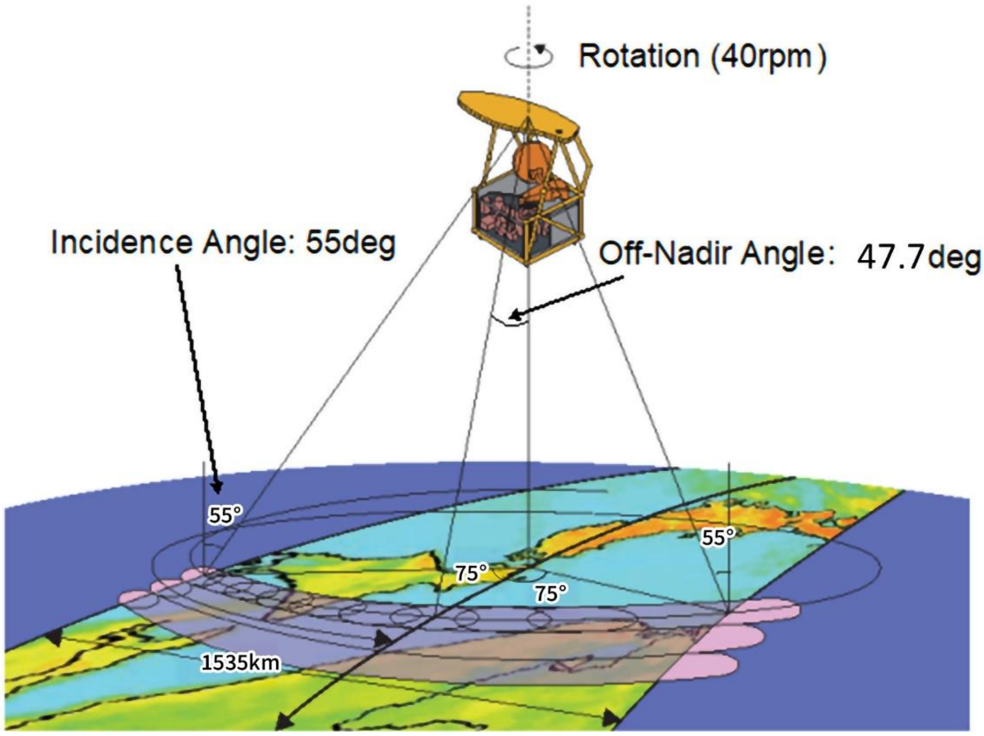


Figure 2-4 Operational principle of AMSR3

2.2.2 Observation Constraints of AMSR3

The AMSR3 conducts continuous observations under fixed operating conditions. However, depending on the operational status of the GOSAT-GW, some portions of the products may be missing, resulting in degraded quality. Table 2-7 presents the operational events that can affect AMSR3 observations and their corresponding impacts on the products. Figure 2-5 shows the observation interruption range of AMSR3 during the lunar calibration of TANSO-3.

Table 2-7 Operational events and their impact on products

Operational event	Description	Frequency	Impact on AMSR3 products
TANSO-3 lunar calibration	During the lunar calibration of TANSO-3, which is a co-mounted sensor, AMSR3 suspends observations for the duration of the event.	Twice per month	Product data are missing during the lunar calibration period. The missing period corresponds to approximately one orbital revolution, affecting three scenes. For the missing range, refer to Figure 2-5.
Out-of-plane orbit control	AMSR3 suspends observations during orbit and attitude maintenance or debris-avoidance operations.	Once per year (irregular)	Product data are missing during the control period. The duration of the missing data depends on the specific operation.
Autonomous Orbit control	Satellite autonomously performs orbit and attitude maintenance. AMSR3 continues observations.	Once every 3 days	During control (approximately 1 min), orbit and attitude stability may degrade, which can lead to reduced product quality during this period.

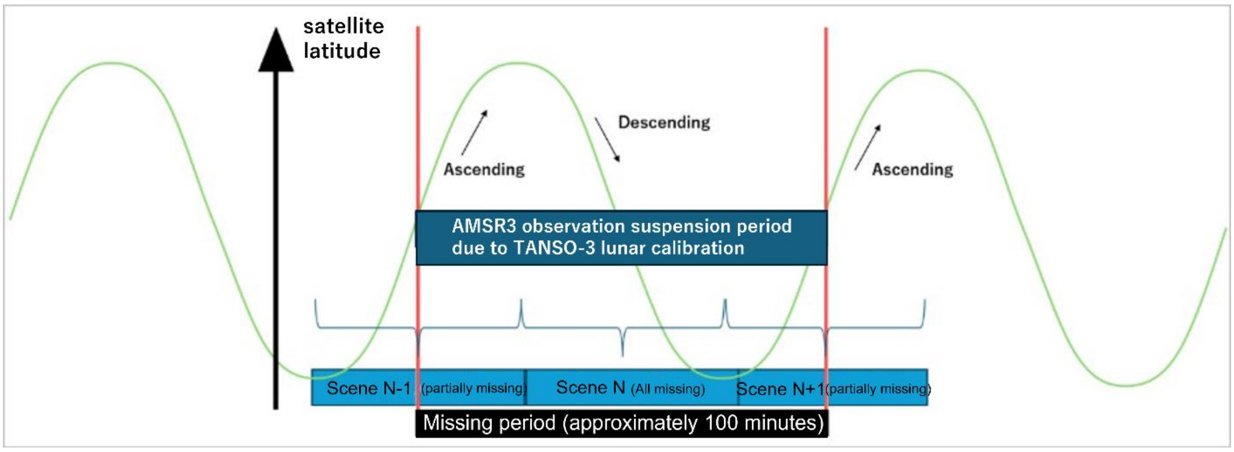


Figure 2-5 AMSR3 observation suspension range during TANSO-3 lunar calibration

The details of the observation constraints and their impacts on the products can be referenced from "Product Information / Operational Information" on G-Portal (https://gportal.jaxa.jp/gpr/?lang=en). Published samples are shown in Figures 2-8, 2-9, and 2-10.

Table 2-8 Operational event list sample

● AMSR3 Event List

The GOSAT-GW orbit control information and information on the periods when the AMSR3 sensor does not observe

As of 2025/12/02 (UT)

From (UT)		To (UT)		Duration	Remarks
Date	Time	Date	Time		
2025/12/05	11:33	2025/12/05	13:14	01:40	TANSO-3 Lunar Calibration
2025/12/04	14:17	2025/12/04	15:58	01:40	TANSO-3 Lunar Calibration
2025/11/06	03:57	2025/11/06	05:38	01:40	TANSO-3 Lunar Calibration
2025/11/05	03:26	2025/11/05	05:07	01:40	TANSO-3 Lunar Calibration
2025/09/08	04:38	2025/09/08	06:19	01:40	TANSO-3 Lunar Calibration
2025/09/07	02:30	2025/09/07	04:11	01:40	TANSO-3 Lunar Calibration

Table 2-9 Missing data list sample(L0 missing information)

● AMSR3 Missing Data List

Shows total missing information of AMSR3 data

As of 2025/12/21 (UT)

From (UT)		To (UT)		Missing time (min)	Remarks
Date	Time	Date	Time		
2025/12/20	14:08:15	2025/12/20	14:08:22	0	
2025/12/20	13:54:09	2025/12/20	14:05:39	11	
2025/12/20	13:41:13	2025/12/20	13:49:18	8	
2025/12/20	05:00:08	2025/12/20	05:00:16	0	
2025/12/20	04:05:03	2025/12/20	04:57:32	52	
2025/12/20	03:08:30	2025/12/20	04:00:14	51	
2025/12/05	11:33:22	2025/12/05	13:17:39	104	TANSO-3 Lunar Calibration
2025/12/04	14:17:18	2025/12/04	16:01:35	104	TANSO-3 Lunar Calibration
2025/11/25	03:04:26	2025/11/25	03:07:49	3	
2025/11/06	03:57:09	2025/11/06	05:41:20	104	TANSO-3 Lunar Calibration

Table 2-10 Fair data list sample(product quality degradation information)

● AMSR3 Latest Version Fair Data List
Shows partially missing information from the latest version of AMSR3 data.

As of 2026/06/01 (UT)

Product	GranuleID	Observate Start(UT)	Observate End(UT)	Missing Packets	Scanning Counts	Missing Scanning Counts	Remarks
L1B-Brightness Temperature(TBB)	GGWAM3_202606011501A001_S1BTBBGAZ01A26158	2026/6/1 15:01	2026/6/1 15:50	0	1966	0	AttitudeDataQA is NG
L1R-Brightness Temperature(TBR)	GGWAM3_202606011501A001_S1RTBRGAZ01A26158	2026/6/1 15:01	2026/6/1 15:50	0	1966	0	AttitudeDataQA is NG
L2-Total Precipitable Water(TPW)	GGWAM3_202606011501A001_S2MTPWGAD01A26169	2026/6/1 15:01	2026/6/1 15:50	0	1966	0	Input L1 is Fair
L2-Could Liquid Water Content(CLW)	GGWAM3_202606011501A001_S2MCLWGOD01A26169	2026/6/1 15:01	2026/6/1 15:50	0	1966	0	Input L1 is Fair
L2-Precipitation(PRC)	GGWAM3_202606011501A001_S2HPRCGAE01A26166	2026/6/1 15:01	2026/6/1 15:50	0	1966	0	Input L1 is Fair
L2-Sea Surface Temperature(SST)	GGWAM3_202606011501A001_S2MSSTGOB01A26162	2026/6/1 15:01	2026/6/1 15:50	0	1966	0	Input L1 is Fair
L2-Sea Ice Concentration(SIC)	GGWAM3_202606011501A001_S2MSICPOC01A26168	2026/6/1 15:01	2026/6/1 15:50	0	1966	0	Input L1 is Fair
L2-Soil Moisture Content(SMC)	GGWAM3_202606011501A001_S2MSMCGLF01A26163	2026/6/1 15:01	2026/6/1 15:50	0	1966	0	Input L1 is Fair
L1R-Brightness Temperature(TBR)	GGWAM3_202605312012D012_S1RTBRGAZ01A26158	2026/5/31 20:12	2026/5/31 21:01	0	1962	0	HotCalibrationSourceQA is NG
L2-Total Precipitable Water(TPW)	GGWAM3_202605312012D012_S2MTPWGAD01A26169	2026/5/31 20:12	2026/5/31 21:01	0	1962	0	Input L1 is Fair
L2-Could Liquid Water Content(CLW)	GGWAM3_202605312012D012_S2MCLWGOD01A26169	2026/5/31 20:12	2026/5/31 21:01	0	1962	0	Input L1 is Fair
L2-Precipitation(PRC)	GGWAM3_202605312012D012_S2HPRCGAE01A26166	2026/5/31 20:12	2026/5/31 21:01	0	1962	0	Input L1 is Fair
L2-Sea Surface Temperature(SST)	GGWAM3_202605312012D012_S2MSSTGOB01A26162	2026/5/31 20:12	2026/5/31 21:01	0	1962	0	Input L1 is Fair
L2-Sea Ice Concentration(SIC)	GGWAM3_202605312012D012_S2MSICPOC01A26169	2026/5/31 20:12	2026/5/31 21:01	0	1962	0	Input L1 is Fair
L2-Soil Moisture Content(SMC)	GGWAM3_202605312012D012_S2MSMCGLF01A26163	2026/5/31 20:12	2026/5/31 21:01	0	1962	0	Input L1 is Fair
L1B-Brightness Temperature(TBB)	GGWAM3_202605312004A009_S1BTBBGAZ01A26158	2026/5/31 20:04	2026/5/31 20:12	0	328	0	TANSO-3 Lunar Calibration / MissingScanQA is NG / HotCalibrationSourceQA is NG

2.2.3 System Configuration and Exterior Views

The AMSR3 consists of two units: a sensor and control unit. This section describes the system configuration and exterior views of the AMSR3.

2.2.3.1 System Configuration

AMSR3 is composed of the subsystems and components listed in Table 2-11.

Table 2-11 Configuration of AMSR3

Unit / component		Abbreviation	Main function
Sensor unit		SU	
	Antenna section	ANT	Receives microwaves emitted from the Earth's surface with a beamwidth that ensures the required receiver measurement resolution, separates them into frequency bands, and sends them to the receiver.
	Calibration section (including thermal control panel)	CAL	Provides two calibration reference sources: High-temperature calibration source (HTS): A microwave absorber whose temperature is controlled to a constant level, supplying high-temperature reference microwaves to the feed horns. Low-temperature calibration source (CSM): A calibration reflector that directs cosmic microwave background radiation (2.7 K) from deep space into the feed horns.
	Receiver unit	RX	Amplifies, band-limits, detects, and integrates microwaves received from antenna section and outputs these signals to the signal processing unit.
	Rotation drive mechanism	ADM	Rotates antenna section, receiver unit, and related components at constant rotational speed.
	Sensor unit disturbance Control/mass-center adjustment mechanism	OBM	Adjusts the mass balance on orbit by driving an internal movable component linearly in both directions in discrete steps.
	Sensor unit signal processing Section	SPS	Controls and monitors each component of the sensor unit.
	Sensor unit Heater control section	TCS	Controls heaters within the sensor unit, including thermal control panel, based on commands from SPS (excluding heaters for G-AS).
	Sensor unit Power distribution section	PDUS	Receives primary power and distributes it to each unit within the sensor unit.
	Structure	STRS	Holds and secures all sensor unit components.
	Deployment mechanism	DEP	Holds main reflector and sensor unit structure in stowed configuration during launch and deploys them in orbit.
	Integration components	SU-INT	Electrically and mechanically integrates each sensor unit component with one another and the satellite system.
Control unit		CU	—
	Rotation drive electronics	ADE	Controls the rotation of the ADM and sends various telemetry signals to the control unit signal processor (SPC).
	Control unit disturbance control/momentum wheel	MWA	Possesses angular momentum equal to that generated by the scanning rotation and rotates in the opposite direction to compensate, controlled by commands received from the control unit signal processor (SPC).
	Control unit Signal processing section	SPC	Controls and monitors each control-unit component, collects HK telemetry, and sends it to the S-band system; also performs automatic anomaly detection and automatic redundancy switching when necessary.
	Control unit Heater control section	TCC	Controls heaters within the control unit and high-temperature calibration source based on commands from SPC.
	Integration components	CU-INT	Electrically and mechanically integrates each control unit component with one another and with the satellite system.

2.2.3.1 Exterior View

The exterior view of AMSR3 is shown in Figure 2-6.

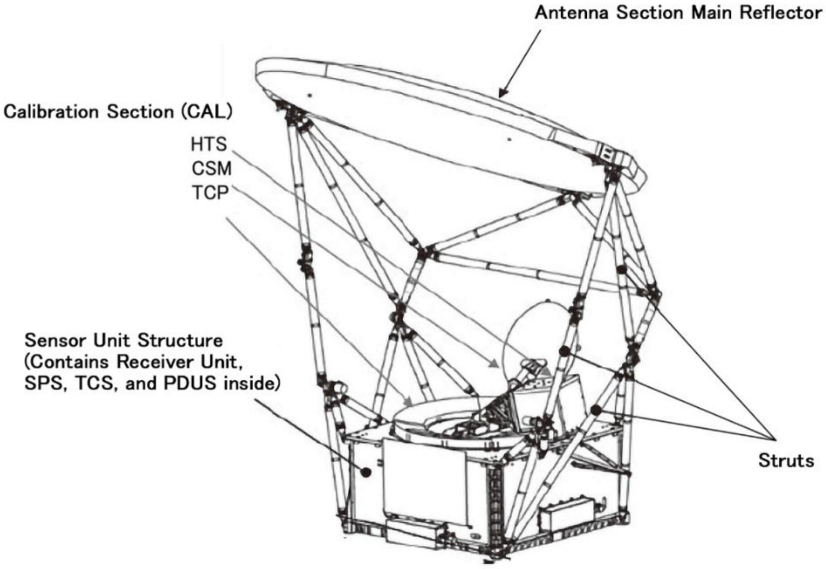


Figure 2-6 Exterior view of AMSR3

2.2.4 Operational Mode

AMSR3 has six operational modes:

(1) Off Mode
(2) Survival Mode
(3) Safe-2 Mode (the state in which the sensor unit maintains rotation of 4 rpm).
(4) Safe-1 Mode
(5) Science Mode
(6) Degraded Mode

The operational modes are defined in Table 2-12, and a transition diagram is shown in Figure 2-7.

Table 2-12 Definitions of AMSR3 operational modes(1/2)

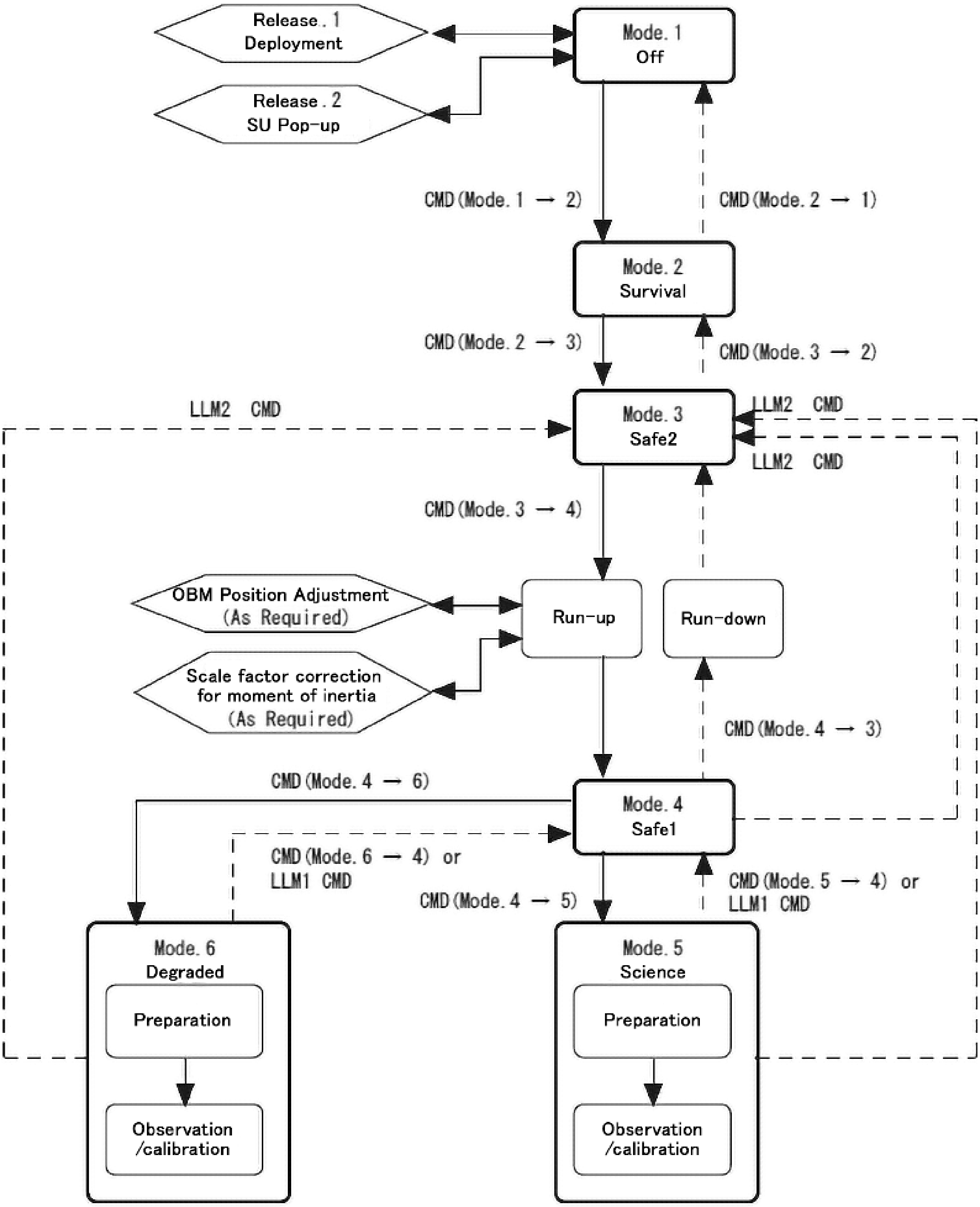
Mode No.	Operational mode		Mode definition	CMD processing	TLM output	Observation data output	Notes
1	All-off		・The sensor system is in an all-off state.	×	×	×	SPC ON command can be received.
	Deployment		・The antenna section is released and deployed.			×	Executed in All-off state.
	SU Pop-up		・Sensor unit is released and pops up.			×	Executed in All-off state.
2	Survival		・Maintains powered-on equipment within the operating temperature range and powered-off equipment within the non-operating temperature range. ・Maintains the rotation drive mechanism (ADM) and disturbance control mechanism at an operable temperature range. ・ADM and MWA are not rotating.			×	
3	Safe2		・Maintains powered-on equipment within operating temperature range and powered-off equipment within non-operating temperature range. ・All equipment is operating except for the receiver unit and receiver power supply. ADM is rotating at 4 rpm. During mode transition, it transiently rotates at a low speed between 4 and 40 rpm.			×	
		Run-up	・The rotation drive mechanism and disturbance control mechanism are running up toward normal rotation. ・If OBM position needs adjustment, OBM heater and OBE are turned ON.			×	Transient state of Safe2 mode.
		OBM Position Adjustment	・The state where OBM position is being adjusted.			×	Transient state of Safe2 mode.
		Run-down	・The rotation drive mechanism and disturbance control mechanism running down toward rotation stop.			×	Transient state of Safe2 mode.
4	Safe1	Normal	・Maintains powered-on equipment within operating temperature range and powered-off equipment within non-operating temperature range. High-temperature calibration source is set to low temperature. ・All equipment is operating except for the receiver unit and receiver power supply. ・ADM and MWA are rotating normally. ADM rotates at a nominal 40 rpm but has a low-speed rotation mode of more than 30 rpm and less than 40 rpm.			×	
	Safe1	Calibration	・In Safe1 (Normal), set temperature of high-temperature calibration source is maintained at Science Mode value. * : For one orbit after lunar calibration, observation data may be acquired while equipment is outside its operating temperature range.			×	
5	Science	Preparation	・Equipment required for steady-state observation is operating, but mission data is not being output. The ADM is rotating at a nominal 40 rpm. However, it has a mode to perform observations at low-speed rotation of more than 30 rpm and less than 40 rpm.			×	
	Science	Observation/ calibration	・Equipment required for steady-state observation is operating, and mission data is being output. The ADM is rotating at a nominal 40 rpm. However, it has a mode to perform observations at low-speed rotation of more than 30 rpm and less than 40 rpm.				
6	Degraded	Preparation	・The power of the equipment required for observation is ON. ・Control heater of the high-temperature calibration source is ON. ・Mission data output is stopped. ・Sensor unit is rotating at 30 rpm to 40 rpm.			×	

Table 2-12 Definitions of AMSR3 operational modes(2/2)

		Observation/ calibration	・Mission data are being output even if there are restrictions on normal observation. The observation frequency channels are halved. ・Sensor unit is rotating at 30 rpm to 40 rpm.				

〇: TLM and mission data output enabled; CMD reception enabled

×: TLM and mission data output disabled; CMD reception disabled



Note: If an LLM command is received during disturbance system anomaly processing, priority shall be given to the disturbance system anomaly processing sequence.
In Science Mode, upon receipt of LLM1, the rotation speed immediately prior to receiving LLM1 shall be maintained.

Figure 2-7 AMSR3 operational mode transition diagram

2.2.5 Radiometric Characteristics

2.2.5.1 Main Beam Efficiency

The main beam efficiency is defined as the ratio of the power of the desired polarization contained within an angular range corresponding to 2.5 × the beamwidth to the total received power and is evaluated as an average value over the observation bandwidth. For AMSR3, the main beam efficiencies for each observation frequency band are 85% or higher for the 165.5 and 183.3 GHz bands, and 90% or higher for all other bands.

2.2.5.2 Temperature Resolution

The temperature resolutions for each frequency band are listed in Table 2-13. The on-orbit values are those obtained during the initial calibration.

Table 2-13 Temperature resolution of AMSR3

Center frequency [GHz] (nominal)	Temperature resolution [K] (specification)	Temperature resolution [K] (on-orbit) (H-/V-polarization)
6.925	≤ 0.34	0.29 / 0.27
7.3	≤ 0.43	0.29 / 0.26
10.25	≤ 0.33	0.33 / 0.32
10.65	≤ 0.7	0.56 / 0.56
18.7	≤ 0.7	0.39 / 0.40
23.8	≤ 0.6	0.32 / 0.35
36.5	≤ 0.7	0.32 / 0.32
89.0 A/B	≤ 1.2	0.58 / 0.54(A) 0.58 / 0.62(B)
165.5	≤ 1.5	NA / 0.73
183.3±3	≤ 1.5	NA / 0.95
183.3±7	≤ 1.5	NA / 1.0

2.2.5.3 Dynamic Range

The dynamic range of AMSR3 brightness temperature is 2.7 to 340 K. This dynamic range is ensured by adjusting the gain and offset of the receiver such that the calibration outputs for both the high- and low-temperature references fall within a specified output range.

2.2.5.4 Linearity

The linearity of AMSR3 is ±1% (RMS) (specification value).

2.2.6 Calibration

The AMSR3 acquires low- and high-temperature calibration data during each 1.5-s scan cycle to correct for variations in the receiver gain. To illustrate the positional relationship between the High Temperature Source (HTS) and the Cold Sky Mirror (CSM), an exterior view of the CAL unit is shown in Figure 2-8.

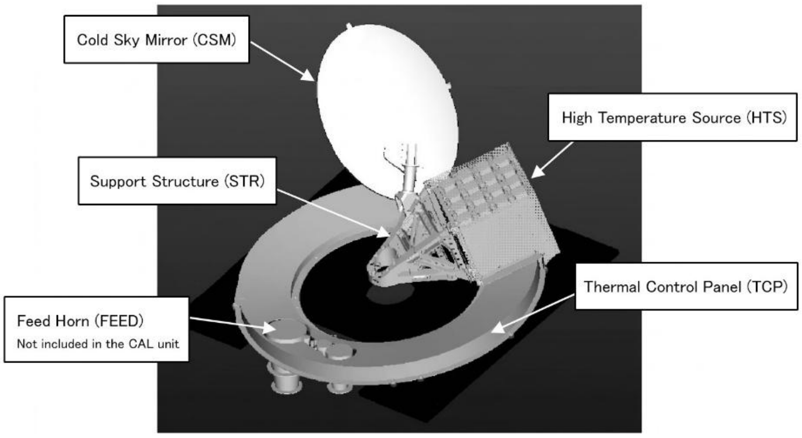


Figure 2-8 Exterior view of CAL unit

2.2.6.1 Low-Temperature Calibration

Low-temperature calibration is performed by observing deep space (brightness temperature of 2.7 K) using a low-temperature calibration source (CSM). However, as the measurement is affected by factors other than the cosmic background radiation, the calibrated brightness temperature becomes higher than 2.7 K.

The brightness temperature of the low-temperature calibration source is influenced by several error factors, including Earth radiation, lunar radiation, radio-frequency interference from geostationary satellites, contamination by sunlight, radiation from the satellite structure, and Earth radiation reflected by the main reflector. These errors are corrected during L1A processing.

2.2.6.2 High-Temperature Calibration

High-temperature calibration is performed by observing a high-temperature calibration source (HTS), which is a microwave absorber with a temperature controlled at approximately 300 K.

The brightness temperature of the high-temperature calibration source contains errors caused by the temperature nonuniformity of the source itself and by discrepancies between the measured temperature and the actual temperature indicated by the platinum sensor. These errors are corrected during L1A processing.

2.2.7 Geometric Characteristics

2.2.7.1 Off-Nadir Angle and Earth Incidence Angle

The off-nadir angle (angle between nadir direction and satellite observation direction) and the Earth incidence angle (angle between local zenith at the observation point and direction to the satellite) are geometric parameters that depend on the Earth’s shape and satellite altitude, and in the hardware design of AMSR3, they are determined by the design of the beam direction relative to the AMSR3 coordinate axes. Figure 2-9 schematically illustrates the relationships between these parameters. For AMSR3, assuming a satellite orbital altitude of 666 km and an Earth radius of 6,378 km, the off-nadir angle is set such that the Earth incidence angle is approximately 55° (excluding 89 GHz-B, 165.5 GHz, and 183.3 GHz bands). Under these conditions, the nominal off-nadir angle is 47.7°.

For the 89 GHz band, two beams (89 GHz-A and 89 GHz-B) are used, offset by 15 km nominally in the along-track direction, and the off-nadir angle of 89 GHz-B is set to 47.3°. As a result, the Earth incidence angle for 89 GHz-B is 54.4°. The Earth incidence angles for the 165.5 and 183.3 GHz bands is approximately 51.9°. The AMSR3 employs a configuration in which seven feed horns simultaneously share the main reflector. Therefore, the off-nadir angles for each channel are achieved by geometrically offsetting the orientations and placements of the individual feed horns.

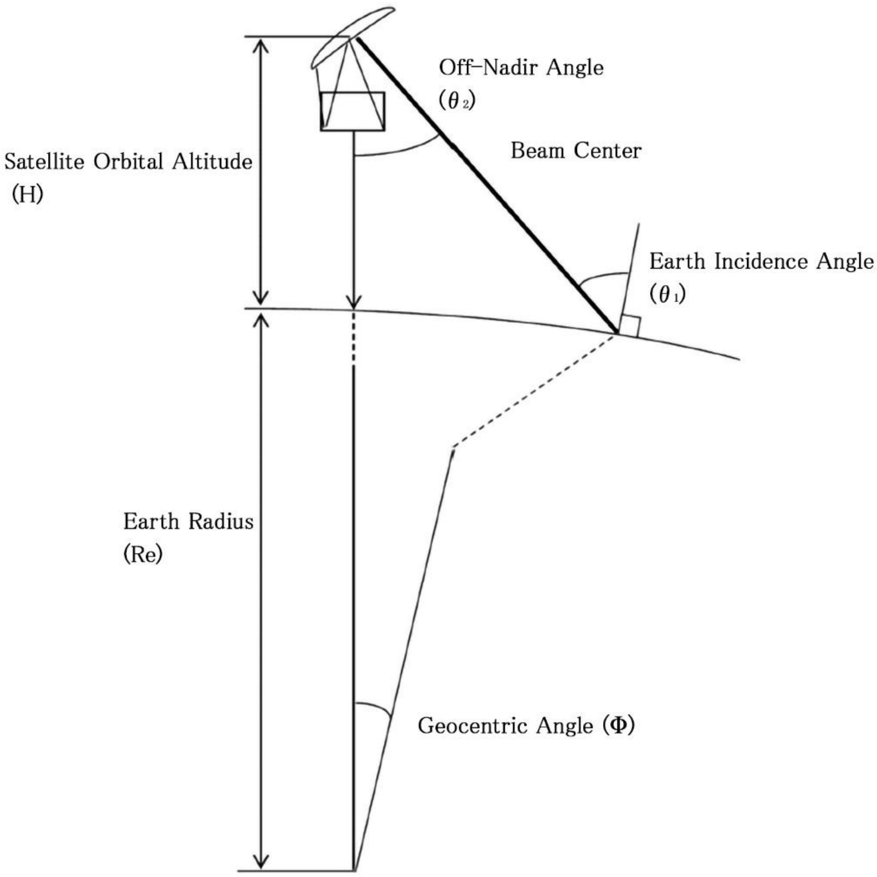


Figure 2-9 Off-nadir angle and Earth incidence angle

2.2.7.2 Scan Angle and Observation Swath

With the off-nadir angle of the AMSR3 set to 47.7°, the movable portion, including the antenna section, is rotated counterclockwise in a conical scanning motion around the geocentric (Z-axis) direction. Consequently, the ground projection of the beam center, when viewed relative to the fixed portion of AMSR3, traces a circular path with a diameter of approximately 1,575 km. When a scan angle of ±75° is ensured with respect to the satellite's flight direction (x-axis), an observation swath of 1,535 km (nominal value) can be secured as the ground projection width. The AMSR3 was designed to ensure that the required scan angle involves meeting two conditions: no obstructions exist within the propagation path of the main beam (from the feed horn to the main reflector and from the main reflector to the Earth's surface) within the specified scan angle range and the signal processing unit acquires and processes data covering the entire specified scan angle range. With regard to interference with the main beam, no obstructions exist within the range of −61° to +58° for the 6.9 GHz band, and within ±61° for the other frequency bands.

2.2.7.3 Rotation Speed, Scan Period, and Sampling Interval

In geometric imaging principle of the AMSR3, the sampling interval in the along-track direction of the satellite is determined as the ground-equivalent distance travelled by the satellite during the time between acquiring data at a given rotation angle of the AMSR3 rotating assembly and acquiring data again at the same rotation angle after one full rotation (scan period). These relationships are schematically illustrated in Figure 2-10. Assuming a satellite orbital altitude of 666 km and an Earth radius of 6, 378 km, the ground-track velocity of GOSAT-GW is 6.82 km/s. When the rotating assembly rotates at 40 rpm, the scan period becomes 1.5 s, resulting in a nominal along-track sampling interval of 10.22 km.

Satellite flight direction

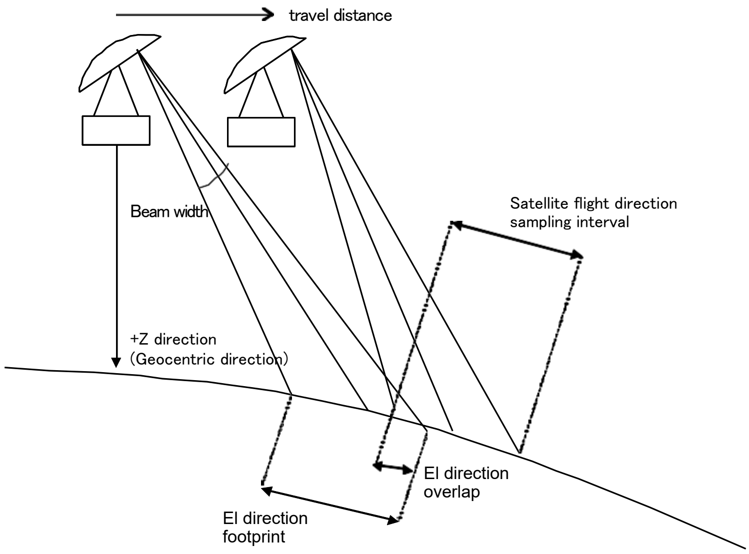


Figure 2-10 Schematic diagram of AMSR3 geometric characteristics (sampling interval, beamwidth, and footprint overlap)

2.2.7.4 Sampling Period, Integration Time, and Sampling Interval

With the rotational speed of the rotating assembly set at 40 rpm, the sampling interval in the scan direction is 8.6 km (nominal) when the sampling period is 2.6 msec. For the 165.5 and 183.3 GHz bands, the sampling interval is 8.0 km (nominal). For the 89 GHz band, the sampling period is 1.3 msec, resulting in sampling intervals of 4.3 km (nominal) for 89 GHz-A and 4.2 km (nominal) at 89 GHz-B. The integration time is 2.4875 msec for all channels except the 89 GHz band for which it is 1.1875 msec (nominal).

2.2.7.5 Beamwidth and Footprint

The beamwidth is designed to be achieved as a characteristic of the antenna section, and the design values of the antenna beamwidth are listed in Table 2-11. The ground-projection shape of the main beam and the ground-equivalent distance (hereafter referred to as the footprint) are determined according to geometric relationships that account for the satellite altitude, off-nadir angle, and beamwidth, as well as the Earth’s shape. For example, as shown in Figure 2-9, the along-track footprint is defined as the range of Earth incidence angles from the upper to lower limit of the beamwidth in the satellite’s flight direction. The footprints corresponding to the nominal beamwidths for each frequency band are listed in Table 2-14 for a satellite altitude of 666 km and an Earth radius of 6,378 km.

Table 2-14 Beamwidth and footprint

Center frequency band	Beamwidth (nominal)	Footprint (scan × along-track)	Remarks
6.925 GHz	1.8°±15%	33 × 57 km	Assuming a satellite orbital altitude of 666 km and an Earth radius of 6378 km
7.3 GHz	1.8°±15%	33 × 57 km	
10.25 GHz	1.2°±15%	22 × 38 km	
10.65 GHz	1.2°±15%	22 × 38 km	
18.7 GHz	0.65°±15%	12 × 21 km	
23.8 GHz	0.75°±15%	14 × 24 km	
36.5 GHz	0.35°±15%	6 × 11 km	
89.0 GHz-A	0.15°±15%	3×5 km	
89.0 GHz-B	0.15°±15%	3×5 km	
165.5 GHz	AZ=0.23°±15 % EL=0.30°±15 %	4×9km	
183.3±3 GHz	AZ=0.23°±0.045° EL=0.27°±0.045°	4×8 km	
183.3±7 GHz	AZ=0.23°±0.045° EL=0.27°±0.045°	4×8 km	

2.2.7.6 Overlap and Underlap

The overlap ratio in the along-track direction of the satellite is defined as the proportion of the footprint obtained in one scan that overlaps, in the along-track direction, with the footprint obtained in the subsequent scan. The condition in which the footprints do not overlap is referred to as an underlap.

Similarly, the overlap ratio in the scan direction is defined as the proportion of the footprint corresponding to adjacent integration intervals that overlap in the scan direction. And a condition in which no overlap occurs is referred to as underlap. Table 2-15 shows the along-track and scan-direction overlap ratios under the nominal design conditions for each observation frequency. A negative percentage indicates underlap.

Table 2-15 Overlap ratios (nominal design conditions)

Frequency band	Overlap ratio	
	Scan direction	Along-track direction
6.925 GHz	79.3%	82.0%
7.3 GHz	79.2%	81.9%
10.25 GHz	71.6%	73.0%
10.65 GHz	71.6%	73.0%
18.7 GHz	57.6%	51.1%
23.8 GHz	60.9%	57.0%
36.5 GHz	41.3%	7.0%
89 GHz A	35.4%	-3.0%
89 GHz B	36.2%	-3.0%
165.5 GHz	11.1%	-19.6%
183.3±3 GHz	30.1%	-32.9%
183.3±7 GHz	30.1%	-32.9%

Chapter 3. Overview of GOSAT-GW/AMSR3 Ground System

3.1 Overall System

An overview of the GOSAT-GW/AMSR3 ground system is shown in Figure 3-1. At the receiving and recording facilities of domestic and high-latitude stations, X- and S-band data are received and processed from the demodulation of the observation data to the generation of APID-sorted data (ASD). The mission operation system uses ASD as an input to perform data processing from level 0 (L0) to L1 and higher-level processing (levels 2 [L2] and 3 [L3]) and provides data storage, management, and user services. This system also generates and delivers near-real-time products to institutional users. The user and research system use L0 data and L1 products provided by the mission operation system to validate the algorithms and parameters related to data processing and calibration. The tracking network system uses a ground network system to perform S-band telemetry reception, command transmission, and ranging operations. The satellite control system formulates mission operation plans and satellite operation plans and performs telemetry and command processing via the tracking network system and high-latitude stations.

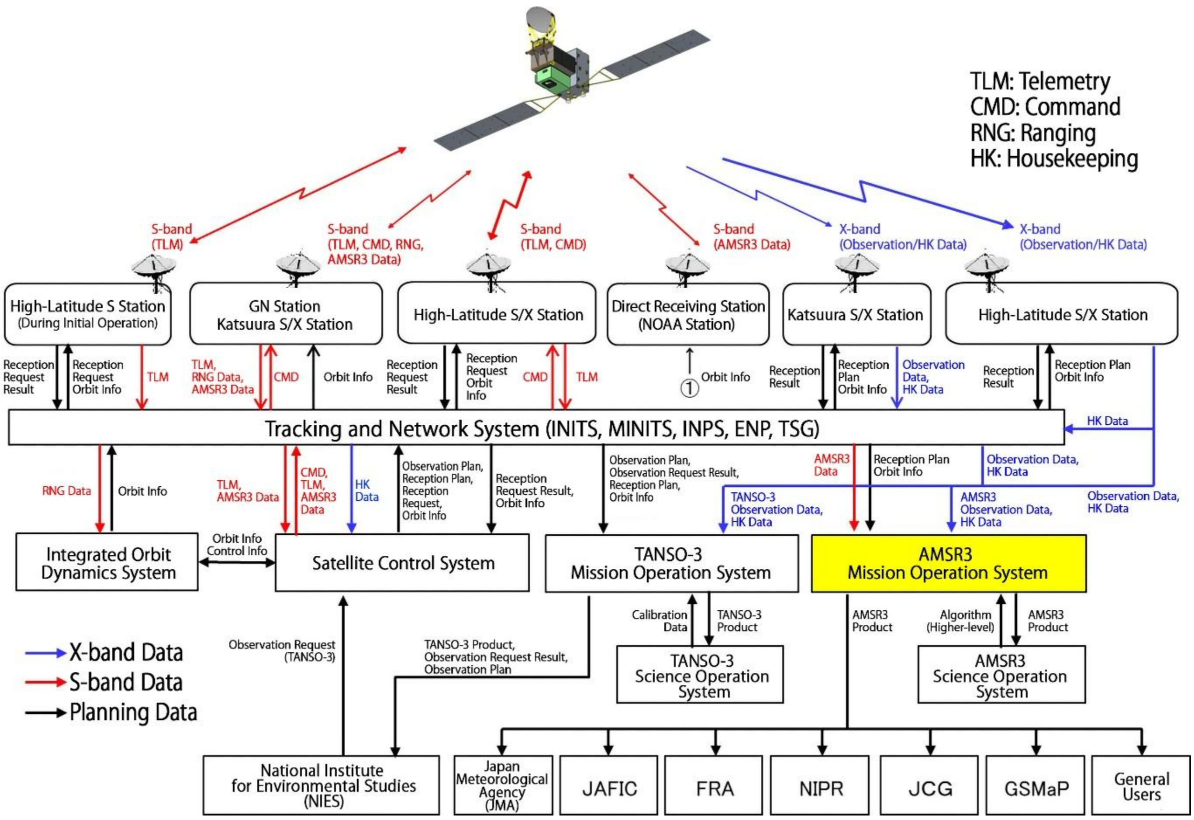


Figure 3-1 GOSAT-GW ground system overview

3.2 Ground System Operational Overview

3.2.1 AMSR3 Data Reception

In AMSR3 operations, there are two types of downlink for real-time observation data within the visibility region (hereafter referred to as local data) and for observation data covering the entire Earth stored in the satellite data recorder (hereafter referred to as global data).

Under nominal ground station operations, high-latitude stations are used to downlink global data, while domestic stations are used to downlink local data in the vicinity of Japan.

Downlinks to high-latitude stations are, in principle, performed for all pathes. To ensure robustness against short-term anomalies or reception failures at the ground stations, observational data from at least the previous two orbits are downlinked during every orbit. This implies that the observational data for a given orbit are downlinked more than once. S-band (TT&C) operations are conducted at these stations.

The receiving and recording facilities used for GOSAT-GW operations are Katsuura Station (S/X-band station) and domestic GN stations (S-band stations); Svalbard Station (S/X-band station) is a high-latitude station.

3.2.1.1 Domestic Stations

Domestic receiving and recording facilities receive and record the observation data acquired by domestic antenna installations and provide the APID-sorted data (ASD) to the mission operation system. During routine operations, the primary role of domestic stations is to receive and transmit local data, as well as real-time HK telemetry data.

3.2.1.2 High-Latitude Station

For GOSAT-GW, the Svalbard Station (located at 78°N) operated by Kongsberg Satellite Services AS (KSAT), a Norwegian company, is used as the high-latitude (polar region) ground station. At the high-latitude station, APID-sorted data (ASD is generated from the observation data and HK telemetry data received via the X band. The ASD is then transmitted to the mission operation system at the Tsukuba Space Center. Routine X-band operations at high-latitude stations primarily involve receiving and transmitting observation and HK telemetry data accumulated in the satellite’s data recorder. Even if the transmission of observation data becomes temporarily unavailable, operations are typically restored by the next path. Therefore, during routine operations, the downlink data are retransmitted from the previous orbit on every orbit.

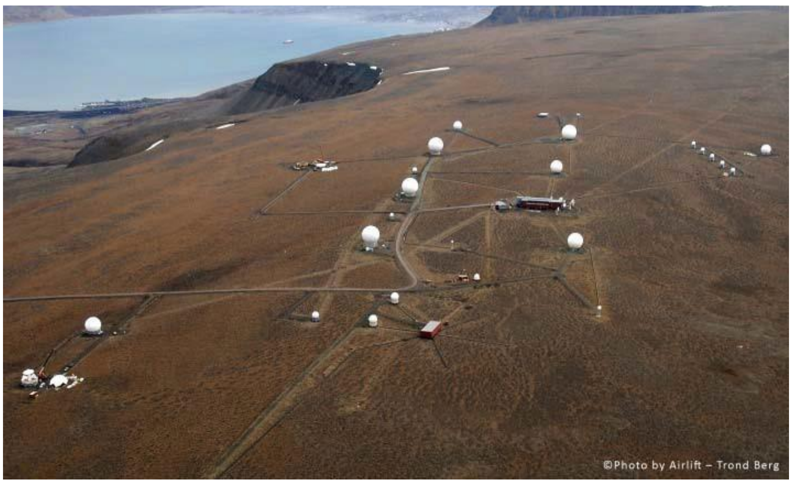


Figure 3-2 KSAT/Svalbard Station (from KSAT/HP)

3.2.2 AMSR3 Data Processing

3.2.2.1 Processing by Mission Operation System

Once observation data received at the high-latitude station and domestic stations are transmitted to the Mission Operation System at Tsukuba Space Center, various processing steps, as APID-sorted data (ASD), are performed. Table 3-1 summarizes the processing categories within the mission operation system, and Table 3-2 defines the AMSR3 observational data. Definitions of the AMSR3 products are provided in Chapter 4.

In routine (standard) processing, data quality is prioritized. When observational data from the same orbital revolution are downlinked multiple times (two or more pathes), these ASDs are merged to compensate for data gaps. By contrast, near-real-time processing prioritizes timeliness. Therefore, no ASD merging process is performed. Standard products generated through routine processing are publicly available on the G-Portal. For institutional users, specific products generated by near-real-time processing are provided in accordance with relevant agreements.

Table 3-1 Processing categories

Processing category	Description
Routine processing	Global data transmitted from the high-latitude station are used as input to generate scene-based L0 data, L1A products, standard products, and research products. During L0 data creation, ASD merging is performed. Statistical processing (L3 processing) is conducted using L1 and L2 products as input.
Near-real-time processing (Japan area)	Local data transmitted from domestic stations are used as input. Upon reception, L0 data, L1 products, and L2 products are generated for the corresponding observation area. The processing target corresponds to the visibility period of the domestic stations and therefore does not constitute a full scene.
Near-real-time processing (global)	Global data transmitted from the high-latitude station are used as input. Upon reception, L0 data, L1 products, and L2 products are generated for observation periods that have not yet been processed.
Reprocessing	When processing algorithms are improved or updated, all previously generated standard products are reprocessed in parallel with routine processing.

Table 3-2 Definition of AMSR3 observation data

Data name	Description
Raw data	Data recorded from the RF signal transmitted by the satellite, after being demodulated by the demodulator and converted into a digital bitstream.
APID-sorted telemetry data (ASD)	Data obtained by applying CCSDS-compliant packet synchronization to the demodulated signal received at the ground facilities, followed by sorting the packets with APID.
HK data	Information transmitted from the satellite that is required for generating products from the sensor’s observation data (e.g., orbital and attitude parameters).
AMSR3 L0 data (master storage data)	APID separated telemetry data are subjected to data sorting based on time, packet sequence counters, and missing data processing (collectively referred to as L0 processing). L0 data are stored on a scene-by-scene basis (including overlaps).

3.2.2.2 Distribution of Products to Operational Agencies

The AMSR3 products for areas around Japan and the global domain, as listed in Table 3-3, are provided to each operational agency in accordance with their respective latency requirements. Latency requirements are defined as the elapsed time from the start of observation to the completion of product delivery, as well as the achievement rate evaluated on a per-path basis. Products for the area around Japan are generated by processing local observation data transmitted in real time from domestic receiving stations. Global products are generated by processing the global observation data retransmitted from high-latitude receiving stations.

Table 3-3 Distribution of products to operational agencies

Recipient agency	Provided data	Requirements
Japan Meteorological Agency (JMA)	L1B brightness temperature near-real-time product (local)	Japan region: ≥80% delivered within observation time + 0.5 hours / ≥95% delivered within observation time + 0.8 hours
	L1B brightness temperature near-real-time product (global)	Global: ≥70% delivered within observation time + 2.5 h / ≥90% delivered within observation time + 4.1 h
	L2 physical quantity near-real-time product (local) (soil moisture content, all-weather sea surface wind speed)	Japan region: ≥80% delivered within observation time + 0.5 h
	L2 physical quantity near-real-time product (global) (sea surface temperature, sea ice concentration, soil moisture content, sea surface wind speed, snow depth, all-weather sea surface wind speed)	Global: ≥70% delivered within observation time + 3.0 h / ≥90% delivered within observation time + 5.0 h
Fisheries Research and Education Agency / Fisheries Information Service Center (JAFIC)	L2 physical quantity near-real-time product (global) (sea surface temperature)	Global: ≥70% delivered within observation time + 3.0 h
Japan Coast Guard	L2 physical quantity near-real-time product (global) (sea surface temperature, high-resolution sea ice concentration)	Global: ≥70% delivered within observation time + 3.0 h
National Institute of Polar Research	L2 physical quantity near-real-time product (global) (sea surface temperature, high-resolution sea ice concentration)	Global: ≥70% delivered within observation time + 3.0 h
GSMaP Processing System	L1B brightness temperature near-real-time product (local)	Japan region: ≥80% delivered within observation time + 0.5 h
	L1B brightness temperature near-real-time product (global)	Global: ≥70% delivered within observation time + 3.0 h
	L2 Physical quantity near-real-time product (global) (precipitation, snowfall)	Global: ≥70% delivered within observation time + 3.0 h

3.2.2.3 Interface with Users

As AMSR3 conducts continuous global observations, no user-side input interface is required to specify observation requests. All observational data are provided to users through the Earth Observation Satellite Data Distribution System (G-Portal).

3.2.2.4 Data Preservation

JAXA stores AMSR3 L0 data as master data. For L1 and higher-level products generated from these data, the latest two generations are retained, except during transitional periods associated with reprocessing. During reprocessing, all products for the entire observation period are regenerated, after which the products from two generations prior are deleted. All stored master data are backed up and maintained at geographically separate locations to ensure data redundancy and reliability.

Chapter 4. AMSR3 Products

4.1 Product Definitions

AMSR3 products consist of brightness temperature products and geophysical quantity products estimated from brightness temperatures based on scientific knowledge. These products are provided as standard and research products, and are generated for each processing level and type.

For product definitions, please refer to the AMSR Data Catalog (https://www.eorc.jaxa.jp/AMSR/datacatalog/index_en.html).

4.1.1 Processing Level

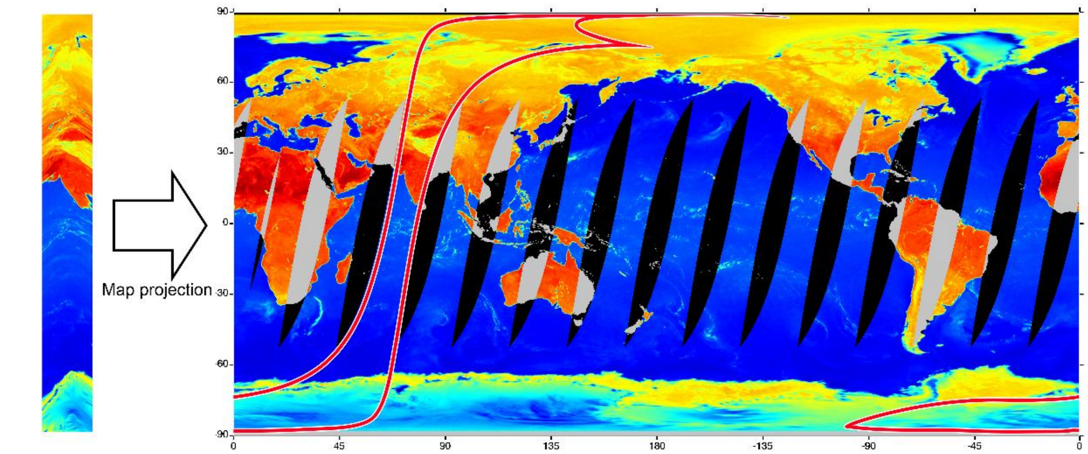
Brightness temperature products are generated during L1 processing. Geophysical quantity products are produced during L2 processing by applying geophysical retrieval algorithms to the brightness temperature products generated in L1. Map-projected brightness temperature products and map-projected geophysical quantity products are created during L3 processing.

In this document, the products generated during L1, L2, and L3 processing are referred to as L1, L2, and L3 products, respectively. The methods used to compute these products are called the “L1 processing algorithms” for L1, and the “higher-level (L2/L3) processing algorithms” for L2 and L3. Table 4-1 presents the definitions of the processing levels used in AMSR3.

Table 4-1 AMSR3 processing levels

Processing level	Description
Level 1	After applying radiometric and geometric corrections to convert Level 0 data into antenna temperature count values, the antenna temperature is calculated using the antenna temperature conversion coefficients and related parameters. The antenna temperature is then converted to brightness temperature and stored. Map projection is not performed.
Level 2	Geophysical quantities calculated from the brightness temperatures for each footprint are stored. Map projection is not performed.
Level 3	Brightness temperatures or geophysical quantities that have undergone gridding and temporal statistical processing are stored. Map projection is applied to the gridded data for the global domain, Arctic region, and Antarctic region.

L1 and L2 products are rectangular data that are not mapped. L3 products are generated by applying map projections to these rectangular data using the latitude and longitude of each observation point. Figure 4-1 shows a comparison of the data before and after map projection.



(a) L1/L2 observation swath data (b) L3 gridded map projection data

Figure 4-1 Comparison of data before and after map projection

4.1.2 Processing Types (Nominal and Near-real-time Processing)

AMSR3 processing includes nominal and near–real time processing. In nominal processing, observations over the global domain are processed by extracting data for a half-orbit segment starting from the southern or northern end of the observation swath, and standard and research products are generated on a scene basis. Near-real time processing is carried out with the highest priority placed on meeting the data delivery time requirements, and products for both the global domain and the Japanese area (local domain) are generated. Global data produced in near-real time processing generally correspond to approximately one orbital revolution. However, if data acquisition fails during the previous orbit, then the processing may include observation data exceeding one revolution.

4.1.3 Product Types (Standard and Research Products)

In the nominal processing flow, two types of AMSR3 products (brightness temperature and geophysical quantity products) are generated as standard and research products. Standard products are essential for achieving mission objectives and are defined based on the development experience of the Advanced Microwave Scanning Radiometer for EOS PM (AMSR-E) onboard NASA's Aqua satellite and AMSR2 onboard the Global Change Observation Mission – Water (GCOM-W). Therefore, their development must be reliable, and the required accuracy targets must be achieved.

Research products are also developed to contribute to the objectives of the AMSR3 mission. Once their practical effectiveness has been demonstrated and they are judged to be stable, they are elevated and defined as standard products. Research products may be provided by the Earth Observation Research Center (EORC). As research products may transition to standard products during the operational period of the AMSR3, the mission operation system handles them in the same manner as standard products. Therefore, the explanations in this document regarding the processing of standard products also apply to the research products.

4.1.4 L1 Products

L1 products consist of three standard products (L1A, L1B, and L1R) and two research products (L1C and L1H), as listed in Table 4-2. Multiple frequency channels are used in combination to process geophysical quantity retrieval. However, as footprints differ among frequencies, combining these data introduces a mismatch in the exact surface area observed. To address this issue, AMSR3, which is similar to AMSR2, provides the L1R product, in which other frequency channels are resampled to match the footprint of lower-frequency channels. In the L1R product, the central latitude and longitude of each observation are unified to the location of the 89 GHz-A horn, and the 6, 10, 23, and 36 GHz channels are used as the basis for resampling.

Table 4-2 AMSR3 L1 product definitions

Product (product code)	Description
L1A (DNA)	Antenna temperature count values converted from L0 data through radiometric and geometric correction processing, along with antenna temperature conversion coefficients and related parameters, are stored. Map projection is not performed.
L1B (TBB)	Brightness temperatures calculated from the L1A antenna temperatures using the conversion coefficients are stored. Map projection is not performed.
L1R (TBR)	Brightness temperatures whose footprint center positions and sizes have been matched across each frequency bands through the spatial matching process applied to the L1B brightness temperatures are stored. Map projection is not performed.
L1H (TBH)	Brightness temperatures whose footprint center positions have been aligned across each frequency bands and whose spatial resolution in the low-frequency bands has been enhanced through the spatial matching process applied to the L1B brightness temperatures are stored. Map projection is not performed.
L1C (TBC)	Brightness temperatures whose footprint center positions have been aligned across each frequency bands through the spatial matching process applied to the L1B brightness temperatures are stored. Map projection is not performed.

4.1.5 L2 Products

L2 products consist of geophysical quantities of products generated on a scene basis using L1 brightness temperatures as the input. Table 4-3 lists the L2 products of AMSR3, and Table 4-4 shows the data for each product.

Table 4-3 List of AMSR3 L2 products

Product (product code)	Data units	Coverage	Resolution
Total precipitable water (TPW)	Scene (half orbit)	Global	15 km
Cloud liquid water (CLW)		Global over ocean	15 km
Precipitation (PRC)		Global	15 km
Sea surface temperature (SST)		Global over ocean	50 km
Sea surface wind speed (SSW)		Global over ocean	15 km
All-weather sea surface wind speed (ASW)		Global over ocean	50 km
Snow depth (SND)		Global over land	30 km
Soil moisture content (SMC)		Global over land	50 km
Sea ice concentration (SIC)		Polar region over ocean	15 km
High-resolution sea ice concentration (HSI)		Polar region over ocean	5 km

Table 4-4 List of stored data in AMSR3 L2 product

Product code	Data1	Data2	Data3
TPW	TPW_Ocean	TPW_Land	-
CLW	CLW	-	-
PRC	PRC_PrecipiRate: Precipitation intensity	PRC_SnowProb: Probability of snowfall	-
SSW	SSW	-	-
SST	SST_6G	SST_10G	SST_Multi
SIC	SIC	-	-
SND	SND	SND_SWE: Snow water equivalent	-
SMC	SMC	-	-
ASW	ASW	-	-
HSI	HSI	-	-

Note: When multiple data items are stored, they are additionally stored as Data1, Data2, Data3, and so on.

4.1.6 L3 Products

L3 products are generated by mapping the L1B brightness temperature (TBB) data and L2 geophysical quantity data onto predefined grid points on the Earth's surface, followed by spatial and temporal overwriting or averaging. Table 4-5 lists the L3 products. Daily and monthly temporal averages are provided. Each product contains global data and is available in ascending and descending types. Table 4-5 shows the data size for each map projection method, and Table 4-6 presents the number of stored data items, and the spatial grids corresponding to each physical quantity.

Table 4-5 List of AMSR3 L3 products

Product Code	Geophysical quantities	Daily Statistical methods	Monthly Statistical methods
TPW	Total Precipitable Water	Overwrite	Average
CLW	Cloud Liquid Water Content	Overwrite	Average
PRC	Precipitation	Overwrite	Average
SST	Sea Surface Temperature	Overwrite	Average
SSW	Sea Surface Wind Speed	Overwrite	Average
ASW	All-weather Sea Surface Wind Speed	Overwrite	Average
SIC	Sea Ice Concentration	Average	Average
HSI	High-resolution Sea Ice Concentration	Average	Average
SMC	Soil Moisture Content	Average	Average
SND	Snow Depth	Average	Average
SIM	Sea Ice Motion Vector	Average	-
TL1	Brightness Temperature 6.925GHz (Level 3)	Average	Average
TL2	Brightness Temperature 7.3GHz (Level 3)	Average	Average
TL3	Brightness Temperature 10.25GHz (Level 3)	Average	Average
TL4	Brightness Temperature 10.65GHz (Level 3)	Average	Average
TL5	Brightness Temperature 18.7GHz (Level 3)	Average	Average
TL6	Brightness Temperature 23.8GHz (Level 3)	Average	Average
TL7	Brightness Temperature 36.42GHz (Level 3)	Average	Average
TH1	Brightness Temperature 89.0GHz (Level 3)	Average	Average
TH2	Brightness Temperature 165.5GHz (Level 3)	Average	Average
TH3	Brightness Temperature 183.3+/-3GHz (Level 3)	Average	Average
TH4	Brightness Temperature 183.3+/-7GHz (Level 3)	Average	Average

Table 4-6 List of stored data in AMSR3 L3 products

Product code	Data1	Data2	Data3	Data4
TL(1-7)/TH1	TL(1-7)_V / TH1_V	TL(1-7)_H / TH1_H	-	-
TH(2-4)	TH(2-4)_V	-	-	-
TPW	TPW_Ocean	TPW_Land	-	-
CLW	CLW	-	-	-
PRC	PRC_PrecipiRate: Precipitation intensity	PRC_SnowProb: Probability of snowfall	-	-
SSW	SSW	-	-	-
SST	SST_6G	SST_10G	SST_Multi	-
SIC	SIC	-	-	-
SIM	SIM_U: Velocity in the X-direction	SIM_V: Velocity in the Y-direction	SIM_E: Zonal velocity	SIM_N: Meridional velocity
SND	SND	SND_SWE: Snow water equivalent	-	-
SMC	SMC	-	-	-
ASW	ASW	-	-	-
HSI	HSI	-	-	-

Note: Monthly SIM products are not provided.

Table 4-7 L3 product projection methods and grid sizes

Projection Method	PS-P (50 km) /EASE2-Q (62.5 km)		EQR-L (0.25°)/ PS-L (25 km) / EASE2-L (25 km)		EQR-M (0.10°)/ PS-M (10 km) / EASE2-M (12.5 km)		EQR-H (0.05°)/ PS-H (5 km) / EASE2-H (6.25 km)		EQR-N (0.25°)*	
	Vertical direction (number of lines)	Horizontal direction (number of pixels)	Vertical direction (number of lines)	Horizontal direction (number of pixels)	Vertical direction (number of lines)	Horizontal direction (number of pixels)	Vertical direction (number of lines)	Horizontal direction (number of pixels)	Vertical direction (number of lines)	Horizontal direction (number of pixels)
EQR	-	-	720	1440	1800	3600	3600	7200	721	1441
PN1	224	152	448	304	1120	760	2240	1520	-	-
PN2	-	-	574	432	1435	1080	2870	2160	-	-
PS1	166	158	332	316	830	790	1660	1580	-	-
EGG	-	-	584	1388	1168	2776	2336	5552	-	-
EGN/EGS	288	288	720	720	1440	1440	2880	2880	-	-

* EQR-N is defined as a grid node for which coordinates are assigned to each grid intersection. In the other spatial grids, the coordinates of the cell center points are assigned to each pixel.

Table 4-8 Number of stored data corresponding to each physical quantity and spatial grid

Physical Quantity	Number of stored data	Processing Unit	Equirectangular (EQR)			Polar Stereographic Northern Hemisphere 1(PN1)				Polar Stereographic Northern Hemisphere 2(PN2)			Polar Stereographic Southern Hemisphere 1(PS1)				EASE-Grid 2.0 Global (EGG)			EASE-Grid 2.0 Northern Hemisphere (EGN)				EASE-Grid 2.0 Southern Hemisphere (EGS)			
			0.25deg	0.10deg	0.05deg	50km	25km	10km	5km	25km	10km	5km	50km	25km	10km	5km	25km	12.5km	6.25km	62.5km	25km	12.5km	6.25km	62.5km	25km	12.5km	6.25km
			EQR-L	EQR-M	EQR-H	PN1-P	PN1-L	PN1-M	PN1-H	PN2-L	PN2-M	PN2-H	PS1-P	PS1-L	PS1-M	PS1-H	EGG-L	EGG-M	EGG-H	EGN-Q	EGN-L	EGN-M	EGN-H	EGS-Q	EGS-L	EGS-M	EGS-H
Brightness Temperature	2※1	Daily / Monthly	○	○	-	-	○	○	-	○	○	-	-	○	○	-	○	○	-	-	○	○	-	-	○	○	-
Atmosphere																											
TPW	2	Daily / Monthly	○	○	-	-	○	○	-	○	○	-	-	○	○	-	○	○	-	-	○	○	-	-	○	○	-
CLW	1	Daily / Monthly	○	○	-	-	○	○	-	○	○	-	-	○	○	-	○	○	-	-	○	○	-	-	○	○	-
PRC	2	Daily / Monthly	○	○	-	-	○	○	-	○	○	-	-	○	○	-	○	○	-	-	○	○	-	-	○	○	-
Ocean																											
SST	3	Daily / Monthly	○	○	-	-	○	○	-	-	-	-	-	○	○	-	○	○	-	-	○	○	-	-	○	○	-
SSW	1	Daily / Monthly	○	○	-	-	○	○	-	-	-	-	-	○	○	-	○	○	-	-	○	○	-	-	○	○	-
ASW	1	Daily / Monthly	○	○	-	-	○	○	-	-	-	-	-	○	○	-	○	○	-	-	○	○	-	-	○	○	-
Cryosphere																											
SIC	1	Daily / Monthly	○	○	-	-	○	○	-	-	-	-	-	○	○	-	○	○	-	-	○	○	-	-	○	○	-
HSI	1	Daily / Monthly	○	○	-	-	○	○	○	-	-	-	-	○	○	○	○	○	-	-	○	○	○	-	○	○	○
SIM	4	Daily	-	-	-	○	-	○	-	-	-	-	○	-	○	-	-	-	-	-※2	-	-※2	-	-※2	-	-※2	-
Land																											
SMC	1	Daily / Monthly	○	○	-	-	-	-	-	○	○	-	-	-	-	-	○	○	-	-	○	○	-	-	○	○	-
SND	2	Daily / Monthly	○	○	-	-	-	-	-	○	○	-	-	-	-	-	○	○	-	-	○	○	-	-	○	○	-

※1 For the brightness temperature products of the 165.5, 183.3 ± 3 GHz, 183.3 ± 7 GHz channels, since the observation is only vertical (V) polarization, the number of stored data is 1.

※2 EASE-Grid SIM data are expected to be made publicly available after a certain period following the release of AMSR3 standard data products.

4.1.7 Product File Name

The file naming convention for AMSR3 L1 products is shown in Table 4-9, for L2 products in Table 4-10, and for L3 products in Table 4-11.

Table 4-9 Naming convention for L1 products

CP	0									1										2										3										4				
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4
FN	G	G	W	A	M	3	_	Y	Y	Y	Y	M	M	D	D	H	H	m	m	X	P	P	P	_	x	L	L	K	K	K	A	A	d	V	V	v	y	y	d	d	d	.	n	c

String	Bit position	Description
GGW	1-3	Satellite name (fixed as GGW)
AM3	4-6	Sensor type (fixed as AM3)
YYYYMMDDhhmm	8-19	Observation start date/time (UTC)
X	20	Orbit: A = Ascending / D = Descending / B = Both (research real-time processing)
PPP	21-23	Path number (001–0XX, scene number at start)
X	25	Processing type: S = Standard (global) / N = Near real-time (global) L = Near real-time (local)
LL	26-27	Processing level & type code
KKK	28-30	Product code
AA	31-32	Area/classification code (Table 3-8)
d	33	Developer code (L1: Z fixed)
VV	34-35	Version major number (00–99); updated for major changes, reprocessing required
v	36	Version minor number (A–Z); updated for small compatible changes, no reprocessing
yyddd	37-41	Creation date (yy = last two digits of year, ddd = day of year)
nc	43-44	File extension (fixed), NetCDF extension

Table 4-10 Naming convention for L2 products (1/2)

```
           ----+----1----+----2----+----3----+----4-
Character  12345678901234567890123456789012345678901
File Name  GGWAM3_YYYYMMDDHHmmXPPP_xLLKKKAAdVVvyyddd
Sample     GGWAM3_202309071216D068_S2MSSTG0A01A23250
```

String	Bit position	Description
GGW	1-3	Satellite name (fixed as GGW)
AM3	4-6	Sensor type (fixed as AM3)
YYYYMMDDhhmm	8-19	Observation start date/time(UTC)
X	20	Orbit: A = Ascending / D = Descending / B = Both (research real-time processing)
PPP	21-23	Path number (001–0XX, scene number at start)
X	25	Processing type: S = Standard (global) / N = Research real-time (global) / L = Research real-time (local) R = Research product / Nominal processing (Global) Q = Research product / Near-real-time processing (Global) P = Research product / Near-real-time processing (Local)
LL	26-27	Processing level & observation mode: 2M: Low frequency (36.42 GHz or lower) or 89.0 GHz A/B first observation point (scan start) 2H: 89.0 GHz A and 89.0 GHz B observation count (scan end)
KKK	28-30	Product code
AA	31-32	Area / Region code: [GlobalProcessing] GA: Global GO: GlobalOcean GL: GlobalLand PO: Polar Ocean Local processing codes: J0: Japan region (received at Katsuura and Okinawa [Masuda] stations) J1: Eastern Japan (received only at Katsuura station) J2: Western Japan (received only at Okinawa [Masuda] station) 00: Default (no receiving-station code)

Table 4-10 Naming convention for L1 products (2/2)

String	Bit position	Description
d	33	Developer code (A–X)
VV	34–35	Major version number (00–99). Updated when making substantial changes such as calibration-temperature recalibration, input-data modification, or major updates to algorithms. When updating the major version, reprocessing of past products is performed.
v	36	Minor version number (A–Z). Updated when making minor changes that maintain compatibility with existing products. Updating the minor version generally does not trigger reprocessing of past products.
yyddd	37–41	Creation date: yy: Last two digits of year (Western calendar) ddd: Day of year

Table 4-11 Naming convention for L3 products (1/2)

```
                                    ----+----1----+----2----+----3----+----4-
Character Position                  12345678901234567890123456789012345678901
File Name                           GGWAM3_YYYYMMDD_tttXPPP_xLLKKKAAdVVvyyddd
Sample (Geophysical Quantity)       GGWAM3_20230901_01DAEQR_S3MSSTGOA03B23250
Sample (Brightness Temperature)     GGWAM3_20230901_01MAEQR_S3MTL1GAA01A23250
```

String	Position	Description
GGW	1-3	Satellite name (Fixed to GGW)
AM3	4-6	Sensor type (Fixed to AM3)
YYYYMMDD	8-15	Start date of statistical period (year is Gregorian, time is UT) * For monthly products, DD=01
ttt	17-19	Statistical period 01D: Daily 01M: Monthly
X	20	Orbit A: Ascending D: Descending B: Both U: Undefined *U is planned to be used for land data assimilation product
PPP	21-23	Map projection type EQR: Equirectangular PN1: Polar Stereographic Northern Hemisphere 1 PN2: Polar Stereographic Northern Hemisphere 2 PS1: Polar Stereographic Southern Hemisphere 1 EGG: EASE-Grid 2.0 Global, Equal-Area (EPSG:6933) EGN: EASE-Grid 2.0 Northern Hemisphere, Lambert Azimuthal (EPSG:6931) EGS: EASE-Grid 2.0 Southern Hemisphere, Lambert Azimuthal (EPSG:6932)
x	25	Processing type S: Standard product / standard processing (global) R: Research product / standard processing (global)
LL	26-27	Processing level and grid size code 3L: 0.25 degree grid / EASE-Grid 2.0 25km / PS 25km 3M: 0.10 degree grid / EASE-Grid 2.0 12.5km / PS 10km 3H: 0.05 degree grid / EASE-Grid 2.0 6.25km / PS 5km 3P: PS 50km 3Q: EASE-Grid 2.0 62.5km 3N: 0.25 degree grid (Grid node, Size 1441x721)
KKK	28-30	Product code
AA	31-32	Area / reception code GA: Global GO: Global over ocean GL: Global over land PO: Polar region over ocean
d	33	Developer code Y (processing system developer) * For the L3 SIM product, this is the algorithm developer code.

Table 4-11 Naming convention for L3 products (2/2)

String	Position	Description
VV	34-35	Major version number (00-99) Updated when making major changes such as recalibration of brightness temperature, changes to input data, or revision of algorithms. When updating the major version, past products are reprocessed.
v	36	Minor version number (A-Z) Updated when making minor changes within a scope that maintains compatibility with existing products. When updating the minor version, as a general rule, past products are not reprocessed.
yyddd	37-41	Creation date yy: Last two digits of the Gregorian year ddd: Day of the year

4.1.8 Scene Definitions

AMSR3 completes one repeat cycle every 3 days, during which it undergoes 44 orbital revolutions around the Earth. Half of an orbital revolution is referred to as a single scene, within which approximately 1,964 scans are performed. An AMSR3 scene is defined as a half-orbit extracted at the points where the observation location of the observation center reaches its northernmost and southernmost extents (Table 4-12). The observation location does not correspond to the satellite nadir but rather to a point on the Earth's surface observed in the forward direction of the satellite's flight path. Therefore, the spatial extent of a scene is shifted forward by approximately 2.5 min relative to the satellite nadir (Figure 4-2).

For each scan, AMSR3 acquires the number of observation points shown in Table 4-13 and observes a swath of approximately 75° centered on the satellite's flight direction (Figure 4-4). As the observation center differs by frequency, the range for scene extraction is defined based on the positions where the observation center of the 89 GHz-A horn scan reaches its northernmost and southernmost extents.

The number of scans in a single scene is estimated to be approximately 1,964, based on the orbital period and scan interval. However, the actual number of scans varies depending on factors such as the instantaneous velocity, altitude, and attitude disturbances of the satellite. In L1 nominal processing, an overlap of 30 scans is added before and after the observation data. Therefore, data corresponding to approximately 60 additional scans are stored per scene.

3[day] / 44[orbital revolutions] / 1.5[sec/scan]
= 3 x 24[hour] x 60[min] x 60[sec] / 88[scene] / 1.5[sec/scan)]
= 1963.6[scan] ≈ 1964[scan]

Table 4-12 AMSR3 scene definitions

Track direction	Definition
Ascending scene	Half orbit scans from southernmost to northernmost point (southernmost point is included at the start of the scene)
Descending scene	Half orbit scans from northernmost to southernmost point (northernmost point is included at the start of the scene)

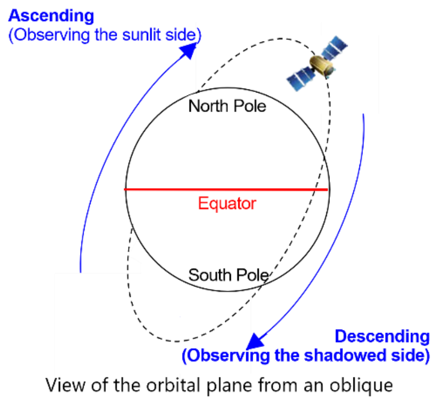


Figure 4-2 Side view of the orbital plane

Table 4-13 Observation center positions

Processing level	Frequency (geophysical quantities)	No. of observation points	Start position	Center position
L1A, L1B	All but 89 GHz	243	1	122
L2	All but precipitation, high-resolution sea ice concentration			
L1A, L1B	89 GHz	486	1	244
L2	precipitation, high-resolution sea ice concentration			

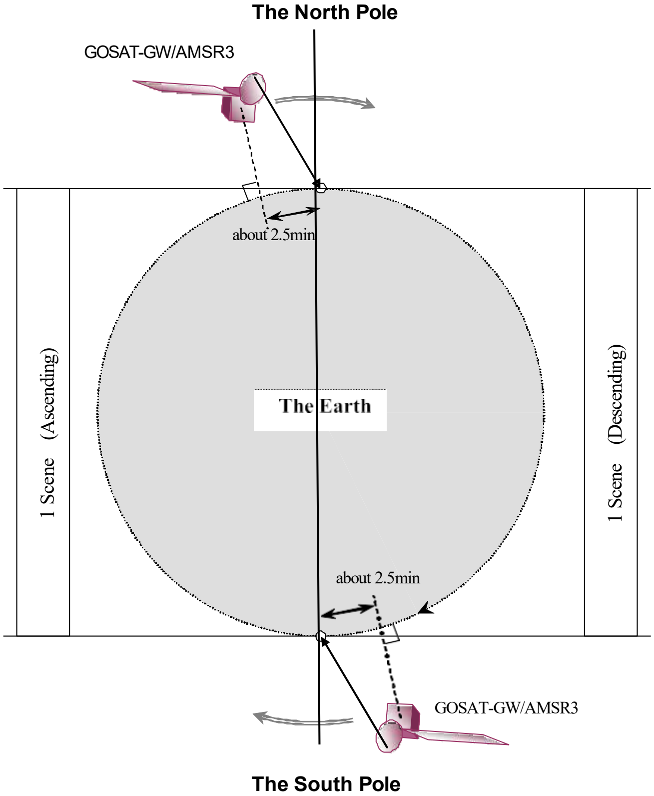


Figure 4-3 AMSR3 relationship between AMSR3 scene definitions and position directly under the satellite

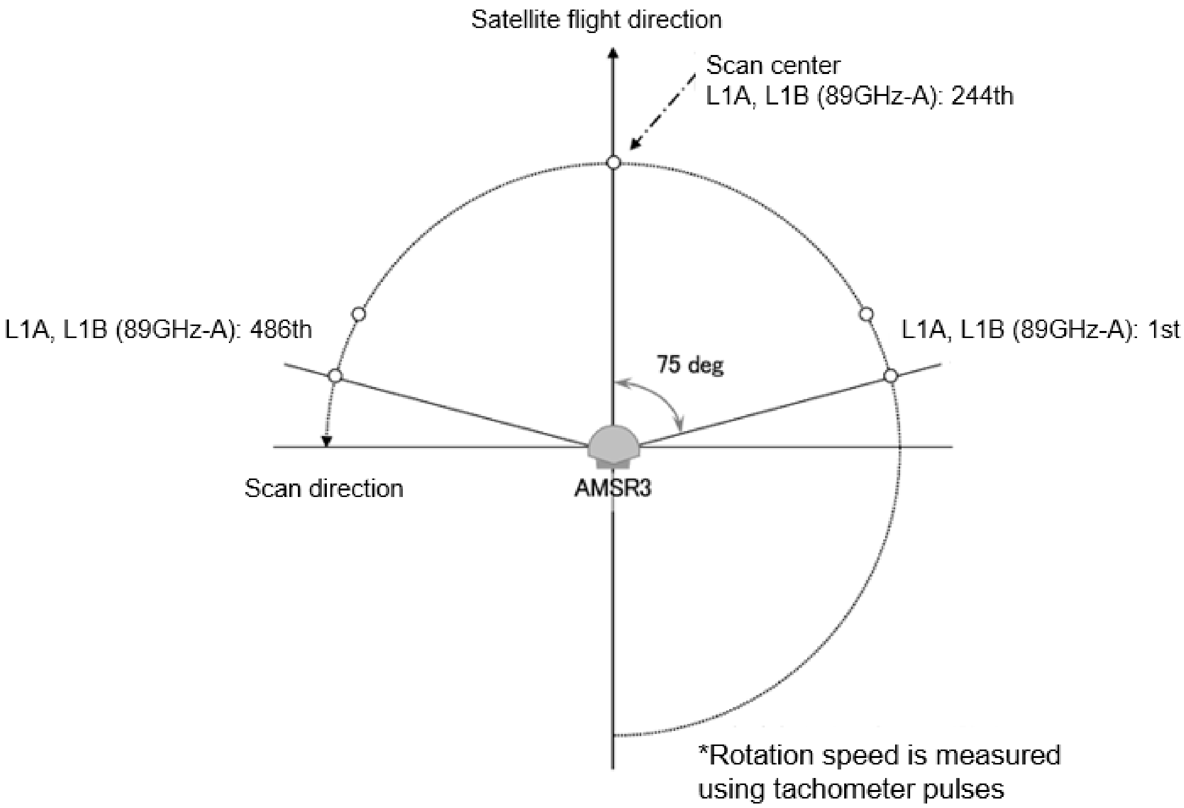


Figure 4-4 Relationship between scan center observation point location and number of data points

4.1.9 Observation Scan and Overlap Scan

An overview of the observation scans is shown in Figure 4-4. The AMSR3 scans the Earth's surface in a counterclockwise arc relative to the flight direction of the satellite, and a single scan contains multiple observation points. In L1 and L2 data, these continuous scans are stored in a two-dimensional array.

An overview of this overlap is presented in Figure 4-5. L1 and L2 consist of half-orbit data from pole to pole along the observation latitude. In L1, however, 30 additional scans are appended before and after the scene near the poles to overlap with adjacent paths. By contrast, L2 does not contain overlapping portions. Therefore, when comparing the same path, L1 contains 60 more scans than L2.

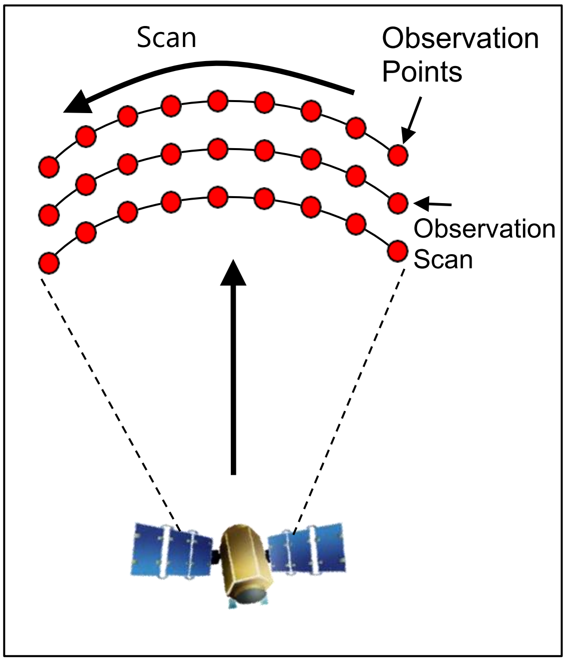


Figure 4-5 Observation scan overview

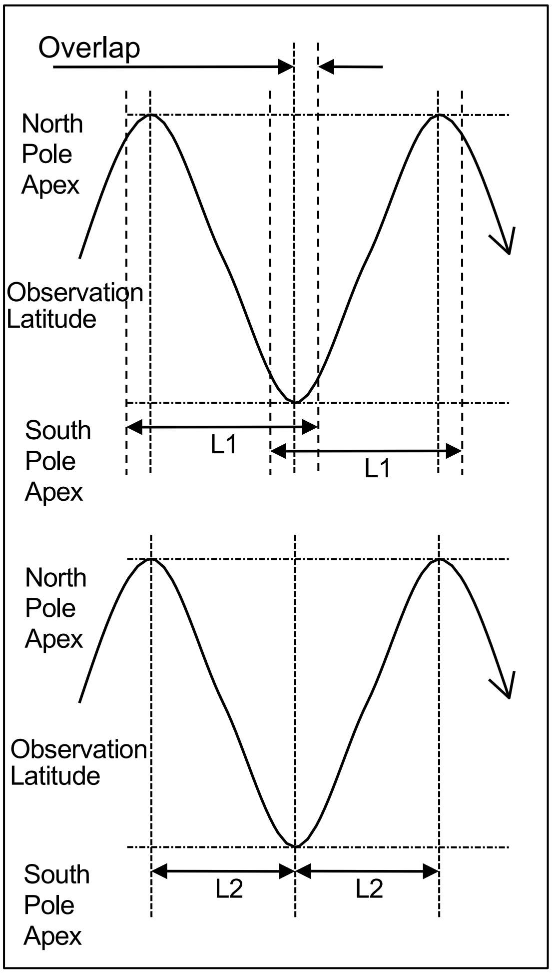


Figure 4-6 Overlap overview

4.1.10 Path Number

The revisit period of the GOSAT-GW is 3 days, during which the satellite completes 44 orbits around Earth. Each orbit is defined with the ascending node as its starting point, and path numbers from 1 to 44 are assigned. The path numbers are assigned in a westward sequence, and for successive orbits, the path number increases by three. Figure 4-7 shows the daily path numbers and orbital positions during the 3-day repeat cycle. Orbits in which the satellite travels from south to north are referred to as ascending orbits, whereas those from north to south are referred to as descending orbits. For the GOSAT-GW, the ascending orbits correspond to observations on the sunlit side (daytime), whereas the descending orbits correspond to observations on the shadowed side (nighttime).

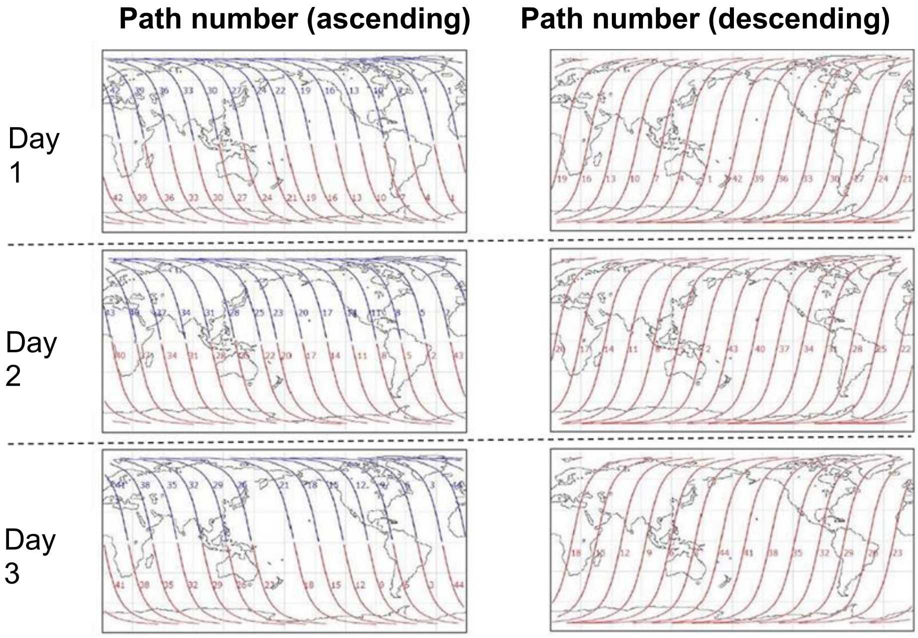


Figure 4-7 Path numbers and orbital positions

The path number stored in each product is defined as follows.

standard products: the path number is at the start of the scene (southernmost in the ascending path and northernmost in the descending path).

near-real-time products: the path number is at the observation start point.

As standard products are generated on a scene basis, there are two types of products for descending and ascending observation data. Figure 4-8 show the path numbers and observation coverage of the standard products on the first day of the repeat cycle. Green areas indicate observation coverage, whereas white gaps represent non-observed areas.

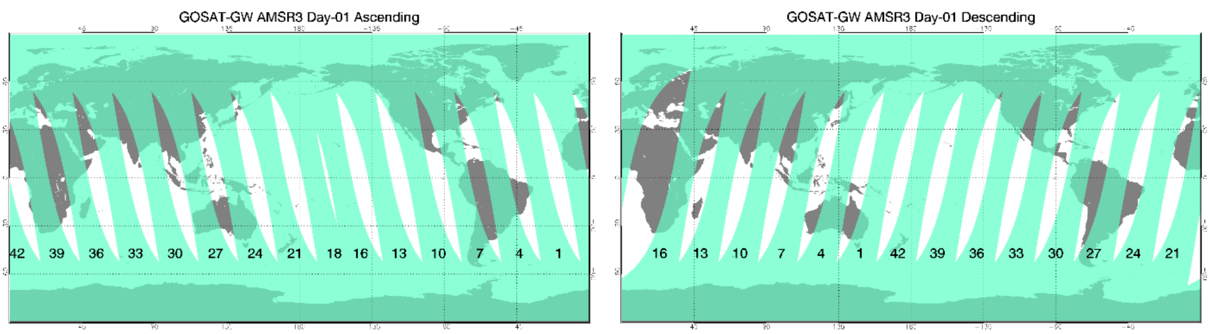


Figure 4-8 Observation path coverage of standard products
(Left: ascending path; Right: descending path)

Note that if for a near-real-time product, the observation starting point on an ascending orbit is located north of the ascending node, the path number assigned to the near-real-time product may differ from that of the standard product, even at the same observation location. Therefore, caution is required when comparing the path numbers between the standard and near-real-time products.

4.1.11 Altitude Correction of Latitude and Longitude

For AMSR3, altitude correction is applied to the latitude and longitude in the L1A product to correct the positional offsets caused by surface elevation. Both altitude-corrected latitude/longitude and non-corrected latitude/longitude data are stored in L1A. In the AMSR3 L1B and L1R products, only the altitude-corrected latitude and longitude are stored.

In contrast, for the AMSR2 L1B products, the latitude and longitude of the observation points are determined as the intersection of the sensor line of sight with the reference Earth ellipsoid, without considering the surface elevation. As the AMSR2 line of sight intersects the Earth's surface at an oblique angle, positional errors increase in high-elevation regions. In the AMSR2 L1R product, altitude corrected latitude and longitude are stored.

4.1.12 Land/Sea Flag

In AMSR3 products, information on the fraction of land within each surface observation footprint is stored. This land information is defined as the LandAreaPercent for each frequency channel and represents the percentage of land area within the footprint of that frequency, which is stored as an integer value ranging from 0% to 100%. A value of 0% indicates water, and a value of 100% indicates land. Figure 4-9 illustrates the land-area fraction.

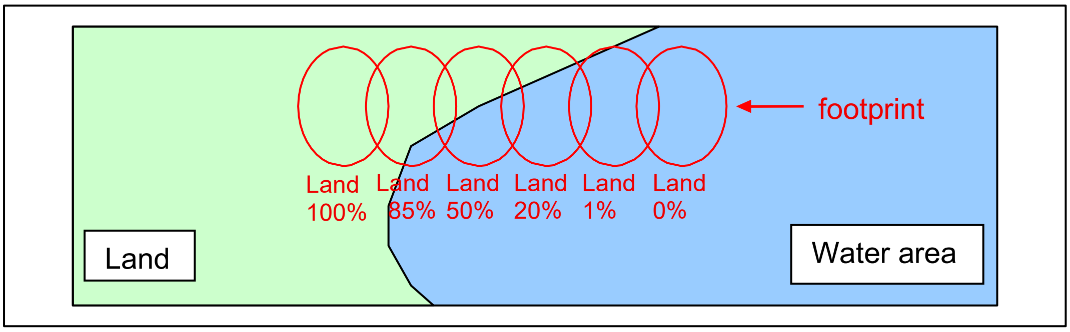


Figure 4-9 Conceptual diagram of land area fraction

4.1.13 Time Format

In AMSR3 L1 products, the observation start time for each 89 GHz-A scan is stored in two formats: TAI93 format (UTC) and calendar date–time format (UTC) with millisecond resolution. The TAI93 format represents the cumulative number of seconds from 00:00:00 (UTC) on January 1, 1993, including leap seconds. A second leap is added or removed to adjust the difference between Universal Time, which is affected by irregularities in the Earth's rotation, and atomic time. As leap seconds occur irregularly, conversion of the TAI93 format requires information of dates on which leap seconds are added or removed.

In AMSR3 L2 products, the observation start time for each 89 GHz-A scan is stored only in a calendar date–time format (UTC) with millisecond resolution. In the AMSR3 L3 daily products, the time for each grid cell, derived using daily statistical processing methods (overwrite or average), is converted to and stored as the elapsed time in seconds from 00:00:00 UTC on the observation date. If a grid cell corresponds to a single observation time, then the time is stored. If multiple observation times correspond to a grid cell, then the stored value depends on the statistical method. For the averaging method, the average time multiplied by −1 is stored, while for the overwrite method, the time of the most recent observation is stored. For the L3 SIM product, the midpoint between the observation times of the two brightness-temperature images used for the estimation is stored. A negative value indicates that the midpoint time precedes 00:00:00 UTC on the observation date specified by the file name.

4.1.14 Data Types, Scale Factors, and Missing Values for Major Variables

In AMSR3 L1 products, 2-byte integer data types are used to reduce the data file size. The value range of a 2-byte integer is 0 to 65,535 for unsigned integers and −32,768 to 32,767 for signed integers. Appropriate scale factors are applied to represent the target data within these ranges. For example, if a brightness temperature value of 28312 is stored and the scale factor for the brightness temperature is 0.01 [K], then the actual brightness temperature is 283.12 [K]. In contrast, L2 and L3 geophysical quantity and brightness temperature products are stored as real number (floating point) data types, with a scale factor of 1.0.

When observational data are not acquired, missing values are stored. For geophysical quantities, the target area for calculation may be limited, and missing values are stored for areas outside the target region. For example, in the case of sea surface temperature, the calculation target is limited to ocean areas. Therefore, land areas are treated as outside the target region, and a missing value of −32768 is stored. The data types, scale factors, and missing values for the major variables are summarized in Table 4-14.

Table 4-14 Data types, scale factors, and missing values for major variables

Data	Storage type	Scale [unit]	Missing value	L3 outside target area	L3 unobserved area
L1Time (ScanTimeTAI93)	8-byte floating-point	1.0[sec]	-9999.0	-	-
L1/L2 Time (ScanTimeUTC)	2-byte integer (signed)	1[UTC]	-32768	-	-
L3 Time	4-byte integer (signed)	1[sec]	-2147483648	-9998.0	-9997.0
L1/L2 Latitude / longitude	4-byte floating-point	1.0[deg]	-9999.0	-	-
L3 Latitude / longitude	4-byte floating-point	1.0[deg]	-9999.0	-9998.0	-9997.0
L1 Observation incidence angle	2-byte integer (signed)	0.01[deg]	-32768	-	-
L1 Observation azimuth angle	2-byte integer (signed)	0.01[deg]	-32768	-	-
L1 Brightness temperature	2-byte integer (unsigned)	0.01[K]	65534 (missing) 65535 (parity error)	-	-
L2/L3 Geophysical quantities & L3 Brightness temperature	4-byte floating-point	Total precipitable water: **1.0 [kg/m²]** Cloud liquid water: **1.0 [kg/m²]** Precipitation: **1.0 [mm/h]** Sea surface temperature: **1.0 [degree Celsius]** Sea surface wind speed: **1.0 [m/s]** All-weather sea surface wind speed: **1.0 [m/s]** Sea ice concentration: **1.0 [%]** High-resolution sea ice concentration: **1.0 [%]** Snow depth: **1.0 [cm]** Soil moisture content: **1.0 [%]** Brightness temperature: **1.0 [K]** Sea ice motion vector*: **1.0 [cm/s]** * −9998.0 is assigned to regions where the physical parameter is not calculated.	-9999.0	-9998.0	-9997.0

4.2 L1 Processing Algorithm

An outline of AMSR3 L1 processing is presented in Table 4-15. The following sections describe the main processing steps for the L1A, L1B, and L1R products, which are provided as standard products.

Table 4-15 Overview of AMSR3 L1 processing

Level	Overview of processing	Storage state of observation data in generated products
L1A	Scene-based product is generated that stores antenna-temperature count values converted from L0 data through radiometric and geometric correction processing, along with antenna-temperature conversion coefficients and related parameters. Using L0 data as input, the following processing (L1A processing) is performed: ・Interpolation of packet loss (L0 data check) ・Calculation of radiometric coefficients for brightness-temperature conversion ・Calculation of geometric information (latitude/longitude, incidence angle, solar azimuth/elevation, etc.) ・Addition of land-surface fraction ・Calculation of the mean elevation of the observation area ・Altitude correction of latitude/longitude using the mean elevation ・Scene extraction (standard processing only) After the intermediate L1A product is created, the following steps are applied to generate the final L1A product: ・Assignment of quality information for each scan and pixel ・Addition of quality information to the global attributes	Count values
L1B	Scene-based product is generated that stores brightness temperatures calculated from the L1A antenna temperatures using conversion coefficients. ・Scan-bias correction of ground-observed data ・Conversion of observation data to brightness temperature ・Assignment of quality information for each scan and pixel, and provision of RFI information ・Addition of quality information to the global attributes	Brightness temperature
L1R	Brightness temperatures of L1B are resampled using pre-calculated resampling coefficients so that their spatial resolution matches that of the lower-frequency channels, and the L1R product is generated.	Brightness temperature

4.2.1 L1A Processing

In L1A processing, L0 data are ingested as input. Radiometric information and geometric information are calculated, and latitude and longitude values are corrected for surface elevation (Figure 4-10). During mission-data loading and validation, AMSR3 mission data are input, and the system checks for data gaps and confirms the status of the instrument hardware.

The time system used for the GOSAT-GW is GPS time. The GPS time is initialized so that the GPS second is equal to 1 s at 00:00 UTC on January 1, 2013, and has since been expressed as accumulated seconds. The GPS time does not include leap seconds. Information on leap seconds is provided externally as a parameter file and used when converting the GPS time to UTC.

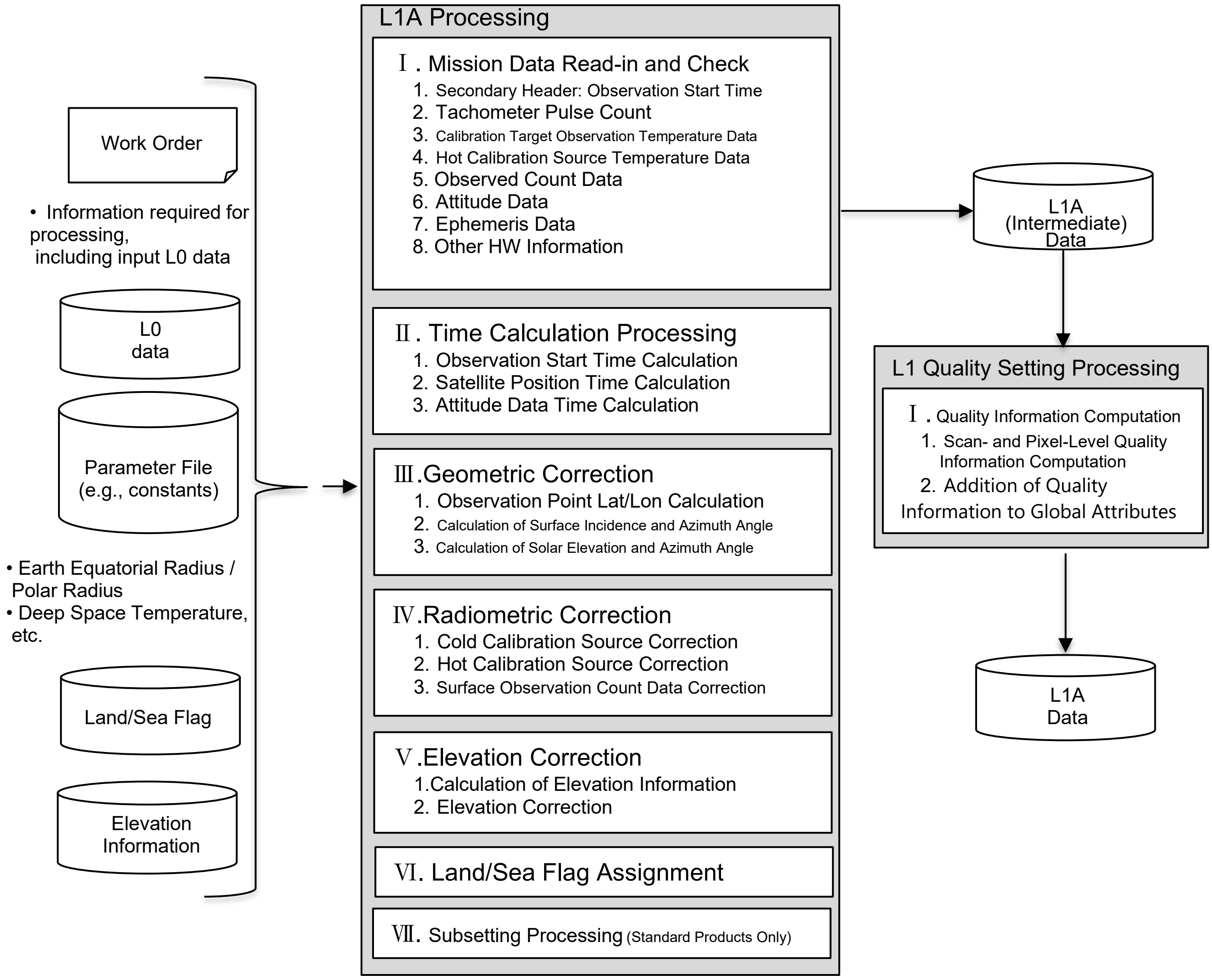


Figure 4-10 L1A product processing flow

4.2.1.1 Geometric Information Calculation

The observation-location information of AMSR3 (e.g., latitude/longitude and incidence angle) is calculated using AMSR3 observation geometry, satellite attitude and position, the Earth model, and other related data.

(1) Calculation of Observation-Point Latitude and Longitude

The processing flow used to calculate the latitude and longitude of the observation points is shown in Figure 4-11.

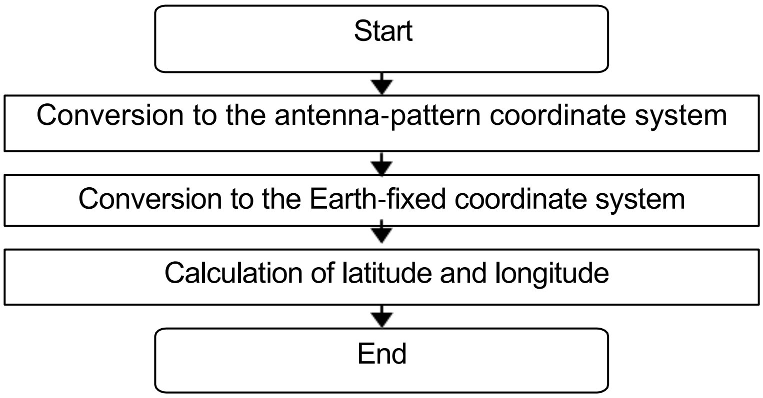


Figure 4-11 Processing flow for calculating observation point latitude and longitude

Calculating the latitude and longitude of an observation point determines where the AMSR3 observation antenna is pointing on the Earth's surface. To accomplish this, the observation direction defined in the antenna-pattern coordinate system must be converted into the Earth-fixed coordinate system, which is used to calculate the location on the Earth’s surface. For this purpose, several appropriate coordinate systems are defined and coordinate transformations are applied repeatedly to calculate the direction that the antenna is pointing in the Earth-fixed coordinate system. Using this direction, the observation points on the Earth’s surface are calculated. A conceptual diagram of the latitude/longitude calculation is shown in Figure 4-12.

(2) Solar Elevation/Azimuth Angles and Surface Incidence/Azimuth Angles

The solar elevation and azimuth angles corresponding to the observation locations are calculated using the latitude and longitude of the observation points calculated above. In addition, the surface incidence and azimuth angles are calculated based on the latitude and longitude. Figure 4-12 shows the definitions of the solar elevation and solar azimuth angles.

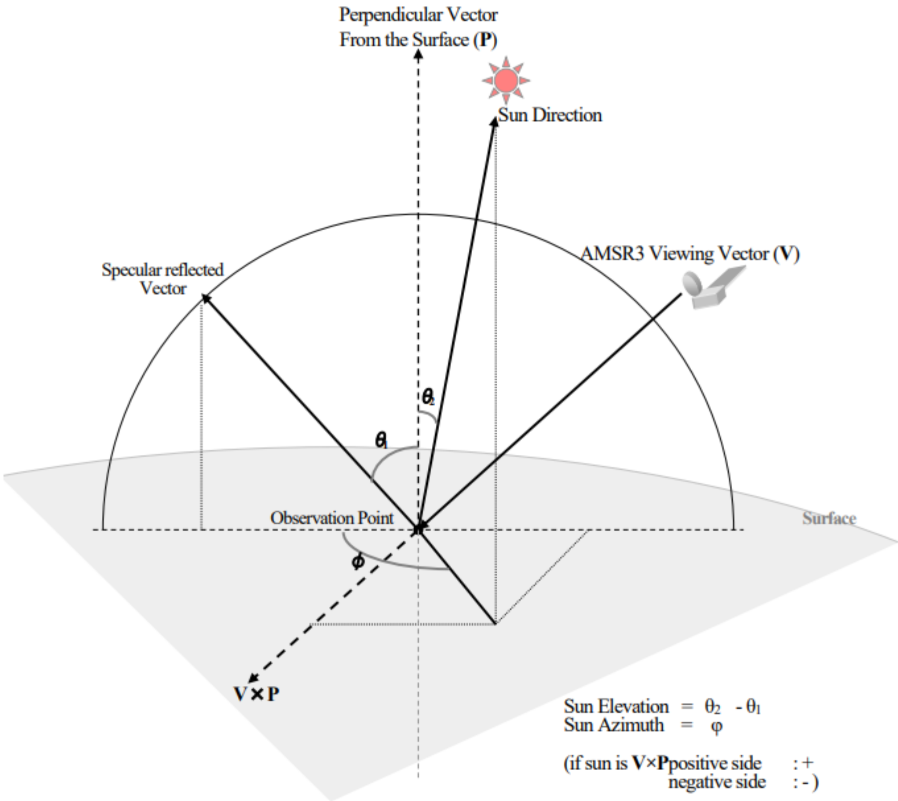


Figure 4-12 Conceptual diagram of the calculation for observation point latitude and longitude

(3) Setting Land/Sea Flag Information for All Frequencies

The land/sea flag information stored in the database is retrieved using the latitudes and longitudes of the observation points calculated above, and the corresponding result is assigned.

4.2.1.2 Calculation of Radiometric Coefficients

The processing flow for calculating the radiometric coefficients is shown below.

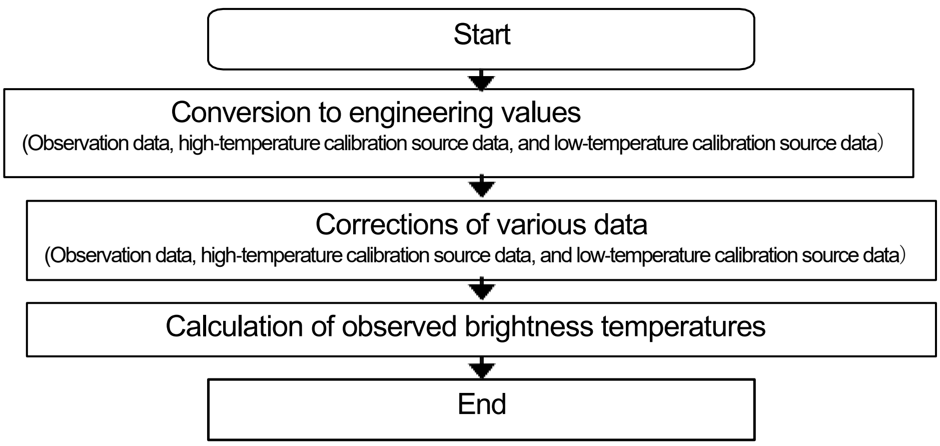


Figure 4-13 Antenna temperature conversion coefficient calculation flow

(1) Conversion to engineering units

Due to the Automatic Gain Control (AGC), the count values exhibit abrupt fluctuations if used as-is. Therefore, the count values are converted into engineering units using the configured Rx offset and gain values.

(2) Corrections for high- and low-temperature calibration sources

Apply the following corrections to the high-temperature calibration source temperature and low-temperature calibration source count values:

① Correction of the high-temperature calibration source temperature (using the designated correction algorithm)

② Correction of the low-temperature calibration source temperature (removal of lunar emissions, terrestrial emissions, radio-frequency interference, and solar contamination)

(3) Averaging

A moving average is applied to the low- and high-temperature calibration data after conversion to engineering units.

(4) Calculation of antenna-temperature conversion coefficients for all frequency bands

Calculate coefficients A and B in the following calibration equation, which converts the observed count value (Cobs) into the antenna temperature (TA) at the input of the primary radiator:

$$TA = A \times C_{obs} + B$$

4.2.1.3 Elevation Correction of Latitude and Longitude

The latitude and longitude for each frequency channel are corrected using elevation information. Using a pre-generated elevation database, the displacement of the footprint caused by the elevation at the central point (latitude and longitude) is calculated and corrected. Corrected latitude/longitude information, along with the elevation data used in the correction, are stored in the product. The curvature of the Earth is not considered in this correction. Figure 4-14 illustrates the concept of elevation correction. First, the intersection between the AMSR3 observation line and the Earth's surface is determined. The central position (latitude and longitude) and incidence angle (θ) for each frequency are read from the product. Referring to the elevation database, the grid point nearest the central position for each frequency is identified, and its average elevation (H) is obtained. Using the average elevation (H) and incidence angle (θ), the horizontal displacement distance (L) is calculated using the following equation:

$$L = H\tan\theta$$

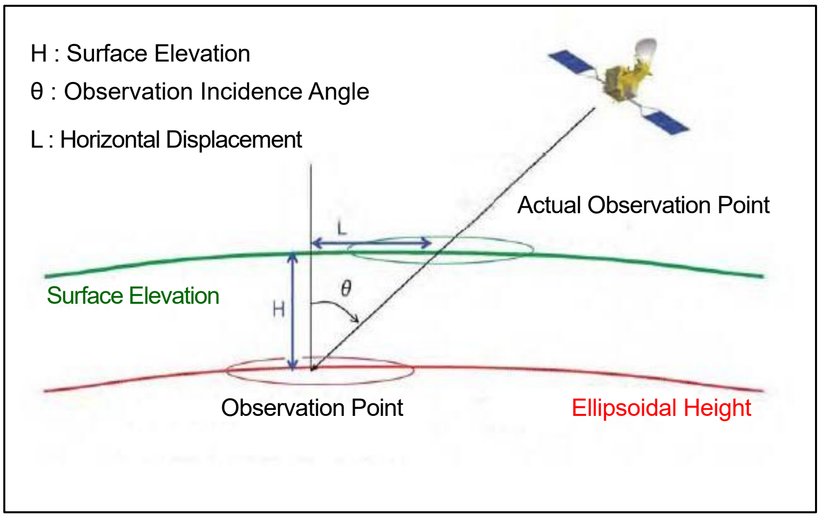


Figure 4-14 Conceptual diagram of elevation correction

4.2.1.4 Computation of Quality Information

Quality information related to data is computed for each observation point, scan, and file in AMSR3, and corresponding quality flags are generated. Radio frequency interference (RFI) identification flags based on comparisons between 6.925 and 7.3 GHz, and between 10.25 and 10.65 GHz, are also provided as quality flags. The data quality information set in the global attribute “AutomaticQAFlag”, along with its evaluation criteria (Table 4-16) and the overall assessment results (Table 4-17), are presented. In addition, scan-by-scan quality information is stored in the “ScanDataQuality” dataset. Each quality flag stores information on a bit-by-bit basis as shown in Table 4-18. Furthermore, pixel-level quality information such as RFI is stored for each frequency and polarization of the observed brightness temperature over land in the “Tb_ChXXX_Quality” dataset (XXX: frequency), as described in Table 4-19.

Table 4-16 Quality Information and Evaluation Criteria for L1A, L1B, and L1R

Data Quality Information	Data Quality Information	Remarks
Number of Missing Scans (MissingScanQA)	Fewer than 21 scans	
Number of Missing Packets (MissingPacketQA)	Fewer than 321 packets	
Antenna Rotation Rate Anomaly (AntennaRotationQA)	Fewer than 21 %	
Hot Calibration Source Temperature Anomaly(HotCalibrationSourceQA)	Fewer than 21 %	
Attitude Data Anomaly (AttitudeDataQA)	Fewer than 1 %	
Ephemeris Data Anomaly (EphemerisDataQA)	Fewer than 21 %	
Geometric Information Calculation Anomaly (QualityofGeometricInformationQA)	Fewer than 1 %	
Brightness Temperature Anomaly (BrightnessTemperatureQA)	Fewer than 21 %	

Table 4-17 Overall Evaluation Criteria for L1A, L1B, and L1R

Evaluation Value	Evaluation Criteria	Remarks
Good	All evaluation items are OK	
Fair	At least one evaluation item is NG	
NG	All evaluation items are NG	

Table 4-18 Quality Information per Scan for L1A, L1B, and L1R

MSB							LSB
7	6	5	4	3	2	1	0
Antenna Rotation Rate 1: Anomaly 0: Normal	Hot Calibration Source Temperature 1: Anomaly 0: Normal	Attitude Angle and Angular Velocity 1: Anomaly 0: Normal	Orbital Position and Velocity 1: Anomaly 0: Normal	Missing Scans (Packet Loss / Data Loss) 1: Missing 0: No Missing	Fixed at 0 (Not used)	Fixed at 0 (Not used)	Fixed at 0 (Not used)

Table 4-19 Per-Pixel Quality Information for L1A, L1B, and L1R

<table>
<tr><th rowspan="2">No</th><th rowspan="2">Channel</th><th colspan="6">MSB</th><th colspan="2">LSB</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>1</td><td>Ch06V</td><td rowspan="21">Count Decrease Flag 1: Occurred 0: Not Occurred</td><td rowspan="21">Fixed at 0 (Not used)</td><td rowspan="21">Fixed at 0 (Not used)</td><td rowspan="21">Fixed at 0 (Not used)</td><td rowspan="21">L1A: Fixed at 0 (Not used)

L1B, L1R: Brightness Temperature Retrieval Result (Anomaly) (Brightness temperature exceeds the threshold or brightness temperature retrieval error)

1: Anomaly
0: Normal</td><td rowspan="21">Geometric Information Computation Result (Anomaly) (Latitude/Longitude are invalid values)

1: Anomaly
0: Normal</td><td colspan="2" rowspan="8">L1A: Fixed at 0 (Not used)
L1B, L1R: Radio Frequency Interference (RFI) Flag
10: Detected
01: Possible
00: None</td></tr>
<tr><td>2</td><td>Ch06H</td></tr>
<tr><td>3</td><td>Ch07V</td></tr>
<tr><td>4</td><td>Ch07H</td></tr>
<tr><td>5</td><td>Ch10uV</td></tr>
<tr><td>6</td><td>Ch10uH</td></tr>
<tr><td>7</td><td>Ch10V</td></tr>
<tr><td>8</td><td>Ch10H</td></tr>
<tr><td>9</td><td>Ch18V</td><td rowspan="13">Fixed at 0 (Not used)</td><td rowspan="13">Fixed at 0 (Not used)</td></tr>
<tr><td>10</td><td>Ch18H</td></tr>
<tr><td>11</td><td>Ch23V</td></tr>
<tr><td>12</td><td>Ch23H</td></tr>
<tr><td>13</td><td>Ch36V</td></tr>
<tr><td>14</td><td>Ch36H</td></tr>
<tr><td>15</td><td>Ch89AV</td></tr>
<tr><td>16</td><td>Ch89AH</td></tr>
<tr><td>17</td><td>Ch89BV</td></tr>
<tr><td>18</td><td>Ch89BH</td></tr>
<tr><td>19</td><td>Ch165V</td></tr>
<tr><td>20</td><td>Ch183r3V</td></tr>
<tr><td>21</td><td>Ch183r7V</td></tr>
</table>

4.2.2 L1B Processing

In L1B processing, the radiometric coefficients calculated during L1A processing are first used to convert the observed count values for each frequency and polarization into antenna temperatures. Then, scan-bias correction is applied, and the data are converted into brightness temperatures (Figure 4-15).

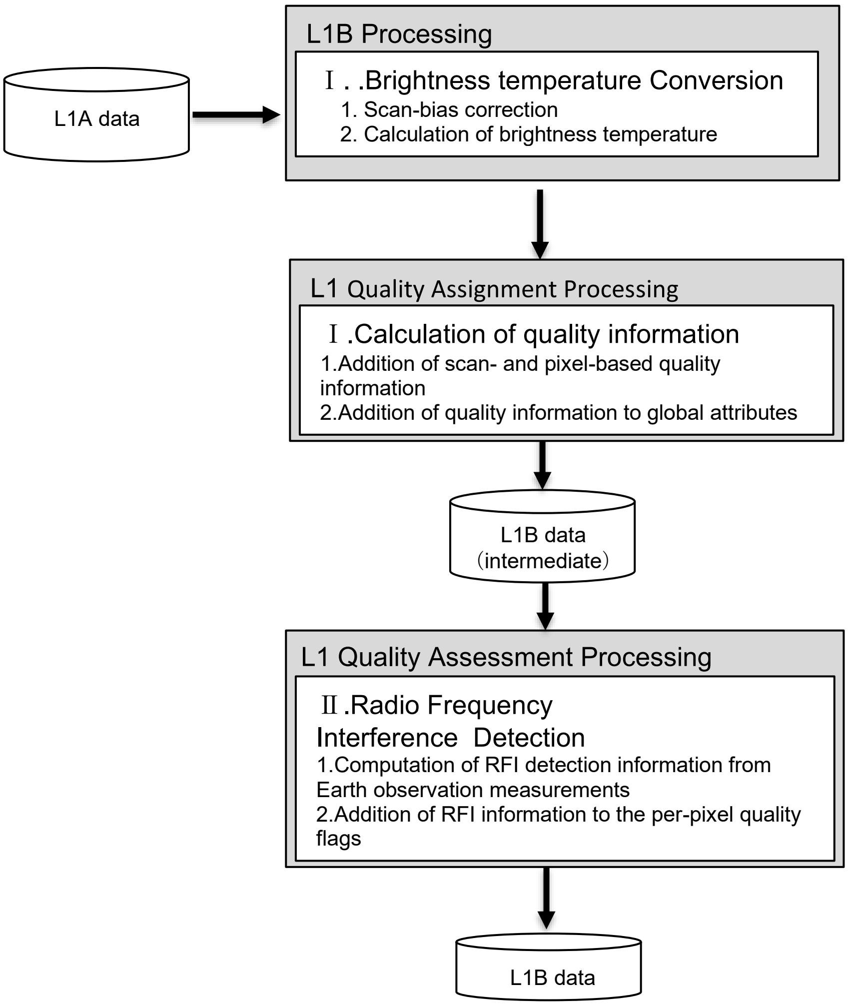


Figure 4-15 L1B Product processing flow

4.2.2.1 MREF Antenna Temperature Calculation

The non-linearity correction of the receiver detection circuit and the MREF antenna temperature T_a are calculated simultaneously using the HTS temperature T_h(K), observed temperature of the cold calibration source T_c (K), averaged cold-calibration data C_c, and observation data count value C_a, according to the following equation:

$$T_a = T_c + (T_h - T_c) \times \left(\frac{\sqrt{\alpha^2 + 4\gamma(C_a - \beta)} - \sqrt{\alpha^2 + 4\gamma(C_c - \beta)}}{\sqrt{\alpha^2 + 4\gamma(C_h - \beta)} - \sqrt{\alpha^2 + 4\gamma(C_c - \beta)}} \right)$$

where α,β,γ: coefficients of the approximation formula for the input/output characteristics of the detection circuit.

$$T'_a = C_1 \times T_a + C_2$$

T'_a: fine-adjusted MREF antenna temperature
T_a: MREF antenna temperature
C_1: fine-adjustment coefficient 1
C_2: fine-adjustment coefficient 2

4.2.2.2 Scan-Bias Correction

Bias may occur in the observed antenna temperature at certain observation points within a single scan owing to effects such as blocking by calibration sources. Therefore, a correction function is incorporated to eliminate this bias. Scan bias is also observed in AMSR, AMSR-E, and AMSR2, where the observed brightness temperature near the beginning of the scan tends to be lower than that near the end of the scan. As the characteristics of this bias differ according to the frequency and polarization, separate correction coefficients are defined for each frequency and polarization. As the coefficients also vary depending on the observation point index within the scan, separate coefficients are assigned to each position. For the observed antenna temperature converted from the observation count value, a scan bias correction is applied using the following equation (the meaning of each coefficient is listed in Table 4-20):

$$Ta'' = Cg(i) \times Ta' + Co(i)$$

Table 4-20 Coefficients used for scan-bias correction

Coefficient	Description	
Ta'	Fine-adjusted MREF antenna temperature	-
Ta''	MREF antenna temperature after scan-bias correction	-
$Cg(i)$	Scan-bias correction gain coefficient for each observation point (i: observation index)	Defined for every observation point
$Co(i)$	Scan-bias correction offset coefficient for each observation point (i: observation index)	Defined for every observation point

4.2.2.3 Brightness Temperature Conversion

The conversion to brightness temperature is performed using the following equations, which consider the spillover effects and cross-polarization contributions:

$$TBv = AvvTAv + AhvTAh + Bv$$
$$TBh = AvhTAv + AhhTAh + Bh$$

where:

TBv, TBh: brightness temperatures for V- and H-polarization
TAv, TAh: observed antenna temperatures for V- and H-polarization
Avv, Ahh: main-polarization contribution coefficients for V- and H-polarization
Ahv, Avh: cross-polarization contribution coefficients for V- and H-polarization
B_v, B_h: brightness-temperature conversion bias terms for V- and H-polarization

4.2.2.4 Quality Information Calculation

The derivation and storage of L1B quality information are performed (see Table 4-16 to 4-19). For quality information on a per-observation-point basis, the values are assigned to “Tb_ChXXX (or XXXXXX)_Quality” (quality flag for frequency XXX (or XXXXXX)).

4.2.3 L1R Processing

The L1R processing generates a product by resampling AMSR3 data from each frequency with spatial resolutions differing such that they are unified to a specified spatial resolution. As part of the quality-information assignment process, the radio-frequency-interference (RFI) identification information is calculated and stored as quality information (see Figure 4-16). The processing principles and methods are described below.

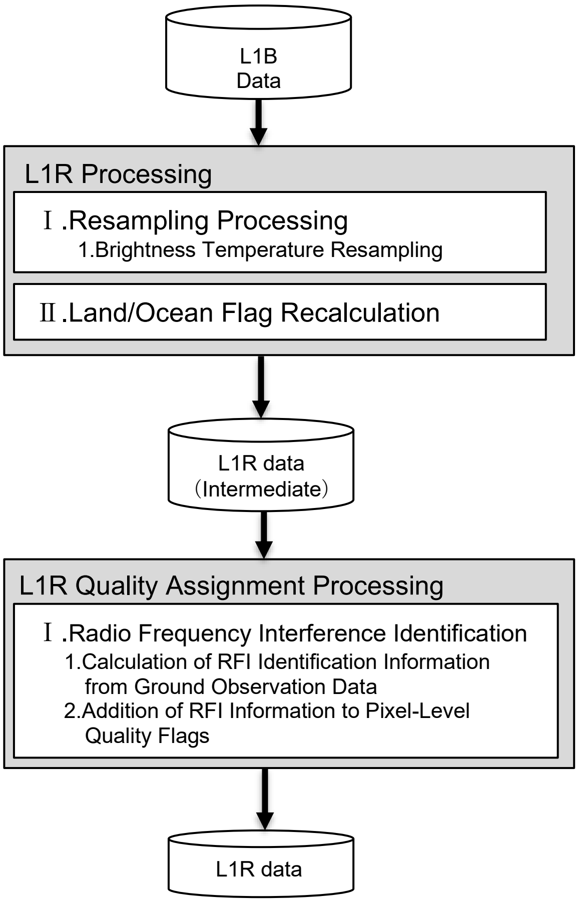


Figure 4-16 L1R product processing flow

4.2.3.1 Resampling Processing

L1R processing resamples the L1B brightness temperature data to match the spatial resolution corresponding to the lower-frequency channels. Resampling is performed by convolving the original brightness temperature data with the weighting parameters (resampling coefficients) calculated using the Backus and Gilbert method. An overview of the processing is shown in Figure 4-17.

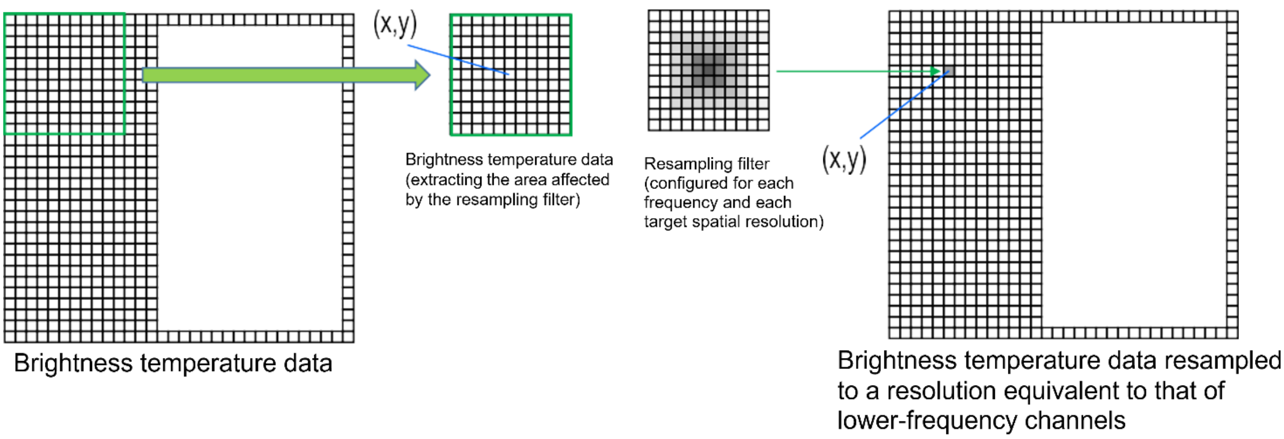


Figure 4-0-17 Overview of L1R processing

In the L1R processing, the frequencies to be resampled are determined based on the following policy:

- The brightness temperatures of the higher-resolution frequencies are resampled to match the resolution of the lower-resolution frequencies.
- Among the AMSR3 frequency channels, certain pairs exhibit nearly identical spatial resolutions. Given that 6.9 and 7.3 GHz share the same spatial resolution, the resampled data are common to both. Similarly, 18 and 23 GHz have almost the same spatial resolution. However, as the resolution at 23 GHz is slightly lower, only resampled data matched to the 23 GHz resolution are generated. In addition, 10.25 GHz, newly introduced in the AMSR3, has the same spatial resolution as 10.65 GHz. Therefore, the resampled data for these channels are also shared.
- The 89-GHz channel consists of two receiver systems (A/B). The processing method for these data (e.g., using only one system or integrating both systems) is determined by how the resampling coefficients are applied. In practice, the data from both systems are simultaneously used as inputs.
- Resampling is performed separately for H- and V-polarizations. For example, when resampling the H-polarization data for a target frequency, the H-polarization L1B brightness temperature data for other frequencies are used, whereas the V-polarization data are not used.
- For the new AMSR3 high-frequency channels (165.5, 183.3±3, and 183.3±7 GHz), resampled datasets are generated only for resolutions equivalent to 23 and 36 GHz, and not for resolutions equivalent to 6 or 10 GHz.

A list of frequencies for which resampling is performed is presented in Table 4-21, summarizing the above policy.

The L1B brightness temperature data for the frequencies marked with ○ or ☆ in Table 4-21 are resampled and output as the L1R product. A ○ mark indicates processing that involves spatial resolution conversion. A ☆ mark indicates processing primarily to align the center latitude and longitude, not for spatial-resolution conversion. The center latitude and longitude shall be aligned to match those of the 89-GHz A-system receiver.

Table 4-21 Frequencies subject to resampling

		Target-resolution frequency			
		6 GHz	10 GHz	23 GHz	36 GHz
Observed frequency	6 GHz	☆	-	-	-
	7 GHz	☆	-	-	-
	10.25 GHz	○	○	-	-
	10.65 GHz	○	☆	-	-
	18 GHz	○	○	○	-
	23 GHz	○	○	☆	-
	36 GHz	○	○	○	☆
	89 GHz	○	○	○	○
	165.5 GHz	-	-	○	○
	183.3 GHz±3	-	-	○	○
	183.3 GHz±7	-	-	○	○
	Center latitude/longitude	89 GHz-A (odd-numbered points)	89 GHz-A (odd-numbered points)	89 GHz-A (odd-numbered points)	89 GHz-A (odd-numbered points)
	Number of observation points	243	243	243	243

Note: Frequencies marked with ○ or ☆ are subject to processing and storage. ○ indicates processing that mainly involves spatial-resolution conversion; ☆ indicates processing primarily for aligning the center latitude and longitude; spatial-resolution conversion is not the main purpose for the latter.

4.2.3.2 Quality Information Calculation

The derivation and storage of L1R quality information are performed (see Table 4-16 to 4-19). For quality information on a per-observation-point basis, the values are assigned to "Tb_FOVYYChXXX_P89o_Quality" (quality flag for frequency XXX at resampling frequency YY).

4.3 Higher-Level (L2/L3) Processing Algorithms

Higher-level processing algorithms compute geophysical quantities derived from brightness temperatures on a footprint-by-footprint basis and generate L2 products that do not apply map projection and are produced on a scene basis. They also generate L3 products, which are grid data in which brightness temperatures or geophysical quantities are mapped onto predefined grids after applying gridding and temporal statistical processing. The L3 products are maps projected for the global domain, Arctic region, and Antarctic region. Details of these processing algorithms are described in the following section. The automatic quality-inspection results of the higher-level processing algorithms are calculated and stored in the global attribute "AutomaticQAFlag" using the method described below, and the contents listed in Table 4-22 are recorded.

p(number of target-area pixels) = NumberOfPixelsAll-NumberOfPixelsOutsideArea,
a(percentage of valid data) = NumberOfPixelsRetrieved/p×100 (%)

Table 4-22 L2/L3 quality information

Item	Assigned value	Description
AutomaticQAFlag*	Good	Number of valid data pixels is equal to or greater than 80% of the target-area pixel count.
	Fair	Number of valid data pixels is less than 80% of the target-area pixel count.
	NG	Either the number of valid data pixels or the target-area pixel count is zero.

*When the L1 "AutomaticQAFlag" is Fair, the L2 "AutomaticQAFlag" becomes Fair or NG. When the L1 "AutomaticQAFlag" is NG, the L2 "AutomaticQAFlag" becomes NG. In other words, the L2 "AutomaticQAFlag" shall not exceed the value of the L1 "AutomaticQAFlag."

4.3.1 Total Precipitable Water

The total precipitable water algorithm estimates ocean TPW, which targets ocean surfaces, and land TPW, which targets land surfaces. The ocean TPW product estimates the vertically integrated total amount of atmospheric water vapor over the global oceans, excluding sea ice and precipitation areas. The land TPW product estimates the vertically integrated total amount of atmospheric water vapor over land surfaces worldwide, excluding snow/ice and vegetated region. Using the polarization differences of the 18- and 23-GHz bands, the algorithm computes the TPW over land while excluding snow/ice and vegetated areas.

4.3.2 Total Cloud Liquid Water

The total cloud liquid water algorithm estimates the vertically integrated amount of CLW in the atmosphere over the global oceans, excluding sea ice and precipitation areas.

4.3.3 Precipitation

The precipitation algorithm estimates two types of precipitation: rainfall for liquid precipitation and snowfall for solid precipitation. In the product, however, precipitation amount is stored and provided together with snow probability (in %). The rainfall product estimates hourly liquid precipitation (rain) on the Earth's surface globally, whereas the snowfall product estimates hourly solid precipitation (snow) globally. Rainfall and snowfall are derived from the daily product using the following equations: For the monthly product, the monthly mean values of Data1 (precipitation intensity [mm/h]) and Data2 (snow probability [%]) from the daily product are stored.

Rainfall = Data1 − Snowfall
Snowfall = Data1 × Data2 / 100.0
(Data1: value of Layer 1 in the PRC product; Data2: value of Layer 2 in the PRC product)

4.3.4 Sea Surface Temperature

The sea surface temperature algorithm estimates the temperature within a few millimeters below the sea surface (near-surface skin temperature) over global oceans, excluding sea-ice and heavy precipitation areas. AMSR3 improves the accuracy based on the knowledge accumulated from AMSR2. AMSR3 derives a 6-GHz SST primarily using the 6.9-GHz band, continuing the AMSR series approach, and a 10-GHz SST primarily using the 10.65-GHz band. A multifrequency SST is computed by combining the SSTs derived from the 6.9-, 7.3-, and 10.65-GHz channels. This multi-frequency SST reduces data loss due to artificial radio-frequency interference and enables SST estimations closer to coastal regions.

4.3.5 Sea Surface Wind Speed

The sea surface wind speed algorithm estimates the wind speed at a height of 10 m above the sea surface over global oceans, excluding sea ice and heavy precipitation areas.

4.3.6 All-weather Sea Surface Wind Speed

The all-weather sea surface wind speed algorithm estimates wind speeds equivalent to the best-track intensities issued by the Japan Meteorological Agency and the U.S. Hurricane Center within typhoon and hurricane regions over global oceans, excluding sea ice areas. The algorithm detects increases in sea-surface whitecaps associated with stronger winds using a combination of horizontally polarized 6.9- and 10.7-GHz channels and then estimates the wind speed. This method allows the estimation of wind speeds up to 70 m/s. Outside the typhoon/hurricane regions, the estimation is performed so as to be consistent with the sea surface wind speed product.

4.3.7 Sea Ice Concentration

The sea ice concentration algorithm estimates the fraction of sea ice within the 18-GHz field of view, based on brightness temperatures at 18.7 and 36.5 GHz. Sea ice is dynamic and moves daily owing to winds and ocean currents. Regions may consist of mixtures of new ice, first-year ice, and multiyear ice.

4.3.8 High-resolution Sea Ice Concentration

Similar to the standard product, the high-resolution sea-ice concentration algorithm estimates the proportion of sea ice in each pixel. The standard sea ice concentration uses 18.7- and 36.5-GHz brightness temperatures; the high-resolution product uses 89-GHz brightness temperatures, resulting in higher spatial resolution. However, under cloudy conditions, distinguishing sea ice from clouds becomes difficult, thereby reducing accuracy.

4.3.9 Soil Moisture Content

The soil moisture algorithm estimates the surface soil moisture over global land areas (including arid and cold regions), excluding ice sheets, dense forests, and strong precipitation areas. The soil moisture content is expressed as volumetric water content (%), representing the fraction of water volume per unit soil volume. Only moisture in the uppermost top soil layer can be retrieved.

4.3.10 Snow Depth

The snow depth algorithm estimates the global depth of snow on the land surface (excluding ice sheets, dense forests, and water bodies).

4.3.11 Sea Ice Motion Vector

The sea ice motion vector algorithm estimates sea ice displacement vectors (latitude/longitude components in cm/s) for pixels identified as sea ice. The motion vectors are derived from the cross-correlation between two images acquired at different times. Using sea ice concentration and multiple brightness temperature channels as inputs, the algorithm determines the daily sea ice motion vector through cross-correlation with the brightness temperature field of the previous day. The output is provided as an L3-equivalent daily gridded dataset. The spatially averaged velocity fields derived from multiple low-frequency channels, which are less affected by wind and clouds, are referenced as needed to determine the optimal motion vector.

4.3.12 Gridding Algorithm

Using the L1B brightness temperatures or L2 geophysical products as inputs, the algorithm generates a daily L3 product by projecting the ascending and descending orbit data for a given UTC day onto a prescribed grid. If multiple orbits with different observation times contributed data to the same grid cell, then the grid cell value is either averaged or overwritten by the most recent observation. The monthly L3 products are generated by time-averaging the daily L3 products for the ascending and descending orbits.

4.4 Product Format

For details on the AMSR3 L1 to L3 product formats, refer to the following format specification documents.

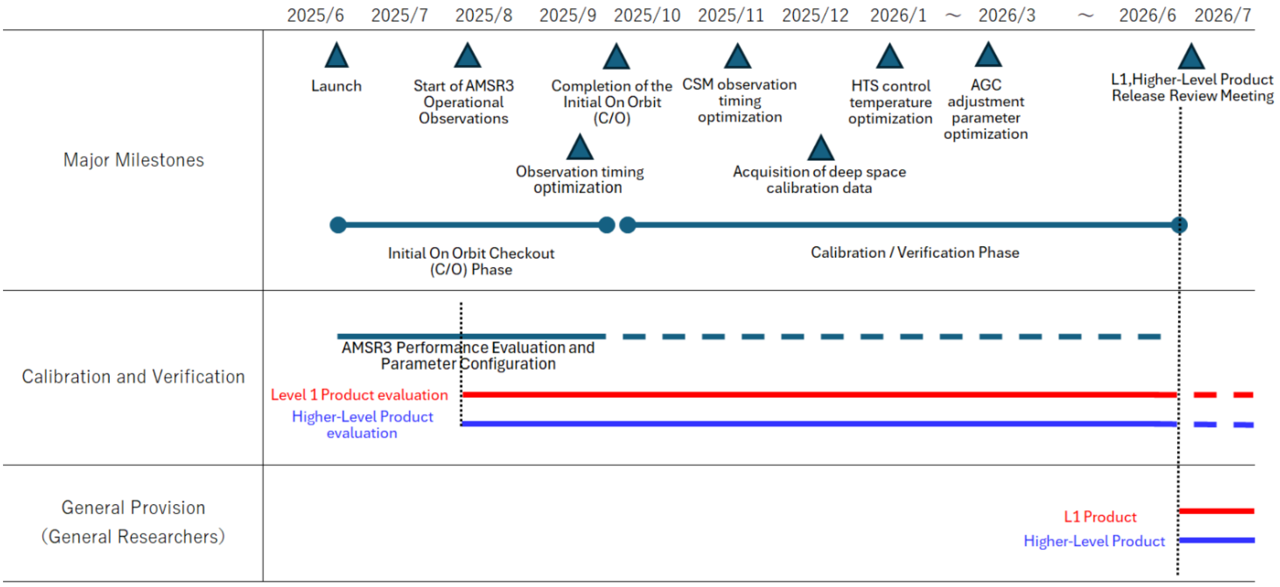
- AMSR3 Level-1A Product Format Specification
- AMSR3 Level-1B Product Format Specification
- AMSR3 Level-1R Product Format Specification
- AMSR3 Level-2 Product Format Specification
- AMSR3 Level-3 Product Format Specification

4.5 Calibration and Validation

The AMSR3 instrument aboard the GOSAT-GW is a multifrequency microwave radiometer designed to observe water-related parameters on a global scale. In addition to the 6.9–89 GHz frequency range used by AMSR2, AMSR3 includes 165.5 and 183.3 GHz bands, providing observations across eight frequency groups (where 6.9 and 7.3 GHz, 10.25 and 10.65 GHz, and 183.3 ± 3 GHz and 183.3 ± 7 GHz are each treated as a single frequency) and 21 channels. The instrument measures the brightness temperatures reaching the satellite, and the geophysical parameter products are derived by combining the brightness temperatures from multiple channels based on scientific knowledge. By routinely generating and providing these global, high-frequency, and stable brightness temperatures and geophysical products, AMSR3 contributes to the monitoring of polar region variability, understanding and prediction of water cycle changes associated with climate change, and operational applications. To achieve these objectives, the mission requires data products that exhibit globally uniform and long-term stable accuracy. Ensuring consistency with the geophysical quantities derived from microwave radiometers aboard other satellites scheduled for operation during the same period and from other sensors is essential.

Calibration and validation of AMSR3 include pre-launch ground tests and sensor model development, post-launch on-orbit data evaluation and calibration, accuracy assessment of the retrieved geophysical parameters, and the publication of validation results. The data-quality requirements described in Table 4-24 are achieved through a series of calibration and validation processes. The initial calibration and verification schedules are listed in Table 4-23. During the initial calibration and validation, on-orbit configuration changes are performed via commands from the ground to improve data quality. As a result, data quality may vary for some AMSR3 products generated during the initial calibration and validation periods.

Table 4-23 AMSR3 initial calibration and verification schedule



4.5.1 Calibration

4.5.1.1 Overview of the Calibration Plan

Ground tests and sensor-model construction are conducted during the pre-launch design and development phases. In the initial post-launch calibration and validation phase, on-orbit calibration, combined and cross-calibration, evaluation of sensor characteristics and data quality, geometric calibration, and other related activities are performed. During the routine evaluation phase, data relevant to the calibration are continuously monitored on an ongoing basis. For the calibration schedule, refer to Table 4-23.

4.5.1.2 Calibration Items

(1) Sensor development phase

During the sensor development phase, the sensor characteristics relevant to the calibration are identified and reflected in the ground test and analysis items, and appropriate correction methods are examined when necessary. The results are incorporated into the construction of the sensor model, which is used to perform brightness-temperature conversion and geometric conversion as inputs to L1 (brightness temperature) processing algorithms. Once the ground tests and analyses of the sensor are completed, the sensor characteristics and correction methods are re-evaluated based on the results, the sensor-model coefficients are determined, and the sensor model used in the initial calibration and validation phases is finalized.

(2) Initial calibration and validation phase

① Brightness temperature calibration

For brightness-temperature calibration, no method exists that enables a uniquely defined absolute evaluation. Therefore, the final calibration is determined through a comprehensive assessment of the consistency among multiple calibration and evaluation techniques, as described below.

a. On-orbit calibration

On-orbit calibration is fundamentally based on a two-point calibration using low- and high-temperature calibration source data. First, the characteristics of each calibration-source dataset are assessed by comparison with various telemetry parameters. If the identified characteristics are already represented in the sensor model, then the model is optimized by adjusting the internal coefficients. If additional characteristics are identified, then further modeling is considered. For a low-temperature calibration source, the required adjustments include removing contributions from the Earth, Moon, spacecraft structure, and other non-deep space signals. For a high-temperature calibration source, adjustments may include refining the model used to compute the effective radiometric temperature from calibration-source telemetry. In addition to the calibration-source data, coefficients derived from pre-launch ground tests based on receiver and antenna-pattern characteristics are used to apply nonlinearity correction and antenna-pattern correction, converting the observed values into brightness temperatures. The brightness temperatures obtained through these steps are then comprehensively evaluated together with the results of sensor cross-calibration (described later), and further corrections are applied as needed.

b. Combined/cross-calibration

As no ideal target exists on Earth for absolute calibration, evaluations are performed through cross-calibration with similar microwave radiometers operating during the same period and through comparisons with results derived from combining ground-based observations, other-sensor observations, and radiative transfer simulations.

c. Sensor characteristics and data-quality evaluation

Sensor characteristics, such as intra- and inter-scan biases, differences between receiver units (e.g., 89 GHz A vs. B systems, 6.9 vs. 7.3 GHz), temperature resolution, and gain stability, are investigated using statistical analyses of actual observations, calibration data, and telemetry data. These results are then evaluated together with deep-space calibration and combined-calibration results. The global distributions and occurrence frequencies of abnormal values caused by artificial radiofrequency interference are evaluated, and appropriate removal methods are determined.

d. Deep-space calibration

For deep-space calibration, the feasibility of implementation is examined by evaluating the failures or risks posed by artificial signals from geostationary or polar-orbiting satellites. If deep-space calibration is performed, then the deep-space temperatures observed by the main reflector during the deep-space calibration maneuver are used for low-temperature absolute calibration (consistency check between the main reflector and CSM), intra-scan bias evaluation and correction, and spillover evaluation (TBD). These results are comprehensively evaluated together with other calibration results.

② Geometric calibration

Geometric accuracy is evaluated by comparing the observed data from each channel with the predefined coastline and island map information. Based on these results, the alignment parameters for each frequency within the sensor model are adjusted to perform a geometric correction. If the geometric errors between polarizations of the same frequency are found to be significant relative to the evaluation accuracy, then a polarization-specific geometric correction is considered.

③ Optimization of L1 processing software

The results obtained through the calibration procedures are applied to the sensor model and L1 processing software to enable optimization.

(3) Routine evaluation phase

Calibration procedures developed during the initial calibration and validation phases are performed routinely. Telemetry data relevant to the calibration, calibration-source data, and brightness temperature values over selected regions, such as tropical rainforests, ice sheets, and oceans, are monitored continuously to evaluate their long-term accuracy and stability. In some cases, the evaluation of long-term trends in geophysical parameters may indicate the need to update brightness-temperature calibration.

(4) Collaboration with international calibration and validation frameworks

Efficient cross-calibration and information exchange are conducted by utilizing international frameworks such as WMO/CGMS GSICS, CEOS/WGCV, and GPM X-Cal.

4.5.2 Validation

4.5.2.1 Overview of the Validation Plan

The primary objectives of the AMSR3 validation plan are to quantitatively define the accuracy of each product, produce products that meet the required accuracy, and improve the algorithms when necessary. Table 4-24 presents the target accuracy for each AMSR3 geophysical parameter (standard product). The brightness temperature is obtained by converting the sensor’s engineering output into the most fundamental observation quantity, whereas all other geophysical parameters are derived by converting the brightness temperatures into physical quantities through the respective retrieval algorithms. Unless otherwise noted, the accuracy is expressed as the root mean square error (RMSE) of instantaneous values. The accuracy of the brightness temperature depends on the calibration accuracy of both the onboard and ground processing. The accuracy of the other geophysical parameters depends on the accuracy of the brightness temperature, performance of the conversion algorithms, and validation methodologies. “Release accuracy” refers to the minimum accuracy required for the data to be released as a dataset that can contribute to climate variability analysis. “Standard accuracy” refers to a useful, standard level of accuracy based on the demonstrated performance of AMSR, AMSR-E, and AMSR2.

Table 4-24 Target accuracy for each AMSR3 geophysical parameter (1/2)

Product Name ID	Stored Geophysical Parameter	Region	Spatial Resolution	Measurement Range	Release Accuracy	Standard Accuracy	Remarks
Brightness temperature (L1B) TBB	Brightness temperature (6–89 GHz)	Global	5-50 km	2.7-340 K	±1.5 K	±0.3 K	Difference between ascending and descending orbits in global mean after bias correction, using AMSR2 or numerical weather prediction model Brightness-temperature estimates as reference for ocean and clear-sky regions
	Brightness temperature (165.5 & 183 GHz)	Global	10 km	2.7-340 K	±1.5 K	±1.0 K	
Resampled brightness temperature (L1R) TBR	Brightness temperature (6–89 GHz)	Global	5-50 km	2.7-340 K	±1.5 K	±0.3 K	Difference between ascending and descending orbits in the global mean after bias correction, using AMSR2 or numerical weather prediction model Brightness temperature estimates as reference for ocean and clear-sky regions
	Brightness temperature (165.5 & 183 GHz)	Global	10 km	2.7-340 K	±1.5 K	±1.0 K	
Total precipitable water TPW	Total precipitable water over ocean	Global Ocean	15 km	0-70 kg/m^2	3.5 kg/m^2	3.0 kg/m^2	RMSE against GPS and radiosonde observations
	Total precipitable water over land	Global Land*	15 km	0-70 kg/m^2	6.5 kg/m^2	3.5 kg/m^2	RMSE against GPS and radiosonde observations *Vegetated and snow/ice-covered areas excluded
Cloud liquid water CLW	Cloud liquid water	Global Ocean	15 km	0-1.0 kg/m^2	0.10 kg/m^2	0.05 kg/m^2	RMSE against optical sensor data
Precipitation PRC	Rainfall	Global	15 km	0-20 mm/h	Ocean: 50 % Land: 120 %	Ocean: 50 % Land: 120 %	Relative error corresponding to 0.5° grid when compared with GPM/DPR and ground-based radar networks
	Snowfall	Global	10 km	0-4mm/h	Ocean: 130%* Land: 200%*	Ocean: 130%* Land: 200%*	Relative error corresponding to a 0.5° grid when compared with GPM/DPR. *Evaluated for monthly accumulations of ≥1 mm/month
Sea surface temperature SST	Sea surface temperature (6 GHz)	Global Ocean	50 km	-2 -35 ℃	0.8 ℃	0.5 ℃	RMSE against buoy observations
	Sea surface temperature (10 GHz)		30 km			0.6 ℃	
	Multi-frequency sea surface temperature		30 km			0.6 ℃	
Sea surface wind speed SSW	Sea surface wind speed	Global Ocean	15 km	0-30 m/s	1.5 m/s	1.0 m/s	RMSE against buoy observations
All-weather sea surface wind speed ASW	All-weather sea surface wind speed	Global Ocean	50 km	0-70 m/s	7 m/s	5 m/s	RMSE against dropsonde observations (for wind speeds ≥ 15 m/s)

Table 4-24 Target accuracy for each AMSR3 geophysical parameter (2/2)

Sea ice concentration SIC	Sea ice concentration	Polar Ocean	15 km	0-100 %	10 %	10 %	RMSE against optical sensor data
High-resolution sea ice concentration HSI	High-resolution sea ice concentration	Polar Ocean	5 km	0-100 %	15 %	15 %	RMSE against optical sensor data
Sea ice motion vector SIM	North–South/East–West sea ice motion speed	Polar Ocean	50 km	0 - 40 cm/s	6 cm/s		North–south / east–west components
Soil moisture content SMC	Soil moisture content	Global Land	50 km	0-40 %	10 %	5 %	Mean absolute error against ground-based observations
Snow depth SND	Snow depth (snow water equivalent)	Global Land	30 km	0-100 cm	20 cm	20 cm	Mean absolute error against ground-based observations

4.5.1.2 Product Validation

Product validation aims to evaluate the accuracy of geophysical products by comparing AMSR3-derived values with in situ measurements obtained from ground-based observations and other sources. Through collaboration with meteorological and oceanographic institutions and research projects worldwide, various routinely acquired in-situ datasets from different regions of the world are provided and effectively utilized for validation. Dedicated observational experiments are conducted for certain geophysical parameters to collect validation data. For the validation schedule, refer to Table 4-23.

(1) Total precipitable water

The TPW product stores the total amount of atmospheric water vapor, which is vertically integrated. The verification of the TPW is primarily conducted using the global radiosonde network. When necessary, additional verification is performed using ground-based microwave radiometers installed on remote islands and ground-based GPS receivers. Cross-comparisons with satellite observations from other global precipitation missions, such as the Global Precipitation Measurement Mission (GPM), and quality assessments using operational numerical weather prediction systems are conducted. The land TPW product follows the same validation approach as the ocean TPW product, but targets land areas, excluding snow/ice-covered regions and vegetated areas.

The specific validation methods are as follows:

The TPW calculated from the temperature, pressure, and relative humidity data obtained by the radiosondes is compared with that estimated by the AMSR3. Global radiosonde data include designated pressure level data and data containing significant levels (such as tropopause points) distributed through the WMO Global Telecommunication System (GTS). GPS-based observational data are obtained from stations registered with the IGS. As ocean TPW only exists over ocean surfaces, radiosondes and GPS receivers must be located on small islands and other locations where land surface radiation does not affect the measurement. Radiosonde and GPS data obtained from land sites are used for the land TPW. When evaluating the retrieval-capable region, validation is also performed, when necessary, over snow/ice-covered regions and vegetated areas, although these are outside the domain for which accuracy is guaranteed. During validation, particularly over vegetated areas, consideration is given to providing results as research products when appropriate. In both the land and ocean cases, match-up datasets are routinely generated by pairing the AMSR3 footprint data with radiosonde and GPS observations that are spatially and temporally collocated, and validation is performed using these datasets.

(2) Cloud liquid water

The CLW product stores the total amount of atmospheric cloud liquid water vertically integrated over the ocean. The CLW is verified using a combination of quality evaluations based on visible/infrared sensor data and observations from ground-based (ocean-based) microwave radiometers. Quantitative validation of CLW is challenging. Methods for measuring CLW include the use of video sondes and aircraft observations. However, video sondes provide only point measurements and aircraft observations are restricted in area and frequency, limiting their efficacy for cloud fields that exhibit discrete spatial distributions and rapid temporal variability. Furthermore, these measurement techniques do not necessarily provide perfect quantitative accuracy. Although CLW estimates based on ground microwave radiometer observations are an indirect form of remote sensing, the observation background is a stable and uniform cosmic microwave background, resulting in higher accuracy compared with satellite-based retrievals. Including vertical information from ceilometers and cloud radars can further improve the accuracy of CLW retrieval. However, direct comparisons with ground microwave radiometers are difficult because AMSR3 CLW cannot be retrieved over land or coastal regions. Cross-comparisons are also conducted with other microwave radiometer, visible and infrared sensors, and cloud radar observations. Comparisons with analyses of operational numerical weather prediction systems are also performed. The validation procedures are as follows:

① Using clear-sky information (cloud-mask information) from visible/infrared sensor data such as the Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS), CLW observations derived from AMSR3 are compared using histograms, and the variability around zero in cloud-free regions is evaluated.

② For cases in which all-sky cameras indicate nearly complete cloud cover (cloud fraction close to 1) with uniform thick cloud distribution, a two-stage validation of the absolute AMSR3 CLW values is conducted using data from ground-based microwave radiometers, visible/infrared sensors (SGLI, MODIS, VIIRS, Himawari/AHI, and EarthCARE/MSI), cloud radar (EarthCARE/CPR), and cloud lidar (EarthCARE/ATLID). Specifically, comparisons are made between ground microwave radiometers, which are considered highly accurate, and visible and infrared sensors, which allow for frequent match-up observations over land. Subsequently, AMSR3 CLW is evaluated using cloud-water products, and cloud masks are derived from visible/infrared sensors over the ocean, the accuracy of which is well established. Vertical cloud information from cloud radar and cloud lidar, as well as light-precipitation information from cloud radar, are used to screen ice clouds during match-ups and account for differences in sensitivity between microwave and visible/infrared observations, thereby improving CLW estimation accuracy. Satellite sensor data from other operational agencies are also incorporated. Ground microwave radiometer data, visible and infrared satellite sensors, cloud radar, and cloud lidar observations are obtained in collaboration with Himawari, GCOM-C, and EarthCARE through either publicly available datasets or data-sharing agreements.

(3) Precipitation

The precipitation product comprises rainfall, which targets liquid precipitation, and snowfall, which targets solid precipitation. These quantities are computed and stored separately. Rainfall is a geophysical variable with highly intense spatiotemporal variability, which makes direct comparison with ground-based observations difficult. When operational periods coincided, comparisons with satellite-borne precipitation radars are performed considering the accuracy and spatial uniformity of the ground-based data. Once the validation data became available, additional verification is conducted using existing operational ground-based radar networks and rain gauge networks.

The snowfall product stores the temporal amount of solid precipitation (snowfall) on the Earth’s surface. Similar to rainfall, snowfall exhibits strong spatiotemporal variability, which makes direct comparisons with ground observations challenging. Compared to rainfall, snowfall has fewer ground-based observations available. Therefore, when operational periods coincide, the satellite-borne precipitation radar and cloud radar are compared. The supplementary use of observations from ground-based radar networks has also been considered.

The specific validation approaches are as follows:

① Comparison with satellite-borne precipitation radars

When satellite-borne precipitation radars, such as GPM/DPR, operate during the same period, routine comparison and validation of these datasets are conducted. For high-latitude regions outside the DPR observation domain, validation is performed using data from satellite-borne cloud radar such as EarthCARE/CPR.

② Comparison with operational ground-based radar networks and rain gauges

A comparative validation is performed using data from operational ground-based radar networks and rain-gauge networks established in Japan, the United States, Europe, and other regions. For validation using Japan’s radar-AMeDAS system, coordination is undertaken with the validation plans for high-accuracy, high-resolution Global Satellite Mapping of Precipitation (GSMaP) and GPM global precipitation maps. Where feasible, coordination with ground-based snowfall observations by principal investigators (PIs) and others is pursued.

③ Participation in international precipitation intercomparison experiments

AMSR3 precipitation validation also contributes to international inter-comparison activities, including precipitation validation under the GPM program and international comparison experiments organized by the International Precipitation Working Group (IPWG) established under the Coordination Group for Meteorological Satellites (CGMS), to ensure the consistency and reliability of precipitation products.

(4) Sea surface temperature

Sea surface temperature (SST) products store the temperature of the upper few millimeters of the ocean surface where microwaves can penetrate (hereafter referred to as quasi-skin SST). Validation of the AMSR3 sea surface temperature is performed primarily using temperature data obtained from fixed and drifting buoys distributed globally.

The specific validation approach is as follows.

No special field campaigns or dedicated observational experiments are planned for the SST validation. NOAA’s iQuam data are publicly available and will be obtained online. As a backup, GTS-fixed and drifting buoy data (without quality control), provided under a comprehensive agreement with the Japan Meteorological Agency (JMA), will also be collected. In addition, various satellite sensor datasets operated and provided by JAXA and other institutions (e.g., SGLI, VIIRS, AHI, ABI, and GMI) will be acquired. Through information exchange with international research programs, such as the CEOS Ocean Virtual Constellation and the Group for High-Resolution Sea Surface Temperature (GHRSST), direct observational data of quasi-skin SST will be utilized when available.

(5) Sea surface wind speed

The sea-surface wind-speed product stores the wind speed at a height of 10 m above the ocean surface. The AMSR3 sea-surface wind speed is validated using wind-speed data from fixed buoys distributed globally. The specific validation methods are as follows. During the initial phase (up to approximately 6 months after launch), wind speed data from fixed buoys obtained via the GTS network are used for validation. GTS fixed buoy data are obtained online daily, and match-up datasets with AMSR3 data are automatically generated. In the subsequent phase (approximately 6 months to 1 year after launch), match-up datasets are generated using wind speed data from fixed buoys operated by the U.S. National Data Buoy Center (NDBC). These match-up datasets are used to perform validation with buoy wind speeds as the reference and to investigate the distribution of the AMSR3 sea surface wind speed, its frequency characteristics, and correlations with other geophysical parameters. When comparable sensors, such as satellite-borne microwave scatterometers, operate during the same period, comparisons with these sensors are conducted.

(6) All-weather sea surface wind speed

The all-weather sea-surface wind speed product is validated by collecting wind speed data from dropsondes deployed within typhoon and hurricane regions and comparing them with the estimated sea-surface wind speeds. When such data cannot be obtained, the maximum wind speed from the best track data (defined as the maximum wind speed within 200 km of the best track center position) is collected and compared with the estimated sea-surface wind speeds. A comparison is performed for strong wind conditions (between 17 and 40 m/s). To evaluate the low-wind-speed conditions, fixed-buoy observations are used for validation in the same manner as for the standard sea-surface wind-speed product to assess the consistency between the two wind-speed products. If other comparable sensors, such as satellite-borne microwave radiometers or microwave scatterometers, operate during the same period, then comparisons with their wind-speed estimates are also conducted. If validation experiments are conducted by other projects or organizations that are expected to significantly contribute to improving the accuracy in high-wind-speed regimes, then participation or collaboration will be considered necessary.

(7) Sea ice concentration

The sea ice concentration product is validated through comparison with optical sensors and other high-resolution observations. The presence or absence of sea ice is determined from high-resolution imagery obtained using optical sensors, after which sea ice concentration data are generated for the AMSR3 observation area. Each concentration category is evaluated, including assessments of temporal and spatial consistency. Sea ice concentration data calculated from optical sensor imagery are used to construct a truth dataset in the same manner as during algorithm development. This dataset is built through multistage observations that synchronize ship-based and on-ice sea-ice surveys, aircraft observations, and satellite observations, thereby establishing truth data in a stepwise manner from the ground level upward. The presence or absence of sea ice is determined based on the constructed dataset. Comparisons are conducted in the Sea of Okhotsk as well as in the Arctic and Antarctic during both winter and summer. The influence of land and atmospheric effects is evaluated by comparing AMSR3 with satellite data with spatial resolutions 10–20 times higher than those of the AMSR series, and the algorithm is validated. To optimize the parameters affecting the accuracy of sea ice concentration estimation, seasonal and regional variations are assessed and tuning is performed accordingly. This requires periodic validation over multiple ocean regions in collaboration with relevant institutions. Particularly, in regions essential for improving estimation accuracy, such as polynya regions and ice-edge zones, tie points for each sea ice type are validated using comparisons with other satellites and through interpretation of sea ice radiative properties obtained from field observations around locations such as Mombetsu Port, Lake Saroma, and polar sea ice regions. The specific validation datasets envisioned include aerial photographs and FORMOSAT, AVHRR, LANDSAT, MODIS, VIIRS, SGLI, AMSR2, GMI, and SAR data.

(8) High-resolution sea ice concentration

The high-resolution sea ice concentration product is validated in the same manner as for the standard sea ice concentration product. The sea ice concentration is estimated based on observational data derived from satellite-borne optical sensors (e.g., MODIS, VIIRS, and SGLI) and field observations collected through dedicated measurement campaigns. The estimated sea ice concentration is then compared with the high-resolution sea ice concentration data retrieved from AMSR3, and the estimation accuracy is evaluated. Each concentration category is assessed and temporal and spatial consistency is verified.

(9) Sea ice motion vector

The sea ice motion vector product is validated by generating match-up datasets between in-situ sea ice velocity data obtained from ultrasonic current meters and AMSR3 data. Eulerian validation is performed using these match-up datasets together with in situ sea ice velocity measurements from ultrasonic current meters. Lagrangian validation is performed using the GPS drift trajectories of the buoys deployed on the ice. Using these methods, the estimation accuracy of the motion vectors in both latitudinal and longitudinal directions is evaluated. The primary validation region is the Arctic Ocean in the Northern Hemisphere. Temporal consistency is assessed using time-series measurements from ultrasonic current meters, whereas spatial consistency is evaluated using buoy observations.

(10) Soil moisture content

The soil moisture product stores volumetric water content in the surface soil layer. Soil moisture retrieval algorithm validation must carefully consider the following four influencing factors:

① Validation under a wide range of soil moisture conditions, from dry to wet

Soil moisture is one of the primary factors that determines the dielectric constant of soil. As water has a much higher dielectric constant than soil particles, an increase in soil moisture significantly alters the surface emissivity and attenuation characteristics of microwaves within the soil.

Under wet conditions, emissivity decreases and attenuation within the soil becomes stronger. Therefore, the brightness temperature observed by AMSR mainly depends on the emissivity near the surface, scattering characteristics associated with surface roughness and surface temperature. In contrast, under dry conditions, attenuation within the soil is small and the contribution of radiation from deeper soil layers increases, making the observations more susceptible to radiative transfer characteristics within the soil and the vertical soil temperature profile. Therefore, differences in dielectric properties and radiative transfer characteristics depending on wet and dry conditions must be considered.

② Validation across different soil types (surface roughness and texture)

In microwave radiative transfer from the soil surface, the surface roughness and soil texture affect the surface scattering and volume scattering within the soil layer, respectively. These behaviors also varied depending on the soil moisture level. Accordingly, validation is necessary under conditions spanning a wide range of soil moisture levels (dry to wet) and differences in surface roughness and soil texture.

③ Validation under varying vegetation conditions (vegetation amount, vegetation type, heterogeneity of vegetation cover)

Microwaves emitted from the soil surface are affected by water contained in the overlying vegetation. Even under identical vegetation water content (total water mass in vegetation per 1 m² [kg]), variations in leaf and stem structure and heterogeneity of vegetation distribution within the footprint can significantly influence microwave radiative transfer. Thus, validation must address diverse vegetation conditions in combination with the conditions described in ① and ②.

④ Validation under heterogeneous soil moisture distribution within the footprint

In reality, the soil moisture distribution is not uniform; it varies owing to precipitation patterns, land cover, microtopography, and other factors. Therefore, footprint-scale validation that considers the spatial distribution of surface soil moisture across satellite footprints spanning several tens of kilometers is required.

The specific validation approaches are as follows:

To perform validation under the conditions described above, approaches a and b are combined, and, as necessary, approach c is added to further advance the algorithm. Approaches d and e are implemented to achieve a more comprehensive understanding of the product’s accuracy and quality in support of broader utilization.

a. Long-term data acquisition within validation regions matching satellite footprint size

A validation region of several tens of kilometers, where the terrain is simple and easily accessible, is established. Within this region, numerous automated soil-moisture sensors and meteorological observation stations have been deployed to construct long-term observation systems. The gathered data are then compared with the satellite product.

b. Validation using long-term observations under diverse climatic conditions

Long-term validation is conducted under various weather, vegetation, and soil-type conditions. To enable comparative studies across various regions worldwide, point-based observations may also be used, provided that the surrounding areas are regarded as relatively homogeneous in addition to the target region defined in (a).

c. Validation using ground-based microwave radiometers under well-controlled conditions

High-accuracy observational data are collected using ground-based microwave radiometers, which perform similarly to satellite sensors, under conditions where the moisture level, soil properties, and vegetation state can be quantitatively measured. These data are used to enhance the algorithm.

d. Cross-validation with other satellite products and model outputs

A cross-comparison is performed with other soil moisture products and outputs from numerical weather prediction models.

e. Validation at satellite footprint scale

Methods are investigated to define footprint-scale soil moisture under heterogeneous soil moisture conditions and implement effective satellite-based validation.

(11) Snow depth

Validating the snow depth product requires a verification plan that accounts for the following four influencing factors:

① Determination of snow-covered/snow-free areas

Snow cover is a seasonal physical parameter, and the presence or absence of snow is an important piece of hydrological information. In permafrost regions, frozen soil is sometimes misidentified as snow, which causes considerable errors when estimating snow depth. Therefore, from the perspective of algorithm development, validating the accuracy of snow-covered and snow-free area detection is essential.

② Diverse snow conditions (snow grain size and layer structure)

Changes in snow grain size and layer structure caused by metamorphism have a substantial impact on microwave radiative transfer characteristics. Accordingly, validation is required under conditions that produce different radiative transfer characteristics.

③ Microwave characteristics of the ground beneath snow

The microwave emission and scattering characteristics of the ground beneath the snow layer determine the boundary conditions for the microwave radiative transfer within the snowpack. Even in winter, the lower boundary conditions differ significantly among regions where surface thawing progresses, where no melt occurs at the base of the snow layer, and where snow accumulates after permafrost has already formed. Therefore, the validation must be conducted under diverse snow conditions, including those with different underlying ground states.

④ Different vegetation conditions (amount and type of vegetation, canopy snow load, and heterogeneity of vegetation cover)

The distribution of water within vegetation above snow, that is, vegetation biomass, leaf and stem structure, canopy snow load, and the heterogeneity of vegetation distribution within the footprint, greatly influences microwave radiative transfer. Therefore, validation must account for variations in vegetation conditions under the diverse scenarios described in ② and ③.

The specific validation approaches are as follows:

To conduct validation under the above conditions, approaches a, b, and c are combined. Approach d is implemented as needed to further refine the algorithm.

a. Validation of snow-covered/snow-free area classification

Comparisons of snow-covered areas throughout the year are conducted globally using datasets, such as other satellite products and model outputs.

b. Validation at satellite footprint scale

A 25-km square validation site is established in a region with simple topography and easy accessibility. In this area, numerous automatic snow depth sensors and meteorological observation instruments have been deployed to establish long-term observation systems. These observations are used to validate the satellite products.

c. Validation using long-term observations under diverse climatic conditions

Long-term validation experiments are conducted under various weather conditions, vegetation, snow characteristics, and soil states.

d. Validation under well-controlled conditions

High-accuracy observational data are collected using a ground-based microwave radiometer, whose performance is comparable to that of a satellite sensor, under conditions in which snow properties, basal snow layer characteristics, and vegetation parameters can be quantitatively measured. The data are used to evaluate and refine the algorithm.

Chapter 5. Data-Providing Service

AMSR3 products are primarily provided through the G-Portal (https://gportal.jaxa.jp/gpr/), which provides all Earth observation satellite data processed at/provided by JAXA. AMSR3 standard products and near-real-time products are provided through this system to users via the Internet. For details, such as data searching or ordering of AMSR3 products, refer to the G-Portal User's Manual.
https://gportal.jaxa.jp/gpr/assets/mng_upload/COMMON/upload/GPortalUserManual_en.pdf

5.1 Product Storage

The AMSR3 products on the G-Portal are basically managed in two generations, starting with the latest generation. However, as the version two generations prior is deleted once the latest generation is reprocessed, there will be a period of reprocessing when the three generations will be mixed. Table 5-1 shows a list of stored products, including the AMSR series from other satellites.

Table 5-1 List of AMSR series product storage

Satellite	Data type	Observation period	Generation
Aqua	AMSR-E standard products	2002/6/1 to 2011/10/4	Most recent generation
ADEOS-Ⅱ	AMSR standard products	2003/4/2 to 2003/10/24	Most recent generation
GCOM-W1	AMSR standard products	From 2012/7/3	Most recent generation
GOSAT-GW	AMSR3 standard products	From 2025/8/11	Two most recent generations

5.2 Product Provision Policy

For details of the right or usage conditions for AMSR3 data, refer to the "AMSR3 Data Distribution Policy" (https://gportal.jaxa.jp/gpr/index/eula).

5.2.1 User Categories

Users are categorized as institutional or general users. The data categories available to users are listed in Table 5-2.

(1) Institutional users
Institutional users are organizations and researchers contributing to the calibration and validation of AMSR3 and climate change research adopted in research announcements (RA), operating weather forecasts and climate models, and verifying the utility of information on fishing, oceanographic conditions, and sea route management, and so on.

(2) General users
General users are defined as users other than those mentioned above.

Table 5-2 Products provided by AMSR3

	L1A Product	L1 Product	L2 Product	L3 Product
Institutional user	×	Near-real time	Near-real time	×
General user	(special user only)	Standard	Standard (※)	L3

(※) JAXA screens the application for "special user" submitted by a user and makes near-real time products available for the users JAXA approves.

5.2.2 Product Provision Procedure

The G-Portal has a storage area from which users can obtain the latest data. The storage area and periods of the latest and near-real-time products are shown in Table 5-3. The storage period could be modified for each product. The access authority of near-real-time products is as shown in Table 5-2.

Table 5-3 G-Portal product storage area/storage period

Product	G-Portal storage area	Storage period
Standard	For latest product	All period
Near-real time (local)	For near-real time product	31 days
Near-real time (global)		31 days

5.2.3 Version Management

The AMSR3 manages the product, algorithm, and parameter versions as information stored in each product. For more details, refer to the format specifications. When reprocessing is conducted due to version upgrades, products with different processing versions may be generated for the same sensor, period, and observation area.

5.2.4 Terms of Use

For the data provision policy and handling of personal information of G-Portal, refer to JAXA's site policy (https://global.jaxa.jp/policy.html).

Chapter 6. How to use AMSR3 data

This document explains and provides basic knowledge on how to use GOSAT-GW/AMSR3 data. For more detailed explanations, please refer to the related documents on the AMSR series website (https://www.eorc.jaxa.jp/AMSR/index_en.html).

- AMSR3 Level 1B Product Format Specification
- AMSR3 Level 1R Product Format Specification
- AMSR3 Higher Level Product Format Specification
- AMSR3 Higher Level Product Format Specification

6.1 Data Display Tools

This chapter explains how to load AMSR3 data using existing tools.

6.1.1 AMSR3 Display Tools

The AMSR3 Display Tool displays the AMSR3 observation data on a map. It supports Windows, Linux, and macOS; therefore, please download and install it on the G-Portal Tools and Documentation website (https://gportal.jaxa.jp/gpr/information/tool).

6.1.1.1 How to Use the Tool

The main screen appears when you launch the tool, as shown in Figure 6-1.

Figure 6-1 Main screen of the AMSR3 display tool

To display a product in this application, you must register the product you wish to display in the library. To register a product file, select "Open File" from the "File" pull-down menu in the main menu, and use the product file loading dialog shown in Figure 6-2.

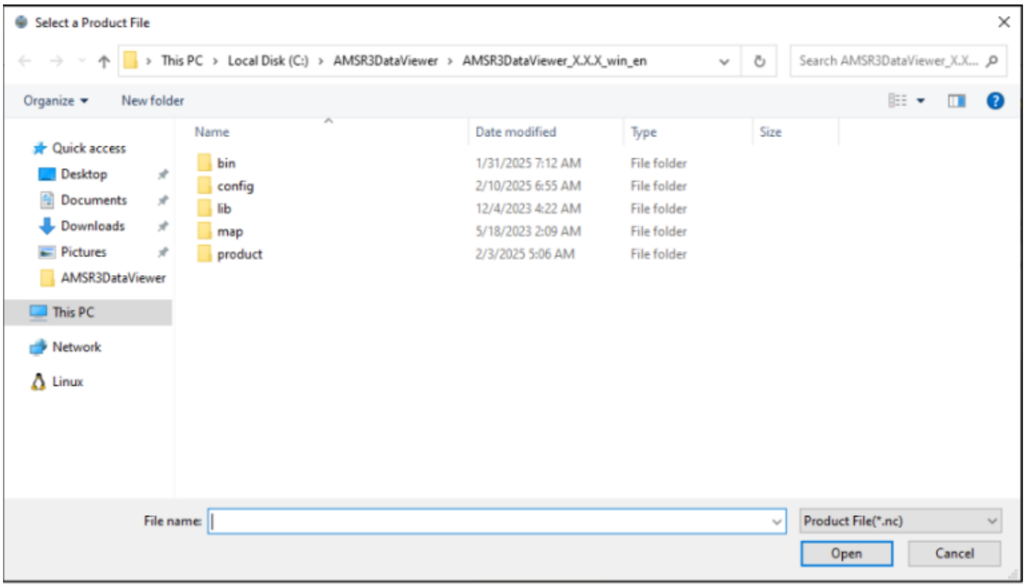


Figure 6-2 Product file loading dialog

Once product registration is complete, check the "Product Selection Checkbox" for the product you want to display from the product list on the main screen, as shown in Figure 6-3. Next, click "Show on Map" at the bottom right to display the selected product on the map.

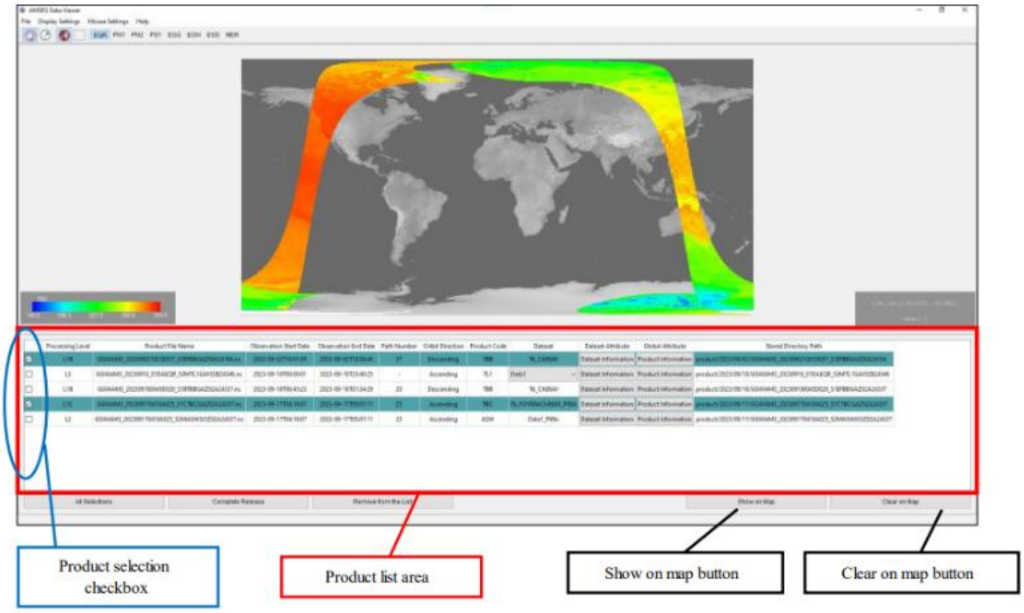


Figure 6-3 Product list section, map display, map clear button

By default, a maximum of 10 products can be displayed simultaneously. For other operation methods, please refer to the AMSR3 Mission Operation System User Tool Instruction Manual (https://gportal.jaxa.jp/gpr/information/tool).

6.1.2 Panoply

Panoply allows users to browse data in NetCDF, HDF, and other datasets. The software was downloaded from the NASA website and installed (https://www.giss.nasa.gov/tools/panoply/).

6.1.2.1 How to Use the Tool

When you start the tool, the screen shown in Figure 6-4 is displayed. Select the file you want to load and click "Open."

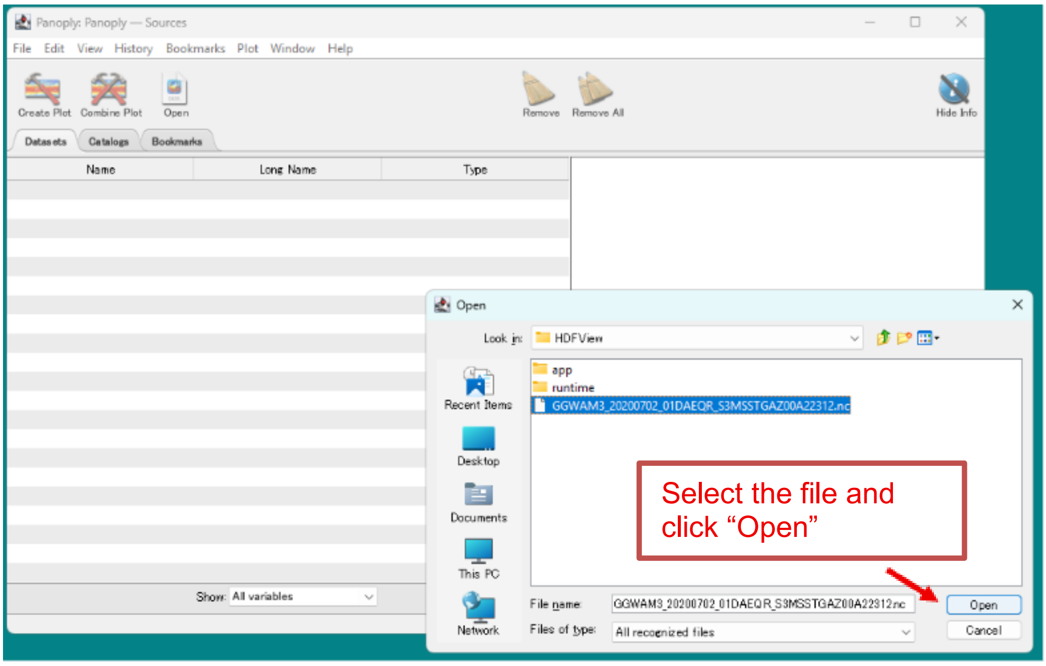


Figure 6-4 Panoply startup screen

Click on the filename at the top left side of the window to display the global attributes on the right side of the window (Figure 6-5).

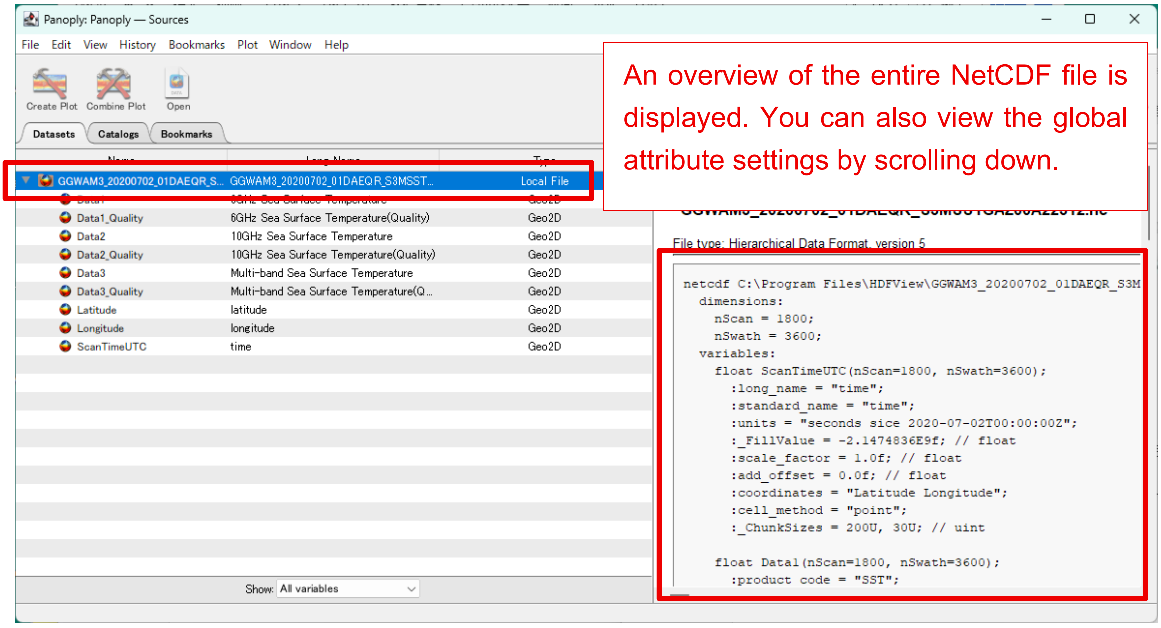


Figure 6-5 Viewing global attributes

Clicking on the dataset name on the left side of the window displays the attributes of the specified dataset on the right side of the window (Figure 6-6).

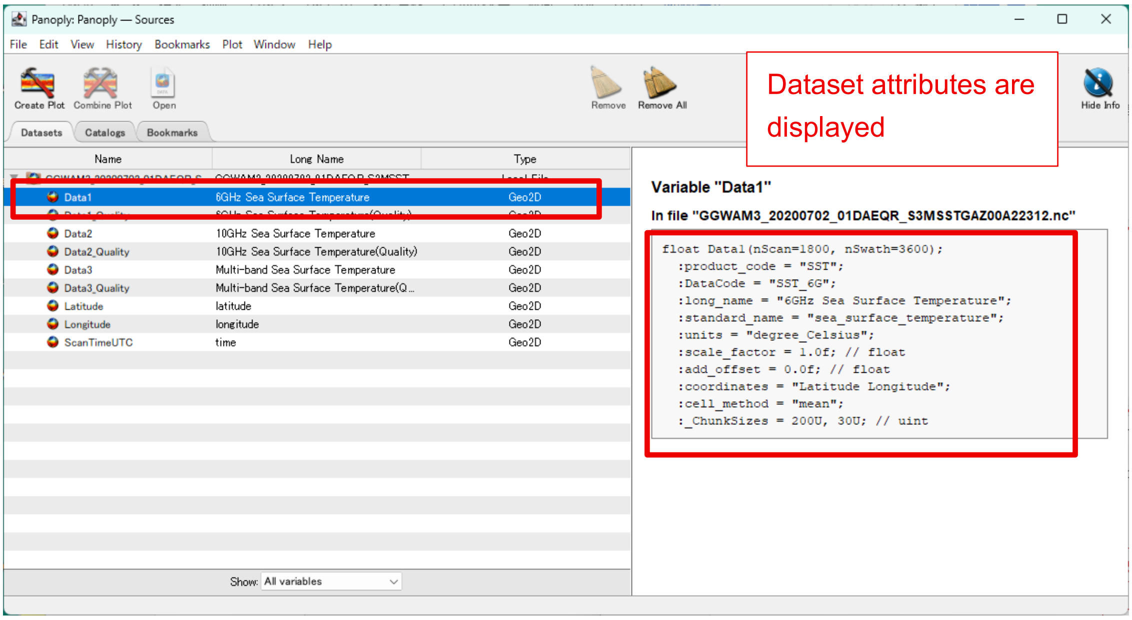


Figure 6-6 Viewing dataset attributes

Double-clicking on a dataset name creates a window in which you can set how the specified dataset is plotted (Figure 6-7).

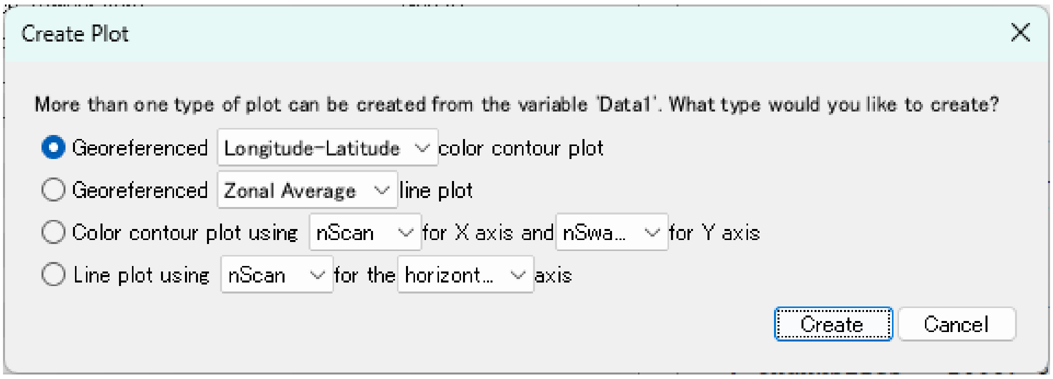


Figure 6-7 Plotting method settings

After setting the plotting method and clicking "Create", the dataset is visualized according to the settings and displayed in the window (Figure 6-8).

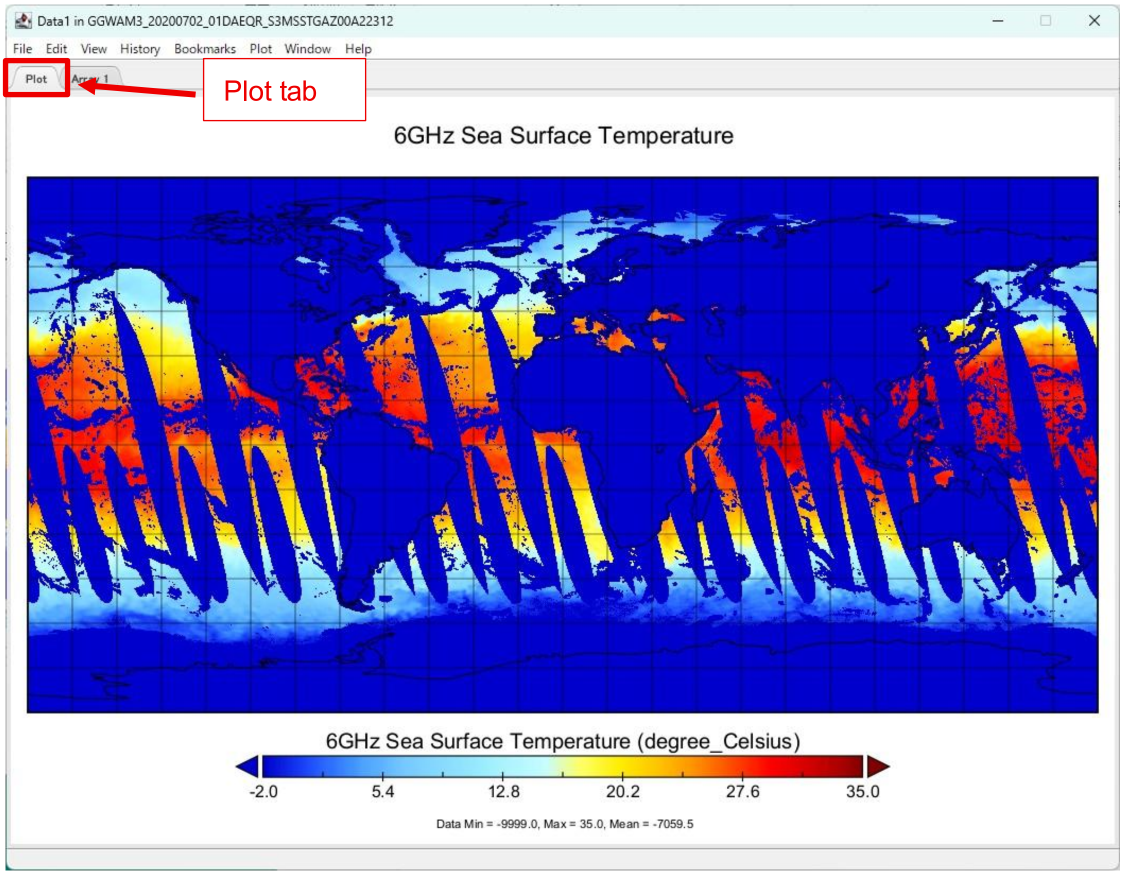


Figure 6-8 Plot image display

In the same window, click on the “Array1” tab to view the stored values of the dataset (Figure 6-9).

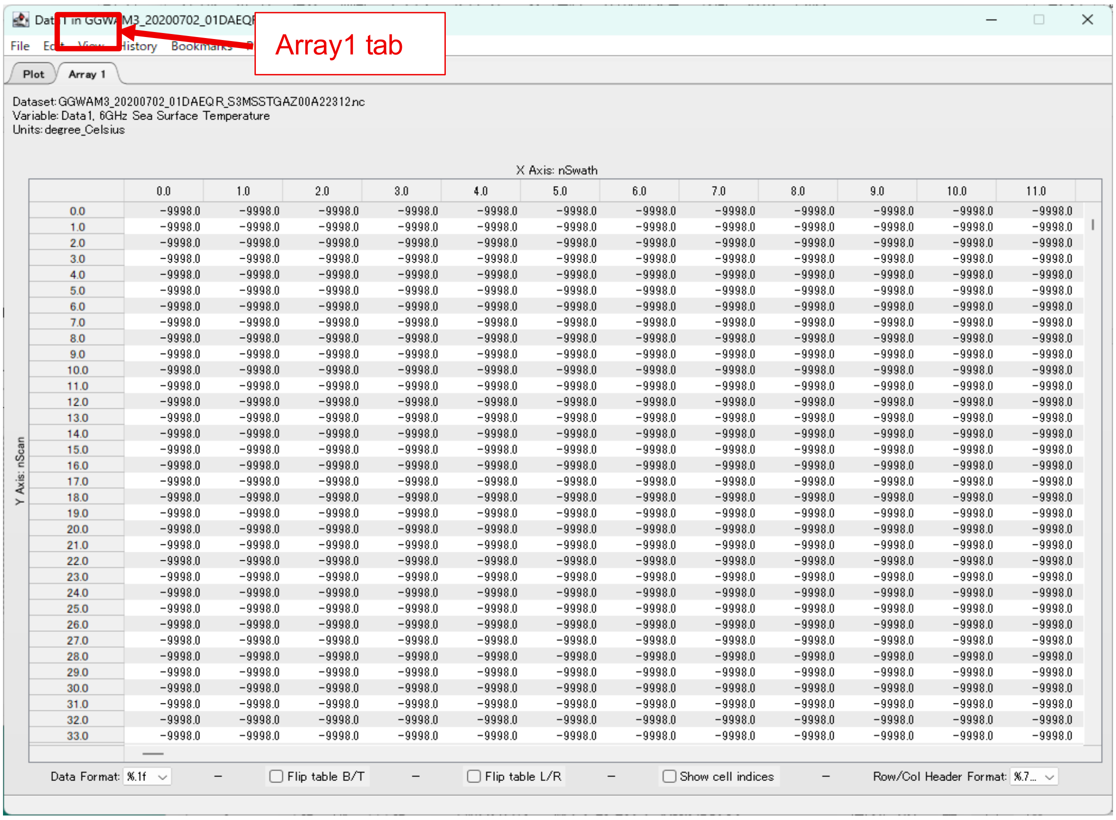


Figure 6-9 Viewing dataset stored values

This document provides an overview of the procedure for displaying AMSR3 products, but for other operating procedures, please refer to the official Panoply documentation (https://www.giss.nasa.gov/tools/panoply/).

6.1.3 QGIS

QGIS is a geographic information system (GIS) with functions for viewing, editing, and analyzing geospatial information data. It was downloaded and installed on the official website of the QGIS development team (https://qgis.org/).

6.1.3.1 How to Use the Tool

Upon starting the tool, the following screen is displayed (Figure 6-10).

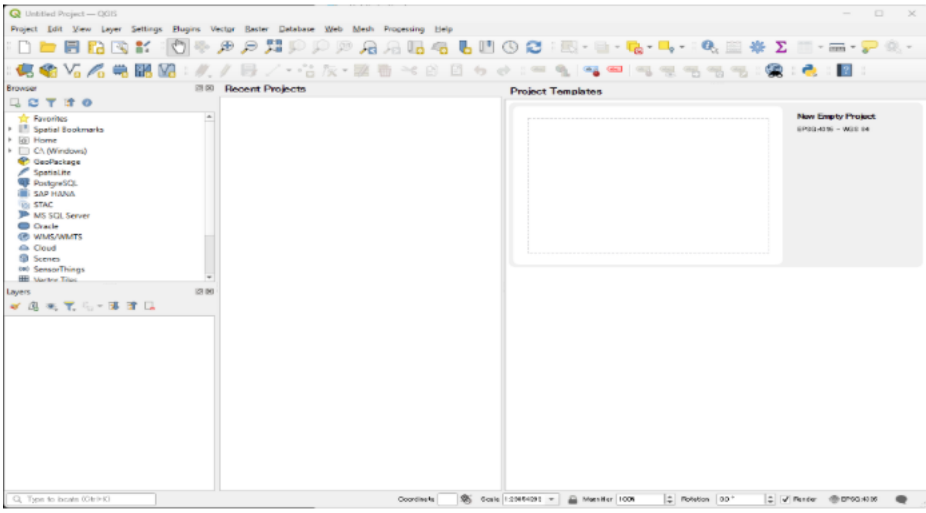


Figure 6-10 QGIS startup screen

Select "Data Source Manager" from the "Layer" pull-down menu in the main menu to display the Data Source Manager window (Figure 6-11). Select "Raster" from the list on the left side of the window, select "File (i)" for the source type on the right side of the window, and click the source browse button (...).

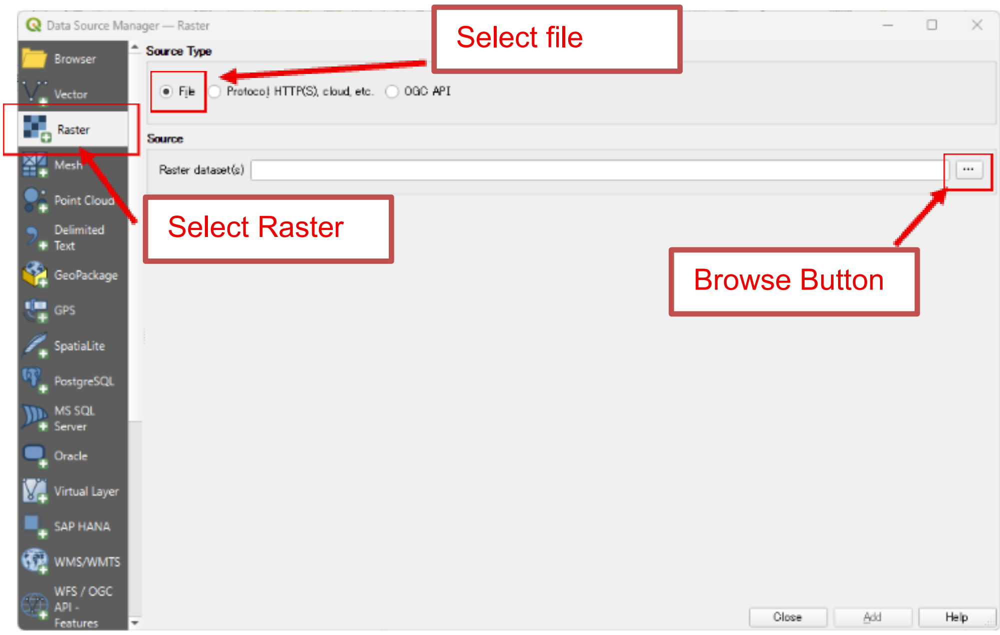


Figure 6-11 Data Source Manager

Select the NetCDF file to be read, then click "Open" (Figure 6-12).

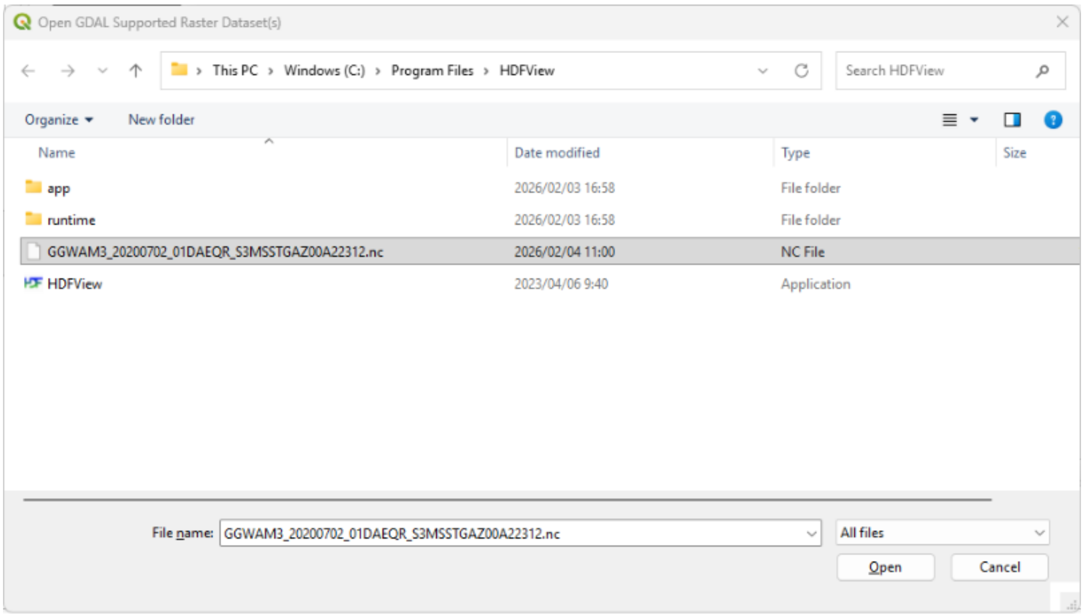


Figure 6-12 Selecting the target file

An option input area is added to the Data Source Manager window. Enter options as necessary, then click "Add" (Figure 6-13).

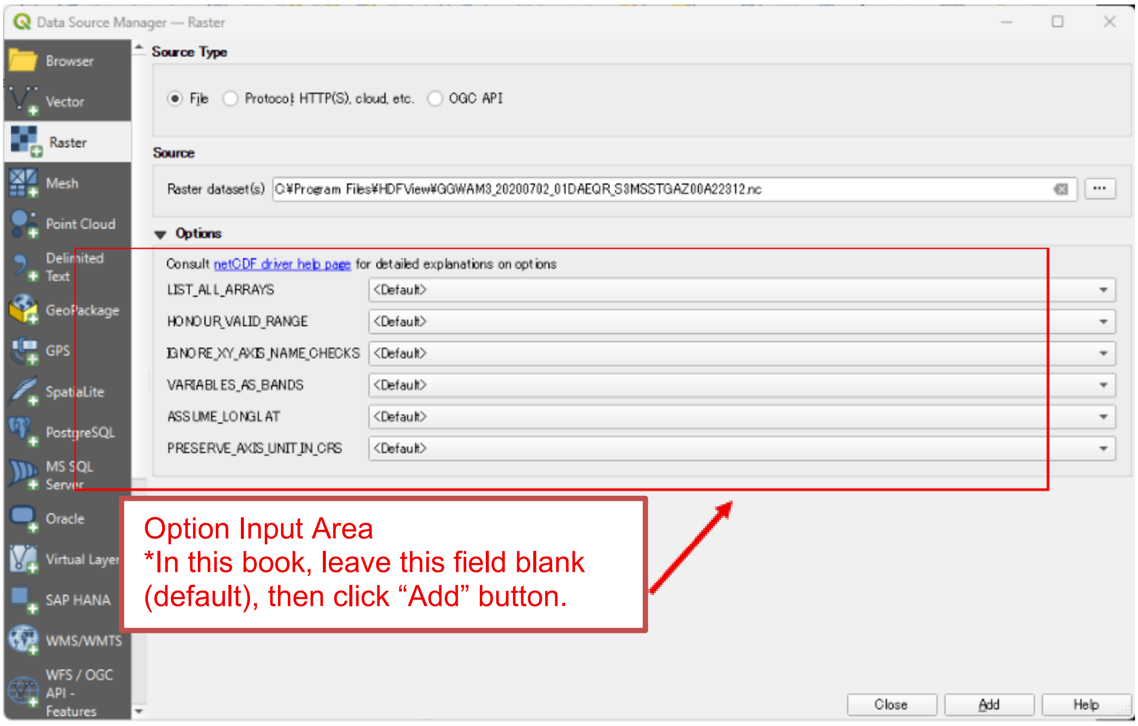


Figure 6-13 Optional Input

The item selection window appears; therefore, select the target dataset and click "Add" (Figure 6-14).

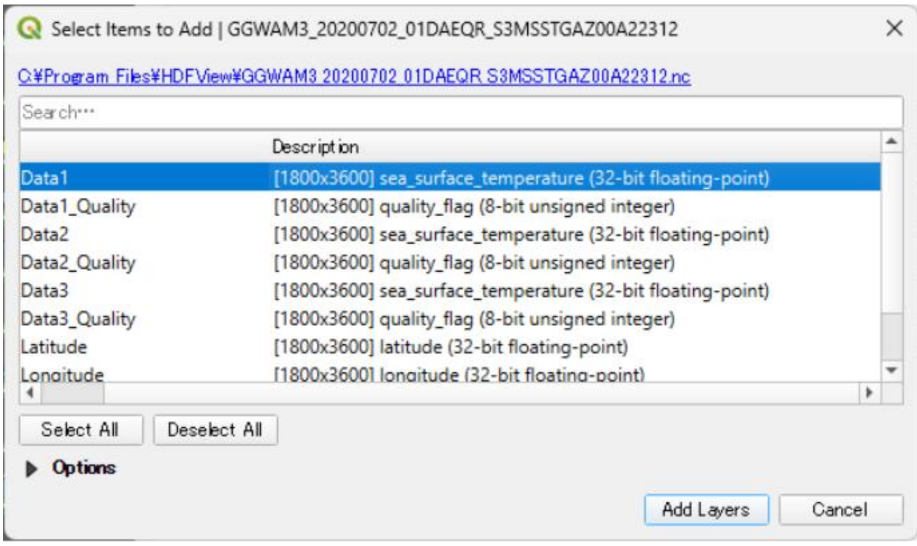


Figure 6-14 Dataset selection

The selected dataset is added as a layer, and the visualized image is displayed in the main window (Figure 6-15).

If the latitude direction is reversed, as in this example, select "Convert" → "Format Conversion (gdal_translate)" from the "Raster" pull-down menu in the main menu.

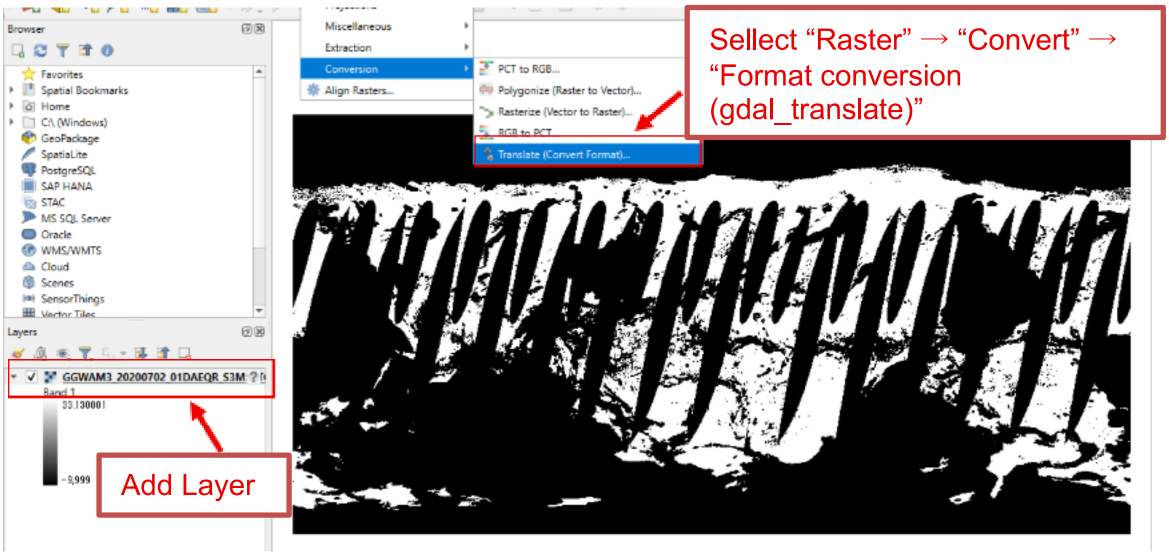


Figure 6-15 Format Conversion

The Raster Conversion window opens. Ensure the layer you just added (Data 1 in this example) is set as the input layer, and click "Select CRS" (Figure 6-16).

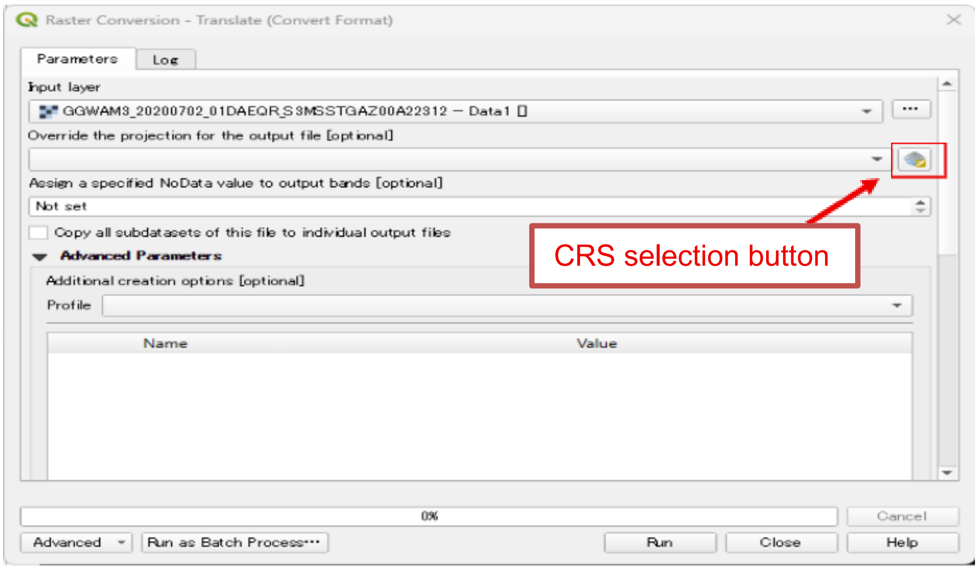


Figure 6-16 Raster Conversion window

A menu for selecting a CRS appears; select a predefined CRS from the list (Figure 6-17).

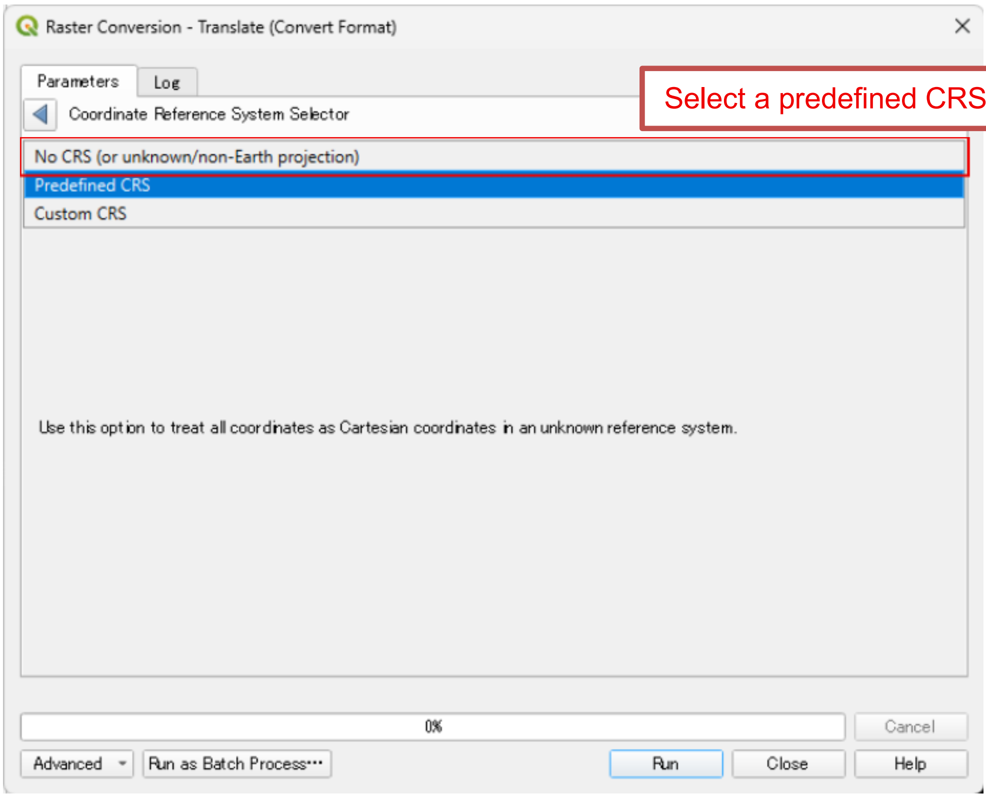


Figure 6-17 CRS settings (1)

Enter "EPSG:4326" (the geographic coordinate system used in AMSR3 products) in the filter field, select EPSG:4326 from the "Predefined Coordinate Reference System (CRS)" menu, and click "Back" to return to the Raster Conversion window (Figure 6-18).

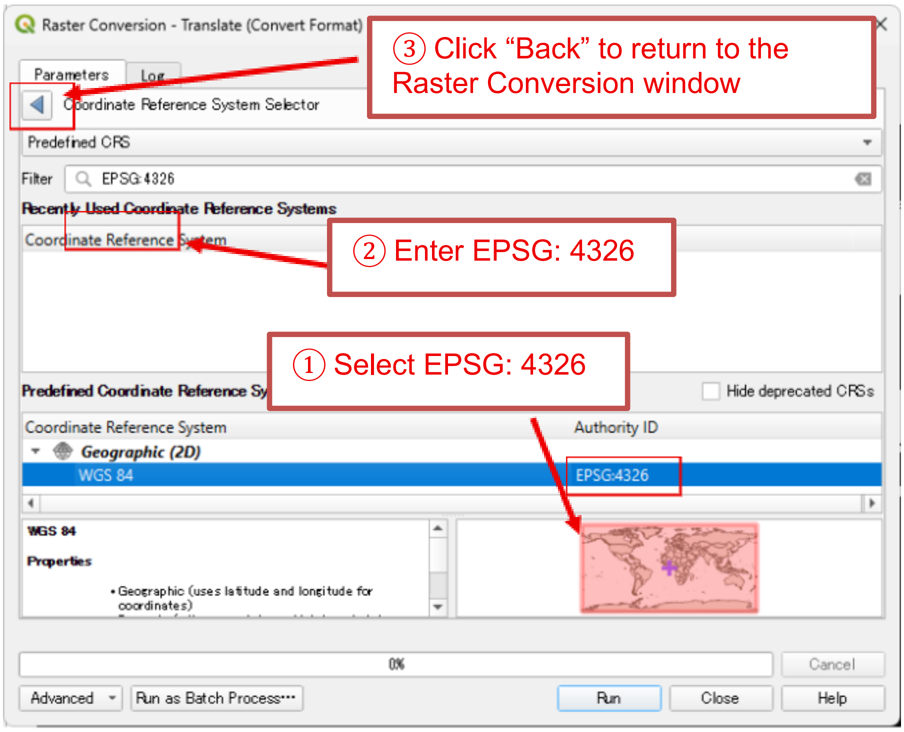


Figure 6-18 CRS settings (2)

After setting the CRS, click on Advanced Parameters to expand the parameter input field (Figure 6-19).

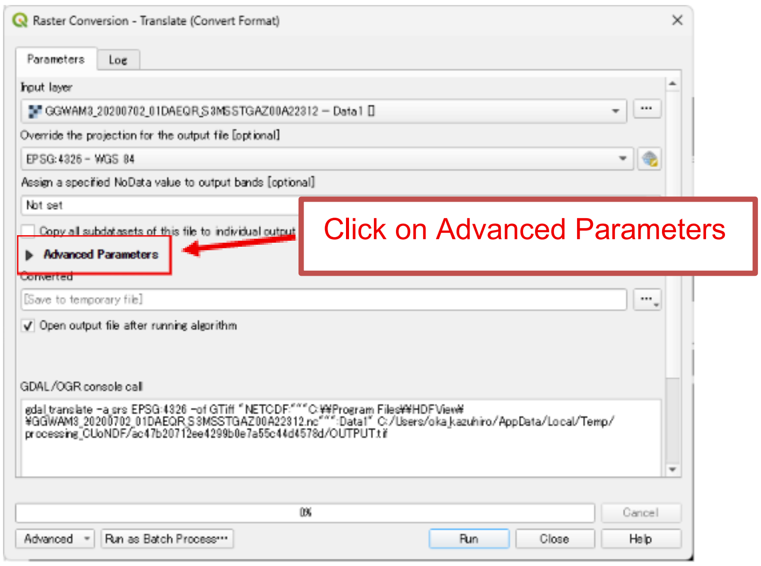


Figure 6-19 Detailed parameter input (1)

Enter the following parameters into the "Additional command line parameters" in the expanded detailed parameter input field, then click "Run" (Figure 6-20).

-a_ullr -180.00 -90.00 180.00 90.00

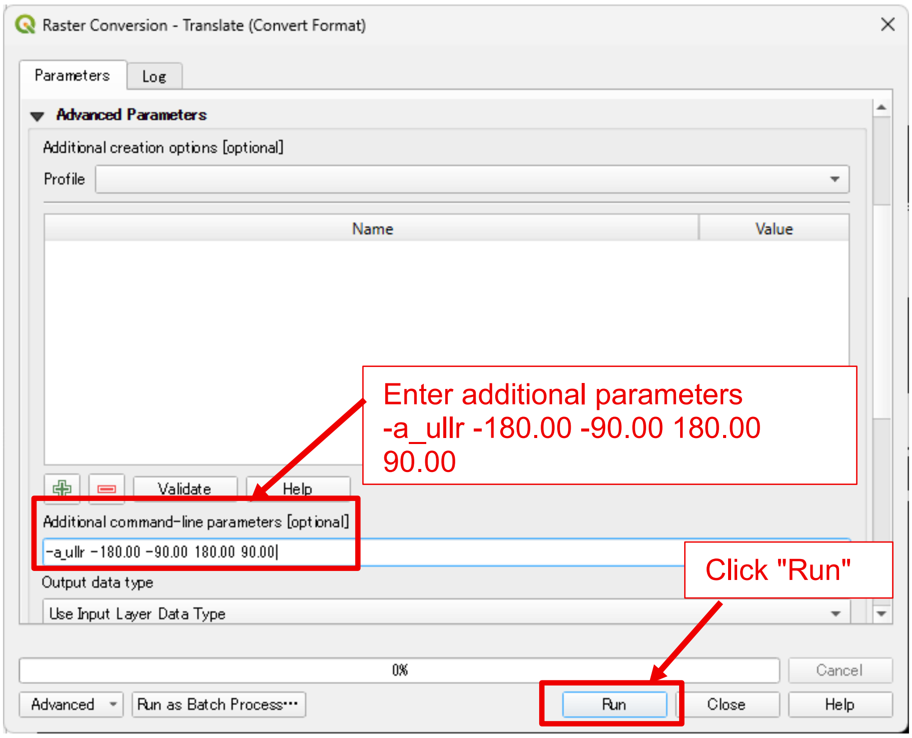


Figure 6-20 Detailed parameter input (2)

The converted layer is added; therefore, right-click the name of the pre-conversion layer (Data1 in this example) in the bottom left of the main window and select "Delete Layer" from the pull-down menu (Figure 6-21).

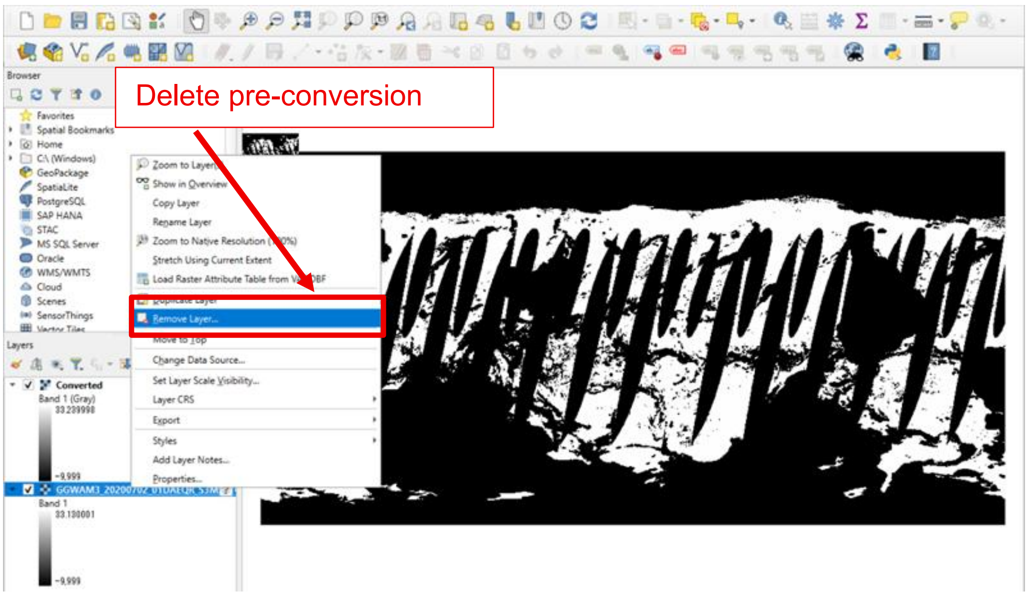


Figure 6-21 Delete pre-conversion layer

Select the converted layer at the bottom left of the main window and click "Full display" in the menu icon to enlarge the display to fit the selected layer (Figure 6-22).

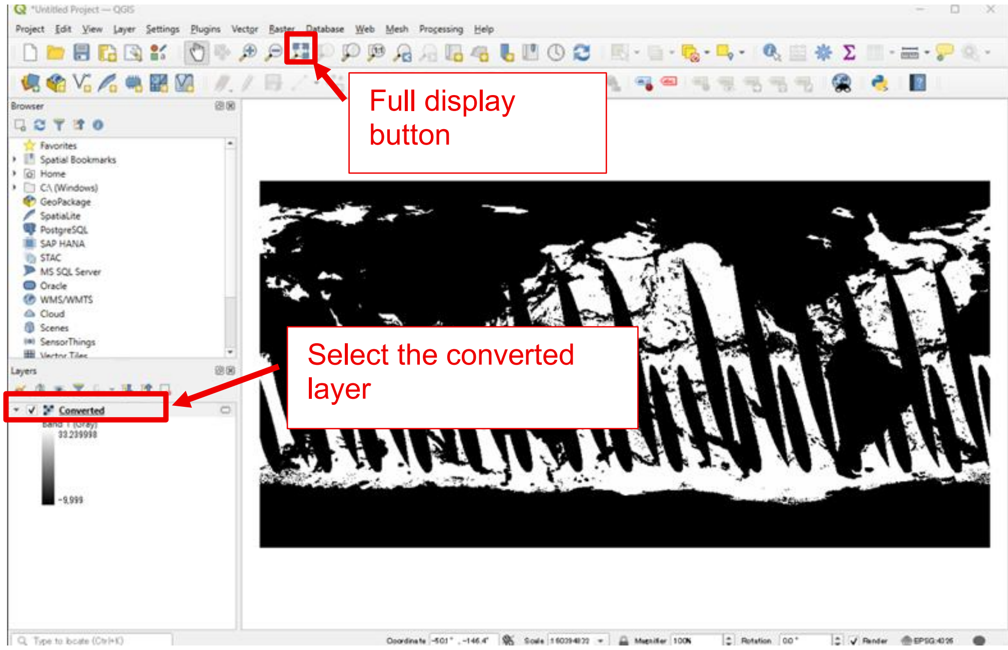


Figure 6-22 Display of converted layer

Double-click the converted layer at the bottom left of the main window to display the Layer Properties window (Figure 6-23), where you can adjust the layer's color and transparency and create a histogram (Figure 6-24).

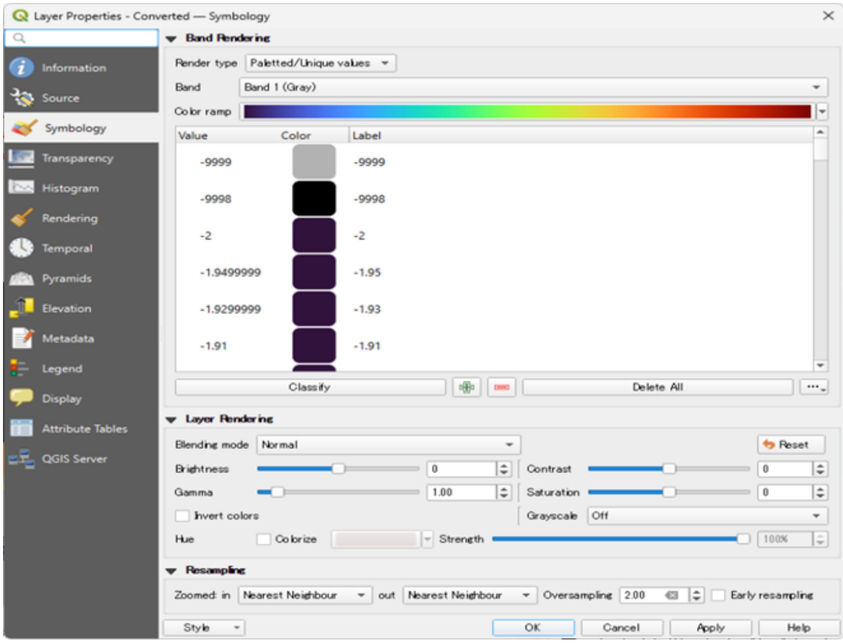


Figure 6-23 Layer Properties window (color adjustment)

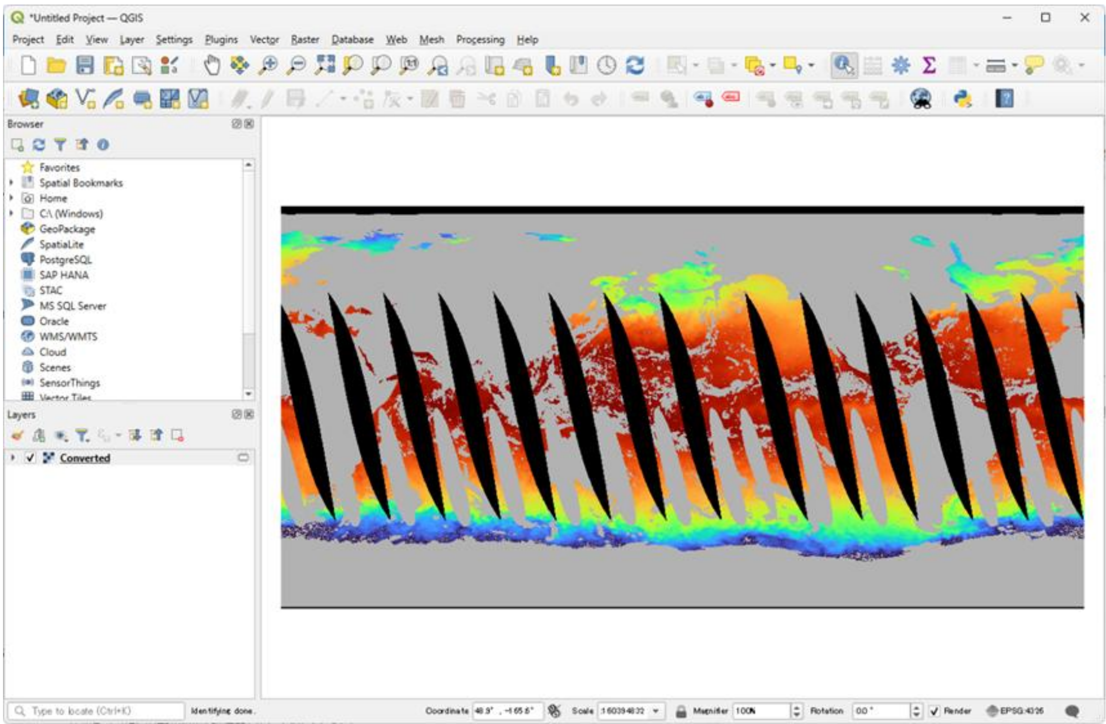


Figure 6-24 Layer after color adjustment

This document provides an overview of the procedure for displaying AMSR3 products; however, for other operating methods, please refer to the official QGIS documentation (https://www.qgis.org/resources/hub/).

6.1.4 OpenGrADS(GrADS)

OpenGrADS is an interactive tool used to process and image geoscience data. Download from the official OpenGrADS website and install it (http://opengrads.org).

6.1.4.1 How to use the tool

Because OpenGrADS's sdfopen cannot read AMSR3 products, the files can be read by opening the control file shown below.

Control file contents

```
DSET GGWAM3_20200702_01DAEQR_S3MSSTGAZ00A22312.nc
DTYPE netcdf
UNDEF -9999
OPTIONS yrev
XDEF 3600 linear 0, 0.1
YDEF 1800 linear -89.95, 0.1
```

```
ZDEF 1 levels 0
TDEF 1 linear 00Z02JUL2020 1dy VARS 1
Data1=>data1 0 y,x "6GHz Sea Surface Temperature"
ENDVARS
```

The contents of the control file are explained below.

・DSET: Dataset file name. Enter the path to the product file to be read.

・DTYPE: Data type. Enter "netcdf" to read a product file.

・UNDEF: Undefined value. Enter a value that will be treated as undefined in OpenGrADS. In this example, we enter -9999, which is a missing value in the AMSR3 L3 product.

・OPTIONS: The order of data in the Y direction (latitude direction) is reversed between OpenGrADS and AMSR3 L3 products. Entering 'yrev' reads the data in the correct order for OpenGrADS.

・XDEF: Grid information in the X direction (longitude). Enter the number of grids (3600), grid alignment (linear), starting position (0), and grid spacing (0.1) in this order.

・YDEF: Grid information in the Y direction (latitude). Similar to XDEF, enter the number of grids (1800), grid alignment (linear), starting position (-89.95), and grid spacing (0.1) in this order.

・ZDEF: Grid information in the Z direction (pressure surface). While not included in the product, this is required in the control file; therefore, please enter it as shown above.

・TDEF: Grid information in the T direction (time axis). Similar to ZDEF, this is not required in the product but is required in the control file; therefore, please enter it, as shown above.

・VARS (ENDVARS): VARS to ENDVARS define the variables. The 1 written in VARS represents the number of variables to be handled. The following line describes the NetCDF file. For Data1=>data1, Data1 on the left is the name of the dataset to be read from the NetCDF file, and data1 on the right is the variable name to be handled within OpenGrADS. In the description of 0 y,x, 0 is the length of the array in the T direction, and y and x represent the Y and X directions, respectively, which must be written in that order. The string in "" next to it is a description of the variable and can be written as desired. If multiple datasets are to be read, change the 1 written in the VARS line to the desired value and write one line for each variable in the NetCDF reading description on the next VARS line.

Store the control file with the above contents and the file to be read in the same directory, and start the program from the location where the two files are stored.

When you start, you will see the following message (Figure 6-25):

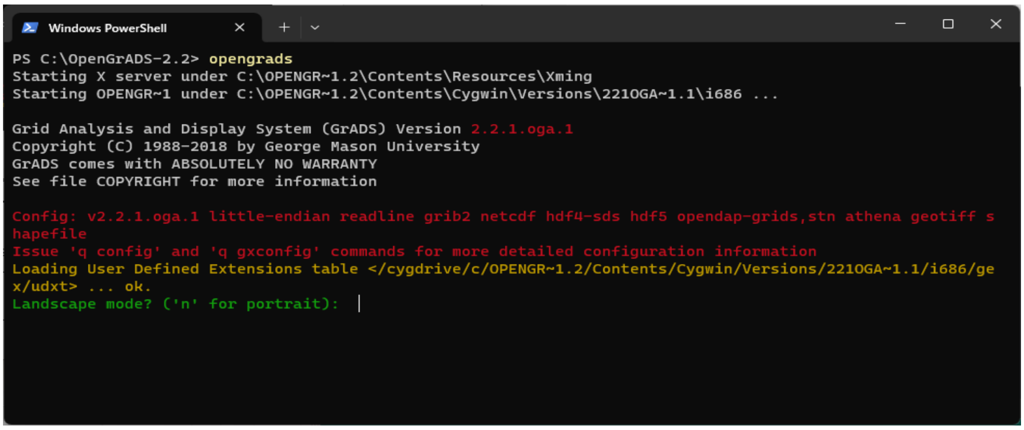


Figure 6-25 OpenGrADS startup screen

When you see the prompt "Landscape mode? ('n' for portrait):", press Enter without typing anything to open the drawing window in landscape mode. Enter 'n' for portrait mode

Open the control file using the following command:

ga -> open <control file name (in this example, test.ctl)>

After executing the command, the following message is output, indicating that the control file has been loaded (Figure 6-26).

Figure 6-26 After the control file is read

The commands for drawing the AMSR3 L3 product dataset (Data1) are as follows:

ga-> set display color white

ga-> clear

ga-> set gxout grfill

ga-> set timelab off

ga-> set clevs -2 2 6 10 14 18 22 26 30 34

ga-> display maskout(data1, (data1+9997))

Line 1: set display color specifies the background color; “white” sets it to white.

Line 2: clear is the command that reflects the set display color command in line 1.

Line 3: set gxout specifies the drawing method. grfill sets the drawing setting to grid fill.

Line 4: set timelab sets the drawing setting for the date when display is executed, by setting it to “off” to hide it.

Line 5: set clevs sets the color, specifying that the dataset values should be divided into 11 colors from -2 to 34.

Line 6: “display” is a command to draw a figure and the result of executing the following maskout command: The maskout expression excludes the value of -9998 (unobserved) from data1.

Once the command is executed, the plotted data set appears in the drawing window (Figure 6-27).

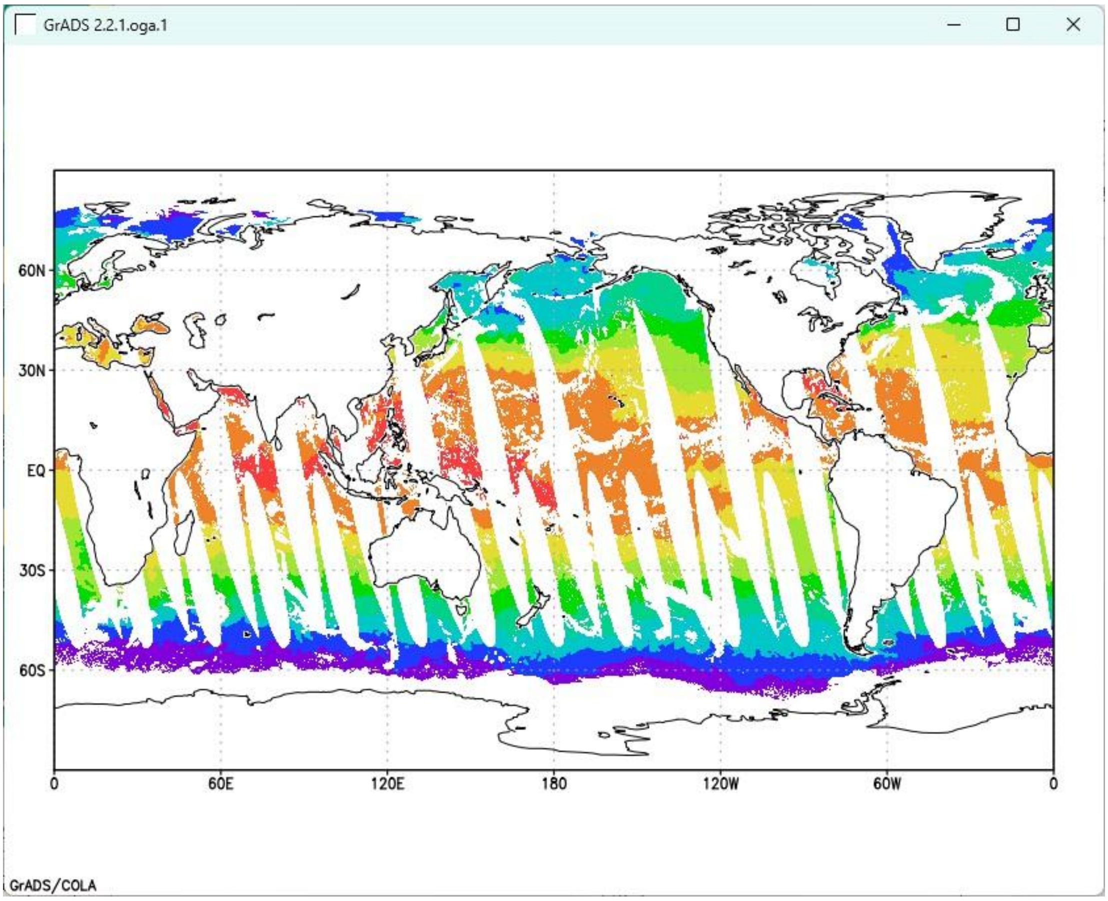


Figure 6-27 AMSR3 product plot image created by OpenGrADS

6.2 Library installation

The sample programs in this book have been tested in the following environments (Table 6-1).

Table 6-1 Sample program verification environment

computer	Intel(R) Xeon(R) Gold 5218
OS	Red Hat Enterprise Linux release 8.4
Python	Python 3.8.8
C Compiler	gcc (GCC) 8.4.1
Fortran Compiler	GNU Fortran (GCC) 8.4.1
HDF5 library	HDF5 version 1.14.4
NetCDF library	NetCDF C version 4.9.2 NetCDF Fortran version 4.6.1

Below is the installation procedure using user privileges only on a Linux computer. The installation destination should be under /home/user1/util, and a directory is created for each library.

Figure 6-28 shows an example of a directory structure.

If you install this directory structure, the old and new versions will coexist when the libraries are upgraded later, and you will be able to use both versions by switching the library path.

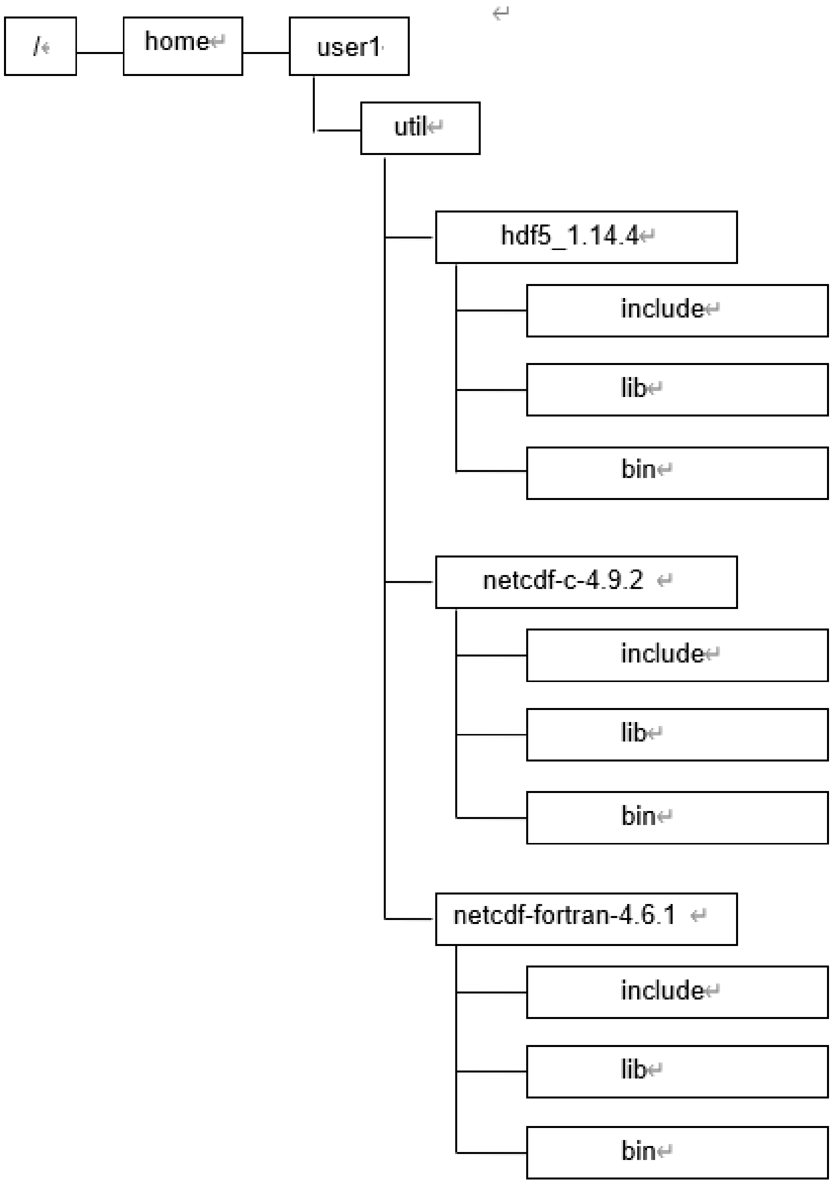


Figure 6-28 Example of directory structure for library installation

6.2.1 Installing the NetCDF library

6.2.1.1 Installing HDF5

(1) Download

Download the source files from the official HDFGroup GitHub (https://github.com/HDFGroup/hdf5).

*The following explanation assumes that you downloaded version 1.14.4.

(2) Extracting the compressed file

Extract the downloaded compressed file to a suitable directory.

```
$ unzip hdf5-hdf5_1.14.4.zip
```

After extraction, a directory called hdf5-hdf5_1.14.4 is created; move into that directory.

```
$ cd hdf5-hdf5_1.14.4
```

(3) Install

Enter the following commands for installation. Specify the installation directory for --prefix=.

*In the example below, the hdf5 version is 1.14.4; therefore, it is set to hdf5_1.14.4.

Replace the version number with the version you will use.

```
$ ./configure --prefix=/home/user1/util/hdf5_1.14.4 ¥
              --with-szlib=no ¥
              --enable-fortran ¥
              FC=gfortran
$ make
$ make install
```

6.2.1.2 Installing the NetCDF-C library

(1) Download

Download the source files from the official NetCDF GitHub (https://github.com/Unidata/netcdf-c).

*The following explanation assumes that you downloaded version 4.9.2.

(2) Extracting the compressed file

Extract the downloaded compressed file to a suitable directory.

```
$ unzip netcdf-c-4.9.2.zip
```

After extraction, a directory called netcdf-c-4.9.2 is created; move into that directory.

```
$ cd netcdf-c-4.9.2
```

(3) Install

Enter the following commands for installation.

Specify the installation directory for --prefix=.

*In the example below, the version of netcdf-c is 4.9.2; therefore, netcdf-c-4.9.2 is used.

Replace the version number with the version you are using.

```
$ ./configure --prefix=/home/user1/util/netcdf-c-4.9.2 ¥ CPPFLAGS=-
              I/home/user1/util/hdf5_1.14.4/include ¥ LDFLAGS=-
              L/home/user1/util/hdf5_1.14.4/lib ¥
--disable-libxml2 ¥
--disable-byterange
$ make
$ make install
```

6.2.1.3 Installing the NetCDF-Fortran Library

(1) Download

Download the source files from the official NetCDF github (https://github.com/Unidata/netcdf-fortran).

*The following explanation assumes that you have downloaded version 4.6.1.

(2) Extracting the compressed file

Extract the downloaded compressed file to a suitable directory.

```
$ unzip netcdf-fortran-4.6.1.zip
```

After extraction, a directory called netcdf-fortran-4.6.1 will be created, so move into that directory.

```
$ cd netcdf-fortran-4.6.1
```

(3) Install

Enter the following commands to install. Specify the installation directory for --prefix=.

*In the example below, the version of netcdf-fortran is 4.6.1; therefore, we use netcdf-fortran-4.6.1. Replace the version number with the version you are actually using.

```
$ ./configure --prefix=/home/user1/util/netcdf-fortran-4.6.1
              ¥ CPPFLAGS=-I/home/user1/util/netcdf-c-4.9.2/include
              ¥ LDFLAGS=-L/home/user1/util/netcdf-c-4.9.2/lib
              ¥ LD_LIBRARY_PATH=/home/user1/util/netcdf-c-4.9.2/lib
$ make
$ make install
```

6.2.1.4 Setting the library path

When using sample programs with the NetCDF library installed in Section 6.2, the library path must be set.

Add the paths of each library installed in 6.2 to the environment variable LD_LIBRARY_PATH.

/home/user1/util/hdf5_1.14.4/lib
/home/user1/util/netcdf-c-4.9.2/lib
/homeuser1/util/netcdf-fortran-4.6.1/lib

6.2.1.5 Setting Environment Variables

Owing to the file-locking function of the HDF5 library, problems may occur when reading AMSR3 products, depending on the environment (e.g., when working with a network file system such as NFS or a parallel file system).

In this case, the file-locking function can be disabled by setting the environment variable HDF5_USE_FILE_LOCKING to FALSE.

For additional information on the file-locking function, please refer to the official HDFGroup documentation on file-locking (https://portal.hdfgroup.org/documentation/hdf5/latest/_file_lock.html).

6.2.2 Checking data using the ncdump command

The ncdump command is included in the NetCDF-C library installed in 6.2.1.2, which is a tool that outputs information about NetCDF files in text format.

6.2.2.1 Displaying Header Information

The ncdump command is located in the bin directory under the directory where the NetCDF-C library is installed. By adding the -h option, only header information is displayed.

$ /home/user1/util/netcdf-c-4.9.2/bin/ncdump -h <NetCDF file name>

```
File(F)  Edit(E)  Setup(S)  Control(O)  Window(W)  Help(H)
netcdf GGWAM3_20200702_01DAEQR_S3HSSTGAZ00A22312 {
dimensions:
        nScan = 3600 ;
        nSwath = 7200 ;
variables:
        float ScanTimeUTC(nScan, nSwath) ;
                ScanTimeUTC:long_name = "time" ;
                ScanTimeUTC:standard_name = "time" ;
                ScanTimeUTC:units = "seconds sice 2020-07-02T00:00:00Z" ;
                ScanTimeUTC:_FillValue = -2.147484e+09f ;
                ScanTimeUTC:scale_factor = 1.f ;
                ScanTimeUTC:add_offset = 0.f ;
                ScanTimeUTC:coordinates = "Latitude Longitude" ;
                ScanTimeUTC:cell_method = "point" ;
        float Data1(nScan, nSwath) ;
                Data1:product_code = "SST" ;
                Data1:DataCode = "SST_6G" ;
                Data1:long_name = "6GHz Sea Surface Temperature" ;
                Data1:standard_name = "sea_surface_temperature" ;
                Data1:units = "degree_Celsius" ;
                Data1:scale_factor = 1.f ;
                Data1:add_offset = 0.f ;
                Data1:coordinates = "Latitude Longitude" ;
                Data1:cell_method = "mean" ;
        float Data2(nScan, nSwath) ;
                Data2:product_code = "SST" ;
                Data2:DataCode = "SST_10G" ;
                Data2:long_name = "10GHz Sea Surface Temperature" ;
                Data2:standard_name = "sea_surface_temperature" ;
                Data2:units = "degree_Celsius" ;
```

Figure 6-29 ncdump command (Header Display)

6.2.2.2 Displaying Data Values

Set the dataset name with the -v option to display the stored values of the specified dataset (Figure 6-30).

The command example below displays the stored values of the dataset named Data1.

$ /home/user1/util/netcdf-c-4.9.2/bin/ncdump -v Data1 <NetCDF file name>

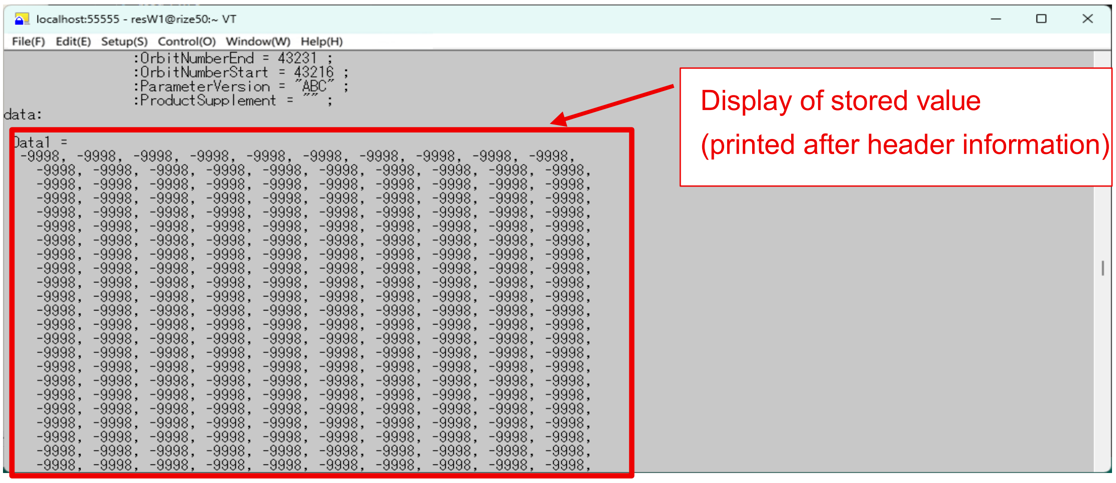


Figure 6-30 ncdump command (displaying stored data values)

6.3 Sample Program

6.3.1 Python Sample Program

In Python, the NetCDF files can be read easily by installing the NetCDF4 module.

Example of installation commands:

$ pip install netcdf4

6.3.1.1 L1B Data Loading

(1) Explanation of the sample program read_L1B.py

The sample program read_L1B.py reads the following attributes and stored data (Table 6-2) from the L1B product specified as an argument and displays the content as text.

Table 6-2 Read target of read_L1B.py

Attribute	Stored Data
<Global Attribute> NumberOfScans NumberOfScansOverlap	Tb_Ch06V

read_L1B.py explanation

```
import sys
import netCDF4
```

Importing Modules

```


# argument check
if len(sys.argv) != 2:
        print("argument: AMSR3 NetCDF Filename")
        sys.exit(1)

# open NetCDF
in_file = sys.argv[1]
print('input file:', in_file)
```

◆Opening a NetCDF file (creating a dataset instance)

Dataset(filepath, mode)

filepath : Set the name of the NetCDF file to be read.

mode : Access mode: 'r' for read.

※For details on class methods, etc., please refer to the netcdf4-python documentation（https://unidata.github.io/netcdf4-python/）.

```
nc = netCDF4.Dataset(in_file, 'r')

# get NumberOfScans
num = nc.getncattr('NumberOfScans')
print('NumberOfScans =', num)

# get NumberOfScansOverlap
ovr = nc.getncattr('NumberOfScansOverlap')
print('NumberOfScansOverlap =', ovr)

# read Dataset & cutoff overlap
data = nc['Tb_Ch06V'][:][ovr:num+ovr, :]

# sample display
print("Tb_Ch06V[scan=0][pixel=0]: {:.2f}".format(data[0, 0]))

# close NetCDF
nc.close()

sys.exit(0)

```

Opening a NetCDF file

In the scan direction index, write ovr:num+over to exclude overlaps.

Loading Data (Tb_Ch06V)
For netcdf4-python
By default, the values are obtained after calculating the scale and offset.

Display the stored value at the position where the number of scans = 0 and the number of pixels = 0 using print().

Closing a NetCDF file

(2) Sample program execution results

The execution result of the sample program is as follows:

read_L1B.py execution result

```
$ python3 ./read_L1B.py GGWAM3_202309030134A020_S1BTBBGAZ00A24253.nc
input file: GGWAM3_202309030134A020_S1BTBBGAZ00A24253.nc
NumberOfScans = 1965
NumberOfScansOverlap = 30
Tb_Ch06V[scan=0][pixel=0]: 239.59
```

6.3.1.2 L1R data loading

(1) Explanation of the sample program read_L1R.py

The sample program read_L1R.py reads the following attributes and stored data (Table 6-3) from the L1R product specified as an argument and displays the content as text.

Table 6-3 Read target of read_L1R.py

Attribute	Stored data
<Global Atribute> NumberOfScans NumberOfScansOverlap	Laitude_P89o Longitude_P89o

read_L1R.py explanation

```
import sys
import netCDF4
# argument check
if len(sys.argv) != 2:
        print("argument: AMSR3 NetCDF Filename")
        sys.exit(1)
# open netCDF
in_file = sys.argv[1]
print('input file:', in_file)
```

Importing Modules

◆Opening a NetCDF file (creating a dataset instance) Dataset (filepath, mode)

filepath : Set the name of the NetCDF file to be read. mode : Access mode: 'r' for read.

※For details on class methods, etc., please refer to the netcdf4-python documentation.（https://unidata.github.io/netcdf4-python/）

```
nc = netCDF4.Dataset(in_file, 'r')
# get NumberOfScans
num = nc.getncattr('NumberOfScans')
print('NumberOfScans =', num)
```

Opening a NetCDF file

```

# get NumberOfScansOverlap
ovr = nc.getncattr('NumberOfScansOverlap')
print('NumberOfScansOverlap =', ovr)

# read Dataset(Latitude) & cutoff overlap
lat = nc['Latitude_P89o'][:][ovr:num+ovr, :]

# read Dataset(Latitude) & cutoff overlap
lon = nc['Longitude_P89o'][:][ovr:num+ovr, :]

# sample display
print("Latitude_P89o[scan=0][pixel=0]: {:.2f}".format(lat[0, 0]))
print("Longitude_P89o[scan=0][pixel=0]: {:.2f}".format(lon[0, 0]))

# close netCDF
nc.close()

sys.exit(0)
```

Loading Data（Latitude_P89o）
For netcdf4-python
By default, the values are obtained after calculating the scale and offset.

In the scan direction index, write ovr:num+over to exclude overlaps.

Display the stored value at the position where the number of scans = 0 and the number of pixels = 0 using print().

Closing a NetCDF file

(2) Sample program execution results

The execution result of the sample program is as follows:

read_L1R.py execution result

```
$ python3 ./read_L1R.py GGWAM3_202309030134A020_S1RTBRGAZ00A24253.nc
input file: GGWAM3_202309030134A020_S1RTBRGAZ00A24253.nc
NumberOfScans = 1965
NumberOfScansOverlap = 30
Latitude_P89o[scan=0][pixel=0]:  -74.76
Longitude_P89o[scan=0][pixel=0]:  -91.28
```

6.3.2 C language sample program

6.3.2.1 L1B Data Loading

(1) Explanation of sample program read_L1B.c

The sample program read_L1B.c reads the following attributes and stored data (Table 6-4) from the L1B product specified as an argument and displays the content as text.

Table 6-4 Read target of read_L1B.c

Attribute	Stored Data
<Global Attribute> NumberOfScans NumberOfScansOverlap <Dataset Attribute> scale_factor add_offset	Tb_Ch06V

read_L1B.c explanation

```
#include <stdlib.h>
#include <stdio.h>
#include "netcdf.h"

// fixed value
#define LMT 2200     // limit of NumberOfScans
#define AM3_DEF_SNUM_HI 486    // high resolution pixel width
#define AM3_DEF_SNUM_LO 243    // low resolution pixel width

int main(int argc, char *argv[]){
        // interface variable
        int retval;              // return value
        int i,j;                 // loop variable
        char *fn    = NULL;      // filename
        int ncid;                // netcdf file id
        int varid;               // variable id

        // attribute variable
        int num;                 // NumberOfScans
        int ovr;                 // NumberOfScansOverlap
```

Include the header file for NetCDF

For near-real (global) products, the number of scans exceeds 2200; therefore, please check the value of NumberOfScans and change it to an appropriate value.

Define the variables for the interface

Define a variable for reading attributes

```
	float scale;		// scale_factor
	float offset;		// add_offset

	// array data
	unsigned short buffer[LMT][AM3_DEF_SNUM_LO]; // read buffer
	float calc_data[LMT][AM3_DEF_SNUM_LO];		// after calculation data

	// argument check
```

Define a variable for reading attributes

The number of array dimensions varies depending on the data.
The number of scans varies slightly depending on the path; therefore, an upper limit (LMT in this program) is defined.
Here, the upper limit is set to 2200.
AM3_DEF_SNUM_HI represents the number of high-resolution pixels (486).
AM3_DEF_SNUM_LO represents the number of low-resolution pixels (243).

```
	if(argc != 2){
		printf("argument: AMSR3 NetCDF Filename¥n");
		exit(1);
	}

	// set filename
	fn = argv[1];
	printf("input file: %s¥n", fn);
```

◆ Opening a NetCDF File
retval = nc_open(path, omode, ncidp);
path: Specifies the name of the NetCDF file to open.
omode: Specifies the open mode. Specifying NC_NOWRITE will make it read-only.
ncidp: Contains the NetCDF ID returned by nc_open.
retval: [Return Value] The value NC_NOERR indicates success; any other value indicates an error.

```
	// NetCDF file open
	retval = nc_open(fn, NC_NOWRITE, &ncid);
	if (retval != NC_NOERR){
		printf("nc_open error: %s¥n" ,nc_strerror(retval));
		exit(retval);
```

```
    }

```

◆Reading an Attribute (Global Attribute)

retval = nc_get_att_int(ncid, varid, name, value);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

varid: Specify NC_GLOBAL for a global attribute.

name: Specifies the attribute name.

value: Contains the attribute value returned by nc_get_att_int.

retval: [Return value] The value NC_NOERR indicates success; any other value results in an error.

※The function to be called depends on the data type of the attribute being read. (nc_get_att_string, nc_get_att_float, etc.)

For details, see the NetCDF documentation (https://docs.unidata.ucar.edu/netcdf-c/).

```
    // get NumberOfScans
    retval = nc_get_att_int(ncid, NC_GLOBAL, "NumberOfScans", &num);
    if (retval != NC_NOERR){
        printf("nc_get_att_int error: %s¥n", nc_strerror(retval));
        exit(retval);
    }
    printf("NumberOfScans = %d¥n", num);
```

The variable num stores the number of scans

```

    // get NumberOfScansOverlap
    retval = nc_get_att_int(ncid, NC_GLOBAL, "NumberOfScansOverlap", &ovr);
    if (retval != NC_NOERR){
        printf("nc_get_att_int error: %s¥n", nc_strerror(retval));
        exit(retval);
    }
    printf("NumberOfScansOverlap = %d¥n", ovr);

```

The variable ovr stores the number of overlaps.

To read stored data, the process is performed in the following order: obtain the dataset ID to be read, then read the data.

◆Obtaining the Dataset ID

retval = nc_inq_varid(ncid, name, varidp);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

name: Specifies the name of the dataset to be read.

varidp: The dataset ID returned by nc_inq_varid is stored here.
retval: [Return value] A value of NC_NOERR indicates success; any other value indicates an error.

```
    // get variable id
    retval = nc_inq_varid(ncid, "Tb_Ch06V", &varid);
    if (retval != NC_NOERR){
        printf("nc_inq_varid error: %s¥n", nc_strerror(retval));
        exit(retval);
    }

```

The variable varid stores the dataset ID of Tb_Ch06V.

◆ Data Retrieval
retval = nc_get_var_ushort(ncid, varid, ip);
ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.
varid: Specifies the dataset ID obtained using nc_inq_varid.
ip: Contains the dataset value returned by nc_get_var_ushort.
The user must allocate memory before calling the function.
retval: [Return Value] The value NC_NOERR indicates success; any other value results in an error.
※The function to be called depends on the data type of the dataset being read.
(nc_get_var_uint, nc_get_var_double, etc.)
For details, see the NetCDF documentation (https://docs.unidata.ucar.edu/netcdf-c/).

```
    // get variable
    retval = nc_get_var_ushort(ncid, varid, &buffer[0][0]);
    if (retval != NC_NOERR){
        printf("nc_get_var_ushort error: %s¥n", nc_strerror(retval));
        exit(retval);
    }

```

The data set Tb_Ch06V loaded by this program is stored as a 2-byte unsigned integer (0 to 65535) and has scale and offset values set; therefore, access the data set attributes to read the scale and offset values.

◆ Read Attribute (Dataset Attribute)
retval = nc_get_att_float(ncid, varid, name, value);
ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.
varid: Specifies the dataset ID obtained using nc_inq_varid.

name: Specifies the attribute name.

value: Contains the attribute value returned by nc_get_att_float.

retval: [Return value] The value NC_NOERR indicates success; any other value results in an error.

※The function to be called depends on the data type of the attribute being read. (nc_get_att_string, nc_get_att_int, etc.)

```
    // get scale_factor
    retval = nc_get_att_float(ncid, varid, "scale_factor", &scale);
    if (retval != NC_NOERR){
        printf("nc_get_att_float(scale) error: %s¥n", nc_strerror(retval));
        exit(retval);
    }
    printf("scale_factor = %5.2f¥n", scale);

    // get add_offset
    retval = nc_get_att_float(ncid, varid, "add_offset", &offset);
    if (retval != NC_NOERR){
        printf("nc_get_att_float(offset) error: %s¥n", nc_strerror(retval));
        exit(retval);
    }
    printf("add_offset = %5.2f¥n", offset);

```

The scale value is stored in the variable scale

The offset value is stored in the variable offset

Remove overlaps from the loaded data and apply scale and offset.
During application, remove the abnormal value (65535).

```
    // cutoff overlap & change scale
    for(j = 0; j < num; ++j){
        for(i = 0; i < AM3_DEF_SNUM_LO; ++i){
            calc_data[j][i] = buffer[j+ovr][i];
            if(calc_data[j][i] != 65535) calc_data[j][i] = calc_data[j][i] * scale + offset;
        }
    }

    // sample display
    printf("Tb_Ch06V[scan=0][pixel=0]: %5.2f¥n", calc_data[0][0]);

```

Add the ovr value to remove the overlap

The abnormal value (65535) is excluded from the calculation of scale and offset.

Output the stored value at the position where the number of scans is 0 and the number of pixels is 0 using printf().

◆Close a NetCDF file

retval = nc_close(ncid);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
    // close
    retval = nc_close(ncid);
    if (retval != NC_NOERR){
        printf("nc_close error: %s¥n", nc_strerror(retval));
        exit(retval);
    }

    exit(0);
}
```

(2) Compilation script (build_read_L1B_c.sh) explanation

The contents of the script build_read_L1B_c.sh used for compilation are explained below.

```
 1 #!/bin/sh
 2
 3 ### environment
 4 export LANG=C
 5
```

On the 7th line, specify the installation directory of the nercdf-c library installed in 6.2 Library Installation.

```
 6 # library directory
 7  NETCDF="/home/user1/util/netcdf-c-4.9.2"
 8
```

On the 10th line, specify the compiler to use. For the GNU C compiler, specify

```
 9 # compiler
10 CC="gcc"
11
12 # source filename
13 CSRC="read_L1B.c"
14
```

```
# output filename
OUT="read_L1B_c"

# library order
LIBS="-lnetcdf"

# c compile
CMD="$CC -g $CSRC -o $OUT -I$NETCDF/include -L$NETCDF/lib $LIBS"
echo $CMD
$CMD
```

Compilation script execution result (compile command) *Line breaks added for readability.

```
$ ./build_read_L1B_c.sh
gcc -g read_L1B.c -o read_L1B_c
-I/home/user1/util/netcdf-c-4.9.2/include
-L/home/user1/util/netcdf-c-4.9.2/lib
-lnetcdf
```

(3) Sample program execution results

The execution result of the sample program is as follows:

read_L1B_c execution result

```
$ ./read_L1B_c GGWAM3_202309030134A020_S1BTBBGAZ00A24253.nc
input file: GGWAM3_202309030134A020_S1BTBBGAZ00A24253.nc
NumberOfScans = 1965
NumberOfScansOverlap = 30
scale_factor =    0.01
add_offset =    0.00
Tb_Ch06V[scan=0][pixel=0]: 239.59
```

6.3.2.2 L1R data loading

(1) Explanation of sample program read_L1R.c

The sample program read_L1R.c reads the following attributes and stored data (Table 6-4) from the L1R product specified as an argument and displays the content as text.

Table 6-5 Read target of read_L1R.c

Attribute	Stored data
<Global Attribute> NumberOfScans NumberOfScansOverlap	Latitude_P89o Longitude_P89o

read_L1R.c Explanation

```
#include <stdlib.h>
#include <stdio.h>
#include "netcdf.h"

// fixed value
#define LMT 2200     // limit of NumberOfScans
#define AM3_DEF_SNUM_HI 486    // high resolution pixel width
#define AM3_DEF_SNUM_LO 243    // low resolution pixel width

int main(int argc, char *argv[]){
        // interface variable
        int retval;              // return value
        int i,j;                 // loop variable
        char *fn    = NULL;      // filename
        int ncid;                // netcdf file id
        int varid;               // variable id

        // attribute variable
        int num;                 // NumberOfScans
        int ovr;                 // NumberOfScansOverlap

        // array data
        float buf[LMT][AM3_DEF_SNUM_LO];        // read data
        float lat[LMT][AM3_DEF_SNUM_LO];        // latitude
        float lon[LMT][AM3_DEF_SNUM_LO];        // longitude
```

Include the header file for NetCDF

For near-real (global) products, the number of scans exceeds 2200; therefore, please check the value of NumberOfScans and change it to an appropriate value.

Define the variables for the interface

Define a variable for reading attributes

Define the array for loading data

The number of array dimensions varies depending on the data.
The number of scans varies slightly depending on the path; therefore, an upper limit (LMT in this program) is defined.
Here, the upper limit is set to 2200.

AM3_DEF_SNUM_HI represents the number of high-resolution pixels (486).
AM3_DEF_SNUM_LO represents the number of low-resolution pixels (243).

```
    // argument check
    if(argc < 2){
        printf("argument: AMSR3 NetCDF Filename¥n");
        exit(1);
    }

    // set filename
    fn = argv[1];
    printf("input file: %s¥n", fn);
```

◆ Opening a NetCDF File

retval = nc_open(path, omode, ncidp);

path: Specifies the name of the NetCDF file to open.

omode: Specifies the open mode. Specifying NC_NOWRITE will make it read-only.

ncidp: Contains the NetCDF ID returned by nc_open.

retval: [Return Value] The value NC_NOERR indicates success; any other value indicates an error.

```
    // NetCDF file open
    retval = nc_open(fn, NC_NOWRITE, &ncid);
    if (retval != NC_NOERR){
        printf("nc_open error: %s¥n", nc_strerror(retval));
        exit(retval);
    }
```

◆ Reading an Attribute (Global Attribute)

retval = nc_get_att_int(ncid, varid, name, value);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

varid: Specify NC_GLOBAL for a global attribute.

name: Specifies the attribute name.

value: Contains the attribute value returned by nc_get_att_int.

retval: [Return value] The value NC_NOERR indicates success; any other value results in an error.

※The function to be called depends on the data type of the attribute being read. (nc_get_att_string, nc_get_att_float, etc.)
For details, see the NetCDF documentation

```
    // get NumberOfScans
    retval = nc_get_att_int(ncid, NC_GLOBAL, "NumberOfScans", &num);
    if (retval != NC_NOERR){
        printf("nc_get_att_int error: %s¥n", nc_strerror(retval));
        exit(retval);
    }
    printf("NumberOfScans = %d¥n", num);
    // get NumberOfScansOverlap
    retval = nc_get_att_int(ncid, NC_GLOBAL, "NumberOfScansOverlap", &ovr);
    if (retval != NC_NOERR){
        printf("nc_get_att_int error: %s¥n", nc_strerror(retval));
        exit(retval);
    }
    printf("NumberOfScansOverlap = %d¥n", ovr);

```

The variable num stores the number of scans

The variable ovr stores the number of overlaps.

To read stored data, the process is performed in the following order: obtain the dataset ID to be read, then read the data.

◆ Obtaining the Dataset ID

retval = nc_inq_varid(ncid, name, varidp);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

name: Specifies the name of the dataset to be read.

varidp: The dataset ID returned by nc_inq_varid is stored here.

retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
    // get variable id(latitude)
    retval = nc_inq_varid(ncid, "Latitude_P89o", &varid);
    if (retval != NC_NOERR){
        printf("nc_inq_varid error: %s¥n", nc_strerror(retval));
        exit(retval);
    }

```

The variable varid will contain the dataset ID of Latitude_P89o.

◆ Data Retrieval

retval = nc_get_var_ushort(ncid, varid, ip);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

varid: Specifies the dataset ID obtained using nc_inq_varid.

ip: Contains the dataset value returned by nc_get_var_ushort.

The user must allocate memory before calling the function.

retval: [Return Value] The value NC_NOERR indicates success; any other value results in an error.

※The function to be called depends on the data type of the dataset being read. (nc_get_var_uint, nc_get_var_double, etc.)

```
// get variable(latitude)
retval = nc_get_var_float(ncid, varid, &buf[0][0]);
if (retval != NC_NOERR){
        printf("nc_get_var_float error: %s¥n", nc_strerror(retval));
        exit(retval);
}

// cutoff overlap(latitude)
for(j = 0; j < num; ++j){
        for(i = 0; i < AM3_DEF_SNUM_LO; ++i){
                lat[j][i] = buf[j+ovr][i];
        }
}

// get variable id(longitude)
retval = nc_inq_varid(ncid, "Longitude_P89o", &varid);
if (retval != NC_NOERR){
        printf("nc_inq_varid error: %s¥n", nc_strerror(retval));
        exit(retval);
}

// get variable(longitude)
retval = nc_get_var_float(ncid, varid, &buf[0][0]);
if (retval != NC_NOERR){
        printf("nc_get_var_float error: %s¥n", nc_strerror(retval));
        exit(retval);
```

The variable buf will contain the data value of Latitude_P89o

The variable varid will contain the dataset ID of Longitude_P89o.

Add the ovr value to remove the overlap

The variable buf stores the data value of Longitude_P89o.

```
    }

    // cutoff overlap(longitude)
    for(j = 0; j < num; ++j){
        for(i = 0; i < AM3_DEF_SNUM_LO; ++i){
            lon[j][i] = buf[j+ovr][i];
        }
    }

    // sample display
    printf("Latitude_P89o[scan=0][pixel=0]: %5.2f¥n", lat[0][0]);
    printf("Longitude_P89o[scan=0][pixel=0]: %5.2f¥n", lon[0][0]);

```

Add the ovr value to remove the overlap

Output the stored value at the position where the number of scans is 0 and the number of pixels is 0 using printf().

◆ Close a NetCDF file

retval = nc_close(ncid);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
    // close
    retval = nc_close(ncid);
    if (retval != NC_NOERR){
        printf("nc_close error: %s¥n", nc_strerror(retval));
        exit(retval);
    }

    exit(0);
}
```

(2) Compilation script (build_read_L1R_c.sh) explanation

The contents of the script build_read_L1R_c.sh used for compilation are explained below.

```
1 #!/bin/sh
2
3 ### environment
4 export LANG=C
```

On the 7th line, specify the installation directory of the nercdf-c library installed in 6.2 Library Installation.

```
5
6 # library directory
7 NETCDF="/home/user1/util/netcdf-c-4.9.2"
8
```

On the 10th line, specify the compiler to use. For the GNU C compiler, specify

```
9 # compiler
10 CC="gcc"
11
12 # source filename
13 CSRC="read_L1R.c"
14
15 # output filename
16 OUT="read_L1R_c"
17
18 # library order
19 LIBS="-lnetcdf"
20
21 # c compile
22 CMD="$CC -g $CSRC -o $OUT -I$NETCDF/include -L$NETCDF/lib $LIBS"
23 echo $CMD
24 $CMD
25
```

Compilation script execution result (compile command) *Line breaks added for readability.

```
$ ./build_read_L1R_c.sh
gcc -g read_L1R.c -o read_L1R_c
-I/home/user1/util/netcdf-c-4.9.2/include
-L/home/user1/util/netcdf-c-4.9.2/lib
-lnetcdf
```

(3) Sample program execution results

The execution result of the sample program is as follows:

read_L1R_c execution result

```
$ ./read_L1R_c GGWAM3_202309030134A020_S1RTBRGAZ00A24253.nc
input file: GGWAM3_202309030134A020_S1RTBRGAZ00A24253.nc
```

```
NumberOfScans = 1965
NumberOfScansOverlap = 30
Latitude_P89o[scan=0][pixel=0]:  -74.76
Longitude_P89o[scan=0][pixel=0]:  -91.28
```

6.3.2.3 Loading L2 low resolution data

(1) Explanation of the sample program read_L2SST.c

The sample program read_L2SST.c reads the following attributes and stored data (Table 6-6) from the L2SST product specified as an argument and displays the content as text.

Table 6-6 Read target of read_L2SST.c

Attribute	Stored data
<Global Attribute> NumberOfScans	Data1_P89o

read_L2SST.c Explanation

```
#include <stdlib.h>
#include <stdio.h>
#include "netcdf.h"

// fixed value
#define LMT 2200    // limit of NumberOfScans
#define AM3_DEF_SNUM_HI 486    // high resolution pixel width
#define AM3_DEF_SNUM_LO 243    // low resolution pixel width

int main(int argc, char *argv[]){
        // interface variable
        int retval;             // return value
        int i,j;                // loop variable
        char *fn    = NULL;     // filename
        int ncid;               // netcdf file id
        int varid;              // variable id

        // attribute variable
        int num;                // NumberOfScans

```

Include the header file for NetCDF

For near-real (global) products, the number of scans exceeds 2200; therefore, please check the value of NumberOfScans and change it to an appropriate value.

Define the variables for the interface

Define a variable for reading attributes

The number of array dimensions varies depending on the data.

The number of scans varies slightly depending on the path; therefore, an upper limit (LMT in this program) is defined.
Here, the upper limit is set to 2200.
AM3_DEF_SNUM_HI represents the number of high-resolution pixels (486).
AM3_DEF_SNUM_LO represents the number of low-resolution pixels (243).

```
// array data
float buffer[LMT][AM3_DEF_SNUM_LO];    // read buffer

// argument check
if(argc != 2){
        printf("argument: AMSR3 NetCDF Filename¥n");
        exit(1);
}

// set filename
fn = argv[1];
printf("input file: %s¥n", fn);

```

Define the array for loading data

◆ Opening a NetCDF File
retval = nc_open(path, omode, ncidp);
path: Specifies the name of the NetCDF file to open.
omode: Specifies the open mode. Specifying NC_NOWRITE will make it read-only.
ncidp: Contains the NetCDF ID returned by nc_open.
retval: [Return Value] The value NC_NOERR indicates success; any other value indicates an error.

```
// NetCDF file open
retval = nc_open(fn, NC_NOWRITE, &ncid);
if (retval != NC_NOERR){
        printf("nc_open error: %s¥n" ,nc_strerror(retval));
        exit(retval);
}

```

◆ Reading an Attribute (Global Attribute)
retval = nc_get_att_int(ncid, varid, name, value);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.
varid: Specify NC_GLOBAL for a global attribute.
name: Specifies the attribute name.
value: Contains the attribute value returned by nc_get_att_int.
retval: [Return value] The value NC_NOERR indicates success; any other value results in an error.
※The function to be called depends on the data type of the attribute being read. (nc_get_att_string, nc_get_att_float, etc.)
For details, see the NetCDF documentation (https://docs.unidata.ucar.edu/netcdf-c/).

```
// get NumberOfScans
retval = nc_get_att_int(ncid, NC_GLOBAL, "NumberOfScans", &num);
if (retval != NC_NOERR){
        printf("nc_get_att_int error: %s¥n" ,nc_strerror(retval));
        exit(retval);
}
printf("NumberOfScans = %d¥n", num);

```

The variable num stores the number of scans

To read stored data, the process is performed in the following order: obtain the dataset ID to be read, then read the data.

◆ Obtaining the Dataset ID
retval = nc_inq_varid(ncid, name, varidp);
ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.
name: Specifies the name of the dataset to be read.
varidp: The dataset ID returned by nc_inq_varid is stored here.
retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
// get variable id
retval = nc_inq_varid(ncid, "Data1_P89o", &varid);
if (retval != NC_NOERR){
        printf("nc_inq_varid error: %s¥n" ,nc_strerror(retval));
        exit(retval);
}

```

The variable varid will contain the dataset ID of Data1_P89o.

◆ Data Retrieval
retval = nc_get_var_ushort(ncid, varid, ip);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

varid: Specifies the dataset ID obtained using nc_inq_varid.

ip: Contains the dataset value returned by nc_get_var_ushort.

The user must allocate memory before calling the function.

retval: [Return Value] The value NC_NOERR indicates success; any other value results in an error.

※The function to be called depends on the data type of the dataset being read.
(nc_get_var_uint, nc_get_var_double, etc.)

For details, see the NetCDF documentation (https://docs.unidata.ucar.edu/netcdf-c/).

```
        // get variable
        retval = nc_get_var_float(ncid, varid, &buffer[0][0]);
        if (retval != NC_NOERR){
                printf("nc_get_var_float error: %s¥n" ,nc_strerror(retval));
                exit(retval);
        }

        // sample display
        printf("Data1_P89o[scan=0][pixel=0]: %5.2f¥n", buffer[0][0]);
```

The data value of Data1_P89o is stored in the variable buffer

Output the stored value at the position where the number of scans is 0 and the number of pixels is 0 using printf().

◆Close a NetCDF file

retval = nc_close(ncid);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
        // close
        retval = nc_close(ncid);
        if (retval != NC_NOERR){
                printf("nc_close error: %s¥n" ,nc_strerror(retval));
                exit(retval);
        }

        exit(0);
}
```

(2) Compilation script（build_read_L2SST.sh） explanation

The contents of the script build_read_L2SST.sh used for compilation are explained below.

```
#!/bin/sh

### environment
```

```
4 export LANG=C
5
```

On the 7th line, specify the installation directory of the nercdf-c library installed in 6.2 Library Installation.

```
6 # library directory
7 NETCDF="/home/user1/util/netcdf-c-4.9.2"
8
```

On the 10th line, specify the compiler to use. For the GNU C compiler, specify

```
9 # compiler
10 CC="gcc"
11
12 # source filename
13 CSRC="read_L2SST.c"
14
15 # output filename
16 OUT="read_L2SST"
17
18 # library order
19 LIBS="-lnetcdf"
20
21 # c compile
22 CMD="$CC -g $CSRC -o $OUT -I$NETCDF/include -L$NETCDF/lib $LIBS"
23 echo $CMD
24 $CMD
25
```

Compilation script execution result (compile command) *Line breaks added for readability.

```
$ ./build_read_L2SST.sh
gcc -g read_L2SST.c -o read_L2SST
-I/home/user1/util/netcdf-c-4.9.2/include
-L/home/user1/util/netcdf-c-4.9.2/lib
-lnetcdf
```

(3) Sample program execution results

The execution result of the sample program is as follows:

read_L2SST Execution result

```
$ ./read_L2SST GGWAM3_202309280118D021_S2MSSTGOZ00A24331.nc
input file: GGWAM3_202309280118D021_S2MSSTGOZ00A24331.nc
NumberOfScans = 1966
Data1_P89o[scan=0][pixel=0]:  -9998.00
```

6.3.2.4 Loading L2 high resolution data

(1) Explanation of the sample program read_L2HST.c

The sample program read_L2HST.c reads the following attributes and stored data (Table 6-7) from the L2HST product specified as an argument and displays the content as text.

Table 6-7 Read target of read_L2HST.c

Attribute	Stored data
<Global Attribute> NumberOfScans	Data1_P89A

read_L2HST.c Explanation

```
#include <stdlib.h>
#include <stdio.h>
#include "netcdf.h"

// fixed value
#define LMT 2200    // limit of NumberOfScans
#define AM3_DEF_SNUM_HI 486    // high resolution pixel width
#define AM3_DEF_SNUM_LO 243    // low resolution pixel width

int main(int argc, char *argv[]){
        // interface variable
        int retval;              // return value
        int i,j;                 // loop variable
        char *fn    = NULL;      // filename
        int ncid;                // netcdf file id
        int varid;               // variable id

```

Include the header file for NetCDF

For near-real (global) products, the number of scans exceeds 2200; therefore, please check the value of NumberOfScans and change it to an appropriate value.

Define the variables for the interface

```
	// attribute variable
	int num;			// NumberOfScans
```

Define a variable for reading attributes

The number of array dimensions varies depending on the data.
The number of scans varies slightly depending on the path; therefore, an upper limit (LMT in this program) is defined.
Here, the upper limit is set to 2200.
AM3_DEF_SNUM_HI represents the number of high-resolution pixels (486).
AM3_DEF_SNUM_LO represents the number of low-resolution pixels (243).

```

	// array data
	float buffer[LMT][AM3_DEF_SNUM_HI];	// read buffer
```

Define the array for loading data

```

	// argument check
	if(argc != 2){
		printf("argument: AMSR3 NetCDF Filename¥n");
		exit(1);
	}

	// set filename
	fn = argv[1];
	printf("input file: %s¥n", fn);

```

◆ Opening a NetCDF File
retval = nc_open(path, omode, ncidp);
path: Specifies the name of the NetCDF file to open.
omode: Specifies the open mode. Specifying NC_NOWRITE will make it read-only.
ncidp: Contains the NetCDF ID returned by nc_open.
retval: [Return Value] The value NC_NOERR indicates success; any other value indicates an error.

```
	// NetCDF file open
	retval = nc_open(fn, NC_NOWRITE, &ncid);
	if (retval != NC_NOERR){
		printf("nc_open error: %s¥n" ,nc_strerror(retval));
		exit(retval);
	}
```

◆ Reading an Attribute (Global Attribute)

retval = nc_get_att_int(ncid, varid, name, value);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open. varid: Specify NC_GLOBAL for a global attribute.

name: Specifies the attribute name.

value: Contains the attribute value returned by nc_get_att_int.

retval: [Return value] The value NC_NOERR indicates success; any other value results in an error.

※The function to be called depends on the data type of the attribute being read. (nc_get_att_string, nc_get_att_float, etc.)

For details, see the NetCDF documentation (https://docs.unidata.ucar.edu/netcdf-c/).

```
// get NumberOfScans
retval = nc_get_att_int(ncid, NC_GLOBAL, "NumberOfScans", &num);
if (retval != NC_NOERR){
        printf("nc_get_att_int error: %s¥n" ,nc_strerror(retval));
        exit(retval);
}
printf("NumberOfScans = %d¥n", num);

```

The variable num stores the number of scans

To read stored data, the process is performed in the following order: obtain the dataset ID to be read, then read the data.

◆ Obtaining the Dataset ID

retval = nc_inq_varid(ncid, name, varidp);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

name: Specifies the name of the dataset to be read.

varidp: The dataset ID returned by nc_inq_varid is stored here.

retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
// get variable id
retval = nc_inq_varid(ncid, "Data1_P89A", &varid);
if (retval != NC_NOERR){
        printf("nc_inq_varid error: %s¥n" ,nc_strerror(retval));
        exit(retval);
}

```

The variable varid will contain the dataset ID of Data1_P89A.

◆ Data Retrieval

retval = nc_get_var_ushort(ncid, varid, ip);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

varid: Specifies the dataset ID obtained using nc_inq_varid.

ip: Contains the dataset value returned by nc_get_var_ushort. The user must allocate memory before calling a function.

retval: [Return Value] The value NC_NOERR indicates success; any other value results in an error.

※The function to be called depends on the data type of the dataset being read. (nc_get_var_uint, nc_get_var_double, etc.)

For details, see the NetCDF documentation (https://docs.unidata.ucar.edu/netcdf-c/).

```
    // get variable
    retval = nc_get_var_float(ncid, varid, &buffer[0][0]);
    if (retval != NC_NOERR){
        printf("nc_get_var_float error: %s¥n" ,nc_strerror(retval));
        exit(retval);
    }

    // sample display
    printf("Data1_P89A[scan=0][pixel=0]: %5.2f¥n", buffer[0][0]); 6
```

The data value of Data1_P89A is stored in the variable buffer

Output the stored value at the position where the number of scans is 0 and the number of pixels is 0 using printf().

◆ Close a NetCDF file

retval = nc_close(ncid);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
    // close
    retval = nc_close(ncid);
    if (retval != NC_NOERR){
        printf("nc_close error: %s¥n" ,nc_strerror(retval));
        exit(retval);
    }

    exit(0);
}
```

(2) Compilation script（build_read_L2HST.sh） explanation

The contents of the script build_read_L2HST.sh used for compilation are explained below.

```
1 #!/bin/sh
2
3 ### environment
4 export LANG=C
5
```

On the 7th line, specify the installation directory of the nercdf-c library installed in 6.2 Library Installation.

```
6 # library directory
7  NETCDF="/home/user1/util/netcdf-c-4.9.2"
8
```

On the 10th line, specify the compiler to use. For the GNU C compiler, specify

```
9 # compiler
10 CC="gcc"
11
12 # source filename
13 CSRC="read_L2HST.c"
14
15 # output filename
16 OUT="read_L2HST"
17
18 # library order
19 LIBS="-lnetcdf"
20
21 # c compile
22 CMD="$CC -g $CSRC -o $OUT -I$NETCDF/include -L$NETCDF/lib $LIBS"
23 echo $CMD
24 $CMD
25
```

Compilation script execution result (compile command) *Line breaks added for readability.

```
$ ./build_read_L2HST.sh
gcc -g read_L2HST.c -o read_L2HST
```

```
-I/home/user1/util/netcdf-c-4.9.2/include
-L/home/user1/util/netcdf-c-4.9.2/lib
-lnetcdf
```

(3) Sample program execution results

The execution result of the sample program is as follows:

read_L2HST Execution result

```
$ ./read_L2HST GGWAM3_202309280118D021_S2HHSTGOZ00A24360.nc
input file: GGWAM3_202309280118D021_S2HHSTGOZ00A24360.nc
NumberOfScans = 1966
Data1_P89A[scan=0][pixel=0]:  -9998.00
```

6.3.2.5 Loading L3 geophysical data

(1) Explanation of the sample program read_L3SST.c

The sample program read_L3SST.c reads the following attributes and stored data (Table 6-8) from the L3SST product specified as an argument and displays the content as text.

Table 6-8 Read target of read_L3SST.c

Attribute	Stored data
	Data1

read_L3SST.c Explanation

```
#include <stdlib.h>
#include <stdio.h>
#include "netcdf.h"


int main(int argc, char *argv[]){
        // interface variable

        int retval;                  // return value
        char *fn    = NULL;          // filename
        int ncid;                    // netcdf file id
        int varid;                   // variable id
        int ndimids[2];              // dimension id
        size_t nscan;                // dimension size nscan
        size_t nswath;               // dimensino size nswath
        int scan;                    // print index(scan)
```

Include the header file for NetCDF

This is an array that stores the dimension IDs of the target dataset (specify 2 in this sample program). Specify a value for the number of dimensions in the dataset. Specifying the constant NC_MAX_VAR_DIMS will set the maximum number of dimensions.

Define the variables for the interface

```
    int swath;              // print index(swath)
    // array data
    float *data1;

    // argument check
    if(argc != 2){
        printf("argument: AMSR3 NetCDF Filename¥n");
        exit(1);
    }

    // set filename
    fn = argv[1];
    printf("input file: %s¥n", fn);

```

Define the variables for the interface

Declare variables for loading data.
(This is simply a declaration: memory for loading data has not yet been allocated.)

◆ Opening a NetCDF File

retval = nc_open(path, omode, ncidp);

path: Specifies the name of the NetCDF file to open.

omode: Specifies the open mode. Specifying NC_NOWRITE will make it read-only.

ncidp: Contains the NetCDF ID returned by nc_open.

retval: [Return Value] The value NC_NOERR indicates success; any other value indicates an error.

```
    // NetCDF file open
    retval = nc_open(fn, NC_NOWRITE, &ncid);
    if (retval != NC_NOERR){
        printf("nc_open error: %s¥n" ,nc_strerror(retval));
        exit(retval);
    }

```

To load stored data, the process is as follows: get the dataset ID to be loaded → get the dimension ID of the dataset → get the size of each dimension → define the memory for the area to be loaded → load the data.

◆ Obtaining the Dataset ID

retval = nc_inq_varid(ncid, name, varidp);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

name: Specifies the name of the dataset to be read.

varidp: The dataset ID returned by nc_inq_varid is stored here.

retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
    // get variable id
    retval = nc_inq_varid(ncid, "Data1", &varid);
    if (retval != NC_NOERR){
        printf("nc_inq_varid error: %s¥n" ,nc_strerror(retval));
        exit(retval);
    }

```

The variable varid will contain the dataset ID of Data1.

◆ Obtaining the dimension ID

retval = nc_inq_vardimid(ncid, varid, dimidsp);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open. varid: Specifies the dataset ID obtained using nc_inq_varid.

dimidsp: Contains the dimension ID value returned by nc_inq_vardimid.

retval: [Return value] The value NC_NOERR indicates success; any other value. indicates an error.

```
    // get dimension id
    retval = nc_inq_vardimid(ncid, varid, ndimids);
    if (retval != NC_NOERR){
        printf("nc_inq_vardimid error: %s¥n" ,nc_strerror(retval));
        exit(retval);
    }
```

Because Data1 is a two-dimensional dataset, the two dimension IDs are stored in the array ndimids.

◆ Obtaining Dimension Size

retval = nc_inq_dimlen(ncid, dimid, lenp);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open. dimid: Specifies the dataset ID obtained using nc_inq_vardimid.

lenp: Contains the dimension size value returned by nc_inq_dimlen.

retval: [Return Value] The value NC_NOERR indicates success; any other value indicates an error.

```
    // get dimension length(nscan)
    retval = nc_inq_dimlen(ncid, ndimids[0], &nscan);
    if (retval != NC_NOERR){
        printf("nc_inq_dimlen error: %s¥n" ,nc_strerror(retval));
```

The size of the array in dimension (nscan) is stored

```
        exit(retval);
    }

    // get dimension length(nswath)
    retval = nc_inq_dimlen(ncid, ndimids[1], &nswath);
    if (retval != NC_NOERR){
        printf("nc_inq_dimlen error: %s¥n" ,nc_strerror(retval));
        exit(retval);
    }

    // allocate memory
    data1 = (float *)calloc((nscan * nswath), sizeof(float));
    if (data1 == NULL){
        printf("calloc error¥n");
        exit(1);
    }
```

The size of the array in dimensions (nswath) is stored

Allocates memory for declared data load variables

◆Data Retrieval

retval = nc_get_var_ushort(ncid, varid, ip);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open. varid: Specifies the dataset ID obtained using nc_inq_varid.

ip: Contains the dataset value returned by nc_get_var_ushort. The user must allocate memory before calling the function.

retval: [Return Value] The value NC_NOERR indicates success; any other value results in an error.

※The function to be called depends on the data type of the dataset being read. (nc_get_var_uint, nc_get_var_double, etc.)

For details, see the NetCDF documentation (https://docs.unidata.ucar.edu/netcdf-c/).

```
    // get variable
    retval = nc_get_var_float(ncid, varid, data1);
    if (retval != NC_NOERR){
        printf("nc_get_var_float error: %s¥n" ,nc_strerror(retval));
        exit(retval);
    }

    // sample display
    scan = 0;
```

The data value of Data1 is stored in the variable data1

```
    swath = 0;
    printf("Data1[scan=%d][swath=%d]: %5.2f¥n", scan, swath, data1[swath + nswath*scan]);

    // free allocated memory
    free(data1);

```

Output the stored value at the position where the number of scans is 0 and the number of pixels is 0 using printf().

Frees allocated memory

◆Close a NetCDF file

retval = nc_close(ncid);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
    // close
    retval = nc_close(ncid);
    if (retval != NC_NOERR){
        printf("nc_close error: %s¥n" ,nc_strerror(retval));
        exit(retval);
    }

    exit(0);
}
```

(2) Compilation script（build_read_L3SST.sh） explanation

The contents of the script build_read_L3SST.sh used for compilation are explained below.

```
1 #!/bin/sh
2
3 ### environment
4 export LANG=C
5
```

On the 7th line, specify the installation directory of the nercdf-c library installed in 6.2 Library Installation.

```
6 # library directory
7  NETCDF="/home/user1/util/netcdf-c-4.9.2"
```

On the 10th line, specify the compiler to use. For the GNU C compiler, specify

```
# compiler
CC="gcc"
# source filename
CSRC="read_L3SST.c"
# output filename
OUT="read_L3SST"
# library order
LIBS="-lnetcdf"
# c compile
CMD="$CC -g $CSRC -o $OUT -I$NETCDF/include -L$NETCDF/lib $LIBS"
echo $CMD
$CMD
```

Compilation script execution result (compile command) *Line breaks added for readability.

```
$ ./build_read_L3SST.sh
gcc -g read_L3SST.c -o read_L3SST
-I/home/user1/util/netcdf-c-4.9.2/include
-L/home/user1/util/netcdf-c-4.9.2/lib
-lnetcdf
```

(3) Sample program execution results

The execution result of the sample program is as follows:

read_L3SST Execution result

```
$ ./read_L3SST GGWAM3_20200702_01DAEQR_S3MSSTGAZ00A22312.nc
input file: GGWAM3_20200702_01DAEQR_S3MSSTGAZ00A22312.nc
Data1[scan=0][swath=0]:  -9998.00
```

6.3.3 Fortran Sample Program

6.3.3.1 L1B Data Loading

(1) Explanation of the sample program read_L1B.f

The sample program read_L1B.f reads the following attributes and stored data (Table 6-9) from the L1B product specified as an argument and displays the content as text.

Table 6-9 Read target of read_L1B.f

Attribute	Stored data
<Global Attribute> NumberOfScans NumberOfScansOverlap <Dataset Attribute> scale_factor add_offset	Tb_Ch06V

read_L1B.f Explanation

```
C
      program main
      implicit none
C include
      include 'netcdf.inc'
C fixed value
      integer,parameter::LMT=2200 ! limit of NumberOfScans
      integer,parameter::AM3_DEF_SNUM_HI=486 ! high resolution pixel width
      integer,parameter::AM3_DEF_SNUM_LO=243 ! low resolution pixel width
C interface variable
      integer retval ! return variable
      integer i, j     ! loop variable
      character fn*512 ! file name
      integer ncid ! netcdf id
      integer varid ! variable id
C attribute variable
      integer num ! NumberOfScans
      integer ovr ! NumberOfScansOverlap
      real(4) scale ! scale_factor
      real(4) offset ! add_offset
```

Include the header file for NetCDF

For near-real (global) products, the number of scans exceeds 2200; therefore, please check the value of NumberOfScans and change

Define the variables for the interface

Define a variable for reading attributes

The number of array dimensions varies depending on the data.
The number of scans varies slightly depending on the path; therefore, an upper limit (LMT in this program) is defined.
Here, the upper limit is set to 2200.
AM3_DEF_SNUM_HI represents the number of high-resolution pixels (486).
AM3_DEF_SNUM_LO represents the number of low-resolution pixels (243).

The data type of the dataset to be read, Tb_Ch06V, is a 2-byte unsigned integer. However, depending on the version of Fortran or the compiler, unsigned values cannot be handled; therefore, in this sample program, a 4-byte integer type is defined as the array to be read.

```
C array data
      integer(4) buffer(AM3_DEF_SNUM_LO, LMT)
      real(4) calc_data(AM3_DEF_SNUM_LO, LMT)
C
C argment check
      if (iargc() .ne. 1) then
        print *, 'argument: AMSR3 NetCDF Filename'
        stop 1
      endif
C
C set file name
      call getarg(1,fn)
      print *, 'input file name : ', trim(fn)
C
```

Define the array for loading data

◆ Opening a NetCDF File
retval = nc_open(path, omode, ncidp);
path: Specifies the name of the NetCDF file to open.
omode: Specifies the open mode. Specifying NC_NOWRITE will make it read-only.
ncidp: Contains the NetCDF ID returned by nc_open.
retval: [Return Value] The value NC_NOERR indicates success; any other value indicates an error.

```
C NetCDF file open
      retval = nf_open(trim(fn), NF_NOWRITE, ncid)
      if (retval .ne. NF_NOERR) then
        print *, 'nf_open error: ', nf_strerror(retval)
```

```
            stop 1
          endif
C
```

◆ Reading an Attribute (Global Attribute)

retval = nc_get_att_int(ncid, varid, name, value);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

varid: Specify NC_GLOBAL for a global attribute.

name: Specifies the attribute name.

value: Contains the attribute value returned by nc_get_att_int.

retval: [Return value] The value NC_NOERR indicates success; any other value results in an error.

※The function to be called depends on the data type of the attribute being read. (nc_get_att_string, nc_get_att_float, etc.)

```
C get NumberOfScans
          retval = nf_get_att_int(ncid, NF_GLOBAL, "NumberOfScans", num)
          if (retval .ne. NF_NOERR) then
            print *, 'nf_get_att_int(NumberOfScans) error: ',
     $                nf_strerror(retval)
            stop 1
          endif
          print '(A, I5)', 'NumberOfScans = ', num
C
C get NumberOfScansOverlap
          retval = nf_get_att_int(ncid, NF_GLOBAL, "NumberOfScansOverlap",
     $                            ovr)
          if (retval .ne. NF_NOERR) then
            print *, 'nf_get_att_int(NumberOfScansOverlap) error: ',
     $                nf_strerror(retval)
            stop 1
          endif
          print '(A, I3)', 'NumberOfScansOverlap = ', ovr
C
```

The variable num stores the number of scans

The variable ovr stores the number of overlaps.

To read stored data, the process is performed in the following order: obtain the dataset ID to be read, then read the data.

◆ Obtaining the Dataset ID

retval = nc_inq_varid(ncid, name, varidp);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open. name: Specifies the name of the dataset to be read.
varidp: The dataset ID returned by nc_inq_varid is stored here.
retval: [Return value] The value NC_NOERR indicates success; any other value. indicates an error.

```
C get variable id
      retval = nf_inq_varid(ncid, "Tb_Ch06V", varid)
      if (retval .ne. NF_NOERR) then
         print *, 'nf_inq_varid(Tb_Ch06V) error: ', nf_strerror(retval)
         stop 1
      endif

```

The variable varid will contain the dataset ID of Tb_Ch06V.

◆ Data Retrieval
retval = nf_get_var_int(ncid, varid, ip);
ncid: Specifies the NetCDF ID (or group ID) obtained using nf_open.
varid: Specifies the dataset ID obtained using nf_inq_varid.
ip: Contains the dataset value returned by nf_get_var_int. The user must allocate memory before calling the function.
retval: [Return Value] The value NF_NOERR results in successful completion; any other value results in an error.
※The function to be called depends on the data type of the dataset being read.

```
C get variable
      retval = nf_get_var_int(ncid, varid, buffer)
      if (retval .ne. NF_NOERR) then
         print *, 'nf_get_var_int(Tb_Ch06V) error: ',
     $           nf_strerror(retval)
         stop 1
      endif
C
```

The variable buffer stores the data value of Tb_Ch06V.

Access the dataset attributes to read the scale and offset values.

◆ Reading Attributes (Dataset Attributes)
retval = nc_get_att_real(ncid, varid, name, value);
ncid: Specifies the NetCDF ID (or group ID) obtained using nf_open.
varid: Specifies the dataset ID obtained using nf_inq_varid.
name: Specifies the attribute name.

value: The attribute value returned by nf_get_att_real is stored here.

retval: [Return value] The value NF_NOERR indicates success; any other value results in an error.

*The function to be called depends on the data type of the attribute being read. (nf_get_att_text, nf_get_att_int, etc.)

```
C get scale_factor
      retval = nf_get_att_real(ncid, varid, "scale_factor",
     $                              scale)
      if (retval .ne. NF_NOERR) then
         print *, 'nf_get_att_float(scale_factor) error: ',
     $            nf_strerror(retval)
         stop 1
      endif
      print '(A, F5.2)', 'scale_factor = ', scale
C
C get add_offset
      retval = nf_get_att_real(ncid, varid, "add_offset",
     $                              offset)
      if (retval .ne. NF_NOERR) then
         print *, 'nf_get_att_float(add_offset) error: ',
     $            nf_strerror(retval)
         stop 1
      endif
      print '(A, F5.2)', 'add_offset = ', offset
C
```

The scale value is stored in the variable scale

The offset value is stored in the variable offset

Remove overlaps from the loaded data and apply scale and offset.
During application, remove the abnormal value (65535).

```
C cutoff overlap & change scale
      do j=1,num
         do i=1,AM3_DEF_SNUM_LO
             calc_data(i, j) = buffer(i, j+ovr)
             if(calc_data(i, j) .ne. 65535) then
                 calc_data(i, j) = calc_data(i, j) * scale + offset
             endif
         enddo
      enddo
```

Add the ovr value to remove the overlap

The abnormal value (65535) is excluded from the calculation of scale and offset.

Output the stored value at the position where the number of scans is 0 and the number of pixels is 0 using printf().

```
C
C sample display
      print '(A, F7.2)', 'Tb_Ch06V[scan=0][pixel=0]:', calc_data(1, 1)
C
```

◆Close a NetCDF file

retval = nc_close(ncid);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
C close
      retval = nf_close(ncid)
      if (retval .ne. NF_NOERR) then
        print *, 'nf_close error: ', nf_strerror(retval)
        stop 1
      endif

      end program main

```

(2) Compilation script（build_read_L1B_f.sh） explanation

The contents of the script build_read_L1B_f.sh used for compilation are explained below.

```
 1 #!/bin/sh
 2
 3 ### environment
 4 export LANG=C
 5
```

On the 7th line, specify the installation directory of the nercdf-fortran library installed in 6.2 Library Installation.

```
 6 # library directory
 7  NETCDF="/home/user1/util/netcdf-fortran-4.6.1"
 8
```

Specify the compiler to use On the 10th line.

For the GNU Fortran compiler, specify "gfortran".

```
 9 # compiler
10 FC="gfortran"
```

```
# source filename
FSRC="read_L1B.f"
# output filename
OUT="read_L1B_f"
# library order
LIBS="-lnetcdff"
# c compile
CMD="$FC -g $FSRC -o $OUT -I$NETCDF/include -L$NETCDF/lib $LIBS"
echo $CMD
$CMD
```

Compilation script execution result (compile command) *Line breaks added for readability.

```
$ ./build_read_L1B_f.sh
gfortran -g read_L1B.f -o read_L1B_f
-I/home/user1/util/netcdf-c-4.9.2/include
-L/home/user1/util/netcdf-c-4.9.2/lib
-lnetcdff
```

(3) Sample program execution results

The execution result of the sample program is as follows:

read_L1B_f Execution result

```
$ ./read_L1B_f GGWAM3_202309030134A020_S1BTBBGAZ00A24253.nc
input file name : GGWAM3_202309030134A020_S1BTBBGAZ00A24253.nc
NumberOfScans =    1965
NumberOfScansOverlap =    30
scale_factor =    0.01
add_offset =    0.00
Tb_Ch06V[scan=0][pixel=0]: 239.59
```

6.3.3.2 L1R data loading

(4) Explanation of the sample program read_L1R.f

The sample program read_L1R.f reads the following attributes and stored data (Table 6-10) from the L1R product specified as an argument and displays the contents as text.

Table 6-10 Read target of read_L1R.f

Attribute	Stored data
<Global Attribute> NumberOfScans NumberOfScansOverlap	Latitude_P89o Longitude_P89o

read_L1R.f Explanation

```
C
      program main
      implicit none
C include
      include 'netcdf.inc'
C fixed value
      integer,parameter::LMT=2200 ! limit of NumberOfScans
      integer,parameter::AM3_DEF_SNUM_HI=486 ! high resolution pixel width
      integer,parameter::AM3_DEF_SNUM_LO=243 ! low resolution pixel width
C interface variable
      integer retval ! return variable
      integer i, j     ! loop variable
      character fn*512 ! file name
      integer ncid ! netcdf id
      integer varid ! variable id
C attribute variable
      integer num ! NumberOfScans
      integer ovr ! NumberOfScansOverlap
C array data
      real(4) buffer(AM3_DEF_SNUM_LO, LMT)
      real(4) lat(AM3_DEF_SNUM_LO, LMT)
      real(4) lon(AM3_DEF_SNUM_LO, LMT)
```

Include the header file for NetCDF

For near-real (global) products, the number of scans exceeds 2200, so please check the value of NumberOfScans and change it to an appropriate value.

Define the variables for the interface

Define a variable for reading attributes

The number of array dimensions varies depending on the data.

The number of scans varies slightly depending on the path. Therefore, an upper limit (LMT in this program) is defined.
Here, the upper limit is set to 2200.
AM3_DEF_SNUM_HI represents the number of high-resolution pixels (486).
AM3_DEF_SNUM_LO represents the number of low-resolution pixels (243).

```
C
C argment check
      if (iargc() .ne. 1) then
        print *, 'argument: AMSR3 NetCDF Filename'
        stop 1
      endif
C
C set file name
      call getarg(1,fn)
      print *, 'input file name : ', trim(fn)
C
```

◆ Opening a NetCDF File
retval = nc_open(path, omode, ncidp);
path: Specifies the name of the NetCDF file to open.
omode: Specifies the open mode. Specifying NC_NOWRITE will make it read-only.
ncidp: Contains the NetCDF ID returned by nc_open.
retval: [Return Value] The value NC_NOERR indicates success; any other value indicates an error.

```
C NetCDF file open
      retval = nf_open(trim(fn), NF_NOWRITE, ncid)
      if (retval .ne. NF_NOERR) then
        print *, 'nf_open error: ', nf_strerror(retval)
        stop 1
      endif
C
```

◆ Reading an Attribute (Global Attribute)
retval = nc_get_att_int(ncid, varid, name, value);
ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.
varid: Specify NC_GLOBAL for a global attribute.
name: Specifies the attribute name.

value: Contains the attribute value returned by nc_get_att_int.
retval: [Return value] The value NC_NOERR indicates success; any other value results in an error.
※The function to be called depends on the data type of the attribute being read.

```
C get NumberOfScans
      retval = nf_get_att_int(ncid, NF_GLOBAL, "NumberOfScans", num)
      if (retval .ne. NF_NOERR) then
        print *, 'nf_get_att_int(NumberOfScans) error: ',
     $             nf_strerror(retval)
        stop 1
      endif
      print '(A, I5)', 'NumberOfScans = ', num
C
C get NumberOfScansOverlap
      retval = nf_get_att_int(ncid, NF_GLOBAL, "NumberOfScansOverlap",
     $                        ovr)
      if (retval .ne. NF_NOERR) then
        print *, 'nf_get_att_int(NumberOfScansOverlap) error: ',
     $             nf_strerror(retval)
        stop 1
      endif
      print '(A, I3)', 'NumberOfScansOverlap = ', ovr
C
```

The variable num stores the number of scans

The variable ovr stores the number of overlaps.

To read stored data, the process is performed in the following order: obtain the dataset ID to be read, then read the data.

◆Obtaining the Dataset ID
retval = nc_inq_varid(ncid, name, varidp);
ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.
name: Specifies the name of the dataset to be read.
varidp: The dataset ID returned by nc_inq_varid is stored here.
retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
C get variable id(latitude)
      retval = nf_inq_varid(ncid, "Latitude_P89o", varid)
      if (retval .ne. NF_NOERR) then
```

The variable varid will contain the dataset ID of Latitude_P89o.

```
            print *, 'nf_inq_varid(Latitude_P89o) error: ',
     $                 nf_strerror(retval)
            stop 1
          endif
C
```

◆ Data Retrieval

retval = nf_get_var_real(ncid, varid, ip);

ncid: Specifies the NetCDF ID (or group ID) obtained using nf_open.

varid: Specifies the dataset ID obtained using nf_inq_varid.

ip: Contains the dataset value returned by nf_get_var_real. The user must allocate memory before calling the function.

retval: [Return value] The value NF_NOERR indicates success; any other value results in an error.

※The function to be called depends on the data type of the dataset being read.

```
C get variable(latitude)
          retval = nf_get_var_real(ncid, varid, buffer)
          if (retval .ne. NF_NOERR) then
             print *, 'nf_get_var_real(Latitude_P89o) error: ',
     $              nf_strerror(retval)
            stop 1
          endif
C
C cutoff overlap(latitude)
          do j=1,num
            do i=1,AM3_DEF_SNUM_LO
                lat(i, j) = buffer(i, j+ovr)
            enddo
          enddo
C
C get variable id(longitude)
          retval = nf_inq_varid(ncid, "Longitude_P89o", varid)
          if (retval .ne. NF_NOERR) then
            print *, 'nf_inq_varid(Longitude_P89o) error: ',
     $                 nf_strerror(retval)
            stop 1
          endif
```

The variable buffer will contain the data value of Latitude_P89o

Add the ovr value to remove the overlap

The variable varid will contain the dataset ID of Longitude_P89o.

```
C
C get variable(longitude)
      retval = nf_get_var_real(ncid, varid, buffer)
      if (retval .ne. NF_NOERR) then
        print *, 'nf_get_var_int(Latitude_P89o) error: ',
     $          nf_strerror(retval)
        stop 1
      endif
```

The variable buffer will contain the data value of Longitude_P89o

```
C
C cutoff overlap(longitude)
      do j=1,num
        do i=1,AM3_DEF_SNUM_LO
            lon(i, j) = buffer(i, j+ovr)
        enddo
      enddo
```

Add the ovr value to remove the overlap

```
C
C sample display
      print '(A, F7.2)', 'Latitude_P89o[scan=0][pixel=0]:', lat(1, 1)
      print '(A, F7.2)', 'Longitude_P89o[scan=0][pixel=0]:', lon(1, 1)
C
```

Output the stored value at the position where the number of scans is 0 and the number of pixels is 0 using printf().

◆ Close a NetCDF file

retval = nc_close(ncid);

ncid: Specifies the NetCDF ID (or group ID) obtained using nc_open.

retval: [Return value] The value NC_NOERR indicates success; any other value indicates an error.

```
C close
      retval = nf_close(ncid)
      if (retval .ne. NF_NOERR) then
        print *, 'nf_close error: ', nf_strerror(retval)
        stop 1
      endif

      end program main

```

(2) Compilation script（build_read_L1R_f.sh） explanation

The contents of the script build_read_L1R_f.sh used for compilation are explained below.

```
1 #!/bin/sh
2
3 ### environment
4 export LANG=C
5
```

On the 7th line, specify the installation directory of the nercdf-fortran library installed in 6.2 Library Installation.

```
6 # library directory
7  NETCDF="/home/user1/util/netcdf-fortran-4.6.1"
8
```

Specify the compiler to use On the 10th line.
For the GNU Fortran compiler, specify "gfortran".

```
9 # compiler
10 FC="gfortran"
11
12 # source filename
13 FSRC="read_L1R.f"
14
15 # output filename
16 OUT="read_L1R_f"
17
18 # library order
19 LIBS="-lnetcdff"
20
21 # c compile
22 CMD="$FC -g $FSRC -o $OUT -I$NETCDF/include -L$NETCDF/lib $LIBS"
23 echo $CMD
24 $CMD
25
```

Compilation script execution result (compile command) *Line breaks added for readability.

```
$ ./build_read_L1R_f.sh
gfortran -g read_L1R.f -o read_L1R_f
-I/home/user1/util/netcdf-c-4.9.2/include
-L/home/user1/util/netcdf-c-4.9.2/lib
```

```
-lnetcdf
```

(3) Sample program execution results

The execution result of the sample program is as follows:

read_L1R_f Execution result

```
$ ./read_L1R_f GGWAM3_202309030134A020_S1RTBRGAZ00A24253.nc
input file name : GGWAM3_202309030134A020_S1RTBRGAZ00A24253.nc
NumberOfScans =    1965
NumberOfScansOverlap =    30
Latitude_P89o[scan=0][pixel=0]:  -74.76
Longitude_P89o[scan=0][pixel=0]:  -91.28
```

Appendix 1

Acronyms

ADEOS-Ⅱ	:	ADvanced Earth Observing Satellite - Ⅱ
ADM	:	Antenna Drive Mechanism
AGC	:	Auto Gain Control
AMSR	:	Advanced Microwave Scanning Radiometer
AMSR-E	:	AMSR for EOS-PM
AMSR2	:	Advanced Microwave Scanning Radiometer 2
AMSR3	:	Advanced Microwave Scanning Radiometer 3
APID	:	Application Process Identifier
ASD	:	APID-sorted data
ASW	:	All-weather Sea Surface Wind speed
BEACH	:	Basement of Earth observation Analysis Core and Hub system
BNFS	:	BEACH Network File System
CCSDS	:	Consultative Committee for Space Data Systems
CEOS	:	Committee on Earth Observation Satellites
CGMS	:	Coordination Group for Meteorological Satellites
CLW	:	Cloud Liquid Water
CMD	:	Command
CSM	:	Cold Sky Mirror
DPR	:	Dual-frequency Precipitation Radar
EarthCARE/CPR	:	Earth Clouds, Aerosols and Radiation Explorer/Cloud Profiling Radar
EORC	:	Earth Observation Research Center
EQR	:	EQuiRectangular
GCOM	:	Global Change Observation Mission
GCOM-C	:	Global Change Observation Mission – Climate
GCOM-W	:	Global Change Observation Mission – Water
GEOSS	:	Global Earth Observation System of Systems
GOSAT-2	:	Greenhouse gases Observing SATellite-2
GOSAT-GW	:	Global Observing SATellite for Greenhouse gases and Water cycle
GPM/DPR	:	Global Precipitation Measurement/Dual-frequency Precipitation Radar
GPM/GMI	:	Global Precipitation Measurement/GPM Microwave Imager
GPM X-Cal	:	GPM Intercalibration (X-Cal)
G-Portal	:	Globe Portal system
GPS	:	Global Positioning System
GSICS	:	Global Space-based Inter-Calibration System
GSMaP	:	Global Satellite Mapping of Precipitation
GTS	:	Global Telecommunication System

Acronyms

HDF	:	Hierarchical Data Format
HK	:	House Keeping
HSI	:	High-resolution Sea Ice Concentration
HTS	:	High Temperature Source
IFOV	:	Instantaneous Field Of View
IGS	:	International GNSS Service
IPWG	:	International Precipitation Working Group
JAXA	:	Japan Aerospace eXploration Agency
KSAT	:	Kongsberg SATellite Services AS
LLM	:	Low-Load-Mode
MODIS	:	MODerate resolution Imaging Spectroradiometer
MREF	:	Main Reflector
MWA	:	Momentum Wheel Assembly
NASA	:	National Aeronautics and Space Administration
NDBC	:	National Data Buoy Center
NOAA	:	National Oceanic and Atmospheric Administration
OBM	:	Orbital Balancing Mechanism
PDUC	:	Power Distributor Unit Control Unit
PDUS	:	Power Distributor Unit Sensor Unit
PRC	:	Precipitation
PS	:	Polar Stereo Map Projection
RA	:	Research Announcement
RF	:	Radio Frequency
RFI	:	Radio-Frequency Interference
RMS	:	Root Mean Square
RMSE	:	Root Mean Square Error
SGLI	:	Second generation Global Imager
SIC	:	Sea Ice Concentration
SIM	:	Sea Ice Motion Vector
SMC	:	Soil Moisture Content
SND	:	Snow Depth
SPC	:	Signal Processor Control Unit
SPS	:	Signal Processor Sensor Unit
SST	:	Sea Surface Temperature
SSW	:	Sea Surface Wind speed
TAI	:	International Atomic Time
TB	:	brightness temperature
TCC	:	Thermal Controller Control Unit

Acronyms

TCS	:	Thermal Controller Sensor Unit
TLM	:	Telemetry
TPW	:	Total Precipitable Water
TT&C	:	Telemetry, Tracking, and Command
UT	:	Universal Time
UTC	:	Coordinated Universal Time
VIIRS	:	Visible and Infrared Imager Radiometer Suite
WGCV	:	Working Group on Calibration and Validation
WMO	:	World Meteorological Organization

Appendix 2 Related Information

Appendix2.1 Bibliography

(1) AMSR3 Level 1 product format specification(FTZ-250040, FTZ-250041, FTZ-250042)

(2) AMSR3 Higher level product format specification(FTZ-250045, FTZ-25006)

(3) AMSR3 Level 1 algorithm Description Document (Japanese)

(4) AMSR3 Higher level Algorithm Description Document (Japanese)

(5) GCOM-W/MOS Earth Observation Satellite Data Archive Policy (Japanese)(SAM-160047)

(6) AMSR3/GOSAT-GW MISSION OPERATIONS INTERFACE SPECIFICATION (MOIS)

(7) AMSR3/GOSAT-GW Ground System Operation Concept (Japanese) (FTZ-180019)

(8) AMSR3/GOSAT-GW Nominal Operations Baseline (Mission Operations) (Japanese) (N/A)

(9) AMSR3/GOSAT-GW Higher-Level Processing System Interface Specification (FTZ-200004-0B) (Japanese)

(10) AMSR3 Algorithm calibration and verification plan (Japanese) (NDX-2021021)

(11) GOSAT-GW Research Project Implementation Plan (Japanese) (NDX-2021021)

(12) AMSR3 Algorithm development plan(NDX-2021022)

(13) G-Portal User's Manual

Appendix2.2 Relevant Websites

■ JAXA's site

(1) JAXA website
https://global.jaxa.jp/

(2) Space Technology Directorate/Satellite System Development Unit/GOSAT-GW
https://www.satnavi.jaxa.jp/files/project/gosat-gw/en/

(3) AMSR series Web
https://www.eorc.jaxa.jp/AMSR/index_en.html

■ Overseas

(1) NetCDF Website
https://www.unidata.ucar.edu/software/netcdf/

(2) HDF Website
http://www.hdfgroup.org/

Appendix2.3 Point of contact

◆About Data distribution and this Data Users Handbook

Japan Aerospace Exploration Agency G-Portal support desk
Japan Aerospace Exploration Agency 2-1-1 Sengen Tsukuba Ibaraki 305-8505 JAPAN
E-mail：z-gportal-support[*]ml.jaxa.jp
(Note) Please change [*] to @.