GOSAT-2 / IBUKI-2 Data Users Handbook

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Preface

Greenhouse gases emitted by humans are inferred as one of the major causes of global warming. ‘The Kyoto Protocol’ was adopted at the third session of the Conference of Parties to the UNFCC (COP3) held in Kyoto in 1997. Japan Aerospace Exploration Agency (JAXA), Ministry of the Environment (MOE) and National Institute for Environmental Studies (NIES) developed the GOSAT (Greenhouse gases Observing SATellite, IBUKI) in order to contribute to global warming countermeasure and started observations of ‘carbon dioxide’ and ‘methane’ in 2009 which have geographical limitations by conventional ground observations.
The global distribution of ground based observation of greenhouse gases are geographically uneven and have geographical gaps. International coordination on data precision and data accumulation technique is necessary to monitor the global concentrations. ‘IBUKI’ has made it possible to observe carbon dioxide and methane concentrations around the globe uniformly. ‘IBUKI’ data revealed that the average annual carbon dioxide aged concentration in the global atmosphere has exceeded 400 ppm in February, 2016.
The 49th session of the Intergovernmental Panel on Climate Change (IPCC), in which experts from around the world participated to evaluate science studies and measures about climate change, was held in Kyoto in May, 2019. From the results of 10 years of ‘IBUKI’, ‘the effectiveness of greenhouse gas observation data using satellite’ was described refinement version of ‘IPCC guidelines on national greenhouse gas inventories’ and announced in 2019.
As the successor to the ‘IBUKI’ mission, ‘IBUKI-2’ was launched on October 29th, 2018, which aims to improve the accuracy of greenhouse gases observation with higher-performance observation sensors, to provide environmental administrations with the latest information on greenhouse gases to contribute international efforts to prevent global warming.
‘IBUKI’ and ‘IBUKI-2’ have spectrometers with world’s highest spectral resolution. They can observe reflection of sunlight at the ground surface and thermal radiation of carbon dioxide and methane from the ground surface simultaneously. This is unique function which they only have in the world. There are two merits to use this characteristics. First is to grasp the regional differences, seasonal variations and annual variations. Second is to acquire long-term data with distinguishing upper and lower tropospheric concentrations.
‘IBUKI-2’ not only improved observation accuracy but also optimizes observation patterns to grasp the greenhouse gas emissions and removals more precisely (enhanced target-point observation functions). In particular, this satellite can observe accurately carbon dioxide sources; power plants or big cities, and large-scale anthropogenic emission sources; oil fields, natural gas fields, waste treatment plants and livestock farms.
In addition to ‘IBUKI’s performances, ‘IBUKI-2’ observes ‘carbon monoxide’ generated by combustion as the new observation target and does not miss the carbon dioxide sources.

`IBUKI-2’ data is distributed free of charge as well as ‘IBUKI’. It is widely available to not only government officials or researchers but also general users.
This handbook is for those who are considering using ‘IBUKI-2’ data and the general public who want to deepen their understanding of observation data. This handbook is organized as one book that summarizes the necessary information for data users such as the definition of product file name, product format, data product distribution, etc. Its structure is designed for easy reference according to the purposes. This handbook is written as a guide book rather than technical book for professional use, the explanation in this handbook is much simplified about standard products including overview of spacecraft and mission operations with regard to ‘IBUKI-2’. For more details, please refer to the information listed in Chapter 2.
We hope the ‘IBUKI-2’ data will be utilized by the users widely as well as ‘IBUKI’ data and will be useful to derive emissions and reductions of greenhouse gases based on greenhouse gas concentrations data with higher accuracy at whole earth and large-scale emission sources. Furthermore, we hope it contributes to reduction policy of greenhouse gas emissions.

GOSAT-2 / IBUKI-2 Data Users Handbook

Contents

Chapter 8. GOSAT-2 Data Product Distribution

Chapter 9. Related Information

Appendix 1 Acronyms

Appendix 2 Terminology

Chapter 1. Introduction

1.1 Purpose

This handbook intends to make the GOSAT-2 (Greenhouse gases Observing Satellite-2, so-called IBUKI-2) data to be acknowledged by users in general and provides them with information about the GOSAT-2 standard products as well as the background knowledge of the spacecraft, sensors, ground systems, and so on; thereby promoting a wide use of the data products and serving users with convenience.

1.2 Scope and Composition

The composition of this handbook is as follows.

Chapter 1	:	Describes the purpose, scope, composition and summary of GOSAT-2 project.
Chapter 2	:	Describes the references and source information.
Chapter 3	:	Describes the outline of GOSAT-2 spacecraft system.
Chapter 4	:	Describes the outline of GOSAT-2 mission operations.
Chapter 5	:	Describes the outline of GOSAT-2 ground systems.
Chapter 6	:	Describes the overview of GOSAT-2 ground system operations.
Chapter 7	:	Describes specifications of GOSAT-2 products and their processing algorithm.
Chapter 8	:	Describes the policy and the way of providing GOSAT-2 products.
Chapter 9	:	Describes the contact details for this book and GOSAT-2 products.
Appendix	:	Acronyms and terminology

Notes:
The specifications and processing algorithm are described in this handbook to give readers essential perspectives as the general overview; for details, please refer to the information in Chapter 2.
The data delivery service defined in chapter 8 deals with GOSAT-2 data products provided by National Institute for Environmental Studies (NIES) for general users.

1.3 GOSAT-2 Project Overview

GOSAT-2 is a follow-on mission of GOSAT which was launched in 2009. It is the joint project of Ministry of the Environment (MOE), NIES and Japan Aerospace Exploration Agency (JAXA).

The Kyoto Protocol in 1997 puts the obligation on developed countries to reduce emissions of greenhouse gases and to submit a report of inventories of all anthropogenic greenhouse gas emissions from sources and removals from sinks. However prior to the creation of the GOSAT, there was no promising transparent method that could be used to evaluate the reports of each country uniformly. GOSAT made it possible to get a uniform map of carbon dioxide and methane concentrations around the globe to solve this problem. Also, GOSAT observation data is useful to improve the estimated accuracy of the emissions and reductions for advancing the climate change prediction and reducing the carbon emissions in the future.

As the successor to the GOSAT mission, GOSAT-2/IBUKI-2 aims to gather observations of carbon dioxide and methane with higher levels of accuracy via even higher-performance onboard observation sensors. In addition, it has new purpose to observing carbon monoxide.

GOSAT-2 system contributes to monitor greenhouse gases emissions, validate the countermeasure effects, and monitor air pollution of PM2.5 or black carbon (soot) concentration in the atmosphere by using light scattering for wavelength.

Chapter 2. References

The following documents are referenced in this handbook as the sources or guides for context and user convenience.

2.1 Products Specifications

Document No.	Title	Remarks
GST-180002	JAXA GOSAT-2 プロダクト定義書 (JAXA GOSAT-2 Product Definition)	JAXA document in Japanese
NIES-GOSAT2-SYS-20160513-0060	国立環境研究所 GOAT-2 プロダクト定義書 (NIES GOSAT-2 Product Definition)	NIES document in Japanese
GST-180055	JAXA GOSAT-GOSAT-2/TANSO-FTS-2 レベル 1 プロダクトフォーマット説明書 ／ GOSAT-2/TANSO-FTS-2 Level 1 Product Description Document	JAXA document in Japanese / English
GST-180056	JAXA GOSAT-2/TANSO-CAI-2 レベル 1 プロダクトフォーマット説明書 ／ GOSAT-2/TANSO-CAI-2 Level 1 Product Description Document	JAXA document in Japanese / English
NIES-GOSAT2-SYS-20190129-053	国立環境研究所 GOSAT-2 プロダクトファイルフォーマット説明書(プロダクト編)	NIES document in Japanese
NIES-GOSAT2-SYS-20190129-054	NIES GOSAT-2 Product File Format Descriptions (Product edition)	NIES document in English
-	GOSAT/GOSAT-2 データポリシー ／ Greenhouse gases Observing SATellite (GOSAT) / Greenhouse gases Observing SATellite-2 (GOSAT-2) Data Policy	JAXA/NIES/MOE document in Japanese / English

2.2 Processing Algorithm

Document No.	Title	Remarks
GST-150005	JAXA GOSAT-2 アルゴリズム基準書 (GOSAT-2 Algorithm Theoretical Basis Document (ATBD))	JAXA document in Japanese
GST-160003	JAXA GOSAT-2/TANSO-CAI-2 レベル 1B アルゴリズム基準書 (Algorism Theoretical Basis Document for GOSAT-2/TANSO-CAI-2 Level 1B)	JAXA document in Japanese
NIES GOSAT2-ALG-20191008-001	GOSAT-2 TANSO-CAI-2 L2 事前処理 アルゴリズム基準書 (Algorithm Theoretical Basis Document for preprocessing GOSAT-2/TANSO-CAI-2 L2)	NIES document in Japanese
NIES GOSAT2-ALG-20191008-002	GOSAT-2 TANSO-CAI-2 L2 雲識別処理 アルゴリズム基準書 (Algorithm Theoretical Basis Document for processing GOSAT-2/TANSO-CAI-2 L2 Cloud Discrimination)	NIES document in Japanese
NIES GOSAT2-ALG-20191008-003	GOSAT-2 TANSO-CAI-2 L2 エアロソル特性導出処理 アルゴリズム基準書 (Algorithm Theoretical Basis Document for processing GOSAT-2/TANSO-CAI-2 L2 Aerosol Property Derivation)	NIES document in Japanese
NIES GOSAT2-ALG-20191008-004	GOSAT-2 TANSO-FTS-2 L2 事前処理 アルゴリズム基準書 (Algorithm Theoretical Basis Document for preprocessing GOSAT-2/TANSO-FTS-2 L2)	NIES document in Japanese
NIES GOSAT2-ALG-20191008-005	GOSAT-2 TANSO-FTS-2 SWIR L2 処理 アルゴリズム基準書 (Algorithm Theoretical Basis Document for processing GOSAT-2/TANSO-FTS-2 SWIR L2)	NIES document in Japanese
NIES GOSAT2-ALG-20191008-006	GOSAT-2 TANSO-FTS-2 TIR L2 雲・エアロソル特性導出処理アルゴリズム基準書 (Algorithm Theoretical Basis Document for processing GOSAT-2/TANSO-FTS-2 L2 Aerosol Property Derivation)	NIES document in Japanese
NIES GOSAT2-ALG-20191008-007	GOSAT-2 TANSO-FTS-2 TIR L2 気温・気体濃度プロファイル導出処理アルゴリズム基準書 (Algorism Theoretical Basis Document for processing GOSAT-2/TANSO-FTS-2 TIR L2 Temperature and Gas Profile Derivation)	NIES document in Japanese

2.3 GOSAT-2 Data Service

Document No.	Title	Remarks
-	GOSAT-2 Product Archive ユーザーズマニュアル / GOSAT-2 Product Archive User Manual	NIES document in Japanese / English
GST-190020	GOSAT-1/2 レベル 1 プロダクト読み出しツール取扱説明書 / GOSAT-1/2 Level 1 product reading toolkit User's manual	JAXA document in Japanese / English
GST-190019	VREASS 取扱説明書 / Viewer for observation data of GOSAT series (VREASS) instruction manual	JAXA document in Japanese / English

Chapter 3. GOSAT-2 Spacecraft System Outline

3.1 Spacecraft System

GOSAT-2 was launched by H-IIA launch vehicle on October 29th, 2018 to the sun-synchronous sub-recurrent orbit in order to improve and continue the observation of greenhouse gases mission as the successor to GOSAT, which was launched in 2009.
Figure 3.1-1 shows an external view of GOSAT-2 and Table 3.1-1 lists up the major specifications.

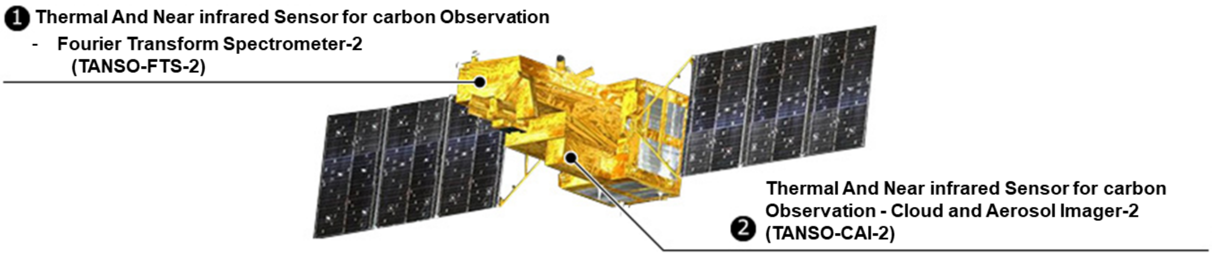


Figure 3.1-1 External view of GOSAT-2

Table 3.1-1 Major Specifications

Entry	Specifications
Main observation target	Carbon Dioxide (CO_2), Methane (CH_4), Carbon Monoxide (CO)
Concentration measurement precision	0.5 ppm (CO_2), 5 ppb (CH_4)- 500 km mesh (terrestrial region)
Mission Instruments	TANSO-FTS-2 TANSO-CAI-2
Dimension	Before deployment of solar array paddle: 5.3 m (X) x 2.7 m (Y) x 2.8 m (Z) / (16.5 m (Y):after deployment of solar array paddle)
Mass	1,800 kg
Power supply	5,000 W (at the end of mission life)
Design life	5 years

GOSAT-2 system consists of two main subsystems: Mission payloads and BUS subsystem.
Figure 3.1-2 shows GOSAT-2 system configuration.

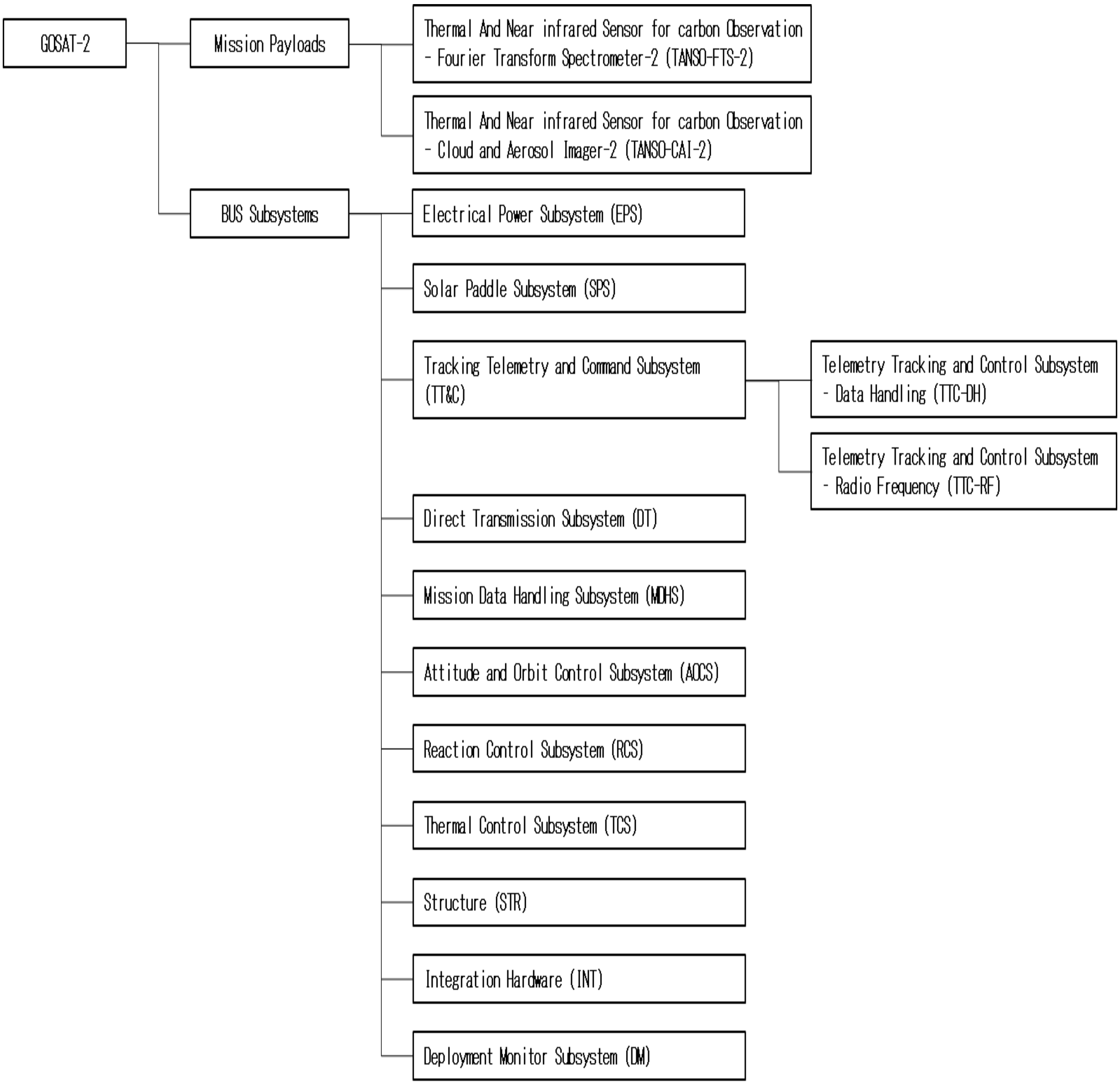


Figure 3.1-2 GOSAT-2 System Configuration

The outlines of each BUS subsystems are as follows. The outlines of Mission payloads are described in next section.

(1) Electrical Power Subsystem (EPS)

- EPS acquires electric power from Solar Paddle Subsystem (SPS) with sunlight. Then it provides conditional power to each component and charges the batteries. It also provides electric power from the charged batteries to electrical loads during eclipse.

(2) Solar Paddle Subsystem (SPS)

- Solar Array Drive Mechanism (SADM) controls the Solar Array Paddle (SAP) to track the sun automatically. SPS generates electric power from solar cells implemented on SAP and supplies power to EPS.

(3) Tracking Telemetry and Command Subsystem (TT&C)

- TT&C receives commands from the ground directly and distributes them to each subsystem after demodulation and decoding.
- TT&C collects HK telemetry, dump telemetry and DM image data from each component and transmits them to the ground after coding and modulation.

(4) Direct Transmission Subsystem (DT)

- DT receives mission data from Mission Data Processor (MDP) and transmits them to the ground directly via X band with QPSK modulation.

(5) Mission Data Handling Subsystem (MDHS)

- MDHS records observation data and bus telemetry then replays and transmits them to DT.

(6) Attitude and Orbit Control Subsystem (AOCS)

- Attitude control by 3-axis control and orbit control.
- Maneuvers to direct to the moon in order to calibrate the mission equipment.

(7) Reaction Control Subsystem (RCS)

- RCS generates moment and thrust for attitude and orbit control.

(8) Thermal Control Subsystem (TCS)

- TCS controls the temperature of each component within specified range for over 5 years from the launch.

(9) Structure (STR)

- STR is the spacecraft structure where each component is installed and supported securely. Design life of STR is over 5 years from the launch to endure in space.

(10) Integration Hardware (INT)

- INT consists of some equipment; the power distribution control unit (PDCU) providing power to equipment and heater, electrical instrumentation connecting each instrument electrically and mechanical instrumentation (e.g. outfitting parts and fastening bracket) assembling each component to STR.

(11) Deployment Monitor Subsystem (DM)

- DM monitors the deployment of SAP and outputs the image data to the ground.

3.2 Overview of Mission Component

GOSAT-2 has two mission components: Thermal And Near infrared Sensor for carbon Observation – Fourier Transform Spectrometer-2 (TANSO-FTS-2), and Thermal And Near infrared Sensor for carbon Observation – Cloud and Aerosol Imager-2 (TANSO-CAI-2).
TANSO-FTS-2 performs spectroscopic observation measuring the short wavelength infrared range and thermal infrared wavelength range which related to solar scattered light reflected by the surface of the earth and atmospheric radiant heat from below.
TANSO-CAI-2 is the auxiliary sensor which has two purposes. One is to improve the derivation accuracy of the TANSO-FTS-2. Another is to derive fine particulate matter and black carbon contents based on aerosol optical thickness and Ångström exponent values of multiple pixels.

3.2.1 TANSO-FTS-2

TANSO-FTS-2 is a 5-bands Fourier spectrometer sensing which can detect from short wavelength infrared (SWIR) range to thermal infrared (TIR) range. It observes the density of CO_2, CH_4, H_2O, O_2, O_3 and CO. TANSO-FTS-2 has an intelligent pointing system to increase the valid data collections by detecting cloud-free areas and repointing scanner.

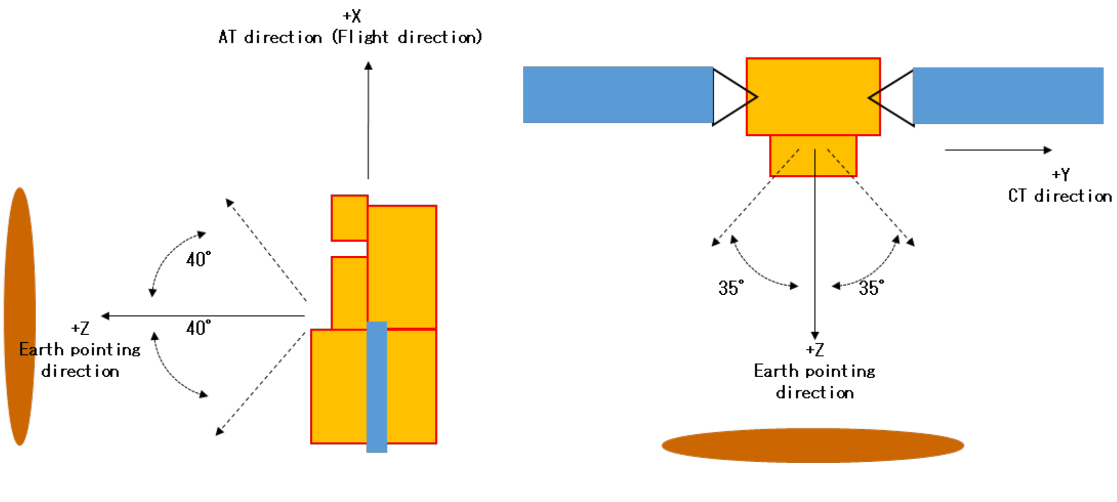
Observation wavelength ranges of TANSO-FTS-2 are as follows.

- From 0.75 μm to 2.3 μm: SWIR
- From 5.55 μm to 14.3 μm: TIR

3.2.1.1 Main functions of TANSO-FTS-2

The main functions of TANSO-FTS-2 are as follows:

a) Observes atmosphere to the earth direction in short wavelength infrared (SWIR) and thermal infrared (TIR) wavelength regions.
b) Observes the same point on the ground during measuring the one interferogram.
c) Points and observes any points within ±40° in the along-track direction and within ±35° in the cross-track direction; including the region that is expected to have the sunglint area.
(cf. Figure 3.2-1)
d) Detects cloud-free areas and repoints scanner within the imaging range of one scene of FOV (Field of View) camera to maximize the number of cloud-free measurements. This function is called the intelligent pointing (IP). IP judges clouds' positions during turnaround time on orbit, and changes the observation field to suitable direction by using 2-axis scanning mechanism. The scanner is turned to the center of the imaging range, if it is unable to judge the clouds positions. The algorithm of judging clouds is over writable via upload data from the ground.
e) Takes the images by FOV camera synchronously with observation. Image data are transmitted to the ground via bus subsystems.
f) Points the scanner at the observation target and fixes the scanner direction within the turnaround time. The accuracy of the observation target position is derived ±0.13 degree (based on 1-sigma, nadir view and knowledge. Target level is within ±0.1 degree) in absolute value with the telemetry during mission period.
g) Performs the solar irradiance calibration using short wavelength infrared and blackbody / deep space calibration using thermal infrared on orbit.
h) Performs the pointing accuracy calibration with pointing the pointing-mirror at the moon by the way of pointing the z-axis of spacecraft toward the moon. The sensitivity calibration is performed at same timing with TANSO-CAI-2.
i) Observes the observation points where is planed across the globe.
j) Has the specific mode for the low battery condition, for instance, when one of solar array paddle breaks down.
k) Derives the atmospheric spectroscopic observation spectrum, even if all sampling lasers are lost.
l) Transmits the interferogram of all bands to bus subsystems.



Optical axis coverage in the Along-Track direction

Optical axis coverage in the Cross-Track direction

Figure 3.2-1 Optical axis coverage of TANSO-FTS-2

3.2.1.2 Major Specifications of TANSO-FTS-2

Table 3.2-1 shows major specifications of TANSO-FTS-2.

Table 3.2-1 Major Specifications of TANSO-FTS-2

	Band 1	Band 2	Band 3	Band 4	Band 5
Polarization	X	X	X	-	-
Wavelength Range [cm^{-1}]	12950-13250	5900-6400	4200-5200	1188-1800	700-1188
Out-of-band Characteristics [cm^{-1}]	< 12750 > 13450	< 5100 > 6800	< 4100 > 5500	< 1000 > 3800	< 600 > 1300
Spectral Resolution [cm^{-1}]	0.2				
FWHM of Instrument function [cm^{-1}]	0.4	0.27			
Aperture Diameter	0.77 mm (Effective Aperture Diameter)				
FOV	15.8 mrad (Angular Field of View)				

Note: The above values indicate nominal values.

3.2.1.3 Overview of TANSO-FTS-2 Interferometer Mechanism

TANSO-FTS-2 is a double pendulum interferometer. Figure 3.2-2 shows a sketch of TANSO-FTS-2 interferometer mechanism.
In this mechanism, the beam splitter wall is combined with the scanner arms through flexure blade. The scanner arms are able to move in CW direction (Forward) and in CCW direction (Backward), using the intersection of flexure blade and scanner arms as the rotation axis.
Moving forward or backward counts as a single scan and acquires one observation data in this motion. Because of the characteristic difference between forward and backward scanning, scanning directions are identified and processing the data in each direction is handled individually.
Interferometer continues forward and backward scanning repeatedly from the start of processing until the stop command is executed. It repeats the order that forward, backward and forward scanning, and does not change this order.

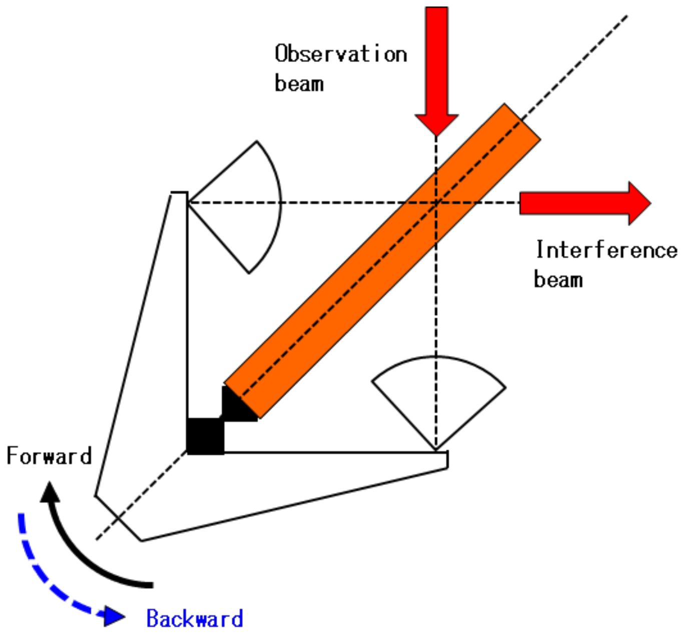


Figure 3.2-2 TANSO-FTS-2 interferometer mechanism

3.2.2 TANSO-CAI-2

TANSO-CAI-2 is the auxiliary sensor which has two purposes. One is to detect cloud areas that cause accuracy reduction for the derivation of column dry air mole fractions of greenhouse gases using the TANSO-FTS-2. Another is to derive content of fine particulate matter and black carbon based on aerosol optical thickness of aerosol and Ångström exponent values of multiple pixels.
TANSO-CAI-2 is a 7 wavelength / 10-bands electronic scanning imager sensing with ultraviolet, visible and near infrared. It observes aerosols and the existence of clouds.
TANSO-CAI-2 has 5 optical systems (tubes) equipped forward/ backward-looking bands individually. Bands 1 - 5 are used for forward-looking (+20°), pointing from nadir to 20° in forward of flight direction (along-track direction: AT direction). Bands 6 - 10 are used for backward-looking (-20°), pointing from nadir to backward of flight direction.
TANSO-CAI-2 has a wide swath / FOV (over 900 km) in a direction perpendicular to flight direction (cross-track direction: CT direction) in order to grasp clouds and aerosols spatial distribution. In addition, optical axis cannot be driven.
Figure 3.2-3 shows a schematic depiction of taking images.

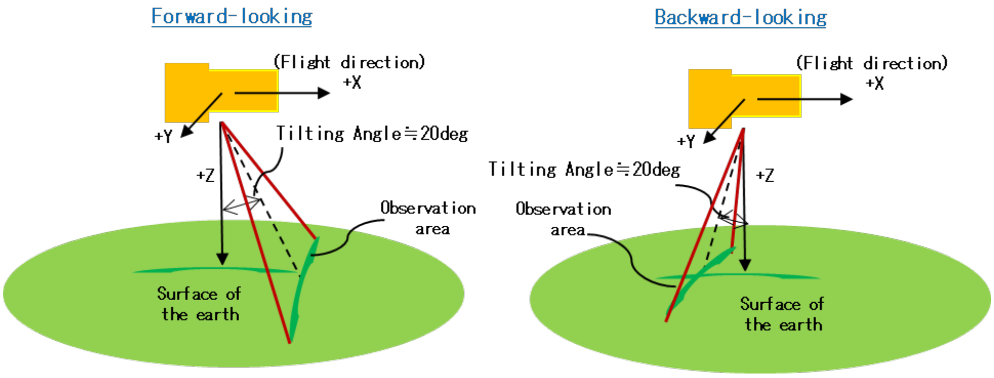


Figure 3.2-3 Schematic depiction of taking images by TANSO-CAI-2

3.2.2.1 Main Functions of TANSO-CAI-2

The main functions of TANSO-CAI-2 are as follows:

a) Measures ultraviolet, visible and near infrared in atmosphere in the ground direction.
b) Performs observation of forward-looking with bands 1 - 5, and backward-looking with bands 6 - 10. (Note: TANSO-CAI-2 is able to observe the same point from two different directions.)
c) Has the specific mode for the low battery condition, for instance, when one of solar array paddle breaks down.
d) Performs daytime observation of whole earth in 6 days.
e) Performs the sensitivity calibration by directing the FOV of TNASO-CAI-2 toward the moon then make all imagers of TANSO-CAI-2 acquire reflected sunlight from the moon by attitude maneuvers. Moreover, the specific imagers can get response characteristics by acquire reflected sunlight from the moon.

3.2.2.2 Major Specifications of TANSO-CAI-2

Table 3.2-2 shows major specifications of TANSO-CAI-2.

Table 3.2-2 Major Specifications of TANSO-CAI-2 (1/2)

	Band 1	Band 2	Band 3	Band 4	Band 5
Optical Tube	Tube 1	Tube 2	Tube 3	Tube 4	Tube 5
Power Source	PWR-1	PWR-2	PWR-3	PWR-4	PWR-5F
Band Group	1	1	1	3	3
Observation data APID	580h	581h	582h	5D0h	5D1h
Packet Length	3448	3448	3448	3448	1900
Pointing Direction	Forward-looking (+20° in AT direction)				
Center Wavelength [μm]	0.339	0.441	0.672	0.865	1.630
Wavelength Width [μm]	0.013	0.012	0.013	0.011	0.073
Resolution [km] (IFOV at the center of the field of the view)	0.46				0.92
Swath [km] (FOV in CT direction)	Over 903 (±33.8°)				
Imaging Cycle [msec]	64				128
Detector	Si CCD				InGaAs
Effective Pixels	2048				1024
Pixel Pitch [μm]	14				25
Number of bits	12 bit				

Note: Values colored in blue are measured values based on test results.

Table 3.2-2 Major Specifications of TANSO-CAI-2 (2/2)

	Band 6	Band 7	Band 8	Band 9	Band 10
Optical Tube	Tube 1	Tube 2	Tube 3	Tube 4	Tube 5
Power Source	PWR-1	PWR-2	PWR-3	PWR-4	PWR-5B
Band Group	2	2	2	3	3
Observation data APID	590h	591h	592h	5D2h	5D3h
Packet Length	3448	3448	3448	3448	1900
Pointing Direction	Backward-looking (-20° in AT direction)				
Center Wavelength [μm]	0.377	0.546	0.672	0.865	1.630
Wavelength Width [μm]	0.012	0.013	0.013	0.011	0.073
Resolution [km] (IFOV at the center of the field of the view)	0.46				0.92
Swath [km] (FOV in CT direction)	Over 903 (±33.8°)				
Imaging Cycle [msec]	64				128
Detector	Si CCD				InGaAs
Effective Pixels	2048				1024
Pixel Pitch [μm]	14				25
Number of bits	12 bit				

Note: Values colored in blue are measured values based on test results.

Chapter 4. GOSAT-2 Mission Operation Outline

4.1 GOSAT-2 Orbital Operations

GOSAT-2 adopts sun-synchronous orbit with 613 km in altitude and 13 o’clock for the local sun time at descending node in order to observe carbon dioxide and methane column concentrations over the whole globe in 6 days (89 revolutions). GOSAT-2 performs out-of-plane control once every several years to control nadir point position at descending node on the equator within ±2.5 km.

4.1.1 Orbit Parameters

Table 4.1-1 GOSAT-2 nominal orbit parameters shows GOSAT-2 nominal orbit parameters.

Table 4.1-1 GOSAT-2 nominal orbit parameters

Parameter	Value	Remarks
Orbit type	Sun-synchronous sub-recurrent orbit	Frozen orbit
Local sun time at descending node	13:00 ±15 min	
Altitude	612.98 km	NOT considered altitude fluctuations
Inclination	97.84 degrees	
Eccentricity	0.00106	
Argument of perigee	90 degrees	
Period	About 98.1 minutes	
Recurrent period	6 days (89 revolutions)	
Longitude of the descending node	Orbit passing above 36.6N, 97.5W	
Longitude repeatability at descending node on the equator	±2.5 km	Depend on frequency of the orbit control of spacecraft

4.1.2 Orbit Control and Maintenance

(1) Keeping sub-recurrent orbit

An orbital period is shortened due to decrease in altitude which is caused by atmospheric friction. It causes deviation from the nominal orbit.

To satisfy the request of longitude repeatability at descending node within ±2.5 km, GOSAT-2 performs orbital altitude controls once in about 3 days.

In the orbital altitude controls, maneuver parameters of injection duration are calculated automatically. It is based on suitable position to keep eccentricity vector of spacecraft by on-board calculation. (Note: Injection strength and timing use fixed values.)

(2) Keeping sun-synchronous orbit

An error of orbital inclination via solar tidal force causes asynchronous between change ratios of right ascension of ascending node and mean orbital angular velocity. It causes deviation from the nominal orbit.

To satisfy the request of local sun time at descending node within 15 minutes, the orbital inclination control is needed. GOSAT-2 will perform orbital inclination control after 2.5 years, the middle of mission life, from the launch.

(3) Debris avoidance

Regarding the debris avoidance, when the collision probability becomes higher, GOSAT-2 will conduct to change the orbital altitude urgently.

4.1.3 The Definitions of Path Number

The definitions of path number are as follows.

(1) Starting point of a path

Starting point is an ascending node.

(2) Path number

The ground trajectory of spacecraft from ascending node to next ascending node via the Arctic and the Antarctic is defined as a one path. The ground trajectory is numbered sequentially path by path toward west until the max number of revolutions of recurrent period. Regarding GOSAT-2, the path number is from 1 to 89.

(3) Standard path definition

Descending path passing the verification point, Lamont, Oklahoma, USA (36.6N, 97.5W) is fixed as No.68.

4.2 TANSO-FTS-2 Operations

4.2.1 Operation Mode of TANSO-FTS-2

Table 4.2-1 lists up the operation mode of TANSO-FTS-2.

Table 4.2-1 TANSO-FTS-2 operation mode

Operation mode	Outline
Off mode	This mode is set effective right after the installation into the spacecraft on the ground, and kept till the primary power is supplied. This mode corresponds to safety mode 2 of spacecraft and TANSO-FTS-2 does not work to stay alive for bus subsystems.
Survival mode	This mode corresponds to safety mode 1 of spacecraft. This mode keeps TANSO-FTS-2 in a state free from any defects, failures, or unrecoverable degradation in case GOSAT-2 is placed in abnormal attitude and/or failure of power supply; wherein the primary power supply to TANSO-FTS-2 is off, while only survival heaters control, and reception of ROM selection command at system start-up are kept valid.
Operational mode (Observation mode)	A mode to observe or calibrate every approximately 4.67 seconds via observation tables specified observation targets and observation conditions, or to set slew mode (non-observing mode). (1) Nominal observation (2) Blackbody calibration: using thermal infrared (3) Deep space calibration: using thermal infrared (4) Solar irradiance calibration: using the solar diffuser plate every revolution (5) Instrument function calibration: using semiconductor laser (6) Electrical calibration: calibrating the signal processor including the analog signal processing unit by applying standard signal voltage (7) Lunar calibration: calibrating via short wavelength infrared at the same timing with TANSO-CAI-2, before and after the full moon, twice every month; changing the spacecraft's attitude appropriately and directing the FOV of sensor to the moon with pointing mechanism (8) Slew: setting for non-observation. Performs during nominal observation mode (1) above, before and after calibration mode (2)-(7) above.
Safe mode	This mode is transition mode from survival mode to operational / diagnostic / outgas mode.
Diagnostic mode	A mode to output row interferogram data without thinning and filtering at high speed. Observation table is not used in this mode. This mode is mainly used for ground tests, initial checkout and special operations with calibrations of on-orbit parameters.
Outgas mode	A mode to outgas before starting observation operation after the launch.

Note: Survival heaters are enabled in all operation modes except off mode.

Observation operations which control sensors and observation data is performed in Operational mode according to the registered observation plan in observation table. Operations in Operational mode include calibrations and maintenance operations.
TANSO-FTS-2 observation is performed at the observation points divided one revolution into 1246 (n=0, 1, ··, 1245) with interval of about 4.67 seconds. Interference signal acquisition time is 4.024 seconds. The remaining about 0.65 seconds called ‘turnaround time’ [1] required when the observation point moves. This turnaround time includes observation point adjustment using intelligent pointing via FOV camera depending on the requests. Figure 4.2-1 shows an image of observation point number.

Path Number	N=	1246
	n	AOL(deg)
0	0	0
	1	0.2889
	2	0.5778
	3	0.8668
	·····	·····
	1245	359.7111
1	0	0
	1	0.2889
	2	0.5778
	3	0.8668
	·····	·····
	1245	359.7111
·····	·····	
14	0	0
	1	0.2889
	2	0.5778
	3	0.8668
	·····	·····
	1245	359.7111

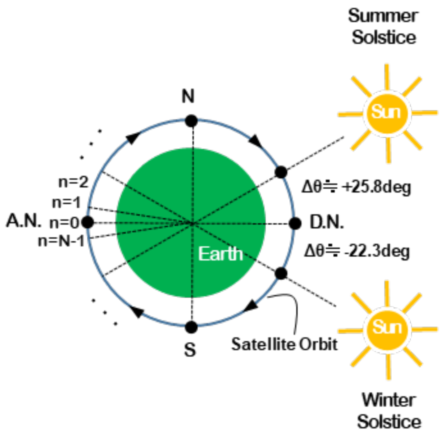


Figure 4.2-1 Observation Point Number image

The observation control via observation tables starts when the spacecraft is at ascending node on orbit. The steps on orbit to the completion of transition to operational mode are as follows:

- Calculate the timing of about 2 minutes before arriving at ascending node.
- Calculate the remaining time until first observation start using spacecraft velocity and position about 2 minutes before arriving at ascending node.
- Calculate the difference between the start time of observation and start time of the last turnaround before the observation start of interferometer module.
- Calculate the turnaround time corresponding to the first observation start requested. Set it on the interferometer module.
- Complete the transition to operational mode.

[1] Turnaround time depends on an argument of latitude.

Observation table is driven until the detection of the ‘End of Table’ flag. Then, next observation table starts from the first step, if it has been uploaded. Otherwise, scanning mirror moves to point to nadir direction and shifts to the diagnostic mode automatically, if next observation table has not been uploaded. Automatic tracking system of TANSO-FTS-2 is designed based on the use of yaw steering [2] via attitude control system of spacecraft; therefore, TANSO-FTS-2 can track the observation point with spacecraft position and velocity in WGS84 system without considering the Earth rotation.

[2] GOSAT-2 controls the yaw angle to keep the pointing in a direction perpendicular to y-axis of spacecraft body and flight direction in the Earth fixes coordinate system with considering the Earth rotation.

4.2.2 TANSO-FTS-2 Orbital Operations

In nominal observation operation, TANSO-FTS-2 observes short wavelength infrared (SWIR using band 1, 2 and 3) radiation and thermal infrared (TIR using band 4 and 5) radiation during daytime of the ground and observes thermal infrared radiation (TIR) radiation during nighttime of the ground.
Moreover, TANSO-FTS-2 performs the calibrations regularly. (cf. Figure 4.2-2, Table 4.2-2)

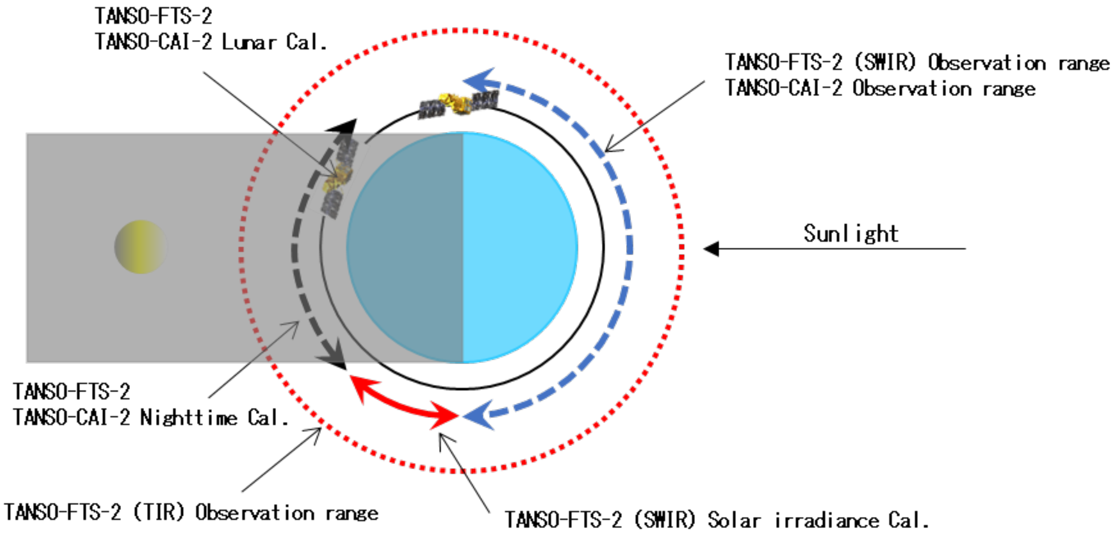


Figure 4.2-2 Orbital Operations of payloads

Figure 4.2-3 shows a basic timeline image of TANSO-FTS-2 orbital operations.

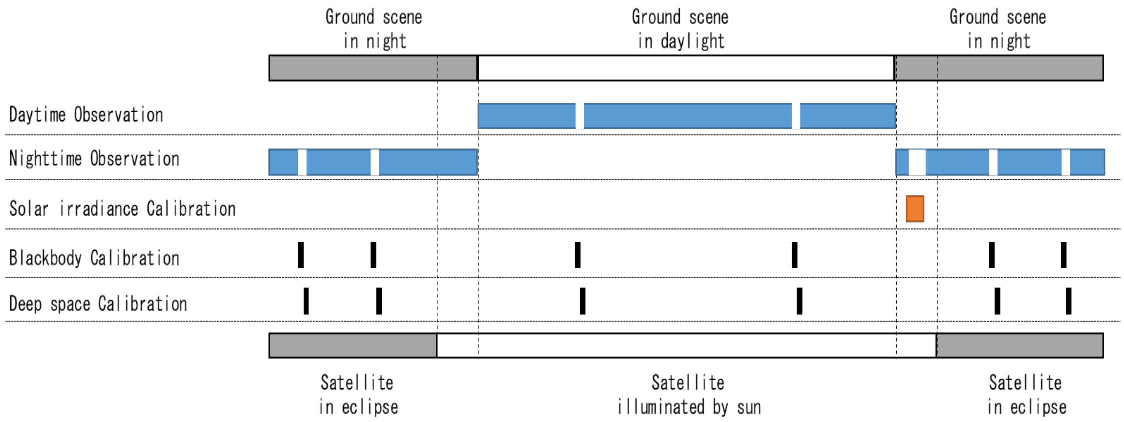


Figure 4.2-3 Timeline image of TANSO-FTS-2 orbital operations

Table 4.2-2 TNASO-FTS-2 orbital operations

Operation	Outline / Frequency
Ground surface observation	Specify each ground surface observation point in WGS84 system at each observation position on orbit every 4.67 seconds and track each surface observation point for 4.024 seconds. Correct each observation point by detecting cloud-free areas via FOV camera for each observation point if necessary.
Solar irradiance calibration	Observe the sunlight dissipated by the solar irradiance diffuser plate to acquire luminance calibration data of SWIR. Perform this calibration at the fixed point of each revolution where observation ground target is nighttime and spacecraft is illuminated by sun. The fixed point is near Antarctica, the argument of latitude value is between 194.26 to 199.45 degrees for about 84 seconds. There are 2 diffuser plates. One is used most often as a routine diffuser plate, the other is used as a reference.
Blackbody calibration	Observe the blackbody to acquire luminance calibration data of TIR. This calibration is performed 6 times every revolution. (2 times under sunlight and 4 times during eclipse)
Nighttime calibration (Dark current calibration)	Acquire luminance calibration data of SWIR during an eclipse on orbit. This calibration is replaced with deep space calibration.
Deep space calibration	Observe deep space to acquire dark current calibration data of SWIR and TIR. This calibration is performed 6 times every revolution. (2 times under sunlight and 4 times during eclipse)
Instrument function calibration	Acquire the observation data of instrument function calibration laser in order to perform instrument function calibration for both Band1 and 2. This calibration is performed once a month.
Lunar calibration	Be performed before and after the full moon, twice every month. Has 4 patterns of calibration, including TANSO-CAI-2. Although specific calibration for TANSO-FTS-2 has only one pattern, TANSO-FTS-2 acquires the observation data at remaining 3 patterns for TANSO-CAI-2 too. TANSO-CAI-2 has two observation directions, forward-looking and backward-looking. TANSO-FTS-2 changes optical axis direction corresponding to the observation direction of TANSO-CAI-2 to acquire calibration data.
Electrical calibration (analog)	Acquire calibration data of electrical characteristics between input terminal of analog filter and sensor by applying sinusoidal analog signal. This calibration is performed once a month.
Electrical calibration (digital)	Acquire calibration data of electrical characteristics between output terminal of AD converter and sensor by applying fixed pattern signal. This calibration is performed once a month.
Lubrication drive operation	Be performed to smooth the movement of drive mechanism of optical axis. This operation is performed once (or more) every revolution.
FOV camera reset	Initialize the FOV camera when it stops working due to SEU etc. There are two types of initialization for rest operation. One is ‘Hard reset’ which turns on / off the power, the other is ‘Soft reset’ which initializes only internal circuits. These calibrations are performed during eclipse.

4.2.2.1 Restrictions and precautions about TANSO-FTS-2 observations

Table 4.2-3 shows some restrictions and precautions about TANSO-FTS-2 observations.

Table 4.2-3 Restrictions and precautions about TANSO-FTS-2 observations

<table>
<tr><th>No.</th><th>Description</th></tr>
<tr><td>1</td><td>Intelligent pointing (IP) function setting:

OFF for consecutive observations of the same ground surface point (e.g. three continuous observations).
OFF in case FOV camera is out of work.
OFF when in calibrations or nighttime at nadir.
Usually ON when daytime at nadir.
</td></tr>
<tr><td>2</td><td>GOSAT-2 performs orbital altitude controls (in-plane orbital controls) to keep the recurrent orbit. Although TANSO-FTS-2 goes on observing during in-plane orbital controls based on the operational plan, TANSO-FTS-2 cannot track the ground surface point accurately because yaw steering function is not working during the orbital controls including attitude transition time before and after it.
The judgement of valid / invalid of TANSO-FTS-2 observation data according to yaw steering on / off status included in ancillary data is as following table.
<table>
<tr><th>No.</th><th>Observation mode (in observation table)</th><th>Status</th><th>Data processing policy of TANSO-FTS-2 observation data</th></tr>
<tr><td>1</td><td rowspan="4">0x00:
Normal Observation</td><td>Detection from ON to OFF</td><td>Invalid one data of observation point just before detection</td></tr>
<tr><td>2</td><td>OFF</td><td>Invalid data</td></tr>
<tr><td>3</td><td>Detection from OFF to ON</td><td>Valid data just after three [a] observation from detection</td></tr>
<tr><td>4</td><td>ON</td><td>Valid data</td></tr>
<tr><td>5</td><td>All other mode</td><td>N/A</td><td>Valid data</td></tr>
</table>
a. In TANSO-FTS-2 internal, trajectory and attitude at observation position is calculated via orbital data based on previous two consecutive observation data.</td></tr>
<tr><td>3</td><td>After the change of attitude, increase of temperature of radiation plate by an injection of direct sunlight, refection light via albedo on the surface of the Earth and infrared radiation of the Earth causes the out of temperature range of sensors of bands 2 - 5(channels 2 - 5) and invalidates light reception data.

Light reception data is invalid in following cases:

Light reception data of B2 - B5 for about 20 hours after lunar calibration because of saturation of signal level. The output of these data is stopped during this period.
Light reception data of B4 and B5 for 25 hours after minus delta semimajor axis control: in-plane orbital control for debris avoidance, etc.
Light reception data of B4 and B5 for 25(TBD) hours after plus/minus delta inclination control: out-of-plane orbital control. The invalid period is determined in detail when orbital control is performed.

The above data is not included in Level 1 products.</td></tr>
</table>

4.3 TANSO-CAI-2 Operations

4.3.1 Operation Mode of TANSO-CAI-2

Table 4.3-1 lists up the operation mode of TANSO-CAI-2.

Table 4.3-1 TANSO-CAI-2 operation mode

<table>
<tr><th colspan="2">Operation mode</th><th>Outline</th></tr>
<tr><td colspan="2">All off mode</td><td>This mode is set effective right after the installation into the spacecraft on the ground, and kept till the primary power is supplied.</td></tr>
<tr><td colspan="2">Safe mode
(LLM: Light Load mode)</td><td>To keep TANSO-CAI-2 state free from any defects, failures, or unrecoverable degradation in case GOSAT-2 is placed in abnormal attitude and/or failure in power supply; Power supply to survival heaters is on.</td></tr>
<tr><td colspan="2">Standby mode 1</td><td>Keep the status necessary for performing observations in observation mode 1. (Primary selected)</td></tr>
<tr><td colspan="2">Standby mode 2</td><td>Keep the status necessary for performing observations in observation mode 2. (Secondary selected)</td></tr>
<tr><td colspan="2">Observation mode 1</td><td>Perform observations. (nominal mode)</td></tr>
<tr><td colspan="2">Observation mode 2</td><td>Perform observations with restricted functions of TANSO-CAI-2 in case Observation mode 1 is not available under low battery condition.</td></tr>
<tr><td rowspan="3">Calibration mode</td><td>Lunar calibration</td><td>Perform once/twice a month.
This mode is equivalent to Observation mode 1 or 2 with regard to TANSO-CAI-2 mode.</td></tr>
<tr><td>Electrical calibration</td><td>Perform before and after the normal observations.
Calibrate the signal processor by applying nominal signal voltage before the analog signal processing unit.</td></tr>
<tr><td>Nighttime calibration (Dark current calibration)</td><td>Perform about once a month if necessary.
Calibrate offset levels by performing night observations.
This mode is equivalent to Observation mode 1 or 2 with regard to TANSO-CAI-2 mode.</td></tr>
</table>

Note: Survival heaters are enabled in all operation modes except All off mode.

TANSO-CAI-2 has two observation modes described in Table 4.3-1. One is observation mode 1 observing the ground surface of daytime normally, the other is observation mode 2 observing with restricted functions of TANSO-CAI-2 according to low battery level.
During TANSO-CAI-2 observations, observations is performed via M-CMD tables [3].

a) Observation mode 1
Nominal observations of TANSO-CAI-2 are basically performed from the beginning of the daytime on the ground to the end. TANSO-CAI-2 performs electrical calibrations before and after observations to verify variation of electrical bias. Also, TANSO-CAI-2 performs electrical calibrations before and after each nighttime calibration.

[3] M-CMD is one of macro commands including the relative execution time. It performs a command sequence group by specifying table number which is registered with some command sequences.

b) Observation mode 2
TANSO-CAI-2 function is partially stopped and observes according to the combination of devices shown in Table 4.3-2.
Forward-looking and backward-looking cannot be individually turned on/off except for band 5 and 10 since they are sharing power supply units. This mode is equivalent to observation mode 1 except for some unavailable bands.

Table 4.3-2 Combination of optical tubes on/off in observation mode 2

Optical Tube	Forward-looking	Backward-looking	Power supply unit	Forward/Backward-looking ON/OFF
Tube 1	Band 1	Band 6	PWR-1	On / Off at same time
Tube 2	Band 2	Band 7	PWR-2	On / Off at same time
Tube 3	Band 3	Band 8	PWR-3	On / Off at same time
Tube 4	Band 4	Band 9	PWR-4	On / Off at same time
Tube 5	Band 5	-	PWR-5F	Forward-looking On / Off independently
Tube 5	-	Band 10	PWR-5B	Backward-looking On / Off independently

The exposure time of TANSO-CAI-2 can be changed by M-CMD tables during observation mode 1 or 2. The exposure time can be set individually for all bands as well as not setting only specified band.

4.3.2 TANSO-CAI-2 Orbital Operations

TANSO-CAI-2 on orbit performs normal daytime ground surface observations and calibrations regularly. (cf. Figure 4.3-1, Table 4.3-3)

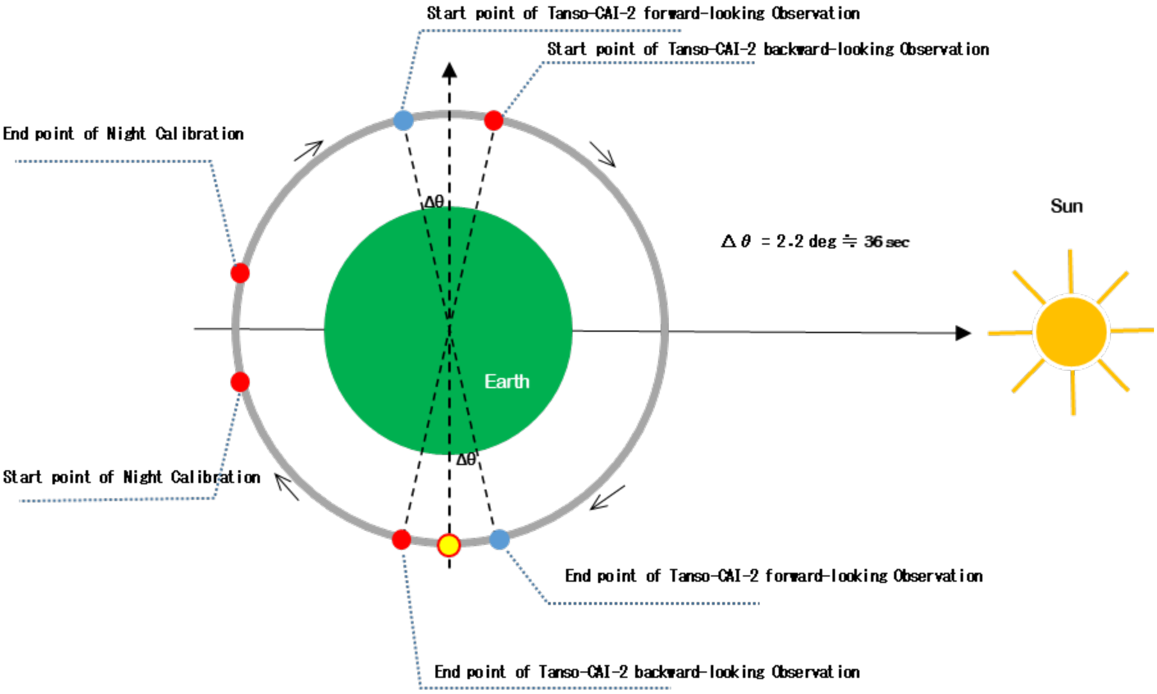


Figure 4.3-1 Orbital Operations of TANSO-CAI-2

Standard operation image of TANSO-CAI-2 is shown in Figure 4.3-2.

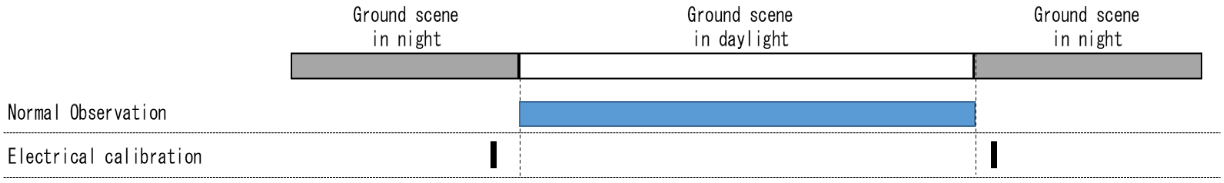


Figure 4.3-2 Example of TANSO-CAI-2 operation timeline

Table 4.3-3 TANSO-CAI-2 orbital operations

Operation	Outline / Frequency
Normal observation	Observe daytime ground surface. There is a difference of about 65 seconds between start/end time of forward-looking and backward-looking.
Lunar calibration	Be performed once/twice a month before and after the full moon. Performs the sensitivity calibration between all imagers and bands with directing the FOV of TNASO-CAI-2 at moon and using reflected sunlight from the moon to all imagers of TANSO-CAI-2 by attitude maneuvers in the CT direction during eclipse. Scanning in the AT direction for forward and backward-looking is performed. Scanning in the CT direction for forward and backward-looking is performed plural times at different timing because it takes long time. This mode is equivalent to observation mode 1 or 2 with regard to TANSO-CAI-2 mode.
Electrical calibration	Perform the calibration for about five seconds by swapping detector signal output and reference voltage output, before and after daytime nadir observation and before and after nighttime/lunar calibration.
Nighttime calibration	Acquire dark observation data at designated observation point where the nadir is in nighttime about once a month if necessary. (Same observation point is observed by forward/backward-looking.)
Dark calibration	Each band 1 - 4, 6 - 9 has 8 pre-scan pixels, and TANSO-CAI-2 monitors the dark current level at these pre-scan pixel outputs. Since each band 5 - 6 has no pre-scan pixel, first 6 pixels of 1024 pixels are treated as dark pixels by masking. TANSO-CAI-2 monitors the dark current level at these masking pixel outputs, too. There is not ‘Dark calibration mode’ as one of TANSO-CAI-2 operation modes since the dark calibration data is always acquired during ‘normal observation’, ‘lunar calibration’, ‘nighttime calibration’, and ‘electrical calibration’.

4.3.2.1 Restrictions and precautions about TANSO-CAI-2 observations

Table 4.3-4 shows some restrictions and precautions about TANSO-CAI-2 observation.

Table 4.3-4 Restrictions and precautions about TANSO-CAI-2 observations

No.	Description
1	TANSO-CAI-2 operations are performed by execution of M-CMD using stored commands with execution time in spacecraft. This process is different from TANSO-FTS-2 operations. Therefore, observation plan corresponding to argument of latitude is converted to timeline corresponding to satellite time by orbital prediction data on the ground system.
2	There is a ground surface area where TANSO-CAI-2 is not able to observe according to the driving angle of TANSO-FTS-2, because the max TANSO-FTS-2 driving angle around the AT-axis is wider than that of TANSO-CAI-2 viewing angle.
3	TANSO-CAI-2 does not observe two revolutions after the ascending node of the beginning of the lunar calibration.

4.4 Observation Operation Image

Figure 4.4-1 shows observation operation image of GOSAT-2 on orbit. Please refer to section 4.2 and 4.3 about each mission instrument operation. Also, the motion image video of spacecraft during observation is viewable at JAXA Digital Archives on the JAXA Web site (http://jda.jaxa.jp/en/). This video (Material No: V100000697, Contents: Concept image of GOSAT-2, Greenhouse Gases Observing Satellite.) can be find by entering keywords 'Concept image of GOSAT-2' into the search box at JAXA Digital Archives.

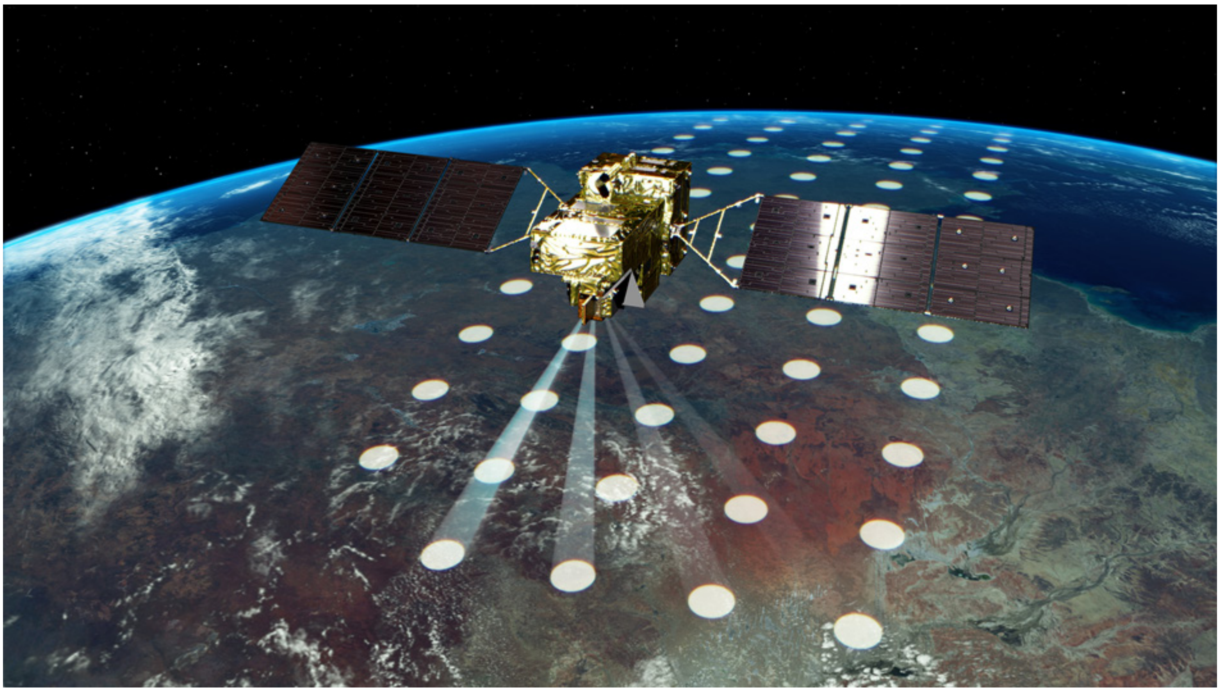


Figure 4.4-1 Observation operation Image

Chapter 5. GOSAT-2 Ground System

5.1 Overview of GOSAT-2 Ground System

The GOSAT-2 ground system consists of JAXA and NIES systems. The JAXA system performs operations such as spacecraft control, data acquisition and primary data processing, whereas the NIES system performs operations such as higher level data processing and products distribution. In addition, a data acquisition station located at high latitude is utilized in order to increase data acquisition opportunities.
Figure 5.1-1 shows an overall configuration of the GOSAT-2 ground system.

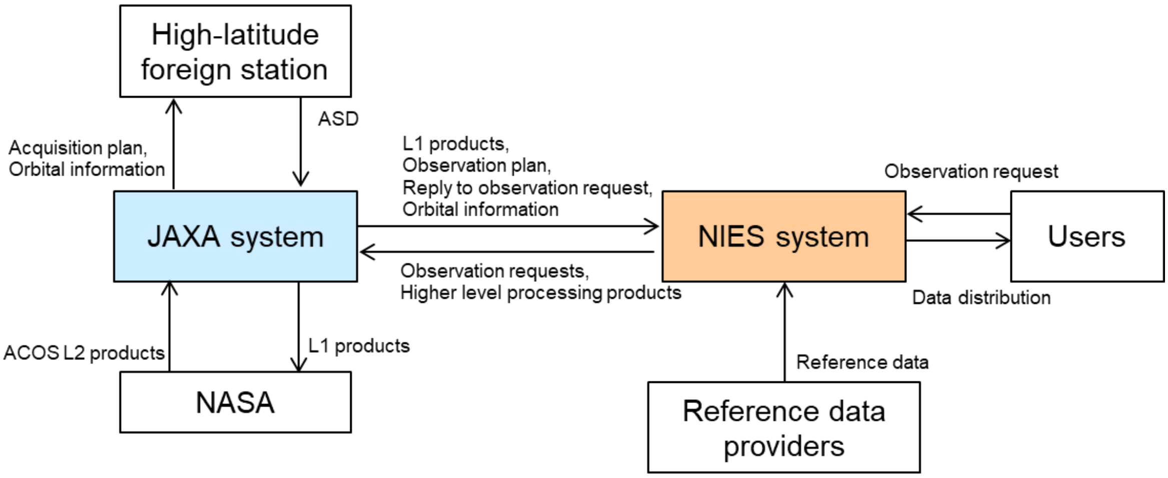


Figure 5.1-1 GOSAT-2 ground system configuration

5.2 JAXA System

Figure 5.2-1 shows JAXA system configuration including interfaces with external systems of related organizations. The outline of general functions of each component in the JAXA system are described below.

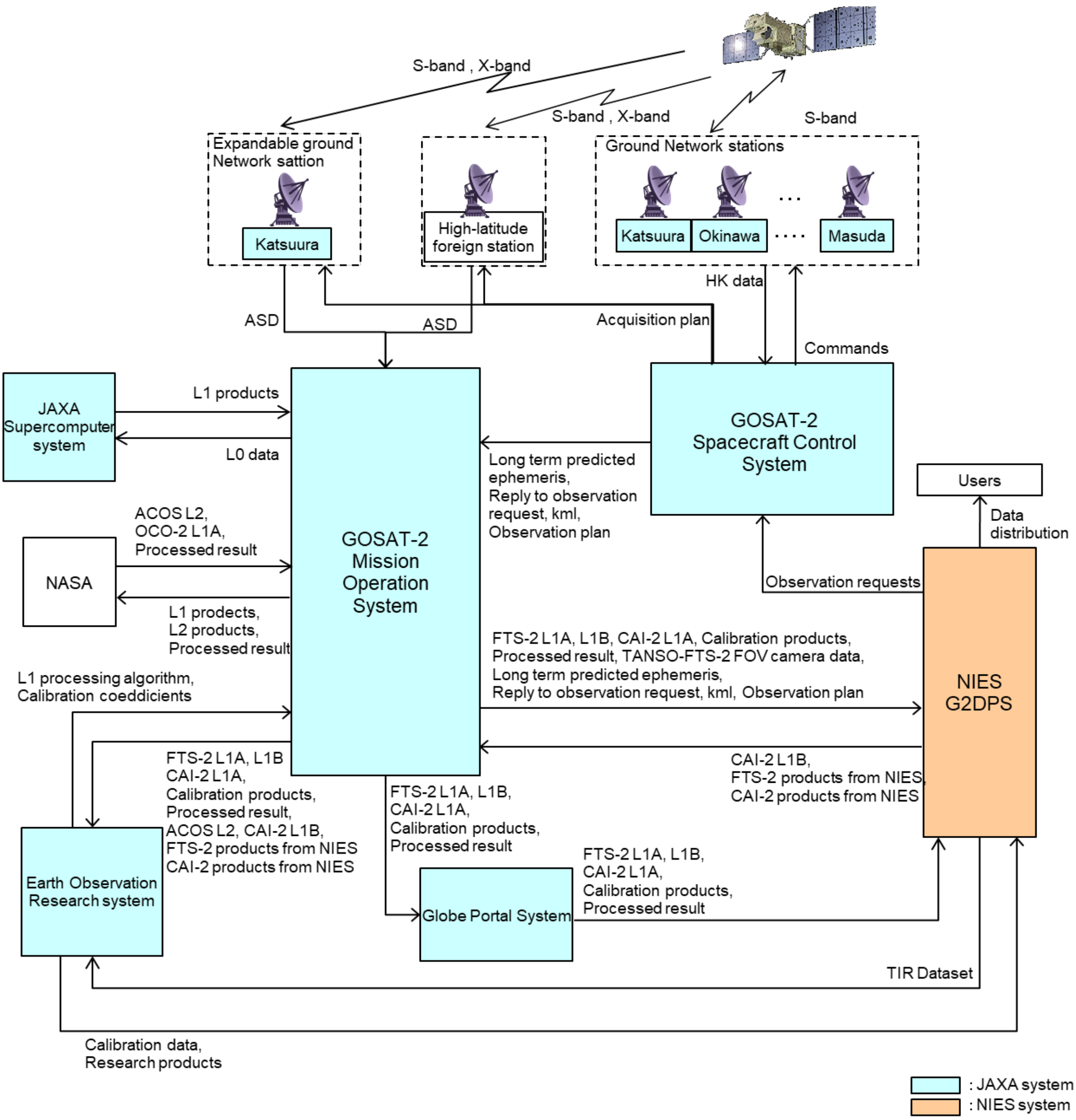


Figure 5.2-1 Overall Configuration of JAXA System

(1) GOSAT-2 Spacecraft Control System

- This system makes TANSO-FTS-2 and TANSO-CAI-2 observation plans based on the requests from NIES and JAXA internal.
- The system provides observation plans, replies to observation requests, the kml files, orbital information, etc. to NIES via GOSAT-2 mission operation system.
- The system generates orbital information (e.g. orbit-prediction values) based on the results of the GOSAT-2 orbit determination.
- The system generates spacecraft operation commands based on the GOSAT-2 observation plans and downlinks plans and transmits them to the spacecraft via ground network system (GN stations).
- The system acquires house-keeping (HK) data from GOSAT-2 and monitors the

conditions of the bus subsystem and sensors on orbit.

(2) GOSAT-2 Mission Operation System

- This system has data interfaces with JAXA external organizations and JAXA internal related facilities and manages these data transmission/reception status.
- The system performs Level 0/Level 1 processing controls, generates Level 1 products, and manages them including file contents (e.g. observation date, data loss situation, and quality of products).

(3) Globe Portal System

- This system provides earth observation data and searches service for them.
- The system provides GOSAT-2 data to external users by ftp server function.

(4) JAXA Supercomputer System

- If the processing algorithm is updated, the system performs Level 1 reprocessing based on Level 0 data stored from the launch and generates Level 1 products.

(5) Earth Observation Research System

- This system is used for conducting 'Validation of Calibration', 'Research and Development Algorithm' and 'Applied Research'.

(6) NASA

- This organization conducts to send/receive data products to/from GOSAT-2 mission operation system using the internet.

(7) High-latitude Foreign Station

- In order to acquire the global observation data, the Svalbard Satellite station (SvalSat), operated by Kongsberg Satellite Services (KSAT), Norway, is utilized as an overseas data acquisition station located at high latitude.
- SvalSat acquires X-band mission data from the spacecraft, generates APID sorted data (ASD), and records them with RAW data in a hard disk.
- The recorded ASD is transmitted to the GOSAT-2 Mission Operation System.
- SvalSat is also used as a backup station for S-band operations.

(8) Ground Network Stations (GN stations)

- The Ground Network stations are utilized to track the spacecraft and to exchange data with the spacecraft for control.

(9) Expandable Ground Network Station (EN station)

- This ground station is used as a backup station when a high-latitude station or the ground network station fails.

5.3 NIES System

Figure 5.3-1 shows NIES system, called as GOSAT-2 Data Processing System (G2DPS), configuration including interfaces with related organizations. The outline of general functions of each component in the NIES system is described below.

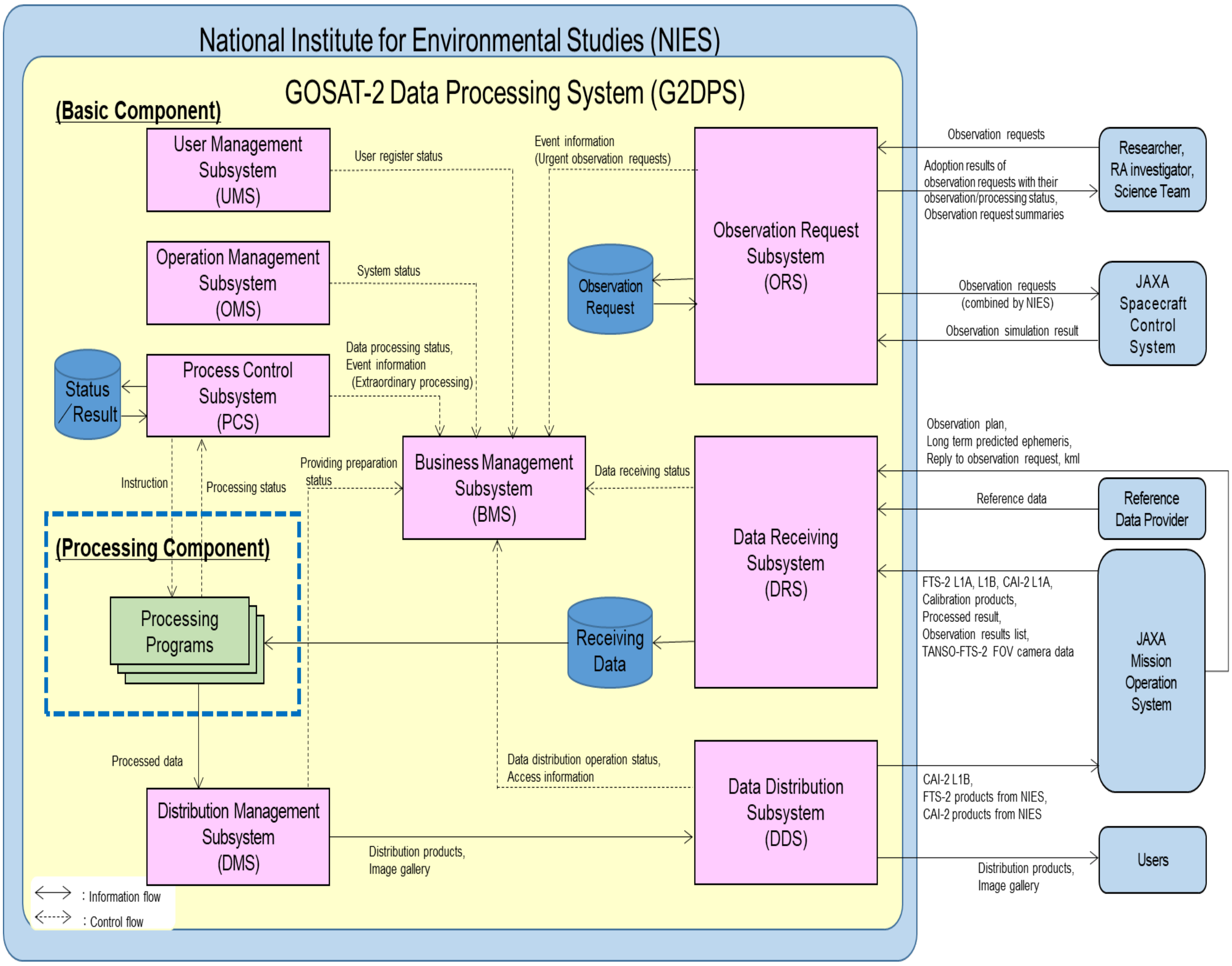


Figure 5.3-1 Overall Configuration of NIES System

(1) NIES/G2DPS Basic Component

a) Observation Request Subsystem

- This subsystem manages individual and combined observation requests and transmits them to JAXA system.
- The subsystem provides adoption results of observation requests with their observation/processing statuses, and observation request summaries to requesting users.

b) Data Receiving Subsystem

- This subsystem receives data necessary for G2DPS operation from JAXA and the reference data providers, and confirms the data.
- After confirmation of the receiving list for each observation date by NIES/G2DPS operators, this subsystem determines the receiving data.
- This subsystem receives replies to observation requests and kml files from JAXA.

c) Process Control Subsystem

- This subsystem controls each processing program on the Processing Component and receives each processing status from it according to the processing plan data entered by NIES/G2DPS operators.
- This subsystem manages processing lists and generates processed lists after the processing.

d) Distribution Management Subsystem

- This subsystem compiles processed data for confirmation and public use.
- This subsystem manages start/end of data release status for confirmation and public use data.
- This subsystem provides data for confirmation: post-processed data, distribution products and the image gallery for confirmation, to NIES internal and specified G2DPS users, and receives the results of confirmation from them.

e) Data Distribution Subsystem

- This subsystem distributes the public data to users and JAXA.

f) User Management Subsystem

- This subsystem manages user accounts for logging into the website.

g) Business Management Subsystem

- This subsystem summarizes statuses of data receiving, data processing, preparation of providing and data distribution operation, and provides an integrated monitoring function and related data operating functions to NIES/G2DPS operators.
- This subsystem generates operation results of summary of monitoring targets described above, system status, the number of registered users, access information and event information (urgent observation requests and extraordinary processing).

h) Operation Management Subsystem

- This subsystem monitors and manages the computer systems and data of NIES/G2DPS.

(2) NIES/G2DPS Processing Component

This system consists of processing programs, performs data analysis processing and generates GOSAT-2 products.

Chapter 6. GOSAT-2 Ground System Operations

6.1 Overview of GOSAT-2 Ground System Operations

Figure 6.1-1 shows the operation overview diagram of GOSAT-2 ground system.
NIES/G2DPS combines the requests from each user into the NIES observation request and send it to the GOSAT-2 spacecraft control system.
GOSAT-2 spacecraft control system creates TANSO-FTS-2 and TANSO-CAI-2 observation plans based on these observation requests from NIES and JAXA internal requests, and creates GOSAT-2 operation plans based on observation plans and bus equipment. GOSAT-2 spacecraft control system also transmits commands to GOSAT-2 via ground network system stations and receive telemetry of GOSAT-2, and monitors the health status of GOSAT-2.
GOSAT-2 observation data is transmitted to the GOSAT-2 mission operation system via a high-latitude foreign station or an expandable ground network station.
The GOSAT-2 mission operation system generates Level 0 data and Level 1 products data, and provides them to NIES/G2DPS.
NIES/G2DPS generates higher level products through higher level processing and provides them to each user.

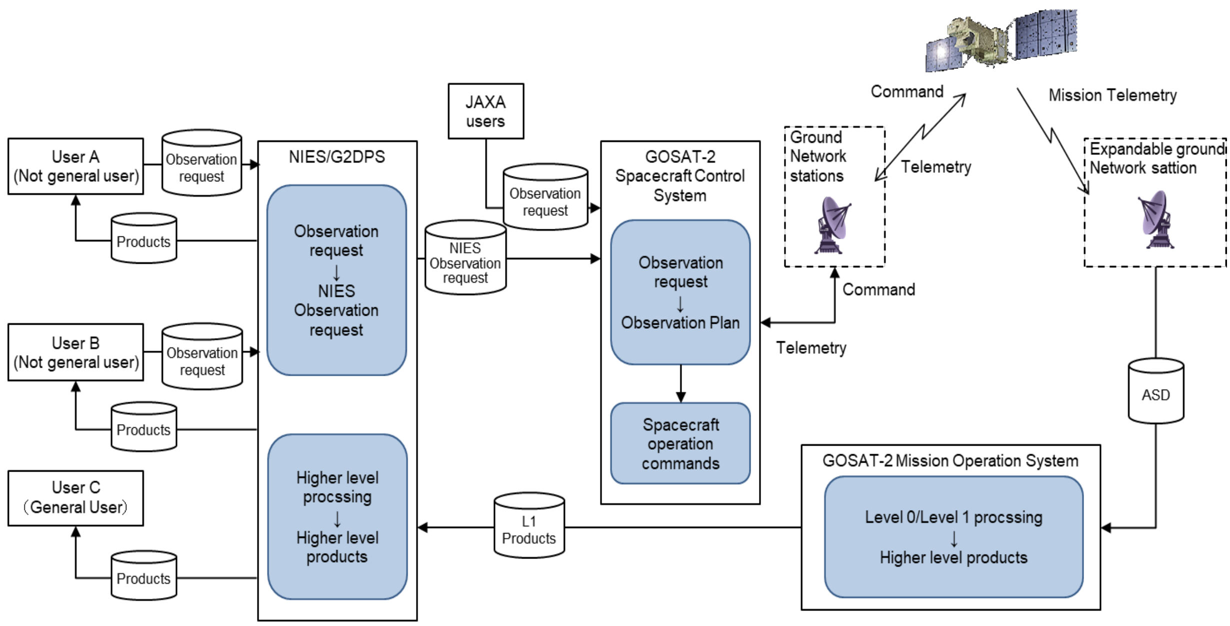


Figure 6.1-1 Operation overview diagram of GOSAT-2 ground system

Chapter 7. GOSAT-2 Products

7.1 Overview of Products

The distribution addresses for GOSAT-2 products vary depending on the processing level. This section provides an overview of all types of GOSAT-2 products.
There are several 'Levels' of GOSAT-2 products in accordance with processing steps, as follows:

- Level 1 products: data representing physical quantities converted from the voltage and current values measured by the sensors.
- Level 2 products: data processed from Level 1 products, column-averaged dry-air mole fraction of greenhouse gases, etc.
- Level 3 products: data on the global distribution of column abundances obtained by applying a statistical processing to Level 2 products of a certain period of time.
- Level 4 products: e.g., greenhouse gas fluxes assessed based on Level 2 products.

Table 7.1-1 shows the GOSAT-2 product list. Table 7.1-2 shows the processing level concept of each TANSO-FTS-2 product.
All GOSAT-2 products at these different levels are classified into three product categories: standard, research and internal products. Each category is described and defined as follows:

(1) Standard products

Standard products are Level 1 products or high-level products which are generated constantly and are available generally, and whose document related to algorithms, formats and results of accuracy assessment will be released to the public.

(2) Research products

Research products are to be distributed to a limited community of users for research on calibration, validation, data processing algorithms and data utilization, and other scientific researches. The Three Parties [4] have no obligation to carry out the validation or comparison and will not release results of accuracy assessment of these products. The term and scope for generating this product may be limited.

(3) Internal products

Internal products are to be available within only Three Parties. However, internal products may be provided to limited research investigators and research organizations with respect to calibration or research on Level 1 processing algorithms of observation sensors, solely for the purpose of carrying out such activities.

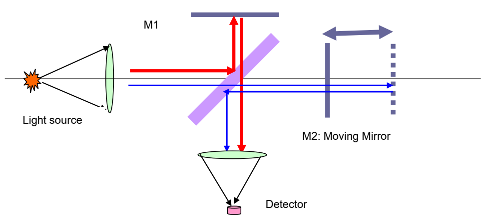
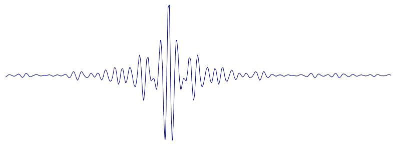
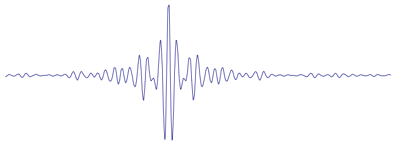
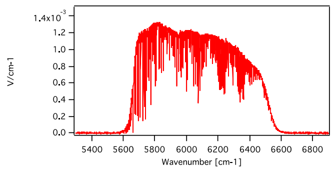
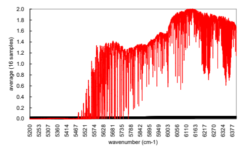
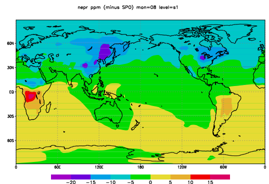
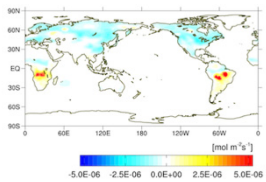
[4] JAXA, NIES and MOE

Table 7.1-1 GOSAT-2 product list

Sensor	Product Name	Category	Stored File		Unit	Format
FTS-2	TANSO-FTS-2 L1A Product	Internal	Common / SWIR / TIR		FTS-2 scene	HDF5
	TANSO-FTS-2 CAL L1A Product	Internal	Solar irradiance	Common / SWIR	Path	HDF5
			Blackbody	Common / SWIR / TIR	Path	
			Deep space	Common / SWIR / TIR	Path	
			Instrument function	Common / SWIR	Path	
			Nighttime	Common / SWIR	Path	
			Lunar	Common / SWIR	Path	
	TANSO-FTS-2 L1B Product	Internal	Common		FTS-2 scene	HDF5
		Standard	SWIR / TIR			
	TANSO-FTS-2 CAL L1B Product	Internal	Solar irradiance	Common / SWIR	Path	HDF5
			Blackbody	Common / SWIR / TIR	Path	
			Deep space	Common / SWIR / TIR	Path	
			Instrument function	Common / SWIR	Path	
			Nighttime	Common / SWIR	Path	
			Lunar	Common / SWIR	Path	
FTS-2 SWIR	GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product	Standard	Daily		Daily	HDF5
	GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product	Standard	Daily		Daily	HDF5
FTS-2 TIR	GOSAT-2 TANSO-FTS-2 TIR L2 Cloud and Aerosol Property Product	Standard	Daily		Daily	HDF5
	GOSAT-2 TANSO-FTS-2 TIR L2 Temperature and Gas Profile Product	Standard	Daily		Daily	HDF5
	GOSAT-2 TANSO-FTS-2 TIR L2 Temperature and Gas Profile Research Product	Research	Daily		Daily	HDF5
CAI-2	TANSO-CAI-2 L1A Product	Internal	Common / Forward looking / Backward looking		CAI-2 scene	HDF5
	TANSO-CAI-2 CAL L1A Product	Internal	Nighttime	Common / Forward looking / Backward looking	Path	HDF5
			Lunar	Common / Forward looking / Backward looking	Path	
	GOSAT-2 TANSO-CAI-2 L1B Product	Standard	CAI-2 frame		CAI-2 frame	HDF5
	GOSAT-2 TANSO-CAI-2 L2 Cloud Discrimination Product	Standard	CAI-2 frame		CAI-2 frame	HDF5
	GOSAT-2 TANSO-CAI-2 L2 Aerosol Property Product	Standard	CAI-2 frame		CAI-2 frame	HDF5
—	GOSAT-2 L4A Global CO_2 Flux Product	Standard	Annually		Annually	NetCDF
	GOSAT-2 L4A Global CH_4 Flux Product	Standard	Annually		Annually	NetCDF
	GOSAT-2 L4B Global CO_2 Distribution Product	Standard	Annually		Annually	NetCDF
	GOSAT-2 L4B Global CH_4 Distribution Product	Standard	Annually		Annually	NetCDF

Note: The details of L3 products are TBD.

Table 7.1-2 Processing level concept of each TANSO-FTS-2 product

Processing/Products	Concept diagram	Supplementary explanation
Photoelectric conversion of observation light		Observation light is modulated by Fourier interferometer, performed photoelectric conversion (photon to current) at detector, and converted to voltage by the first stage amplifier.
Equal-timing interferogram L1A/UTS		Record voltage at the time synchronized to internal clock by each band. Therefore, the horizontal-axis shows time and the vertical-axis shows voltage. Record the zero point passage time simultaneously. These data are transmitted to the ground system.
Equal-distance interferogram L1A		Convert equal-timing interferogram into equal-distance interferogram. In this result, horizontal-axis shows optical path difference and the vertical-axis shows voltage.
Spectrum L1B		(FTS-2 SWIR) Observation spectrums before sensitivity calibration (V/cm^{-1}) and after sensitivity calibration (W/cm^2/str/cm^{-1}) (FTS-2 TIR) Spectrum after sensitivity calibration using blackbody/deep space calibration data (W/cm^2/str/cm^{-1}) and spectrum adopted effective FOV correction (W/cm^2/str/cm^{-1})
Column amount concentration L2	(SWIR) XCO_2 = 400.0 ppm (ex.) XCH_4 = 1.90 ppm (ex.) (TIR) CO_2@500hPa = 400.0 ppm (ex.) CH_4@500hPa = 1.95 ppm (ex.)	(SWIR) Column-averaged dry-air mole fraction derived from observation spectrum (TIR) Vertical profiles of gas concentrations derived from observation spectrum
Global distribution of column amount concentration L3 (TBD)		Global distributions of CO_2 and CH_4 concentrations
Global flux L4A		Net emissions and uptake of CO_2 and CH_4

7.1.1 TANSO-FTS-2 L1A Product

TANSO-FTS-2 L1A product consists of the data converted from the equal-timing sampling interferogram of TANSO-FTS-2 L1A/UTS (uniform time sample) into the equal-distance sampling interferogram, and the data appended time, position and radiometric correction information of the observation points. TANSO-FTS-2 L1A products have two types, daytime/nighttime observation products, by observation mode. The products are also divided into different files depending of which information is related to SWIR, TIR, or common (SWIR/TIR) respectively.

7.1.2 TANSO-FTS-2 L1B Product

TANSO-FTS-2 L1B product is the data converted from the equal-distance sampling interferogram of TANSO-FTS-2 L1A into the spectrum information via Fourier transform, and is corrected with radiometric correction. TANSO-FTS-2 L1B product contains the calibration data information which has been used for the radiometric correction. One TANSO-FTS-2 L1B product is generated from one TANSO-FTS-2 L1A product.

7.1.3 CAM Data

TANSO-FTS-2 FOV camera data in TANSO-FTS-2 L0 data [5] is converted to JPEG files and grouped by scene as CAM data. These image data are provided at original resolution size.

7.1.4 GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product

TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product is a dataset of multiple individual retrieval results under the assumption of clear-sky condition from spectral radiance data in TANSO-FTS-2 L1B Product using MAP method [6]. This product stores solar induced chlorophyll fluorescence data retrieved from band 1 spectral radiance data in TANSO-FTS-2 L1B Product as well as column-averaged dry-air mole fraction of atmospheric gases retrieved from band 2 and 3 spectral radiance data in TANSO-FTS-2 L1B Product.
In principle, all TANSO-FTS-2 SWIR data are subject to process to generate this product.

7.1.5 GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product

TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product stores column-averaged dry-air mole fraction of atmospheric gases retrieved by a full-physics method based on MAP method using band 1-3 spectral radiance data in TANSO-FTS-2 L1B Products. TANSO-FTS-2 SWIR data acquired under the condition where cloud-free or only optically thin cirrus clouds are present within the TANSO-FTS-2 instantaneous field of view, are used to generate this product.

[5] L0 data: data obtained by rearranging ASD, which compressed and divided at onboard, for each observation point and decompressing them.
[6] MAP method: maximum a posteriori method

7.1.6 GOSAT-2 TANSO-FTS-2 TIR L2 Cloud and Aerosol Property Product

TANSO-FTS-2 TIR L2 cloud and aerosol property product stores the clear-sky discrimination results from the threshold method, the slicing method and the split-window method, as well as cloud and aerosol properties for cloudy cases, which are retrieved from band 4-5 radiance data in TANSO-FTS-2 L1B product. In principle, all data of TANSO-FTS-2 TIR are subject to process to generate this product.

7.1.7 GOSAT-2 TANSO-FTS-2 TIR L2 Temperature and Gas Profile Product

TANSO-FTS-2 TIR L2 temperature and gas profile product is a dataset extracted items for general users from TANSO-FTS-2 TIR L2 temperature and gas profile research product (cf. section 7.1.8).

7.1.8 GOSAT-2 TANSO-FTS-2 TIR L2 Temperature and Gas Profile Research Product

TANSO-FTS-2 TIR L2 temperature and gas profile research product stores vertical profiles of air temperature and gas concentrations retrieved from band 4-5 radiance spectrums in TANSO-FTS-2 L1B product using MAP method. This product is generated only in cases cloud free condition within the instantaneous field of view of TANSO-FTS-2.

7.1.9 TANSO-CAI-2 L1A Product

TANSO-CAI-2 L1A product stores TANSO-CAI-2 L0 data, observation point position and radiometric correction information. Observed digital value is not converted into luminance data. GOSAT-2 TANSO-CAI-2 L1A product is stored one file by each revolution.
TANSO-CAI-2 normally acquires observation data in the condition of daytime on the ground, therefore GOSAT-2 TANSO-CAI-2 L1A product stores about half revolution data. Also, band 1- 5 (forward-looking) data and band 6-10 (backward-looking) data are stored separately for different files.

7.1.10 GOSAT-2 TANSO-CAI-2 L1B Product

TANSO-CAI-2 L1B product contains spectral radiance data per pixel converted from sensor outputs, stored as digital values in TANSO-CAI-2 L1A product. Band-to-band registration of each forward- and backward-looking band is applied to this product. In addition, ortho-correction is performed to observation location data based on an earth ellipsoid model, which are decimated and stored in TANSO-CAI-2 L1A product, using digital elevation model data to put information of observation location with regard to elevation to all pixels.

7.1.11 GOSAT-2 TANSO-CAI-2 L2 Cloud Discrimination Product

TANSO-CAI-2 L2 cloud discrimination product stores clear-sky confidence levels per pixel, which are calculated by combining the results of threshold tests for multiple features such as reflectance ratio and Normalized Difference Vegetation Index (NDVI), obtained from spectral radiance data in TANSO-CAI-2 L1B product.
This product also stores cloud status bit data, in which results of individual threshold tests

and quality flags for cases liable to be erroneously recognized, are summarized.

7.1.12 GOSAT-2 TANSO-CAI-2 L2 Aerosol Property Product

TANSO-CAI-2 L2 aerosol property product stores aerosol property data retrieved from spectral radiance data in TANSO-CAI-2 L1B product using MWP method [7]; over the ocean, data derived from the 5 bands in the sight direction that are not affected by sun glint (specular reflection of sunlight), and on land, data from the 10 bands of forward- and backward-looking are utilized. The spatial resolution of this product is approximately 2 km for some specified areas including Asia, and approximately 5 km for other areas.

7.1.13 GOSAT-2 L3 Product

L3 product is TBD.

7.1.14 GOSAT-2 L4A Global CO_2 Flux Product

L4A global CO_2 flux product stores monthly global CO_2 surface fluxes estimated from atmospheric CO_2 concentration data such as TANSO-FTS-2 SWIR L2 column-averaged dry-air mole fraction product (CO_2).

7.1.15 GOSAT-2 L4A Global CH_4 Flux Product

L4A global CH_4 flux product is a version of L4A global CO_2 flux product.

7.1.16 GOSAT-2 L4B Global CO_2 Distribution Product

L4B global CO_2 distribution product stores global three-dimensional distributions of CO_2 concentration estimated from L4A global CO_2 flux product using an atmospheric transport model.

7.1.17 GOSAT-2 L4B Global CH_4 Distribution Product

L4B global CH_4 distribution product is a CH_4 version of L4B global CO_2 distribution product.

[7] MWP method: multi-wavelength and multi-pixel

7.2 Product Storage Unit

Data storage units of each GOSAT-2 products file are different depending on each sensor and processing level. Each explanation of standard product storage units for general users, and the definitions of scene and frame unit are described below.

(1) The Definition of TANSO-FTS-2 scene

A single TANSO-FTS-2 scene is defined as one span data divided one-revolution data into four, starting at ascending node. (cf. Figure 7.2-1)

Each TANSO-FTS-2 observation data has an assigned orbital observation point (observation point ID) which one revolution divided into N (N=1246), starting at ascending node. At the descending node, point C, the observation point ID is numbered as half of N.

Scene No.01	From the ascending node (A) to the end point of nighttime observation (B)
Scene No.02	From the start point of daytime (B) to the descending node (C)
Scene No.03	From the descending node (C) to the end point of daytime observation (D)
Scene No.04	From the start point of nighttime observation (D) to the next ascending node (A)

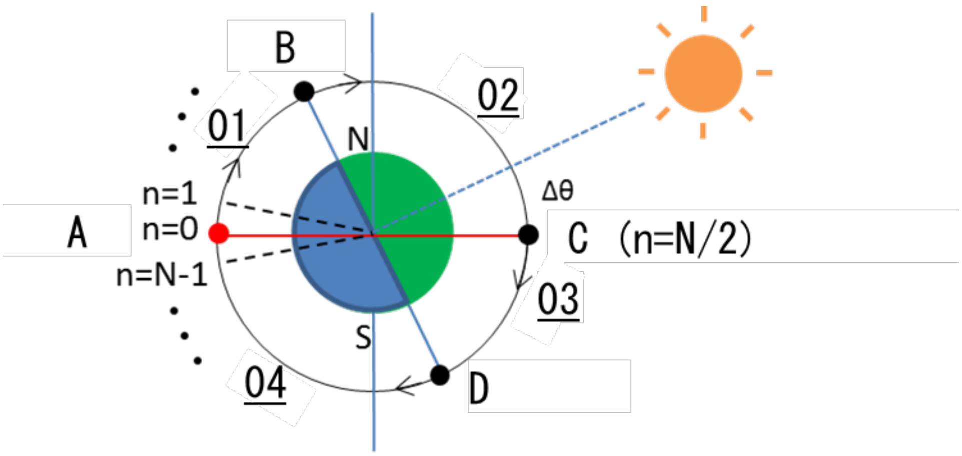


Figure 7.2-1 Definition of TANSO-FTS-2 scene

(2) The Definition of TANSO-CAI-2 scene

A single TANSO-CAI-2 scene is defined as one-revolution (one path) data starting at ascending node. Figure 7.2-2 shows a TANSO-CAI-2 scene image.

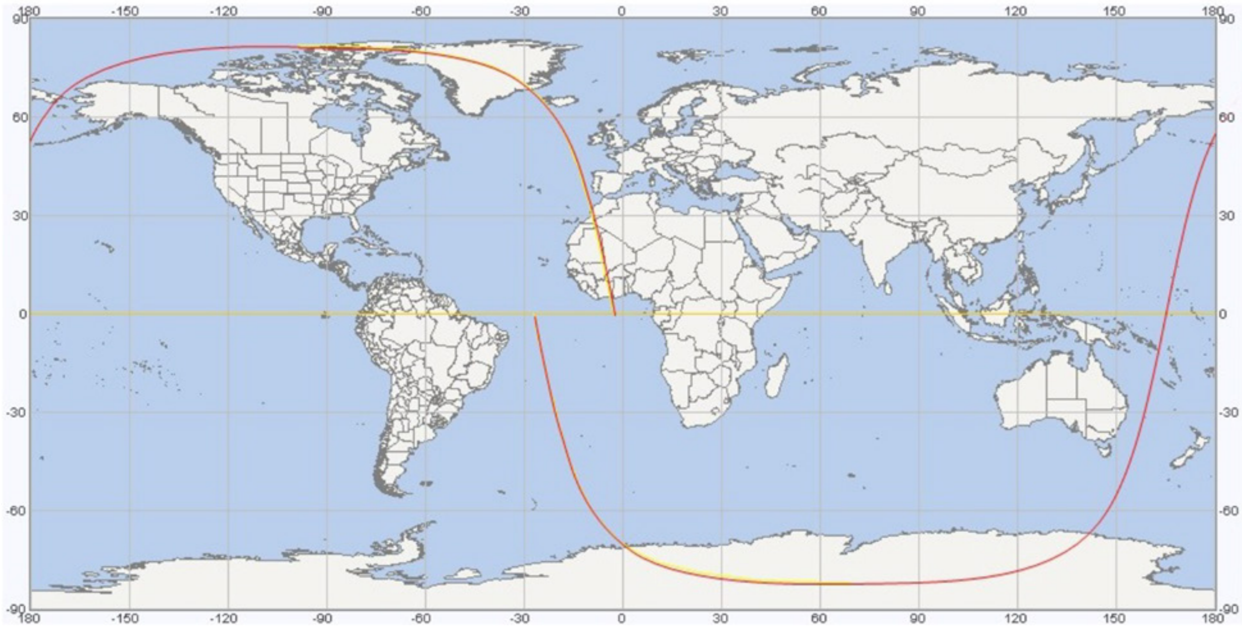


Figure 7.2-2 TANSO-CAI-2 scene image (Path number: 1)

(3) The Definition of TANSO-CAI-2 frame

TANSO-CAI-2 frame is defined as one span data divided one TANSO-CAI-2 scene into 36 equal parts by the argument of latitude at observation point of central pixel. Figure 7.2-3 shows a TANSO-CAI-2 frame image.

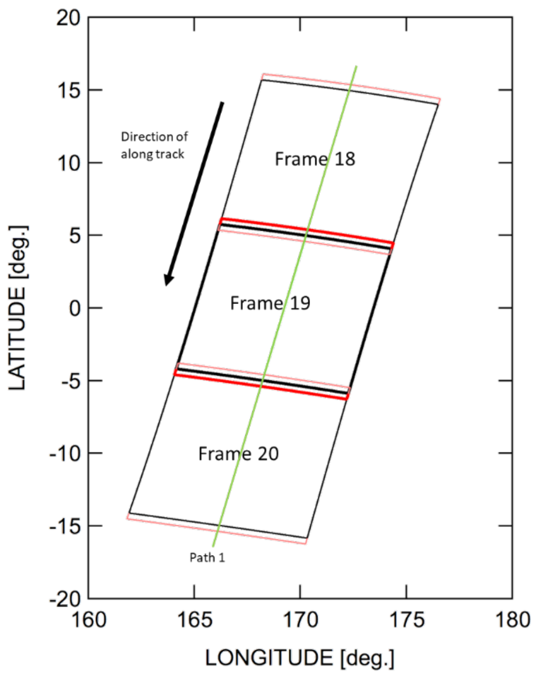


Figure 7.2-3 Example of TANSO-CAI-2 frame (Path number: 1)

7.2.1 TANSO-FTS-2 L1B Product

TANSO-FTS-2 L1B product stores by one scene. SWIR and TIR specific data files are generated for each scene. There may be no SWIR specific data, because SWIR observation mode data is normally acquired only during daytime.
Also, one spectrum data is not divided into multiple products.

7.2.2 TANSO-FTS-2 L2 Product

TANSO-FTS-2 L2 product storage unit is for each one day (00:00 - 23:59UTC).

7.2.3 TANSO-FTS-2 L1B Product

TANSO-FTS-2 L1B product storage unit is one frame.

7.2.4 TANSO-CAI-2 L2 Product

TANSO-CAI-2 L2 product storage unit is one frame as well as TANSO-CAI-2 L1B product.

7.2.5 L3 Product

L3 product is TBD.

7.2.6 L4A Product

L4A product storage unit is for each one year.

7.2.7 L4B Product

L4B product storage unit is for each one year.

7.3 The Definition of Product File Names

File name definitions of the standard products for general users are described below.

7.3.1 TANSO-FTS-2 L1B Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
G	O	S	A	T	2	T	F	T	S	2	Y	Y	Y	Y	M	M	D	D	H	H	m	m	P	P	P	S	S	_	1	B	B	D	C	0	0	O	O	O	O	A	A	A	B	B	B	.	h	5

GOSAT2 : Satellite Name (Fixed)
TFTS2 : Sensor Name TANSO-FTS-2 (Fixed)
YYYYMMDDHHmm : Observation time at first observation point of scene (year, month, day, hour, minute) (UTC)
PPP : Path No. (001-089)
SS : Scene No. (01-04)
- 01 : From ascending node (observation point ID: 0) to the end of night observation
- 02 : From the start of day observation to descending node (observation point ID: 622)
- 03 : From descending node (observation point ID: 623) to the end of day observation
- 04 : From the start of night observation to next ascending node (observation point ID: 1245)

1B : Processing Level (Fixed)
B : Band
- S : SWIR file
- T : TIR file

D : Orbit data used for processing (Using GPS or determined orbit data: Fixed)
C : Correction coefficients used for processing
- N : Using nominal coefficients
- U : Using updated coefficients

00 : Reserved
OOOO : Operation Mode
- OB1D : Observation Mode (day)
- OB1N : Observation Mode (night)
- OB2D : Observation Mode (day, not full bands)
- OB2N : Observation Mode (night, not full bands)

AAA : Algorithm Version (000-999)
BBB : Parameter Version (000-999)
h5 : Extension (Fixed)

7.3.2 GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
G	O	S	A	T	2	T	F	T	S	2	Y	Y	Y	Y	M	M	D	D	_	0	2	S	W	P	R	V	M	M	N	N	R	R	o	o	o	o	.	h	5

GOSAT2 : Satellite Name (Fixed)
TFTS2 : Sensor Name TANSO-FTS-2 (Fixed)
YYYYMMDD : Observation date (year, month, day) (UTC)
02 : Processing Level (Fixed)
SWPR : Product code (Fixed)
V : Processing identifier
- V : Steady
- T : Test

MMNN : Product version
- MM : Major (00-99)
- NN : Minor (00-99)

RR : Revision (00-99)
oooo : Input data version (0000-9999)
h5 : Extension (Fixed)

7.3.3 GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
G	O	S	A	T	2	T	F	T	S	2	Y	Y	Y	Y	M	M	D	D	_	0	2	S	W	F	P	V	M	M	N	N	R	R	o	o	o	o	.	h	5

GOSAT2 : Satellite Name (Fixed)
TFTS2 : Sensor Name TANSO-FTS-2 (Fixed)
YYYYMMDD : Observation date (year, month, day) (UTC)
02 : Processing Level (Fixed)
SWFP : Product code (Fixed)
V : Processing identifier
- V : Steady
- T : Test

MMNN : Product version
- MM : Major (00-99)
- NN : Minor (00-99)

RR : Revision (00-99)
oooo : Input data version (0000-9999)
h5 : Extension (Fixed)

7.3.4 GOSAT-2 TANSO-FTS-2 TIR L2 Cloud and Aerosol Property Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
G	O	S	A	T	2	T	F	T	S	2	Y	Y	Y	Y	M	M	D	D	_	0	2	T	C	A	P	V	M	M	N	N	R	R	o	o	o	o	.	h	5

GOSAT2 : Satellite Name (Fixed)
TFTS2 : Sensor Name TANSO-FTS-2 (Fixed)
YYYYMMDD : Observation date (year, month, day) (UTC)
02 : Processing Level (Fixed)
TCAP : Product code (Fixed)
V : Processing identifier
- V : Steady
- T : Test

MMNN : Product version
- MM : Major (00-99)
- NN : Minor (00-99)

RR : Revision (00-99)
oooo : Input data version (0000-9999)
h5 : Extension (Fixed)

7.3.5 GOSAT-2 TANSO-FTS-2 TIR L2 Temperature and Gas Profile Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
G	O	S	A	T	2	T	F	T	S	2	Y	Y	Y	Y	M	M	D	D	_	0	2	T	T	G	P	V	M	M	N	N	R	R	o	o	o	o	.	h	5

GOSAT2 : Satellite Name (Fixed)
TFTS2 : Sensor Name TANSO-FTS-2 (Fixed)
YYYYMMDD : Observation date (year, month, day) (UTC)
02 : Processing Level (Fixed)
TTGP : Product code (Fixed)
V : Processing identifier
- V : Steady
- T : Test

MMNN : Product version
- MM : Major (00-99)
- NN : Minor (00-99)

RR : Revision (00-99)
oooo : Input data version (0000-9999)
h5 : Extension (Fixed)

7.3.6 GOSAT-2 TANSO-CAI-2 L1B Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
G	O	S	A	T	2	T	C	A	I	2	Y	Y	Y	Y	M	M	D	D	H	H	m	m	P	P	P	F	F	F	_	1	B	C	C	L	1	B	V	M	M	N	N	R	R	o	o	o	o	.	h	5

GOSAT2 : Satellite Name (Fixed)
TCAI2 : Sensor Name TANSO-CAI-2 (Fixed)
YYYYMMDDHHmm : Start time of observation [8] (year, month, day, hour, minute) (UTC)
PPP : Path No. (001-089)
FFF : Frame No. (001-036)
1B : Processing Level (Fixed)
C : Band (Fixed) , not distinguished with forward and backward-looking
CL1B : Product code (Fixed)
V : Processing identifier
- V : Steady
- T : Test

MMNN : Product version
- MM : Major (00-99)
- NN : Minor (00-99)

RR : Revision (00-99)
oooo : Input data version (0000-9999)
h5 : Extension (Fixed)

[8] In principle, it is observation time of the first line without margin in forward-looking frame. If there is no forward-looking frame, it is observation time of the first line without margin in backward-looking frame. (Same for GOSAT-2 TANSO-CAI-2 L2 Cloud Discrimination Product and GOSAT-2 TANSO-CAI-2 Aerosol Property Product)

7.3.7 GOSAT-2 TANSO-CAI-2 L2 Cloud Discrimination Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
G	O	S	A	T	2	T	C	A	I	2	Y	Y	Y	Y	M	M	D	D	H	H	m	m	P	P	P	F	F	F	_	0	2	C	C	L	D	D	V	M	M	N	N	R	R	o	o	o	o	.	h	5

GOSAT2 : Satellite Name (Fixed)
TCAI2 : Sensor Name TANSO-CAI-2 (Fixed)
YYYYMMDDHHmm : Start time of observation (year, month, day, hour, minute) (UTC)
PPP : Path No. (001-089)
FFF : Frame No. (001-036)
02 : Processing Level (Fixed)
C : Band (Fixed), not distinguished with forward and backward-looking
CLDD : Product code (Fixed)
V : Processing identifier
  V : Steady
  T : Test
MMNN : Product version
  MM : Major (00-99)
  NN : Minor (00-99)
RR : Revision (00-99)
oooo : Input data version (0000-9999)
h5 : Extension (Fixed)

7.3.8 GOSAT-2 TANSO-CAI-2 L2 Aerosol Property Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
G	O	S	A	T	2	T	C	A	I	2	Y	Y	Y	Y	M	M	D	D	H	H	m	m	P	P	P	F	F	F	_	0	2	C	A	E	R	P	V	M	M	N	N	R	R	o	o	o	o	.	h	5

GOSAT2 : Satellite Name (Fixed)
TCAI2 : Sensor Name TANSO-CAI-2 (Fixed)
YYYYMMDDHHmm : Start time of observation (year, month, day, hour, minute) (UTC)
PPP : Path No. (001-089)
FFF : Frame No. (001-036)
02 : Processing Level (Fixed)
C : Band (Fixed), not distinguished with forward and backward-looking
AERP : Product code (Fixed)
V : Processing identifier
- V : Steady
- T : Test

MMNN : Product version
- MM : Major (00-99)
- NN : Minor (00-99)

RR : Revision (00-99)
oooo : Input data version (0000-9999)
h5 : Extension (Fixed)

7.3.9 L3 Product

L3 product is TBD.

7.3.10 GOSAT-2 L4A Global CO_2 Flux Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
G	O	S	A	T	2	Y	Y	Y	Y	M	M	y	y	y	y	m	m	_	4	A	C	O	2	F	V	M	M	N	N	R	R	o	o	o	o	.	n	c

GOSAT2 : Satellite name (Fixed)
YYYYMM : Start month of flux estimation (year, month) (UTC)
yyyymm : End month of flux estimation (year, month) (UTC)
4A : Processing level (Fixed)
CO2F : Product code (Fixed)
V : Processing identifier
- V : Steady
- T : Test

MMNN : Product version
- MM : Major (00-99)
- NN : Minor (00-99)

RR : Revision (00-99)
oooo : Input data version (0000-9999)
nc : Extension (Fixed)

7.3.11 GOSAT-2 L4A Global CH_4 Flux Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
G	O	S	A	T	2	Y	Y	Y	Y	M	M	y	y	y	y	m	m	_	4	A	C	H	4	F	V	M	M	N	N	R	R	o	o	o	o	.	n	c

GOSAT2 : Satellite name (Fixed)
YYYYMM : Start month of flux estimation (year, month) (UTC)
yyyymm : End month of flux estimation (year, month) (UTC)
4A : Processing level (Fixed)
CH4F : Product code (Fixed)
V : Processing identifier
  V : Steady
  T : Test
MMNN : Product version
  MM : Major (00-99)
  NN : Minor (00-99)
RR : Revision (00-99)
oooo : Input data version (0000-9999)
nc : Extension (Fixed)

7.3.12 GOSAT-2 L4B Global CO_2 Distribution Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
G	O	S	A	T	2	Y	Y	Y	Y	M	M	y	y	y	y	m	m	_	4	B	C	O	2	C	V	M	M	N	N	R	R	o	o	o	o	.	n	c

GOSAT2 : Satellite name (Fixed)
YYYYMM : Start month of concentration distribution calculation (year, month) (UTC)
yyyymm : End month of concentration distribution calculation (year, month) (UTC)
4B : Processing level (Fixed)
CO2C : Product code (Fixed)
V : Processing identifier
V : Steady
T : Test
MMNN : Product version
MM : Major (00-99)
NN : Minor (00-99)
RR : Revision (00-99)
oooo : Input data version (0000-9999)
nc : Extension (Fixed)

7.3.13 GOSAT-2 L4B Global CH_4 Distribution Product

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
G	O	S	A	T	2	Y	Y	Y	Y	M	M	y	y	y	y	m	m	_	4	B	C	H	4	C	V	M	M	N	N	R	R	o	o	o	o	.	n	c

GOSAT2 : Satellite name (Fixed)
YYYYMM : Start month of concentration distribution calculation (year, month) (UTC)
yyyymm : End month of concentration distribution calculation (year, month) (UTC)
4B : Processing level (Fixed)
CH4C : Product code (Fixed)
V : Processing identifier
- V : Steady
- T : Test

MMNN : Product version
- MM : Major (00-99)
- NN : Minor (00-99)

RR : Revision (00-99)
oooo : Input data version (0000-9999)
nc : Extension (Fixed)

7.4 Product Format

7.4.1 Data Storage Format

GOSAT-2 products for general users are stored and provided in HDF5 or NetCDF format as shown in Table 7.1-1. Outlines of HDF5 and NetCDF format are described below.

(1) HDF

HDF(Hierarchical Data Format) is a self-descriptive generic file format designed by the National Center for Supercomputing Applications (NCSA) of U.S.A. HDF is a platform-independent file format and stores multiple types of data objects necessary for data analysis and associated files into a single file, while images, charts, annotations, image palettes, etc. are included in the objects mentioned above. Meta-data, describing data types, location of the data in the file, and so on, are also included in the file.

HDF has a hierarchical structure; the physical file format to store the data is defined as the lowest layer, while the upper layers include applications to perform operations such as HDF file management, data manipulation, validation, and analysis. HDF is not prepared for simply defining a file format but is composed of various kinds of supporting software to facilitate operations such as data storing, searching, visualizing, analyzing, and managing with the HDF file.

HDF5, version 5 of HDF, adopted to the GOSAT-2 products, has resolved the problems in the preceding versions; storing limit of data sets up to 20,000, file size limit of 2GB for file generation, and so forth.

(2) NetCDF

NetCDF (Network Common Data Form) is a self-descriptive, array-oriented file format, which was designed in 1989 led by Unidata, USA. NetCDF stores meta-data in addition to regular data. Like HDF5, NetCDF is not only a file format but is composed of software libraries.

There exists a close relationship between HDF5 and NetCDF. That is to say, NetCDF of version 4.1 and later adopts HDF5 format to the data storage layer, and allows read-in access to the data in HDF5.

7.4.2 Format Examples

In order to display and/or analyze a GOSAT-2 product, it should be read in accordance with its data format. As libraries are available for HDF5 and NetCDF, the products are read-in using the libraries as a common practice.

Table 7.4-1 lists up the document names and sections explaining the format of the standard products.

Table 7.4-1 Standard products and format documents

<table>
<tr><th>Product Name</th><th>Delivery status</th><th>Document name</th><th>Related section</th></tr>
<tr><td>TANSO-FTS-2 L1B Product</td><td>X</td><td>GOSAT-2/TANSO-FTS-2 Level 1 Product Description Document</td><td>Chapter 3</td></tr>
<tr><td>GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product</td><td></td><td rowspan="11">NIES GOSAT-2 Product File Format Descriptions (Product edition)</td><td>Volume 4</td></tr>
<tr><td>GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product</td><td></td><td>Volume 5</td></tr>
<tr><td>GOSAT-2 TANSO-FTS-2 TIR L2 Cloud and Aerosol Property Product</td><td></td><td>Volume 6</td></tr>
<tr><td>GOSAT-2 TANSO-FTS-2 TIR L2 Temperature and Gas Profile Product</td><td></td><td>Volume 7</td></tr>
<tr><td>GOSAT-2 TANSO-CAI-2 L1B Product</td><td>X</td><td>Volume 1</td></tr>
<tr><td>GOSAT-2 TANSO-CAI-2 L2 Cloud Discrimination Product</td><td>X</td><td>Volume 2</td></tr>
<tr><td>GOSAT-2 TANSO-CAI-2 L2 Aerosol Property Product</td><td></td><td>Volume 3</td></tr>
<tr><td>GOSAT-2 L4A Global CO_2 Flux Product</td><td></td><td>Volume 8</td></tr>
<tr><td>GOSAT-2 L4A Global CH_4 Flux Product</td><td></td><td>Volume 9</td></tr>
<tr><td>GOSAT-2 L4B Global CO_2 Distribution Product</td><td></td><td>Volume 10</td></tr>
<tr><td>GOSAT-2 L4B Global CH_4 Distribution Product</td><td></td><td>Volume 11</td></tr>
</table>

Note: The symbol ‘X’ means that the product is generally available as of May 2020.

7.5 Update of Product Version

Each GOSAT-2 product will be upgraded in version depending on updating of the processing algorithm. This section describes the upgrade rules for each product.
Each product will be reprocessed using upgraded version and provided as needed, therefore, it is need to be careful of product version to download the necessary data. In addition, please refer to Web site described in section 8.5 about ‘Differences with standard product versions’ and ‘Relationship of observation periods and product versions’.

7.5.1 TANSO-FTS-2 L1B Product

Upgrade status of TANSO-FTS-2 L1B product is confirmable by the information of algorithm version (corresponding to ‘AAA’ in section 7.3.1) and parameter version (corresponding to ‘BBB’ in section 7.3.1) given to the file name. The upgrade polices are described individually below. Also, Table 7.5-1 shows the image of version increment.

(1) Algorithm version
The processing algorithm version is expressed as a 3-digit number. The upgrade policy for each digit is as follows:

- 1st digit: major version
  This digit is incremented in the case changing L1 product format or when there is no plan of next update is scheduled for a while.
- 2nd and 3rd digit: minor version
  This 2-digit number is incremented in the case updating algorithm. Each digit is used to distinguish between major and minor corrections.

(2) Parameter version
The processing parameter file set is expressed as a 3-digit number. The upgrade policy for each digit is same as algorithm version.

Table 7.5-1 Image of TANSO-FTS-2 L1B Product Version Increment

Date	Changed contents	Version upgrade type	Version common name(*)
Aug. 1, 2019	Initial release	**Major** version (Major corrections)	V100.100
Sep. 1, 2019	Correction of log contents (There is no impact on a product.)	Minor version (Minor corrections)	V101.100
Oct. 1, 2019	Update of parameters (There is a small impact on a product.)	Minor version (Minor corrections)	V101.101
Nov. 1, 2019	Change of processing method (There is an impact on a product.)	Minor version (Major corrections)	V110.110
Dec. 1, 2019	Change of algorithms and processing parameters (There is a large impact on a product.)	**Major** version (Next update is undecided.)	V200.200

*As a general notation of version common name, there is the first letter ‘V’ followed by a major version and minor version separated by a dot.

7.5.2 TANSO-FTS-2 L2 Products

The version up status of TANSO-FTS-2 L2 product can be confirmed by the product version, revision and input data version. The upgrade polices are described individually below. Table 7.5-2 shows the image of version increment.
Also, data users need only to pay attention to the change of product version number, because revision and input data version numbers are given for management purpose.

(1) Product version
The product version consists of major version and minor version, and each one is expressed by a 0-padded 2-digit integer. (It is corresponding to 'MMNN' field in section 7.3.2 to 7.3.5.)

The increment policy of major version and minor version is described as follows:

- Major version is incremented if the impact on derived product is large.
- Minor version is incremented if the impact on derived product is small.

(2) Revision
The revision is expressed by a 0-padded 2-digit integer. The revision is incremented when there is any change without impact to the derived product. (It is corresponding to 'RR' field in section 7.3.2 to 7.3.5.)

(3) Input data version
The input data version, which is given to a set of input data and reference data used for data processing, is expressed by a 0-padded 4-digit integer. The input data version is incremented when any version of an input data or a reference data is changed. (It is corresponding to 'oooo' field in section 7.3.2 to 7.3.5.)

Table 7.5-2 Image of TANSO-FTS-2 L2 Product Version Increment

Date	Changed contents	Product version(*)	Revision	Input data version
Aug. 1, 2019	Initial release	01.00	00	0001
Sep. 1, 2019	Correction of log contents (There is no impact on a product.)	01.00	01	0001
Oct. 1, 2019	Version change of reference data (There is a small impact on a product.)	01.01	00	0002
Nov. 1, 2019	Change of algorithms and processing parameters (There is a large impact on a product.)	02.00	00	0003

*As a general notation, there is a dot between major version and minor version.

7.5.3 TANSO-CAI-2 L1B Product and L2 Products

The upgrade policies of TANSO-CAI-2 L1B product and L2 product are same as TANSO-FTS-2 L2 product described in section 7.5.2.

7.5.4 L3 Products

L3 product is TBD.

7.5.5 L4 Products

The version up status of L4 product can be confirmed by the product version, revision, and input data version. The upgrade policies are described individually below.

(1) Product version

The product version consists of major version and minor version, and each one is expressed by a 0-padded 2-digit integer. (It is corresponding to ‘MMNN’ field in Section 7.3.10 to 7.3.13.)

The increment policy of major version and minor version is described as follows:

- Major version upgrade of the model: Major version is incremented.
- Minor version upgrade of the model and version upgrade of a priori information etc. used for the model: Minor version is incremented.

(2) Revision

The revision is expressed by a 0-padded 2-digit integer. The revision is incremented when there is any change of the model or a priori information etc. (It is corresponding to ‘RR’ field in Section 7.3.10 to 7.3.13.)

(3) Input data version

The input data version, which is given to a set of observation data of atmospheric concentration (TANSO-FTS-2 L2 and ground-based measurement data) used for the model processing, is expressed by a 0-padded 4-digit integer. The input data version is incremented when any version of observation data of atmospheric concentration is changed. (It is corresponding to ‘oooo’ field in Section 7.3.10 to 7.3.13.)

7.6 TANSO-FTS-2 Processing Algorithm

Figure 7.6-1 shows outline of TANSO-FTS-2 processing flow diagram from L0 to L1B. Figure 7.6-2 shows outline of L2 processing flow diagram. Refer to section 2.2, each algorithm theoretical bases documents for each processing algorithm details for TANSO-FTS-2 standard products.
The reference manual describing the details of the algorithm will be obtained from the NIES GOSAT-2 products distribution website, GOSAT-2 Product Archive. The method to obtain the document is explained in section 8.5.

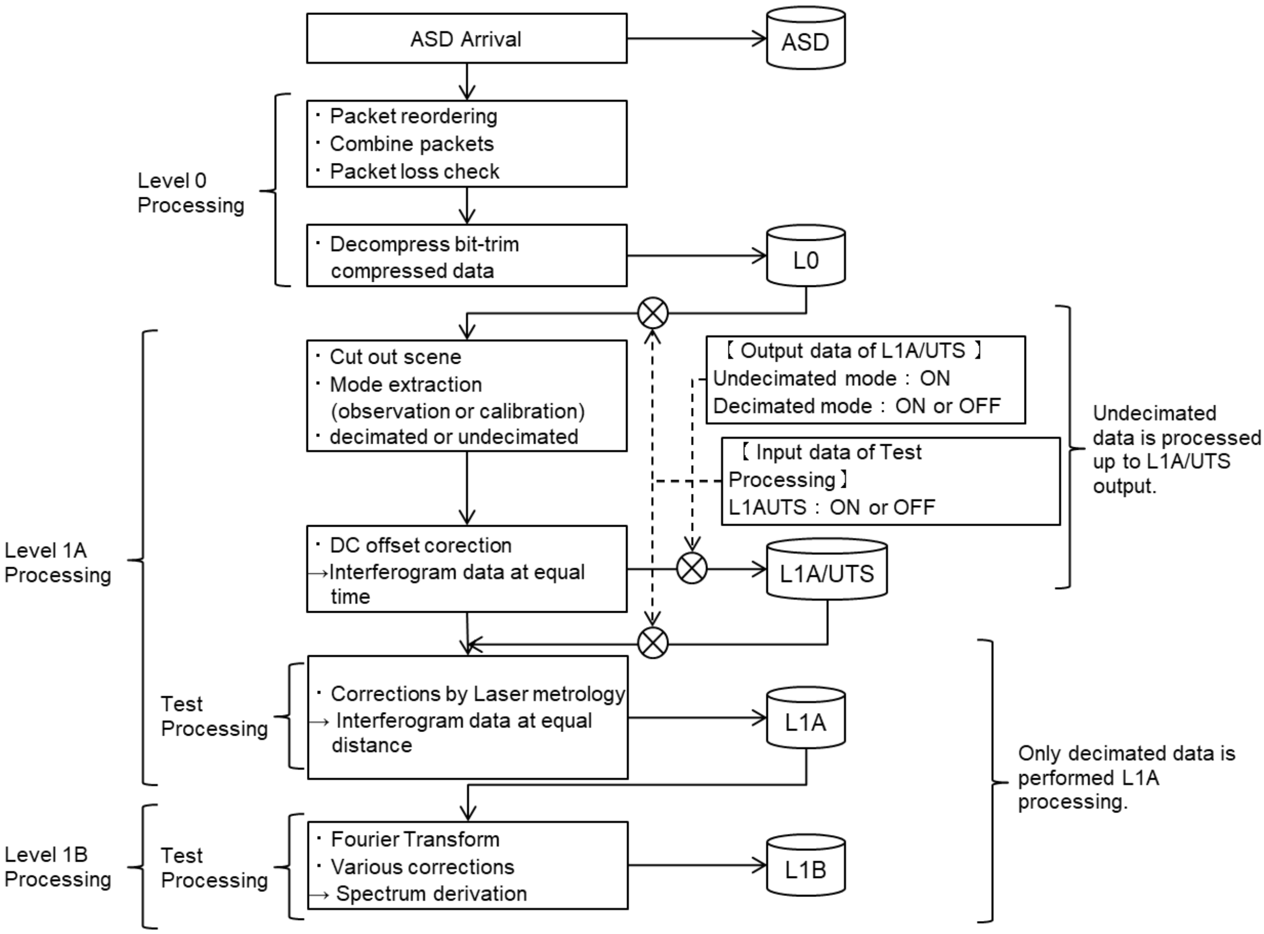


Figure 7.6-1 TANSO-FTS-2 processing flow diagram from L0 to L1B

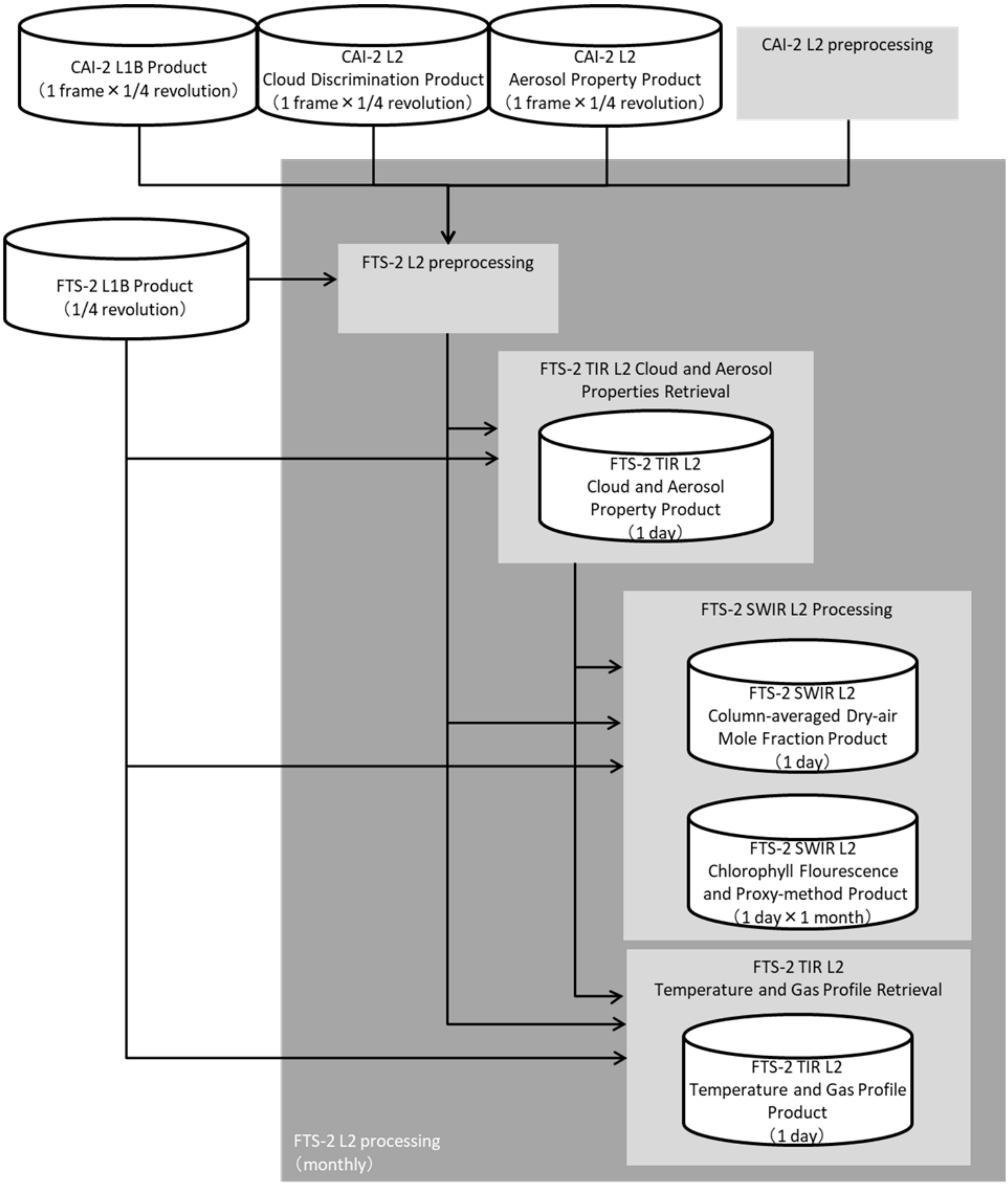


Figure 7.6-2 TANSO-FTS-2 L2 processing flow diagram

7.6.1 TANSO-FTS-2 L1A Processing Algorithm

TANSO-FTS-2 Level 1A processing is performed on Level 0 by adding some information to the interferogram output from the sensor. Major specifications of the appended information in TANSO-FTS-2 L1A product are listed below.

[Appended information]
- Observation ID
- Observation time
- Spacecraft position and velocity (ECI,ECR) and attitude at the observation time
- Geometric information at the observation point
- Sun and Moon position at the observation point (ECI,ECR)
- Sunglint flag
- Quality flag
- Land/Ocean flag
- Viewing vector
- CAM data near the observation time

7.6.2 TANSO-FTS-2 L1B Processing Algorithm

TANSO-FTS-2 L1B processing is performed on TANSO-FTS-2 L1A (intererogram) by converting to spectrum with Fourier transform and various corrections.
About SWIR, two types of spectrum are stored: spectrum before sensitivity calibration (V/cm^{-1}) and spectrum after sensitivity calibration ($W/cm^2/str/cm^{-1}$) are stored.
TIR stores two types of spectrum: spectrum after sensitivity calibration using blackbody/deep space calibration data ($W/cm^2/str/cm^{-1}$) and spectrum corrected with finite field of view correction ($W/cm^2/str/cm^{-1}$).
Major specifications of the appended information in TANSO-FTS-2 L1B product are listed below.

[Appended information]
- Observation ID
- Observation time
- Spacecraft position and velocity (ECI,ECR) and attitude at the observation time
- Latitude and longitude at the observation point
- Sun and Moon position at the observation point (ECI,ECR)
- Sunglint flag
- Quality flag
- Land/Ocean flag
- Viewing vector
- CAM data near the observation time
- Granule ID used for calculation

7.6.3 TANSO-FTS-2 Higher level Processing Algorithm

7.6.3.1 FTS-2 SWIR L2 Processing Algorithm

FTS-2 SWIR L2 Processing retrieves several physical quantities from SWIR spectral radiance data in TANSO-FTS-2 L1B Products using MAP method.
GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product stores a dataset of multiple individual retrieval results under the assumption of clear-sky condition.
GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product contains column-averaged dry-air mole fraction of atmospheric gases retrieved by a full-physics method.
Major dataset in these products are listed below.

[GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product]
- Solar induced chlorophyll fluorescence
- XCH_4 (proxy method)
- XCO (proxy method)

[GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product]
- XCO_2 (full-physics method)
- XCH_4 (full-physics method)
- XCO (full-physics method)
- XH_2O (full-physics method)

7.6.3.2 FTS-2 TIR L2 Processing Algorithm for Temperature and Gas Profile

FTS-2 TIR L2 processing algorithm for temperature and gas profile has been improved for GOSAT-2 based on the processing algorithm for CO_2 and CH_4 concentration profiles which was developed for GOSAT (Saitoh et al., 2009, 2012, 2016).
This processing retrieves the height profiles of CO_2, CH_4, O_3, temperature, H_2O, and N_2O using FTS-2 Bands 4 (5.5-8 μm) and 5 (8-15 μm). It simultaneously estimates temperature and the concentrations of CO_2, H_2O, and O_3 in the CO_2 absorption bands at 10 and 15 μm, and temperature and the concentrations of CH_4, H_2O, O_3, and N_2O in the CH_4 absorption bands at 7 and 8 μm. In the estimation, the Maximum A Posteriori (MAP) method is adopted to retrieve the temperature and gas concentrations. As major a priori data, the global spectral model data JRA55 (temperature, H_2O, O_3) and the calculated values by the atmospheric transport model NICAM-TM (CO_2, CH_4) and the atmospheric transport model ACTM (N_2O) are used. The input is defined on the full grid layers of up to 110 layers, while the output is set on the retrieval grid layers of up to 30 layers by applying linear mapping in the retrieval processing.
After pre-screening using the L2 cloud flag products of CAI-2 and FTS-2, and the FTS-2 L1B quality flag, the concentration profiles are retrieved. The retrieved value is determined by the convergence test of the χ-squared value. Table 7.6-1 shows the retrieved values of the FTS-2 TIR L2 gas profile products.

Table 7.6-1 Retrieved values of FTS-2 TIR L2 gas profile products

	Physical quantities to be retrieved	Explanation	Remarks
1	CO_2	CO_2 vertical distribution [ppmv]	Up to 30 layers
2	Temperature	Temperature vertical distribution [K]	Same as the number of CO_2 layers
3	O_3	O_3 vertical distribution [ppmv]	Same as the number of CO_2 layers
4	CH_4	CH_4 vertical distribution [ppmv]	Up to 30 layers
5	H_2O	H_2O vertical distribution [ppmv]	Same as the number of CH_4 layers
6	N_2O	N_2O vertical distribution [ppmv]	Same as the number of CH_4 layers
7	Emissivity*	Ground-surface emissivity or sea-surface emissivity	500 wavenumbers
8	Surface temperature*	Ground-surface temperature or sea-surface temperature [K]	

* It is retrieved as a parameter for spectral correction (Saitoh et al., 2016).

References

1. Saitoh, N., R. Imasu, Y. Ota, and Y. Niwa, CO_2 retrieval algorithm for the thermal infrared spectra of the Greenhouse Gases Observing Satellite: potential of retrieving CO_2 vertical profile from high-resolution FTS sensor, J. Geophys. Res., Vol. 114, doi:10.1029/2008JD011500, 2009.
2. Saitoh, N., M. Touno, S. Hayashida, R. Imasu, K. Siomi, T. Yokota, Y. Yoshida, T. Machida, H. Matsueda, and Y. Sawa, Comparisons between XCH_4 from GOSAT shortwave and thermal infrared spectra and aircraft CH_4 measurements over Guam, SOLA, Vol. 8, doi:10.2151/sola.2012-036, 2012.
3. Saitoh, N., S. Kimoto, R. Sugimura, R. Imasu, S. Kawakami, K. Shiomi, A. Kuze, T. Machida, Y. Sawa, and H. Matsueda, Algorithm update of the GOSAT/TANSO-FTS thermal infrared CO_2 product (version 1) and validation of the UTLS CO_2 data using CONTRAIL measurements, Atmos. Meas. Tech., 9, 2119-2134, doi:10.5194/amt-9-2119-2016, 2016.

7.6.3.3 FTS-2 TIR L2 Processing Algorithm for Cloud and Aerosol Property

FTS-2 TIR L2 processing algorithm for cloud and aerosol property has been improved for GOSAT-2 based on the cloud property processing algorithm which was developed using the GOSAT data. This processing uses three methods: threshold method, slicing method, and split window method, and retrieves the cloud and aerosol property using the TIR data during both the daytime and nighttime. Table 7.6-2 shows the retrieved values of FTS-2 TIR L2 cloud and aerosol property products.

Threshold method
After the estimation of the ground surface emissivity, when the actual observed value is lower than the predictive estimation of brightness temperature in the atmospheric window region based on meteorological data and ground surface information, it is determined that clouds are present in the field of view. Considering measurement errors, a value which is a few K lower than the simulated value is set as the threshold. When the field of view is determined to be cloudy, the brightness temperature for the observed radiance spectrum is set as the cloud top temperature, and the pressure height corresponding to the temperature from meteorological data is set as the cloud top pressure. When the field of view is determined to be clear, the ground surface temperature and sea surface temperature in the field of view are calculated.

Split window method
When it is determined that clouds are present using the threshold method, cloud microphysical quantities are retrieved using the split window method. The atmospheric window region at around 10 μm are divided into two channels of 8.5 and 11 μm, and the brightness temperature difference between the two channels are calculated. Based on the wavelength dependence of the observed radiance spectrum and the difference in the complex refractive index of water and ice, the cloud optical thickness and the effective radius of cloud particles are retrieved (Antonelli et al., 2002).

Slicing method
The algorithm applied to the GOSAT data based on the CO_2 slicing method which is a method for detecting cirrus (Someya et al., 2016) has been improved for GOSAT-2. From spectral channels in 15 μm band, the altitude maximizing the sensitivity profile of the weighting function is calculated, and the spectral channels are sorted in order of altitude. Virtual channels are constructed by combining the sorted channels as appropriate. In order to detect upper, middle, and lower clouds using a combination of three patterns of channels with different sensitivity height, the channels to be used are optimized by radiation calculation assuming cloudy in advance. The slicing method estimates the optical thickness from cloud discrimination, cloud top height, and effective cloud amount in the field of view, using the ratio of the brightness temperature difference between clear and cloudy areas in the channel used.

Table 7.6-2 Retrieved values of FTS-2 TIR L2 cloud and aerosol property

	Physical quantities to be retrieved	Explanation	Remarks*		
			(1)	(2)	(3)
1	Cloud flag	Cloud screening result	X	X	X
2	Cloud top temperature	Retrieved value at cloud top temperature [K]	X	X	X
3	Cloud top height	Cloud top height calculated from cloud top temperature and meteorological data [km]	X	X	X
4	Cloud top pressure	Cloud top pressure calculated from cloud top temperature and meteorological data [hPa]	X	X	X
5	Optical thickness	Retrieved optical thickness		X	X
6	Cloud particle type	Cloud particle phase, ice type, etc.		X	
7	Effective radius	Effective radius assuming cloud particle type [μm]		X	
8	Effective cloud amount in FOV	Cloud amount in FTS-2 FOV assuming optically thick clouds			X
9	Emissivity	Ground-surface emissivity or sea-surface emissivity	X		
10	Surface temperature	Ground-surface temperature or sea-surface temperature [K]	X		

* Parameters estimated by (1) threshold method, (2) split window method, and (3) slicing method are described in the remarks.

References

1. Antonelli, P., S. A. Ackerman, W. P. Menzel, A. Huang, B. A. Baum, and W. L. Smith, Retrieval of Cloud Top Height, Effective Emissivity, and Particle Size, from Aircraft High Spectral Resolution Infrared Measurements, SPIE, 4539, 50-61, 2002.
2. Someya, Y., R. Imasu, N. Saitoh, Y. Ota, and K. Shiomi : A development of cloud top height retrieval using thermal infrared spectra observed with GOSAT and comparison with CALIPSO data, Atmos. Meas. Tech., 9, 1981-1992, doi:10.5194/amt-9-1981-2016, 2016.

7.7 TANSO-CAI-2 Processing Algorithm

Figure 7.7-1 shows outline of TANSO-CAI-2 L1B processing flow diagram. Figure 7.7-2 shows outline of L2 processing flow diagram. Refer to Section 2.2, each algorithm theoretical bases document for each processing algorithm details for TANSO-CAI-2 standard products. The reference manual describing the details of the algorithm will be obtained from the NIES GOSAT-2 products distribution website, GOSAT-2 Product Archive. The method to obtain the document is explained in section 8.5.

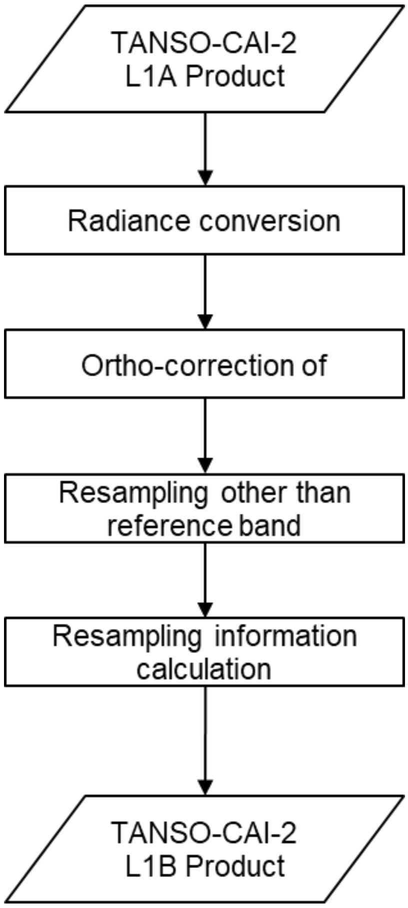


Figure 7.7-1 TANSO-CAI-2 L1B processing flow diagram

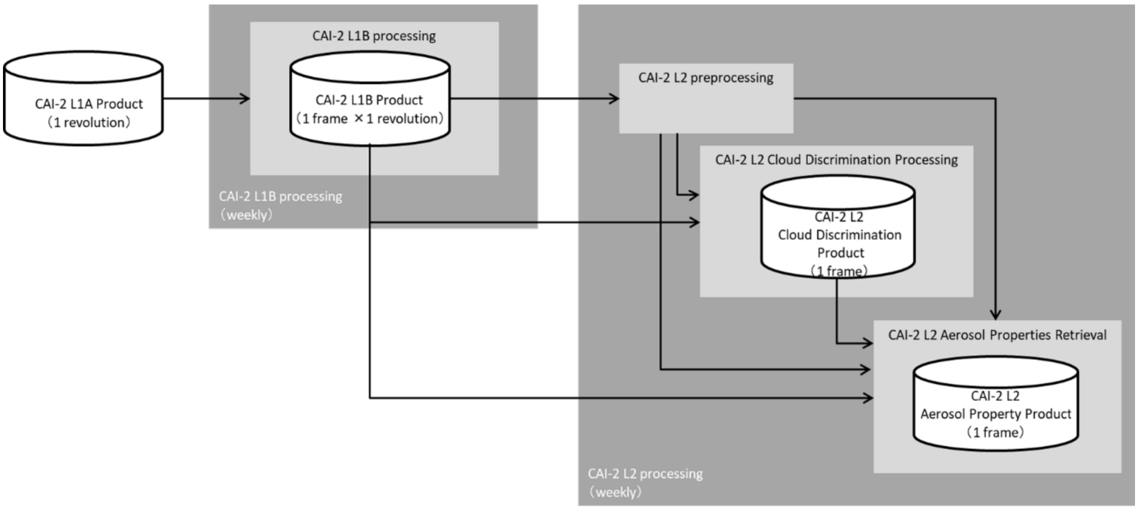


Figure 7.7-2 TANSO-CAI-2 L2 processing flow diagram

7.7.1 TANSO-CAI-2 L1A Processing Algorithm

TANSO-CAI-2 L1A processing is performed on TANSO-FTS-2 L0 data by adding position and radiometric correction information of the observation points.
Major specifications of the appended information in TANSO-CAI-2 L1A product are listed below.

[Appended information]

- Number of points
- Line exposure time
- Gain, various sensor temperatures and exposure duration
- Latitude and longitude at representative point
- Spacecraft orbit data at representative point (ECI,ECR)
- Spacecraft attitude data at representative point
- Sensor zenith and azimuth angles at representative point
- Sun position at representative point (ECI,ECR)
- Moon position at representative point (ECI,ECR)
- Quality flag

7.7.2 TANSO-CAI-2 L1B Processing Algorithm

TANSO-CAI-2 L1B processing is performed on the sensor output stored as digital value in TANSO-CAI-2 L1A product by converting to spectral radiance.
Major specifications of the appended information in TANSO-CAI-2 L1B product are listed below.

[Appended information]
- Spectral radiance

7.7.3 TANSO-CAI-2 Higher level Processing Algorithm

7.7.3.1 Overview of the L2 Cloud Discrimination Algorithm

TANSO-CAI-2 (CAI-2) onboard GOSAT-2 has several functions, one of which is the clear-sky/cloudy discrimination in observation pixels. For TANSO-FTS-2 (FTS-2) observation, the presence of cloud in the observation field of view (FOV) may lead to inaccurate estimates of greenhouse gas concentrations. In other words, discriminating presence/absence of clouds in FTS-2 FOV is essential and CAI-2 supports that function. This section provides the overview of the CAI-2 cloud-discrimination algorithm.

There are two types of CAI-2 cloud-discrimination algorithms: the Cloud and Aerosol Unbiased Decision Intellectual Algorithm (CLAUDIA) 1 based on conventional threshold tests; and CLAUDIA3 based on newly developed machine learning (as of May 2020, CLAUDIA1 is implemented to calculate cloud discriminations.) The following paragraphs outlines each algorithm.

First, CLAUDIA1 applies a series of four individual tests to each observation pixel: (i) Solar reflectance test, (ii) Wavelength dependence of reflectance test, (iii) Normalized Difference Vegetation Index (NDVI) test and (iv) Cloud discrimination over desert area test, and the individual test results are merged to calculate a clear confidence level (CCL). Each CCL is a real number of [0, 1], and indicates completely cloudy with 0.0 and completely clear with 1.0. CLAUDIA1 is characterized by being able to express the ambiguity between clear and cloudy instead of uniquely specifying each observation pixel as clear or cloudy. In fact, the clear/cloudy of a satellite observation pixel is not always uniquely determined. For example, the cases where the CAI-2's spatial resolution of 460×460m is partially covered with clouds, and where thin clouds cover the entire observation pixel, are not identified as neither perfectly cloudy nor clear. CLAUDIA1 is programmed to be able to express such ambiguous states.

CLAUDIA3 is an algorithm based on the machine learning called Support Vector Machine (SVM). SVM is one of the supervised pattern recognition methods, which first determines a decision function (called separating hyperplane) that defines which class (clear or cloudy) to belong according to the features of training samples, and then using the decision function, determines the training samples (support vectors) related to the structure of the decision function. The cloud discrimination for each satellite observation pixel is performed using this decision function. SVM does not perform individual discrimination tests but determines a separating hyperplane in a multi-dimensional space with each discrimination test as a feature, and thus, the value equivalent to the CCL used in CLAUDIA1 does not exist in CLAUDIA3. However, by taking the absolute value of the decision function, the thus obtained value can be used as the CCL.

For more details about specifications of CAI-2, and CLAUDIA1 and CLAUDIA3 algorithms, please refer to the respective ATBD.

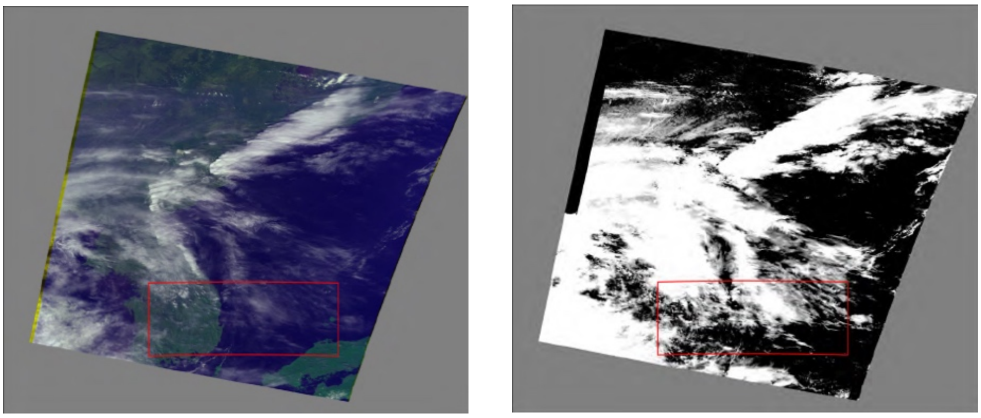


Figure 7.7-3 CAI-2 RGB composite (left) and CLAUDIA1 cloud discrimination result (right) based on data as of March 9, 2019

7.7.3.2 L2 Aerosol Algorithm

The algorithm for generating the GOSAT-2/CAI-2 L2 aerosol product over land is based on the Multi-Wavelength and Multi-Pixel Method (MWPM) of Hashimoto and Nakajima (2017). For over ocean, the Simultaneous Retrieval of Aerosol and Water leaving radiance (SIRAW) of Shi et al. (2016; 2019) is planned to be introduced, and the simplified version is currently in operation. In addition, the operational versions of these algorithms, i.e. ν-MWPM and ν-SIRAW, are implemented with neural networks to accelerate the radiance simulation (Takenaka et al., 2011).

The major parameters to be retrieved and the success criteria are listed in Table 7.7-1. Fine mode aerosol optical thickness (AOTfine) and black carbon volume fraction (BCF) in the fine mode aerosol are related with the surface-related variables, i.e. equivalent PM2.5 and black carbon (BC) concentration are equivalent values estimated by the assumed aerosol optical model in the retrieval algorithms. The spatial resolution of the product is normally with 5 km by 5 km resolution and 2 km by 2 km resolution for some specified areas in Asia.

Table 7.7-1 Major Parameters in GOSAT-2 CAI-2 L2 Aerosol Property Product

Parameter	Definition	Full (extra) success criteria
AOT550, AOT1600	Total aerosol optical thickness at λ= 550nm and 1600nm	Precision: less than 0.1 in the area of effective surface reflectance less than 7% (14%)
AOT550fine	Fine mode aerosol optical thickness at 550nm	n/a
AOT550coarse	Coarse mode aerosol optical thickness at 550nm	n/a
AE	Ångström exponent	Precision: less than 0.3 in the area of effective surface reflectance less than 7% (14%)
BCF	Black carbon (soot) volume fraction in fine mode aerosol	Precision: less than 0.1 in the area of effective surface reflectance less than 7% (14%)
ePM2.5	Equivalent PM2.5 (μg/m^3)	Precision: less than 20 μg/m^3 in the area of effective surface reflectance less than 7% (14%)

References

Hashimoto, M., and T. Nakajima, 2017: Development of a remote sensing algorithm to retrieve atmospheric aerosol properties using multi-wavelength and multi-pixel information. J. Geophys. Res., doi: 10.1002/2016JD025698.

Shi, C., M. Hashimoto and T. Nakajima, 2019: Remote sensing of aerosol properties from multi-wavelength and multi-pixel information over the ocean. Atmos. Chem. Phys., 19, 2416-2475.

Shi, C., T. Nakajima, and M. Hashimoto, 2016: Simultaneous retrieval of aerosol optical thickness and chlorophyll concentration from multi-wavelength measurement over East China Sea. J. Geophys. Res., 121, 14084-14101, doi: 10.1002/2016JD025790.

Takenaka, H., T. Y. Nakajima, A. Higurashi, A. Higuchi, T. Takamura, R. T. Pinker, and T. Nakajima, 2011: Estimation of solar radiation using a neural network based on radiative transfer. J. Geophys. Res., 116, D08215, doi:10.1029/2009JD013337.

7.8 Calibration and Validation

7.8.1 Calibration

GOSAT-2 product ‘calibration’ is performed for Level 1 product.

7.8.1.1 Summary of Calibration Plan

Calibration is an evaluation process to clarify the characteristics of the sensors and to confirm that the radiometric and geometric accuracies, spectral and image qualities satisfy the conditions given to their accuracy, and is performed on Level 1 product. Such evaluations are carried out by characterization in Pre-Flight Test (PFT), on-orbit calibration after the launch using calibration mode data, and observation data.
Also, calibration results are reflected in updating Level 1 processing algorithm.

7.8.1.2 Calibration Schedule

‘Calibrations’ using calibration and observation data were conducted during initial calibration verification operation period, from February to July in 2019, to evaluate the sensors’ characteristics. After that, calibrations indicated in section 7.8.1.3 are conducted and overall ‘Calibrations’ will be conducted by reviewing evaluation results and future calibration plan regularly in nominal observation operation.

7.8.1.3 Calibration Items

Table 7.8-1 shows calibration items of TANSO-FTS-2. Table 7.8-2 shows calibration items of TANSO-CAI-2.

Table 7.8-1 TANSO-FTS-2 Calibration and Validation Items

Calibration item Evaluation item		Data	Frequency	Evaluation
Radiometric calibration	Solar irradiance calibration (reference)	Solar irradiance calibration data	Once every three months	Once every three months
	Solar irradiance calibration (routine)	Solar irradiance calibration data	Once every revolution	Once every month
	Blackbody calibration,Deep space calibration	Blackbody calibration data Deep space calibration data	6 times every evolution	Once every month
	Instrument line shape function calibration	Instrument line shape function calibration data	Once every month	Once every month
	Dark calibration	Dark calibration data	Substitute with Deep space calibration	—
	Electrical calibration	Electrical calibration data	Once every month	Once every month
Geometric calibration	Pointing accuracy	CAM data	—	Once every month
	Orientation stability	CAM data	—	Once every month

Table 7.8-2 TANSO-CAI-2 Calibration and Validation Items

Calibration item Evaluation item		Data	Frequency	Evaluation
Calibration and Evaluation	Sensitivity calibration	Lunar calibration data Observation data Electrical calibration data	Once every month	Determined by trend evaluation (The first frequency is once every month)
	Offset calibration	Dark current calibration data	Once every month	
Stray light evaluation	Stray light evaluation	Lunar calibration data Observation data	Once every month	

7.8.2 Validation overview

Every measurement has an unavoidable uncertainty associated with it. When using data products retrieved from satellite observations, it is necessary to clarify whether the degree of uncertainty meets user's purposes. The process of clarifying such measurement uncertainties is "validation." The validation for GOSAT-2 Product intends for the Level 2 products.

In case of satellite remote sensing, however, it is impossible to know the true value of the observation target. Therefore, for GOSAT-2 Product validation, biases and scatters of Level 2 products are calculated by being compared with the independent observations with a smaller uncertainty.

Upon validation, it is preferable to conduct validation at as many places as possible after matching the observation conditions as much as possible. Further, the data used for validation should be observation results with a single standard and uniform quality on a global scale.

The purpose of validation is to evaluate the uncertainties of GOSAT-2 Product. At the same time, it has significance in view of assessing the validity of the Level 2 processing algorithm. When the result of validation analysis indicates that the uncertainty is not sufficiently small, the cause should be clarified and reflected in improving the Level 2 processing algorithm. The validation concept is illustrated in Figure 7.8-1.

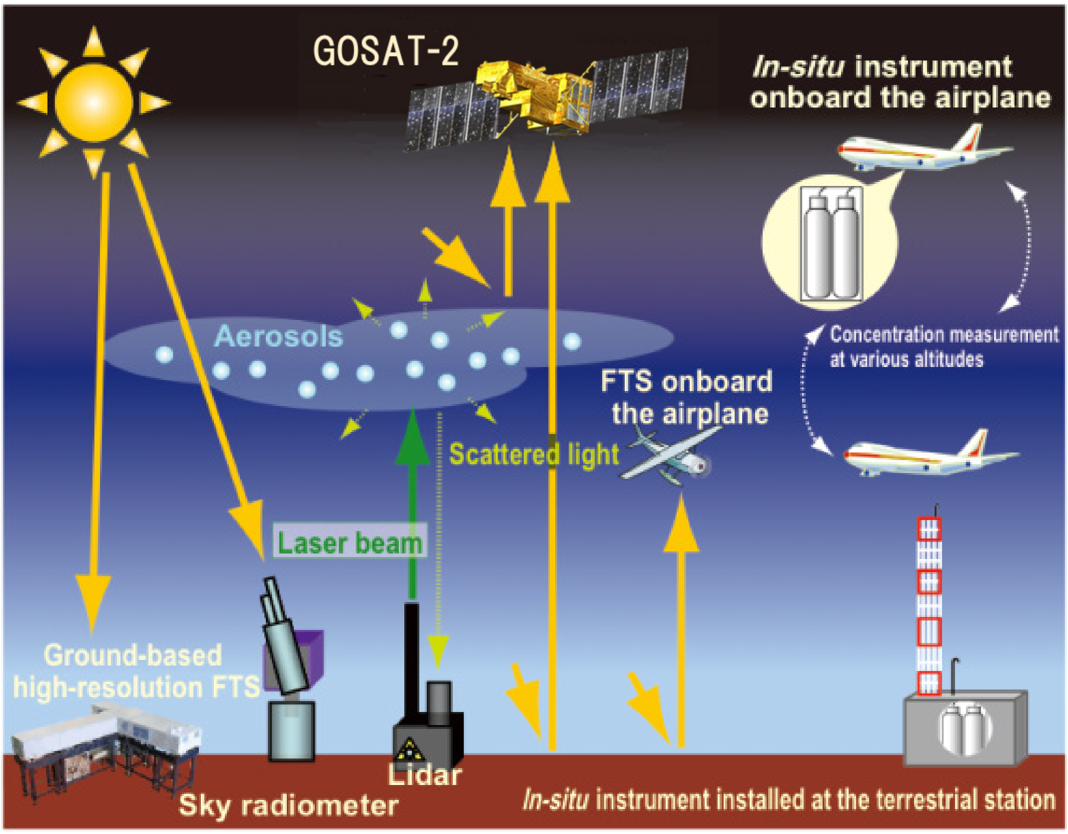


Figure 7.8-1 GOSAT-2 Product Validation Concept

7.8.2.1 Validation of GOSAT-2 TANSO-FTS-2 SWIR L2

(1) Column-averaged Dry-air Mole Fraction Product

From TANSO-FTS-2 SWIR spectra, column-averaged dry-air mole fractions of XCO_2, XCH_4, XCO and XH_2O are retrieved. The data used for the validation include observation data from Total Carbon Column Observing Network (TCCON), and Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL), which operates passenger aircraft-based measurements of atmosphere around the world.

Further, additional observational instruments for GOSAT-2 Product validation are installed at several sites to obtain specific observations regularly, aiming for a more precise validation to clarify error sources.

(2) Solar Induced Chlorophyll Fluorescence Product

From TANSO-FTS-2 SWIR spectra, Solar Induced chlorophyll Fluorescence (SIF), which is an index of plant photosynthetic activity, can be retrieved.

For the validation of SIF observed by the satellite, it is considered practical to use SIF data measured by spectroradiometers installed at vegetation flux observation sites after confirming their precision and scaling them up to the satellite footprint size.

However, there are only a limited number of sites where vegetation flux observations are conducted in the world. Currently, several satellites such as OCO-2, GOME and TROMPOMI are observing SIF and hence it is thought to be effective to combine the comparisons of these satellite-based observations with ground-based ones in the process of validation.

7.8.2.2 Validation of GOSAT-2 TANSO-FTS-2 TIR L2

(1) Cloud and Aerosol Property Product

From TANSO-FTS-2 TIR spectra, Cloud and Aerosol Property Product, cloud flags, cloud optical thickness and cloud particle types can be retrieved.

The validation of cloud flags can be performed in the same procedure as CAI-2 Cloud Discrimination Product. For the validation of cloud optical thickness in the visible region, lidar and cloud radar data can be used. There are several satellites which observe cloud optical thickness. These satellite data are just auxiliary, but the comparison with them may be effective for validation.

The validation for cloud particle types can be performed if data from aircrafts and cloud particle sondes are available. For the cloud particle type like cirrus clouds, lidar observations can be used for validation.

(2) Temperature and Gas Profile Product

From TANSO-FTS-2 TIR spectra, Temperature and Gas Profile Product, vertical profiles of temperature, CO_2, CH_4 and H_2O, can be retrieved. For the vertical profiles of temperature and H_2O, the results of radiosonde observations conducted by meteorological organizations can be used for validation. For the vertical profile of CO_2, results measured continuously by aircraft observations such as CONTRAIL can be used for the validation. For the vertical profile of CH_4 validation, results from air sampled at different altitude levels by aircraft observations of CONTRAIL and NOAA are can be used for the validation though the number is small.

Vertical profiles estimated by ground-based FTS observations can also be used for validation.

7.8.2.3 Validation of GOSAT-2 TANSO-CAI-2 L2

(1) Cloud Discrimination Product

From TANSO-CAI-2, integrated clear-sky confidence level and cloud status bit data can be retrieved. For validation of these parameters, visual cloud-cover observations conducted by meteorological organizations can be used.

(2) Aerosol Property Product

From TANSO-CAI-2, aerosol optical thickness, PM2.5 and black carbon (soot) volume fraction can be retrieved

For aerosol optical thickness, the results of network observations in regional scale or global scale such as AERONET and SKYNET are available for validation. PM2.5 observations are conducted mainly in metropolitan areas, and the results obtained from them are used for validation. Regarding soot volume fractions, the number of observation points is limited and the validation in a global scale is not easy. Still, there are some areas where observations are made, and the validation is performed making the most of data from these areas.

Chapter 8. GOSAT-2 Data Product Distribution

8.1 Data Storage

Level 1 or higher Data products for users are stored and managed at NIES/G2DPS. The total data volume for the five years of GOSAT-2 mission is estimated to be 8PB including the data for validation and for reference such as meteorological ones.

8.2 Basic Policy of Data Policy

Data policy is defined by the joint name of JAXA, NIES and MOE as the terms and conditions to users related to data obtained by GOSAT and GOSAT-2.

(1) The GOSAT/GOSAT-2 Data will be distributed on a “non-discriminatory” basis as provided for in the Principles Relating to Remote Sensing of the Earth from Space issued by the United Nations.

(2) The GOSAT/GOSAT-2 Data will be processed in a prompt manner with the help from inside and outside Japan and will be provided at large to promote data utilization.

(3) The GOSAT/GOSAT-2 Data Policy takes into consideration the following missions of Japan Aerospace Exploration Agency (hereinafter referred to as “JAXA”), National Institute for Environmental Studies of Japan (hereinafter referred to as “NIES”), and Ministry of the Environment of Japan (hereinafter referred to as “MOE”) (hereafter collectively referred to as the “Three Parties”), to the maximum extent possible.

a) JAXA contributes to improvement of satellite data thorough calibration of GOSAT/GOSAT-2 sensors, data processing for Level 1 and development and verification of infrared algorithms, and promotes data utilization inside and outside of Japan through data distribution.

b) NIES contributes to deepening of scientific understanding of the global carbon cycle and spatial distribution of related materials, and improving of future climate prediction through high level processing of the GOSAT/GOSAT-2 Data and validation, distribution and utilization research of the processing results, as well as the measures concerning global warming by MOE through technical development for verification of inventories for greenhouse gas and particulate matter in each country using satellites and emission reduction activities.

c) MOE will utilize the GOSAT/GOSAT-2 Data in its environmental administration through the data use for research and development to monitor and verify emission of greenhouse gases and the contribution to the measures for global warming in each country, while maintaining the balance between international cooperation and national interests.

8.3 User Category

Table 8.3-1 shows the user categories of the GOSAT-2 Data.

Table 8.3-1 User Category

User Category	Description
Project Staff (PS)	Researchers, scientists, and staff members who belong to the GOSAT-2 Project implementation body (Three Parties) and engage in the GOSAT-2 Project, or those who belong to other organizations but engage in the GOSAT-2 Project as contractors to any of the Three Parties.
RA Investigator (RA)	PI and Co-I [9] approved and registered by the Three Parties.
Science Team Member (ST)	A member of the GOSAT-2 Science Team organized by the Three Parties, or a designated researcher by the member for the purpose of the Science Team.
Alliance Organization (sensor development, calibration and validation, research, data processing, provision of necessary data, data distribution) (AO)	An organization which has been approved by the Three Parties and signed a cooperative agreement with any of the Three Parties, in order to collaborate in the aspect of sensor development, calibration and validation, research, or to cooperate the GOSAT-2 data distribution. Note that a researcher [10] who contracted with an AO solely for the purpose of carrying out the above-mentioned activities and who is recognized by the Three Parties is regarded as a member of the AO.
General User (GU)	All data users other than the above-defined users.

[9] PI stands for Principal Investigator representing a research theme approved by the Three Parties as a result of the RA selection. CO-I stands for Co Investigator participating in the research theme.

[10] A researcher here may be a user of higher-level data processed by an AO.

8.4 Data Distribution

8.4.1 Policies on Release of the GOSAT-2 Data

(1) The data distribution of standard products to all users will start immediately after the completion of the calibration and validation. However, the data will be provided with priority to users other than general users (cf. section 8.3) earlier than general users in cases where such data distribution contributes to the development of the GOSAT/GOSAT-2 sensors, calibration and validation or data utilization researches.

(2) The GOSAT-2 Data other than standard products are not distributed in principle. However, the processed products in appropriate scope may be distributed at the appropriate timing to users other than general users.

8.4.2 Timing of the Start of the GOSAT-2 Data

(1) Standard products

a) As for Level 1 products, products after the calibration of its sensor(s) and its validation are scheduled to be released 9 (nine) months after the launch. However, Level 1 products before the calibration may be distributed for the purpose of a good influence on calibration works prior to 9 (nine) months after the launch to users other than general users at the discretion of the Three Parties.

b) As for Level 2 products, products after the validation are scheduled to be released 12 (twelve) months after the launch. However, Level 2 products before the validation may be distributed prior to 12 (twelve) months after the launch to users other than general users at the discretion of the Three Parties. As for products after above-mentioned distribution, the release timing of each product will be discussed by the Three Parties when products are updated.

c) As for Level 3 and 4 products, products will be released by the procedures similar to Level 1 and 2 as soon as it is ready.

(2) Research products

Research products are not distributed in principle. However, the processed product in appropriate scope may be distributed at the appropriate timing to users other than general users.

(3) Internal products

Internal products are not distributed in principle. However, the processed product in appropriate scope may be distributed at the appropriate timing to users other than general users.

8.4.3 Method for Distribution of the GOSAT-2 Data

The GOSAT-2 Data shall be distributed online in principle after making an arrangement between a distributed party and JAXA or NIES in the form of agreement, contract or online agreement on the promise of abiding by terms and conditions concerning the utilization of the GOSAT-2 Data (cf. section 8.4.6).

8.4.4 Distribution Timing of the GOSAT-2 Standard Products

Table 8.4-1 shows the distribution timing of standard products.

Table 8.4-1 Distribution of standard products

Product Name	Distribution Timing	Data Storage Period
TANSO-FTS-2 L1B Product	Targeted for 9 months after launch	Entire operation period
GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product	Targeted for 12 months after launch	Entire operation period
GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product	Targeted for 12 months after launch	Entire operation period
GOSAT-2 TANSO-FTS-2 TIR L2 Cloud and Aerosol Property Product	Targeted for 12 months after launch	Entire operation period
GOSAT-2 TANSO-FTS-2 TIR L2 Temperature and Gas Profile Product	Targeted for 12 months after launch	Entire operation period
GOSAT-2 TANSO-CAI-2 L1B Product	Targeted for 12 months after launch	Entire operation period
GOSAT-2 TANSO-CAI-2 L2 Cloud Discrimination Product	Targeted for 12 months after launch	Entire operation period
GOSAT-2 TANSO-CAI-2 L2 Aerosol Property Product	Targeted for 12 months after launch	Entire operation period
L3 Product (TBD)	TBD	Entire operation period
GOSAT-2 L4A Global CO_2 Flux Product	TBD	Entire operation period
GOSAT-2 L4A Global CH_4 Flux Product	TBD	Entire operation period
GOSAT-2 L4B Global CO_2 Distribution Product	TBD	Entire operation period
GOSAT-2 L4B Global CH_4 Distribution Product	TBD	Entire operation period

8.4.5 Rights to The GOSAT-2 Data

(1) The Three Parties shall own all intellectual property rights including but not limited to copyrights in relation to all the data they provide, except intellectual property rights possessed by a third party.

(2) When a user has generated high-level, value-added data products [11], the Three Parties shall not exercise their copyrights, i.e., rights as the copyright holders of the original data, to the derivative data and the user may use the value-added data based on his/her own copyrights as the developer of the data.

8.4.6 Terms and Conditions Concerning the Utilization of the GOSAT/GOSAT-2 Data

(1) The use of the data for any purpose in opposition to peaceful use is prohibited.

(2) Any publication of outcomes obtained in consequence of the use of the data must be accompanied by any one of the following indications.

- JAXA/NIES/MOE
- Japan Aerospace Exploration Agency / National Institute for Environmental Studies / Ministry of the Environment

The user is also required to indicate that the original data are provided by JAXA/NIES/MOE, if he or she has generated high-level, value-added data and provides a third party with such data (including publications). When each indication required above is difficult, as in the case of each indication on an academic paper or the documents based on the Paris Agreement, it is to be shown at the end of the paper or anywhere appropriate.

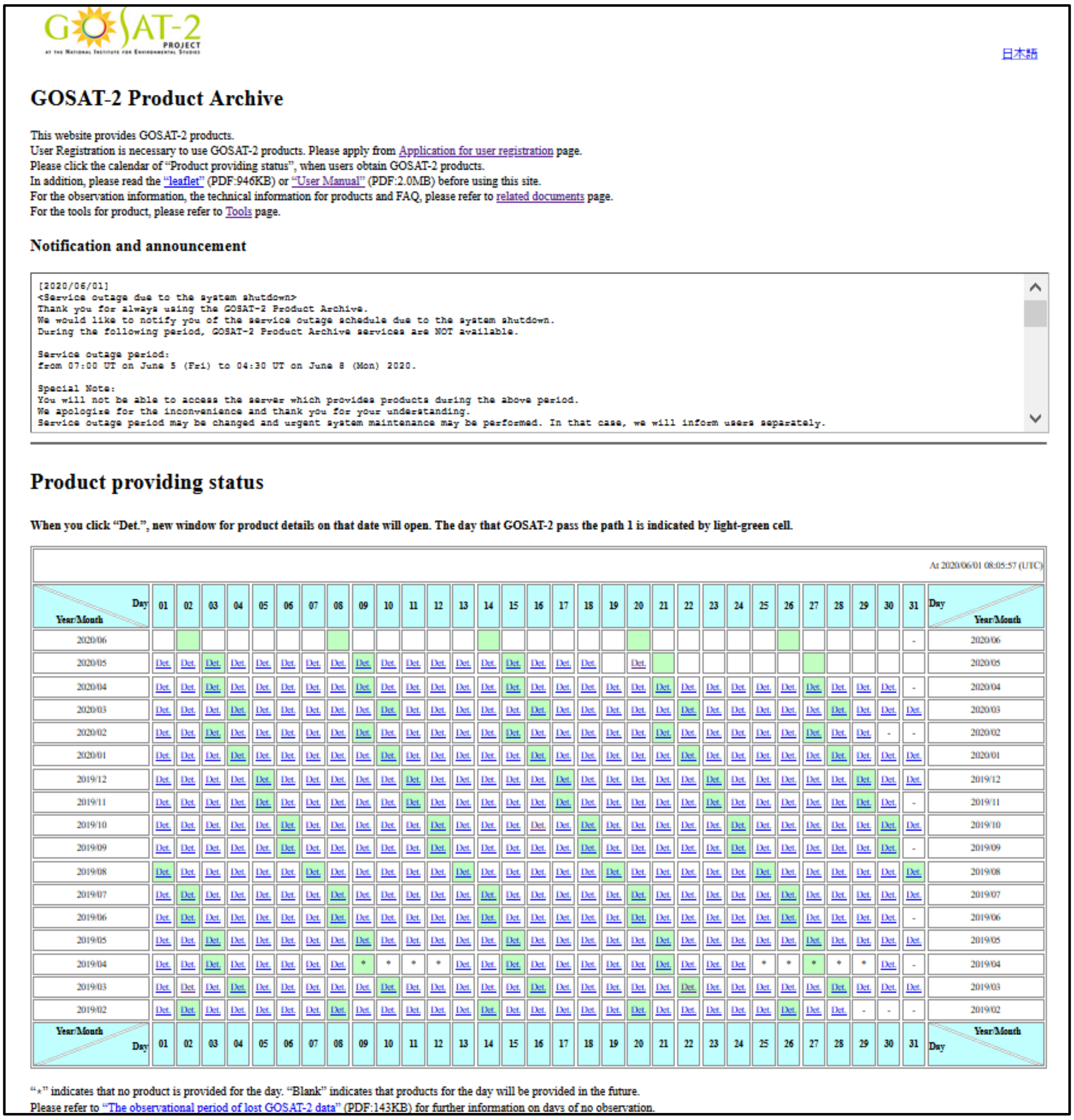
(3) Users are allowed to redistribute standard products to a third party (limited to products which the Three Parties release to the public). In the preceding case, a distributing party shall ensure that a distributed party complies with this Data Policy. Users are prohibited to use the data for any other purpose than the Three Parties and user agreed and to redistribute the data to a third party.

(4) The Three Parties shall not be liable for any missing data, degradation of data quality, delay in data delivery, or any other situation in which the data cannot be provided, as a result of problems that occur to the spacecraft or the ground facilities.

[11] High-level, value-added products are, of modified products, those that have been modified by applying high-level data processing and which are irreversible to the original data. High-level data processing here includes data analyses or a combination of satellite data acquired by different missions, image processing based on external information other than the original data, conversion to physical quantities, and so forth.

8.5 How to Search and Get GOSAT-2 Data Products

Data products are provided to general users from GOSAT-2 Product Archive.



日本語

GOSAT-2 Product Archive

This website provides GOSAT-2 products.
User Registration is necessary to use GOSAT-2 products. Please apply from Application for user registration page.
Please click the calendar of "Product providing status", when users obtain GOSAT-2 products.
In addition, please read the "leaflet" (PDF:946KB) or "User Manual" (PDF:2.0MB) before using this site.
For the observation information, the technical information for products and FAQ, please refer to related documents page.
For the tools for product, please refer to Tools page.

Notification and announcement

```
[2020/06/01]
<Service outage due to the system shutdown>
Thank you for always using the GOSAT-2 Product Archive.
We would like to notify you of the service outage schedule due to the system shutdown.
During the following period, GOSAT-2 Product Archive services are NOT available.

Service outage period:
from 07:00 UT on June 5 (Fri) to 04:30 UT on June 8 (Mon) 2020.

Special Note:
You will not be able to access the server which provides products during the above period.
We apologize for the inconvenience and thank you for your understanding.
Service outage period may be changed and urgent system maintenance may be performed. In that case, we will inform users separately.
```

Product providing status

When you click "Det.", new window for product details on that date will open. The day that GOSAT-2 pass the path 1 is indicated by light-green cell.

At 2020/06/01 08:05:57 (UTC)

Day / Year/Month	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Day / Year/Month
2020/06																															-	2020/06
2020/05	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.		Det.												2020/05
2020/04	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	2020/04
2020/03	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2020/03
2020/02	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	-	2020/02
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2019/12	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/12
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2019/09	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	2019/09
2019/08	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/08
2019/07	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/07
2019/06	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	2019/06
2019/05	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/05
2019/04	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	*	*	*	*	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	*	*	*	*	*	Det.	-	2019/04
2019/03	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/03
2019/02	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	-	-	2019/02
Year/Month / Day	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Day / Year/Month

"*" indicates that no product is provided for the day. "Blank" indicates that products for the day will be provided in the future.
Please refer to "The observational period of lost GOSAT-2 data" (PDF:143KB) for further information on days of no observation.

Figure 8.5-1 GOSAT-2 Product Archive Home Screen

https://prdct.gosat-2.nies.go.jp/en/

8.5.1 Overview of GOSAT-2 Product Archive functions

(1) Application for User registration

For user registration, follow the instruction shown on the page “Application for user registration”

TopPage
日本語

GOSAT-2 Product Archive

Application for user registration

User Registration is necessary to use GOSAT-2 Products.

[User registration procedure]

(1) Please read “GOSAT_GOSAT-2 Data Policy”(Satellite Observation Center website).

(2) Please download “Application form for user registration” (Word : 71KB) and input the required fields in it.

(3) Please send an e-mail attached the user registration form with the subject of “Application for user registration” to GOSAT-2 Support (gosat-2_desk@nies.go.jp).

(4) GOSAT-2 Support (gosat-2_desk@nies.go.jp) will send “Notification of your user registration application acceptance” by e-mail. If you don't receive “Notification of your user registration application acceptance” e-mail within 3 business days, please contact GOSAT-2 Support (gosat-2_desk@nies.go.jp).

(5) After user registration is completed, GOSAT-2 Support (gosat-2_desk@nies.go.jp) will send “Notification of your user registration completion” by e-mail.

[Suspension of service use and deletion of user registration information]

If a user want to suspend this service use and delete you user registration information, please send an e-mail written your user ID to GOSAT-2 Support (gosat-2_desk@nies.go.jp).

[Site Policy] [Privacy Policy] [Contact] [NIES Web] [Sitemap]

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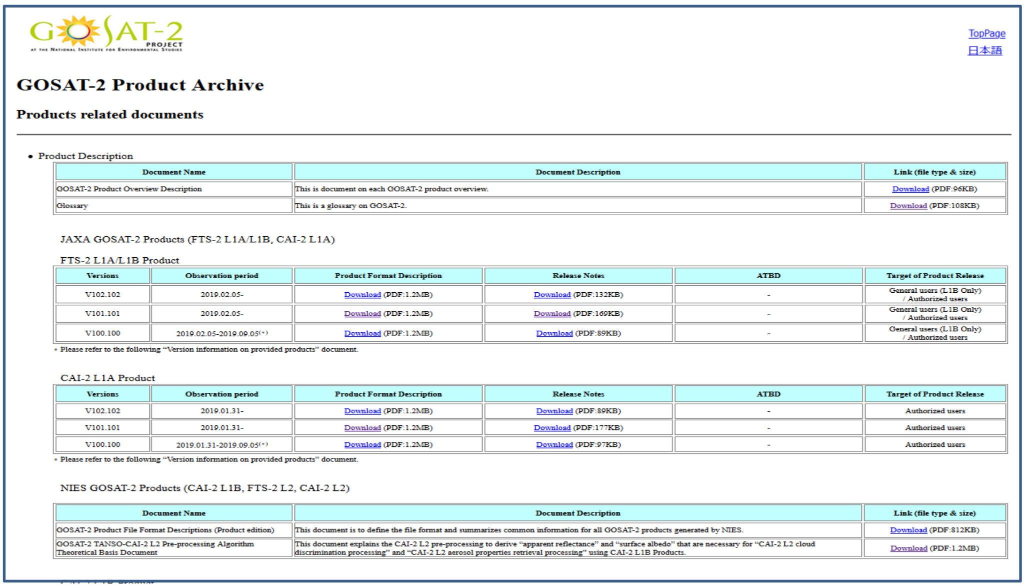
Figure 8.5-2 Application for user registration page

(2) Provision of Information

From the page “Product related documents”, documents related to GOSAT-2 Product are provided, which include product descriptions, algorithm theoretical basis documents, information on provided products, information on satellite observational operation and technical information.



TopPage
日本語

GOSAT-2 Product Archive

Products related documents

- Product Description

Document Name	Document Description	Link (file type & size)
GOSAT-2 Product Overview Description	This is document on each GOSAT-2 product overview.	Download (PDF:96KB)
Glossary	This is a glossary on GOSAT-2.	Download (PDF:108KB)

JAXA GOSAT-2 Products (FTS-2 L1A/L1B, CAI-2 L1A)

FTS-2 L1A/L1B Product

Versions	Observation period	Product Format Description	Release Notes	ATBD	Target of Product Release
V102.102	2019.02.05-	Download (PDF:1.2MB)	Download (PDF:132KB)	-	General users (L1B Only) / Authorized users
V101.101	2019.02.05-	Download (PDF:1.2MB)	Download (PDF:169KB)	-	General users (L1B Only) / Authorized users
V100.100	2019.02.05-2019.09.05(*)	Download (PDF:1.2MB)	Download (PDF:89KB)	-	General users (L1B Only) / Authorized users

* Please refer to the following “Version information on provided products” document.

CAI-2 L1A Product

Versions	Observation period	Product Format Description	Release Notes	ATBD	Target of Product Release
V102.102	2019.01.31-	Download (PDF:1.2MB)	Download (PDF:89KB)	-	Authorized users
V101.101	2019.01.31-	Download (PDF:1.2MB)	Download (PDF:177KB)	-	Authorized users
V100.100	2019.01.31-2019.09.05(*)	Download (PDF:1.2MB)	Download (PDF:97KB)	-	Authorized users

* Please refer to the following “Version information on provided products” document.

NIES GOSAT-2 Products (CAI-2 L1B, FTS-2 L2, CAI-2 L2)

Document Name	Document Description	Link (file type & size)
GOSAT-2 Product File Format Descriptions (Product edition)	This document is to define the file format and summarizes common information for all GOSAT-2 products generated by NIES.	Download (PDF:812KB)
GOSAT-2 TANSO-CAI-2 L2 Pre-processing Algorithm Theoretical Basis Document	This document explains the CAI-2 L2 pre-processing to derive “apparent reflectance” and “surface albedo” that are necessary for “CAI-2 L2 cloud discrimination processing” and “CAI-2 L2 aerosol properties retrieval processing” using CAI-2 L1B Products.	Download (PDF:1.2MB)

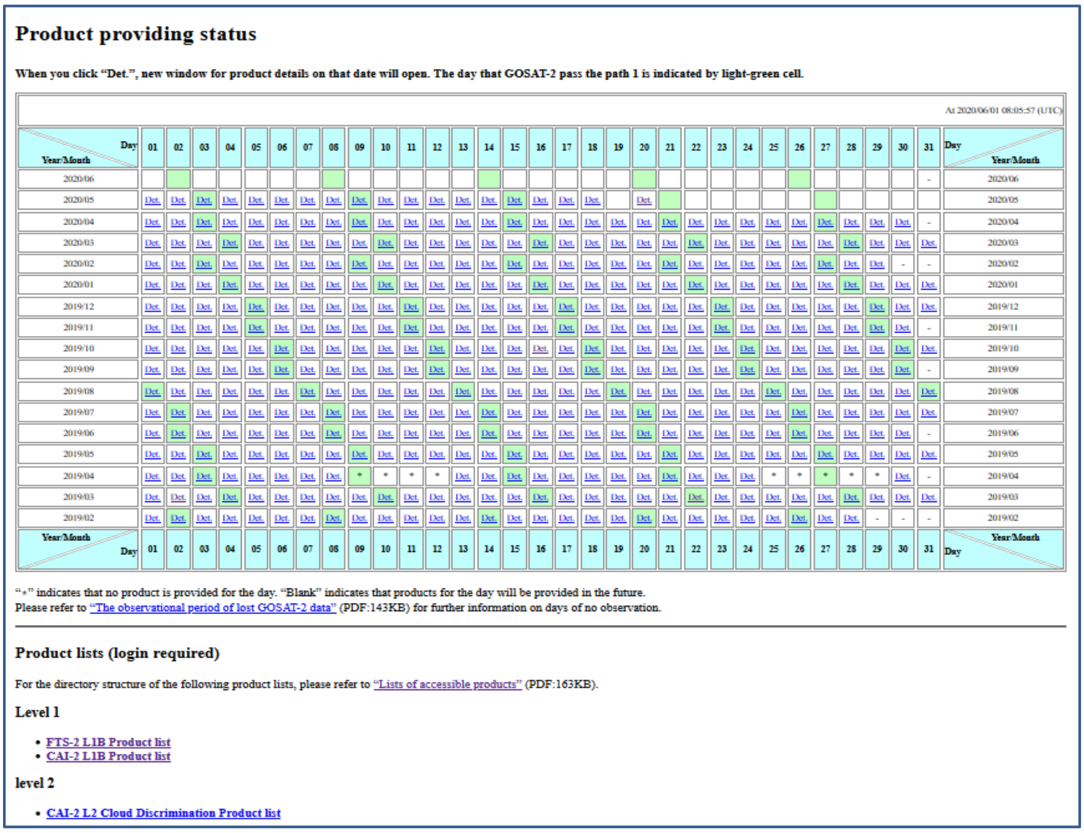
Figure 8.5-3 Product related documents page

(3) Product download

From Home screen, clicking “Det.” in “Product providing status” opens the page “Product details”. When downloading, “User authentication” window opens. Enter your “User name” and the “password” to continue.

Products are downloadable also from each “Product list” link on the Home screen and on the page “Product details”.

For more details about the downloading procedure, refer to the “Users Manual”:
https://prdct.gosat-2.nies.go.jp/en/documents/User_Manual_en.pdf



Product providing status

When you click “Det.”, new window for product details on that date will open. The day that GOSAT-2 pass the path 1 is indicated by light-green cell.

At 2020/06/01 08:05:57 (UTC)

Day / Year/Month	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Day / Year/Month
2020/06																															-	2020/06
2020/05	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.		Det.												2020/05
2020/04	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	2020/04
2020/03	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2020/03
2020/02	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	-	2020/02
2020/01	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2020/01
2019/12	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/12
2019/11	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	2019/11
2019/10	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/10
2019/09	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	2019/09
2019/08	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/08
2019/07	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/07
2019/06	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	2019/06
2019/05	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/05
2019/04	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	*	*	*	*	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	*	*	*	*	*	Det.	-	2019/04
2019/03	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	2019/03
2019/02	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	Det.	-	-	-	2019/02
Year/Month / Day	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Year/Month / Day

“*” indicates that no product is provided for the day. “Blank” indicates that products for the day will be provided in the future.
Please refer to “The observational period of lost GOSAT-2 data” (PDF:143KB) for further information on days of no observation.

Product lists (login required)

For the directory structure of the following product lists, please refer to “Lists of accessible products” (PDF:163KB).

Level 1

- FTS-2 L1B Product list
- CAI-2 L1B Product list

level 2

- CAI-2 L2 Cloud Discrimination Product list

Figure 8.5-4“Product providing status” chart and “Product list” links

8.6 User Support Tools

The following user support tools are available for using the product.

- GOSAT/GOSAT-2 Level 1 product reading toolkit
- VREASS (Viewer for observation data of GOSAT series)

Above tools and instruction manuals are available from tool page [12] of 'GOSAT-2 Product Archive', NIES website.

8.6.1 GOSAT/GOSAT-2 Level 1 Product Reading Toolkit

GOSAT/GOSAT-2 Level 1 product reading toolkit (GTK) is a programming library to read GOSAT/GOSAT-2 Level 1 product. Table 8.6-1 shows GTK support products.
GTK supports multiple Operating Systems (Linux, Windows10 (Cygwin) and macOS) and multiple computer languages (C, FORTRAN, IDL and MATLAB). Please refer to GOSAT-1/2 Level 1 product reading toolkit User's manual (described in section 2.3 (2)) regarding to the way of tool installation and operation.

Table 8.6-1 GTK support products

Spacecraft Name	Sensor	Processing Level	Product Name	Version	Note
GOSAT	FTS	L1A	TANSO-FTS-1 Level 1A Product	V2XX	
		L1B	TANSO-FTS-1 Level 1B Product	V2XX	
	CAI	L1A	TANSO-CAI-1 Level 1A Product	V130	Not supported in Fortran
GOSAT-2	FTS	L1A	TANSO-FTS-2 Level 1A Product	V1XX	
		L1B	TANSO-FTS-2 Level 1B Product	V1XX	
	CAI	L1A	TANSO-CAI-2 Level 1A Product	V1XX	Not supported in Fortran

8.6.2 Viewer for Observation Data of GOSAT Series

Viewer for observation data of GOSAT series (VREASS) is observation data mapping and simple viewing application for TANSO-FTS and TANSO-CAI on GOSAT, and TANSO-FTS-2 and TANSO-CAI-2 on GOSAT-2. Table 8.6-2 shows VREASS support products and display contents.
VREASS supports Windows 10 (64bit) and macOS 10 (64-bit). The installation and operation methods are explained in VREASS manual ((3) in section 2.3).

[12] https://prdct.gosat-2.nies.go.jp/en/tool.html

Table 8.6-2 VREASS support products

<table>
<tr><th rowspan="2">Spacecraft</th><th rowspan="2">Sensor Name</th><th rowspan="2">Processing Level</th><th rowspan="2">BAND or FWD/BWD</th><th colspan="2">Product</th><th colspan="2">Display Content</th></tr>
<tr><th>Code</th><th>Description</th><th>Mapping</th><th>Simple Viewer</th></tr>
<tr><td rowspan="14">GOSAT</td><td rowspan="8">FTS</td><td>L1B</td><td>–</td><td>(Note 1)</td><td>TANSO-FTS L1B Product</td><td>Observation points display (Note 2)</td><td>Spectrum / CAM data</td></tr>
<tr><td rowspan="5">L2</td><td rowspan="3">SWIR</td><td>C01S(L2)</td><td>L2 CO_2 column amount (SWIR)</td><td rowspan="3">Pseudo-Color image</td><td rowspan="3">–</td></tr>
<tr><td>C02S(L2)</td><td>L2 CH_4 column amount (SWIR)</td></tr>
<tr><td>C03S</td><td>L2 H_2O column amount (SWIR)</td></tr>
<tr><td rowspan="2">TIR</td><td>P01T</td><td>L2 CO_2 profile (TIR)</td><td rowspan="2">Pseudo-Color image</td><td rowspan="2">–</td></tr>
<tr><td>P02T</td><td>L2 CH_4 profile (TIR)</td></tr>
<tr><td rowspan="2">L3</td><td rowspan="2">SWIR</td><td>C01S(L3)</td><td>L3 global CO_2 distribution (SWIR)</td><td rowspan="2">Pseudo-Color image</td><td rowspan="2">–</td></tr>
<tr><td>C02S(L3)</td><td>L3 global CH_4 distribution (SWIR)</td></tr>
<tr><td rowspan="5">CAI</td><td>L1B</td><td>–</td><td>TRB0</td><td>TANSO-CAI L1B Product</td><td>RGB/
Pseudo-Color image</td><td>RGB/
Pseudo-Color image</td></tr>
<tr><td>L2</td><td>–</td><td>CLDM</td><td>L2 cloud flag</td><td>Pseudo-Color image</td><td>–</td></tr>
<tr><td rowspan="3">L3</td><td rowspan="3">–</td><td>TRCL</td><td>L3 global radiance distribution</td><td>RGB image</td><td>–</td></tr>
<tr><td>TRCF</td><td>L3 global reflectance distribution (clear sky)</td><td rowspan="2">Pseudo-Color image</td><td rowspan="2">–</td></tr>
<tr><td>NDVI</td><td>L3 global NDVI</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="15">GOSAT2</td><td rowspan="7">FTS2</td><td rowspan="3">L1B</td><td>SWIR</td><td rowspan="3">(Note 1)</td><td rowspan="3">TANSO-FTS-2 L1B Product</td><td rowspan="2">Observation points display (Note 2)</td><td rowspan="2">Spectrum / CAM data</td></tr>
<tr><td>TIR</td></tr>
<tr><td>common</td><td>CAM data</td><td>CAM data</td></tr>
<tr><td rowspan="4">L2</td><td rowspan="2">SWIR</td><td>SWPR</td><td>GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product</td><td rowspan="4">Pseudo-Color image</td><td rowspan="4">–</td></tr>
<tr><td>SWFP</td><td>GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product</td></tr>
<tr><td rowspan="2">TIR</td><td>TCAP</td><td>GOSAT-2 TANSO-FTS-2 TIR L2 Cloud and Aerosol Property Product</td></tr>
<tr><td>TTGP</td><td>GOSAT-2 TANSO-FTS-2 TIR L2 Temperature and Gas Profile Product</td></tr>
<tr><td rowspan="7">CAI2</td><td rowspan="2">L1A</td><td>FWD</td><td rowspan="2">OBSM</td><td rowspan="2">TANSO-CAI-2 L1A Product</td><td rowspan="2">RGB/
Pseudo-Color image</td><td rowspan="2">RGB/
Pseudo-Color image</td></tr>
<tr><td>BWD</td></tr>
<tr><td rowspan="2">L1B</td><td>FWD</td><td rowspan="2">CL1B</td><td rowspan="2">TANSO-CAI-2 L1B Product</td><td rowspan="2">RGB/
Pseudo-Color image</td><td rowspan="2">RGB/
Pseudo-Color image</td></tr>
<tr><td>BWD</td></tr>
<tr><td rowspan="3">L2</td><td>FWD</td><td rowspan="2">CLDD</td><td rowspan="2">GOSAT-2 TANSO-CAI-2 L2 Cloud Discrimination Product</td><td rowspan="3">Pseudo-Color image</td><td rowspan="3">–</td></tr>
<tr><td>BWD</td></tr>
<tr><td>–</td><td>AERP</td><td>GOSAT-2 TANSO-CAI-2 L2 Aerosol Property Product</td></tr>
</table>

Note 1: Depend on operation mode (cf. Table 8,6-3)
Note 2: 'Spectrum/CAM data' can be confirmed from 'Observation points display' on the map by simple viewer.

Table 8.6-3 Operation mode and Code in FTS/FTS-2 L1B product

Spacecraft	Sensor Name	Processing Level	Product	
			Code	Operation Mode
GOSAT	FTS	L1B	OB1D	FTS Observation mode I, Sunlit observation data
			OB1N	FTS Observation mode I, Shadow observation data
			OB2D	FTS Observation mode II, Sunlit observation data
			SPOD	FTS specific observation mode, Sunlit observation data
			SPON	FTS specific observation mode, Shadow observation data
GOSAT2	FTS2	L1B	OB1D	Observation Mode (day)
			OB1N	Observation Mode (night)
			OB2D	Observation Mode (day,not full bands)
			OB2N	Observation Mode (night,not full bands)

Chapter 9. Related Information

9.1 Related Website

9.1.1 JAXA's website

(1) JAXA home page

https://global.jaxa.jp/

(2) JAXA/EORC (GOSAT)

https://www.eorc.jaxa.jp/GOSAT/index.html

(3) JAXA Satellite Navigator (GOSAT-2)

http://www.satnavi.jaxa.jp/e/project/gosat2/

9.1.2 NIES's website

(1) NIES home page

http://www.nies.go.jp/index-e.html

(2) NIES/Satellite Observation Center

http://www.nies.go.jp/soc/en/

(3) GOSAT-2 Project

http://www.gosat-2.nies.go.jp/

(4) GOSAT-2 Product Archive

https://prdct.gosat-2.nies.go.jp/en/

(5) GOSAT Project

http://www.gosat.nies.go.jp/en/

(6) GOSAT Data Archive Service

https://data2.gosat.nies.go.jp/index_en.html

9.1.3 MOE's website

(1) MOE/GOSAT series

http://www.env.go.jp/en/earth/ondanka/gosat.html

9.2 About GOSAT-2 Data

The inquiries about GOSAT-2 data are as follows.

Satellite Observation Center, Center for Global Environmental Research,
National Institute for Environmental Studies of Japan
16-2 Onogawa, Tsukuba, Ibaraki, 305-8506 JAPAN
Acceptance time: 10:00-17:00 (JST), weekends and holidays excluded

- Whole (General content)
  TEL : +81-29-850-2731
  E-mail : gosat-2-info@nies.go.jp
- About research recruitment
  TEL : +81-29-850-2966
  E-mail : gosat-prj1@nies.go.jp
- About GOSAT-2 product and service
  E-mail : gosat-2_desk@nies.go.jp

Appendix 1 Acronyms

	Acronyms		Definition
[A]	ACOS	:	Atmospheric CO2 Observations from Space
	AO	:	Alliance Organization
	AOCS	:	Attitude & Orbit Control Subsystem
	APID	:	Application Processor IDentifier
	ASD	:	APID Sorted Data
	AT	:	Along Track
[B]			
[C]	Co-I	:	Co-Investigator
	CT	:	Cross Track
[D]	DM	:	Deployment Monitor subsystem
	DT	:	Direct Transmission subsystem
[E]	EPS	:	Electrical Power Subsystem
[F]			
[G]	G2DPS	:	GOSAT-2 Data Processing System
	GOSAT	:	Greenhouse gases Observing SATellite
	GOSAT-2	:	Greenhouse gases Observing SATellite-2
	GU	:	General User
[H]	HDF5	:	Hierarchical Data Format Version 5
	HK	:	House Keeping
[I]	INT	:	Integration Hardware
[J]	JAXA	:	Japan Aerospace Exploration Agency
[K]	KSAT	:	Kongsberg Satellite Services
[L]	L	:	Level
[M]	MAP	:	Maximum A Posteriori
	MDHS	:	Mission Data Handling Subsystem
	MOE	:	Ministry of the Environment
[N]	NASA	:	the National Aeronautics and Space Administration
	NCSA	:	National Center for Supercomputing Application
	NetCDF	:	Network Common Data Form
	NIES	:	National Institute for Environmental Studies
[O]	OCO-2	:	Orbiting Carbon Observatory-2
[P]	PI	:	Principal Investigator
	PS	:	Project Staff
[Q]			
[R]	RA	:	Research Announcement
		:	RA Investigator
	RCS	:	Reaction Control Subsystem
[S]	SPS	:	Solar Paddle Subsystem
	ST	:	Science Team
	STR	:	Structure
	SvalSat	:	Svalbard Satellite station
	SWIR	:	Short Wave InfraRed

[T]	TANSO-CAI-2	:	Thermal And Near infrared Sensor for carbon Observations - Cloud and Aerosol Imager – 2
	TANSO-FTS-2	:	Thermal And Near infrared Sensor for carbon Observations - Fourier Transform Spectrometer – 2
	TCS	:	Thermal Control Subsystem
	TIR	:	Thermal InfraRed
	TT&C	:	Tracking Telemetry and Command subsystem
	TTC-DH	:	Telemetry Tracking and Control subsystem - Data Handling
	TTC-RF	:	Telemetry Tracking and Control subsystem - Radio Frequency
[U]			
[V]	VRESS	:	VieweR for obsErvAtion data of goSat Series
[W]			
[X]			
[Y]			
[Z]			

Appendix 2 Terminology

(1) Interferogram

A pattern of light intensity produced by a Fourier interferometer, which splits an incoming light beam into two paths and makes the two split beams meet again to interfere each other while the distance for one light beam to travel is gradually changed to make a difference from the distance for the other light beam.

(2) Sunglint

A phenomenon where the water surface appears very bright because the sunlight is reflected in observation direction by specular reflection, when the sunlight reflects off the water surface at almost the same that sunlight incident angle and reflection angle.
The actual sunglint region affected by small waves on the water will be larger than geometrical specular reflection region, also this region size depends on the positional relationship between the sun and sensor, wind speed at sea, etc.

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（CAI-2 L2 Cloud Discrimination Algorithm）
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