

Cooperation with domestic and overseas research institutes, etc.

Although ground-based stations are able to carry out high-precision observation, findings vary depending on the observation station. Meanwhile, even though satellites are able to thoroughly observe the earth, observation is hindered when there are clouds. Therefore, in order to accurately ascertain the behavior of greenhouse gases, it is important to have ground-based observation data and satellite data complement each other while utilizing the strengths of each. Thus, collaboration and research are being carried out together with concerned government ministries and agencies and research institutes in Japan, as well as overseas research institutes such as NASA.



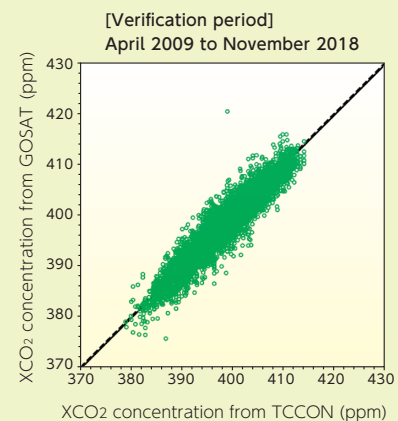
Furthermore, in order for satellite data to be used, the accuracy of observation results needs to be verified. One standard for verification is ground-based observation, and this includes the Total Carbon Column Observing Network (TCCON), which carries out observation based on high-resolution observation instruments that have been installed worldwide. As such, the accuracy satellite data is verified through comparisons with the observation results of TCCON, observation results regarding the atmosphere obtained from the Comprehensive Observation Network for Trace Gases by Airliner (CONTRAIL), which is a project for observation by commercial aircraft, and so on.



TCCON observation points
(Source: <https://tccodata.org>)



Japan Airlines 777-200ER being used for CONTRAIL
©Japan Airlines



It can be seen that the observation results of TCCON and GOSAT regarding the CO₂ concentration (XCO₂ concentration) from the ground to the upper part of the atmosphere, almost completely match with each other.

(Source:
https://www.gosat.nies.go.jp/eng/gosat_lailet_en.pdf)

Is it possible to use data from the GOSAT Series?

Data from the GOSAT Series can be downloaded from the following websites free of charge. For details, please visit the websites.



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

GOSAT-2
<https://prdct.gosat-2.nies.go.jp/index.html.en>



GOSAT



GOSAT-2

In addition, videos regarding the GOSAT Series are posted on the websites. For details, please visit the video channel of the Ministry of the Environment.
(<https://www.youtube.com/user/kankyosho/featured>)

<Contact point for inquiries>

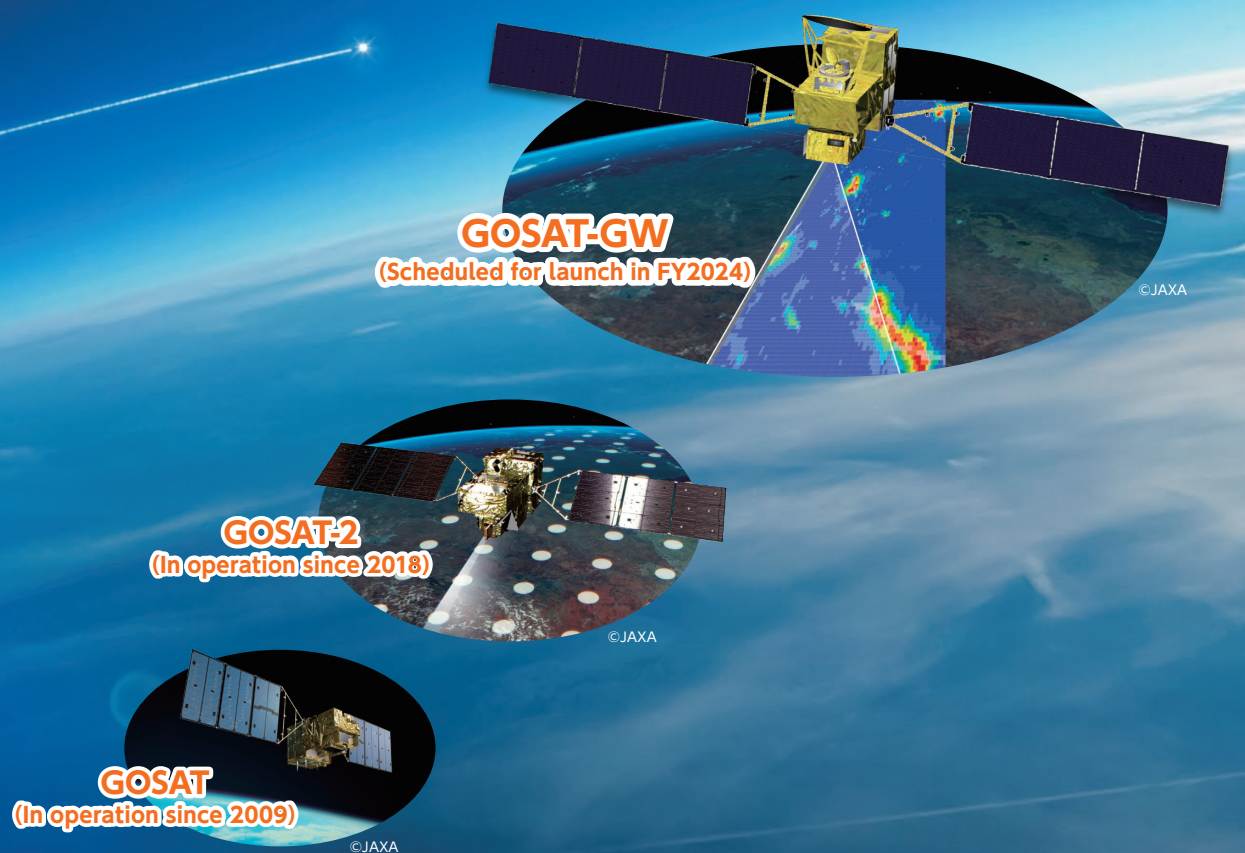
Ministry of the Environment

Global Environment Bureau, No. 5 Godochosha
1-2-2 Kasumigaseki, Chiyoda-ku, Tokyo 100-8975
Tel.: 03-3581-3351 (main line) URL:<https://www.env.go.jp>



Up to now and from now on

— Observing the global atmosphere with the GOSAT Series —



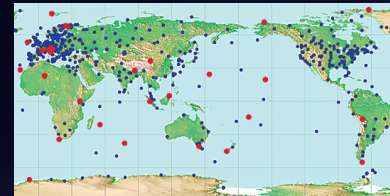
The GOSAT Series consists of the earth-observing satellites GOSAT, GOSAT-2, and GOSAT-GW, which observe greenhouse gases.

GOSAT was launched in 2009, and GOSAT-2 in 2018. Both of these are still carrying out observation today. GOSAT-GW is scheduled to be launched in FY2024.

The GOSAT Series is aimed at contributing to science and policies related to climate change, and is a project that is jointly promoted by the three entities: the Ministry of the Environment (MOE), the National Institute for Environmental Studies (NIES), and the Japan Aerospace Exploration Agency (JAXA).

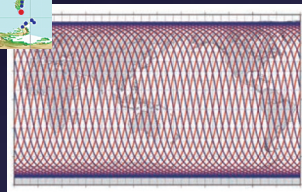
Observing every corner of earth with 56,000 observation points!

While ground-based greenhouse gas observation is carried out by stations at approximately 220 locations, GOSAT observes 56,000 points over a period of three days. This overwhelmingly large number of observation points has made it possible to see the behavior of greenhouse gases in great detail.



From National Institute for Environmental Studies website

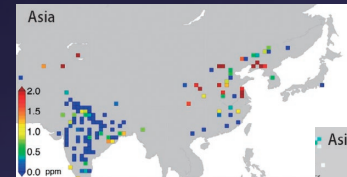
From Japan Meteorological Agency website



Locations of ground-based stations (left) and ground track of GOSAT (right)

Successfully capturing concentrations in large cities, etc.

Data from GOSAT shows that in areas affected by human activities, such as large cities, CO₂ and CH₄ concentrations are higher than surrounding areas. These results have indicated that it may be possible to estimate concentrations of human-induced CO₂ and CH₄ in specific regions.



From Ministry of the Environment press releases (September 1, 2016 and November 27, 2015)

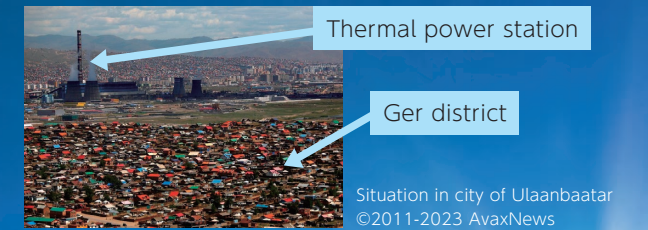


These are regions where GOSAT has observed high concentrations of human-induced CO₂ (left) and human-induced CH₄ (right). (Only regions regarding which there is GOSAT data are shown.) The more reddish colors indicate regions with higher human-induced concentrations.

Together with the world Contributions of GOSAT Series

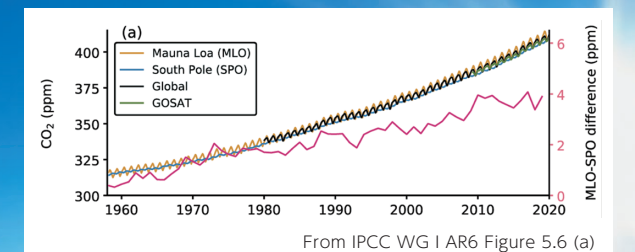
Helping with international cooperation through transferring technologies overseas, etc.

In regard to the country of Mongolia, CO₂ emissions calculated from statistical information were compared with such emissions calculated from GOSAT data, and in the results, it was found that these roughly matched. The Mongolian government is planning to utilize these results in the future. Going forward, cases like this will be broadly disseminated internationally, and data of the GOSAT Series will be used to help with international cooperation.



Contributing to development of climate change-related science

The results of research conducted by Japanese researchers using GOSAT data, including Yoshida et al. (2013), have been included in reports of the "Intergovernmental Panel on Climate Change (IPCC)" that give a scientific basis to the climate-change policies of the governments of countries. In addition, as of 2021, approximately 540 papers related to GOSAT had been published throughout the world. These are some of the ways GOSAT has been contributing to the development of climate change-related science.



Contributing to climate-change policies

The "2019 IPCC Guidelines," which are used by countries worldwide for the calculation of greenhouse gas emissions and sequestration, express the hope that the accuracy of emission reports by countries will be improved with the GOSAT Series. Thus, the results of the GOSAT Series have been contributing to the climate-change policies of countries.



GOSAT observation results included in IPCC Sixth Assessment Report (The GOSAT observation results are shown with the green line that starts in 2009.)

2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. (Source: <https://www.ipcc.ch/working-group/tfi/>)

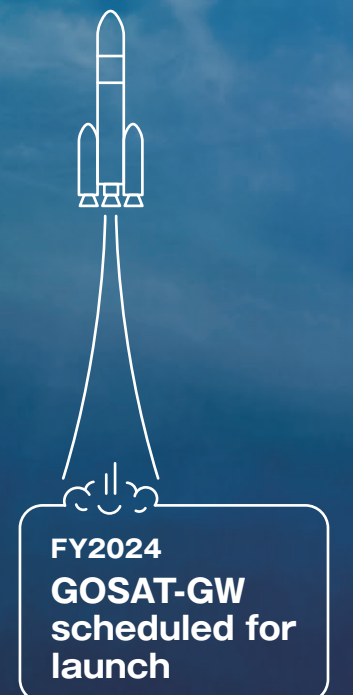
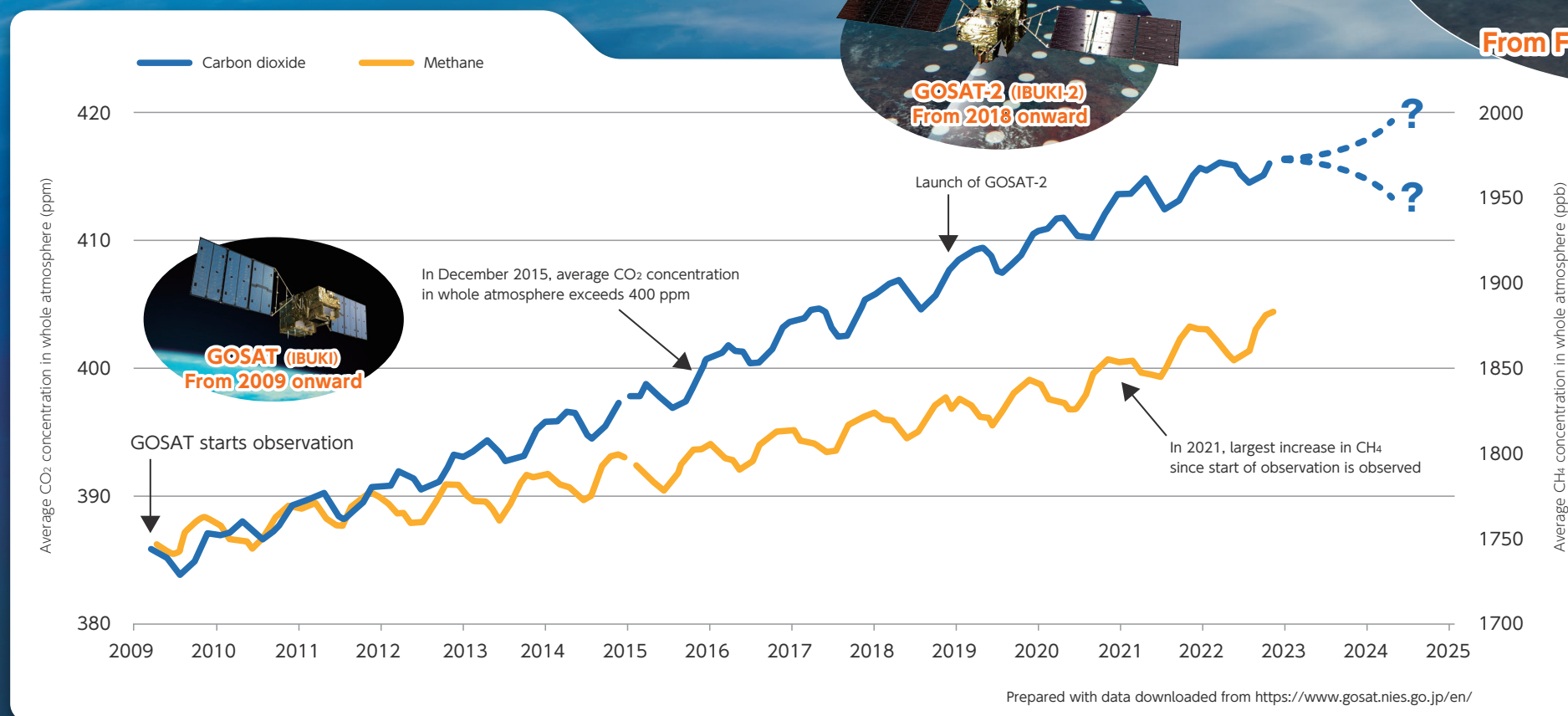
What GOSAT Series has captured

Capturing fluctuations in concentrations of greenhouse gases

In order to estimate and predict the future risks of global warming, it is essential to ascertain average concentrations in the entire global atmosphere (whole atmosphere), from the ground surface up to the upper part of the atmosphere. The long-term observations of carbon dioxide (CO₂) and methane (CH₄) in the whole atmosphere made by the GOSAT Series are unparalleled in the world.



Observation results of GOSAT Series



Prepared with data downloaded from <https://www.gosat.nies.go.jp/en/>

Ever-evolving GOSAT Series

World's first observing of greenhouse gases from space!

Greenhouse gases Observing SATellite (GOSAT) nickname: IBUKI



This is the world's first satellite to have the main purpose of observing major greenhouse gases (CO₂ and CH₄).

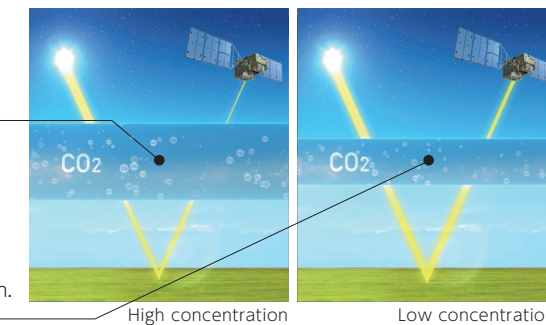
The satellite has been continuously carrying out observation since its launch in January 2009, and it still does so today, which is long after the end of its five-year design life. During this period, it has revealed fluctuations in whole-atmosphere mean CO₂ and CH₄ concentrations, and annual fluctuations in emission and absorption volumes of greenhouse gases on a subcontinental scale.

High concentration

When the concentration is high, the light becomes weaker along its path.

Low concentration

When the concentration is low, the light does not become weaker along its path.



The GOSAT Series ascertains atmospheric concentrations of carbon dioxide (CO₂) and methane (CH₄) by observing the intensity of sunlight reflected from the earth's surface. In the case of GOSAT and GOSAT-2, "points" are observed that have a diameter of approximately 10 km.

Doubling valid data with automatic cloud avoidance!

Greenhouse gases Observing SATellite-2 (GOSAT-2) nickname: IBUKI-2

GOSAT-2, which was launched in October 2018, observes the entire earth in great detail over a period of six days. Equipped with improved sensor functions and new functions, GOSAT-2 is aimed at identifying sources of emissions of greenhouse gases from human activities, and boosting the accuracy of emission estimates.

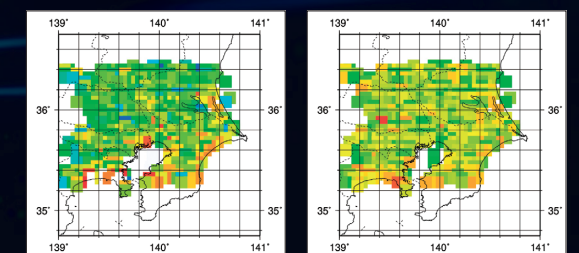
Function 1 Observation while avoiding clouds

A newly installed function called "Intelligent Pointing" makes it possible to observe while automatically detecting the presence of, and avoiding, clouds, which hinder observation. This function increases the quantity of valid observation data.



Function 2 Concentrated observation of target points

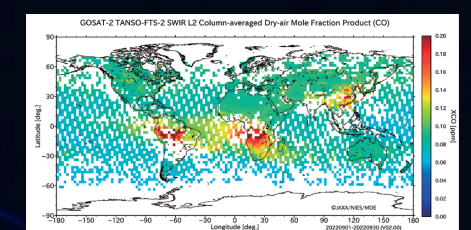
GOSAT-2 features an enhanced function for the concentrated observation of target points that are believed to be large-scale emission sources of major greenhouse gases, such as industrial regions and large cities. This function accurately ascertains emissions from large-scale sources through the collection of large amounts of high-precision data.



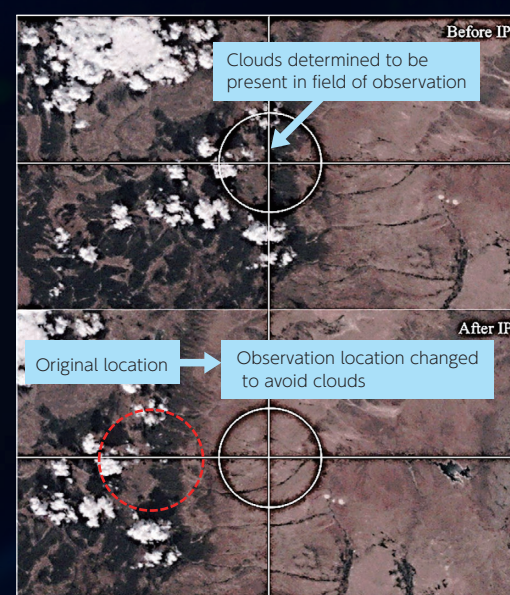
Example of results from focused observation of Kanto region with GOSAT-2 (3/2019 to 12/2022; CO₂ on left and CH₄ on right); areas with higher concentration than surrounding areas indicated in red. Analysis: University of Tokyo

Function 3 Observation of carbon monoxide (CO)

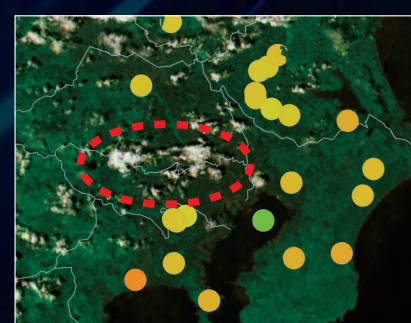
GOSAT-2 newly carries out the observation of carbon monoxide (CO). CO is attributable for the most part to combustion, and this includes fuel consumption. Thus, by simultaneously measuring CO, GOSAT-2 discerns whether CO₂ that has been observed is being affected by the air of cities, and assesses the impact of biomass combustion, which includes forest fires.



CO concentrations are higher in regions with large amounts of fossil fuel consumption, forest fires, and so on. (Average values for September 2022)



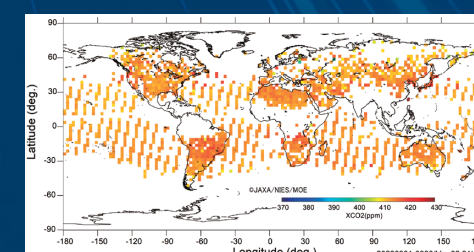
(Top) Confirming of clouds in observation area
(Bottom) Changing of location to one without clouds
©JAXA



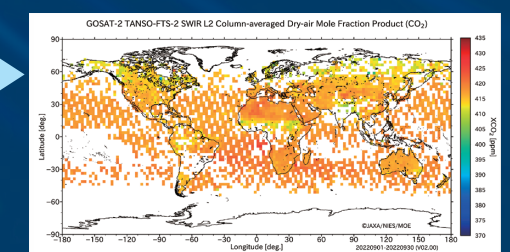
The circles colored in yellow and so on are observation points. It can be seen that observation is being carried out while avoiding clouds that are located around the border between Tokyo and Saitama Prefecture.
©NIES

Comparison of CO₂ observation results from GOSAT and GOSAT-2

CO₂ observation results from GOSAT (September 2022)



CO₂ observation results from GOSAT-2 (September 2022)



Clear-sky observation data has been increased, so it can be expected that the accuracy of estimations of greenhouse gas emissions will be improved.

Transitioning from point-based to surface-based observation! Spatial resolution of 3 km (target resolution of 1 km)*!

Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW)

GOSAT-GW, the third satellite in the GOSAT Series, is an earth-observing satellite that observes greenhouse gases, as well as water cycles, including precipitation distributions. It is equipped with Total Anthropogenic and Natural Emissions mapping SpectrOMeter-3 (TANSO-3) and Advanced Microwave Scanning Radiometer 3 (AMSR3).

Change to observation method

The observation sensors have been changed for the GOSAT-GW, so rather than performing point-based observation as had been done previously, it performs surface-based observation. In Wide Mode, this satellite seamlessly observes a "surface" that is 911 km wide (at a resolution of 10 km). In Focus Mode, it is able to carry out the detailed observation of points that are estimated to be large-scale sources, through observing a 90 km-wide area at a spatial resolution of 3 km (target resolution of 1 km). It can be expected that the large amounts of data obtained through the two abovementioned observation modes will make emission estimates highly accurate.

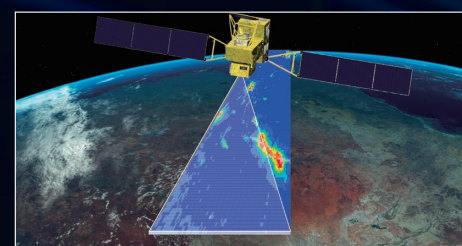
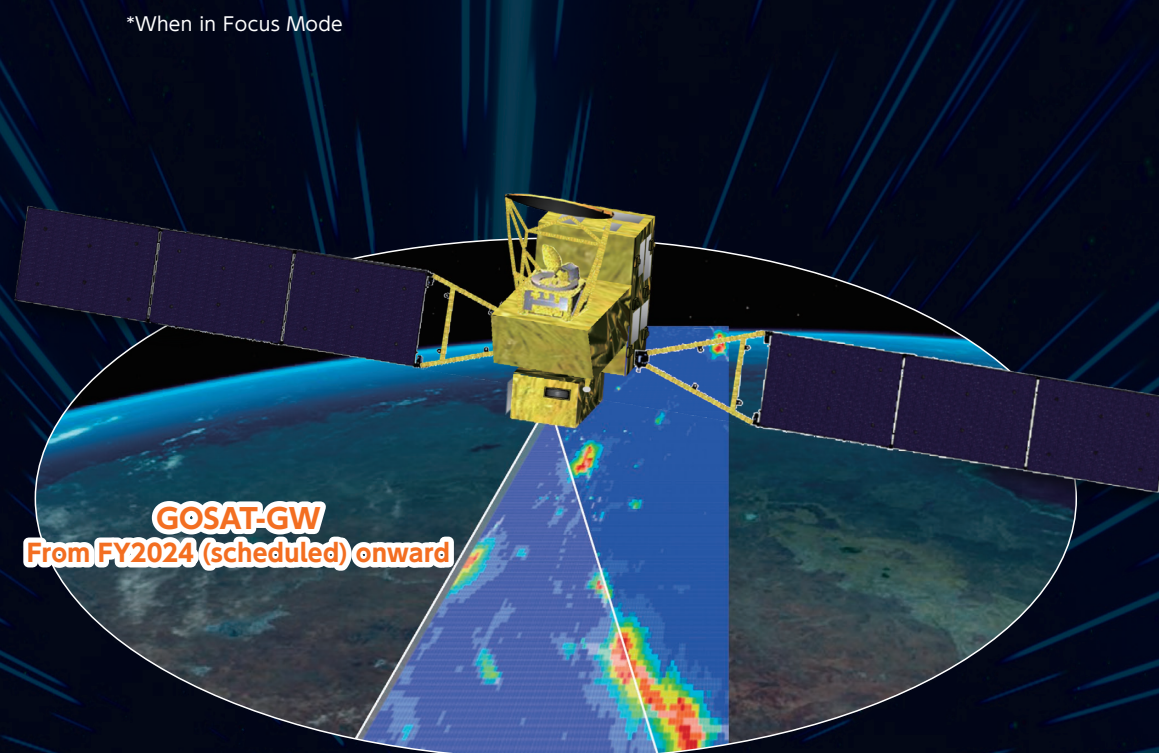


Illustration of observing with Wide Mode



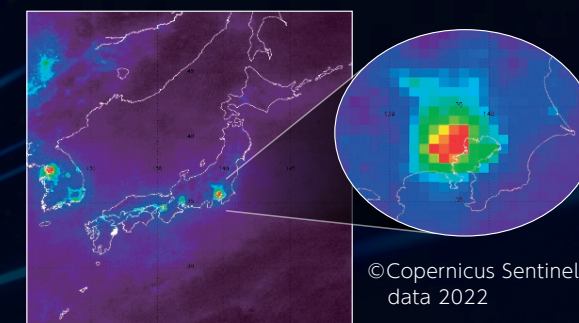
Illustration of observing with Focus Mode



*When in Focus Mode

Change to observation targets

GOSAT-GW will observe nitrogen dioxide (NO₂) in addition to carbon dioxide (CO₂) and methane (CH₄). NO₂ is discharged together with CO₂ during the burning of fossil fuels, and thus it is expected that simultaneously measuring NO₂ will make it possible to identify human-induced CO₂ emission sources and accurately estimate emissions. Emissions from human-induced sources and natural sources will be separately estimated, and effective measures for reducing CO₂ will be examined and implemented, and this will contribute to the realization of decarbonized societies.

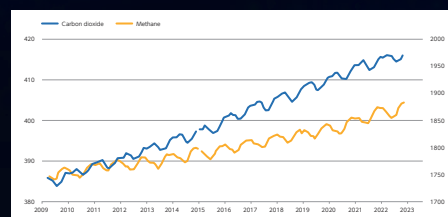


NO₂ observation results from European satellite (Left) Japan area, (right) Tokyo area
The points with high NO₂ emissions are indicated in red.
In the case of GOSAT-GW, CO₂ will also be simultaneously observed.

■ Aims of GOSAT-GW

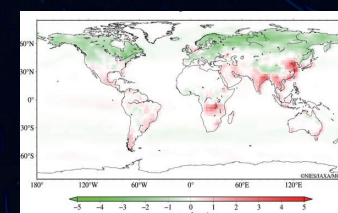
Long-term monitoring of greenhouse gases of entire earth

Long-term observation will be needed in order to ascertain the effects of the reduction of greenhouse gases through decarbonization. Thus, GOSAT-GW will continuously monitor total atmospheric concentrations of greenhouse gases.



Verification of human-induced greenhouse gas emissions by country

On a monthly basis, GOSAT-GW is able to obtain around 100 to 1,000 times more data than GOSAT-2, and it is expected that this will help make the ascertaining of greenhouse gas emissions more accurate. The greenhouse gas emissions that are estimated based on the abovementioned data will be aimed at contributing to ensuring transparency regarding the reports on emissions by country that countries prepare and announce based on the Paris Agreement.



Aiming to improve reliability of emission reports through comparative verification

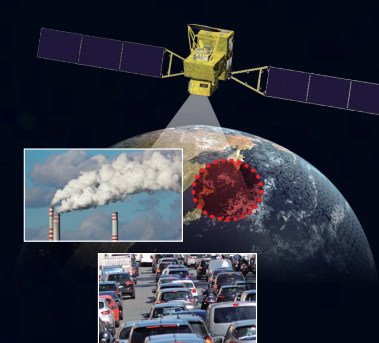
Absorption & emission volumes estimated using GOSAT-GW data (illustration)



Emission reports of countries

Detection of large-scale emission sources, etc.

GOSAT-GW is aimed at making estimations of emissions from large cities and large-scale emission sources highly accurate, based on the use of NO₂ observation results and so on. Furthermore, GOSAT-GW is aimed at detecting as-yet-unknown emission sources, which have not yet been identified with current observation technologies.



Aiming to monitor large-scale emission sources and detect as-yet-unknown emission sources

Based on long-term monitoring and the estimation of human-induced greenhouse gas emissions, the GOSAT Series will contribute to: the improvement of the transparency of reports on greenhouse gas emissions that countries issue based on the Paris Agreement, the development of climate-change science, and the building of decarbonized societies.