Satellite-based Biomass Estimation of Forests

In forest-related projects, credits are generated through increased biomass accumulation, which enhances CO_2 absorption. Satellites are used to observe forests, estimate biomass levels, and calculate CO_2 absorption. Satellite-based biomass estimation is employed continuously to assess the project's impact, from credit generation to utilization and invalidation.

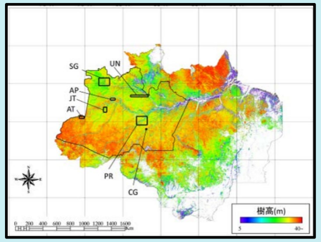
Service

■ Service Overview

- Satellites observe forests, measuring forest distribution, canopy volume, and vertical structure.
- Data obtained from satellites is used to estimate forest biomass and calculate CO_2 absorption.

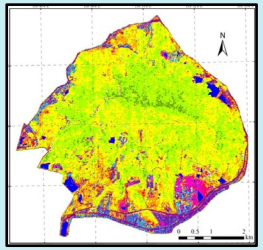
■ Example of Provided Service

Tree Height Map



Source: National Research and Development Agency, Forestry and Forest Products Research Institute

Biomass Distribution

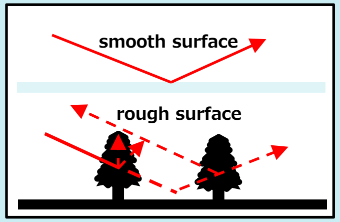


Source: JAXA

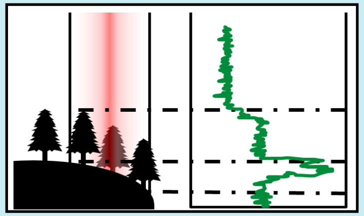
■ Observation Mechanism by Satellite

- SAR satellites distinguish between forested and non-forested areas based on surface roughness: smooth surfaces, such as water, reflect minimal radar back to the satellite, while rough surfaces, like forests, reflect a portion of the radar signal.
- By analyzing LiDAR reflection waveforms and volume scattering from SAR satellites, the physical characteristics of forests can be determined, enabling biomass estimation.

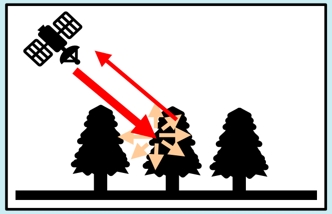
Methods for Distinguishing Forest and Non-Forest Areas Using SAR Satellites



Forest Physical Properties Assessment Using Satellite LiDAR



Representation of Volume Scattering in SAR Satellites



Satellite-based Evidence for Mid-Season Drainage/AWD Implementation in Fields

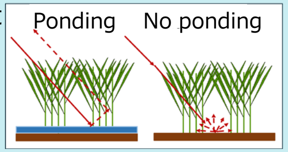
In rice cultivation, extending the mid-season drainage period (in Japan) or implementing AWD (Alternate Wetting and Drying, in other countries) reduces methane emissions, enabling carbon credit generation. Satellites monitor the fields, providing evidence for project implementation. Continuous satellite-based observation verifies the project's progress from credit generation to utilization and invalidation.

Service

■ Service Overview

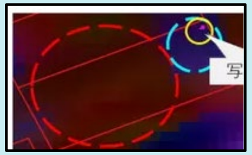
- Satellite imagery is used to detect the presence or absence of ponding in the fields, and the demonstration of this service is underway.

Method for Identifying the Presence/Absence of Ponding in the Fields



■ Example of Provided Service

Color-coding the Presence/Absence of Water in the Fields



Source : Jizoku

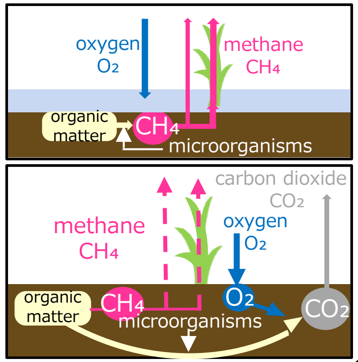
■ Observation Mechanism by Satellite

- Using the property of SAR satellites, where the radio wave reflection characteristics differ due to variations in ground roughness, the presence or absence of ponding in the fields is identified.
- In particular, L-band SAR, with its relatively long wavelength, can penetrate through rice plants, enabling the detection of ponding.

■ Methodology for Extending Mid-Season Drainage Periods (Japan) and Alternate Wetting and Drying (AWD, elsewhere)

- Mid-season drainage/AWD involves draining water and allowing the field surface to dry, which helps prevent excessive tillering (branching near the base) and reduces water usage, as well as methane emissions.
- In low-oxygen environments, microorganisms in the soil produce methane. Flooding rice paddies reduces oxygen, promoting methane production.
- Mid-season drainage/AWD increases soil oxygen, suppressing microbial activity. Extending the drainage period or implementing AWD reduces methane emissions, enabling carbon credit registration.

Mechanism of Methane Generation



Satellite observation for the creation, verification, and monitoring of credits

Satellite observation for monitoring the integrity of credit-eligible projects

Satellite-based Seagrass Mapping

In the seagrass restoration and conservation project, the increase in seagrass area leads to a higher CO_2 absorption rate, generating credits. Satellite-based monitoring is used to track seagrass locations and areas and estimate CO_2 absorption. Satellite observation will continue throughout the entire process, from the generation of credits to their use and invalidation and will consistently assess the ongoing impact of the project.

Service

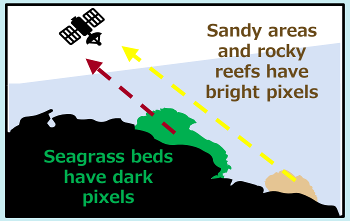
■ Service Overview

- Satellite observation data, along with ground survey data as training data, are used to classify seagrass beds and other areas, enabling the creation of a detailed seagrass map.
- The CO_2 absorption rate is then estimated based on the seagrass area.
- Research and demonstration of the above services are underway.

■ Observation Mechanism by Satellite

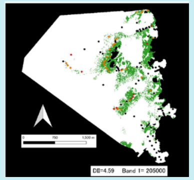
- By using multi-band images from optical satellites, it is possible to identify the location of seagrass beds, as their radiance is darker compared to sandy areas or rocky reefs.

Identification of Seagrass Beds Based on Differences in Radiance

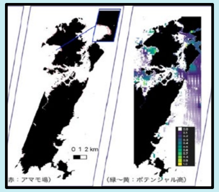


■ Example of Provided Service

Mapping of Blue Carbon



Source: Japan Blue Economy Technology Research Association



Source: UMITRON

■ What is blue carbon?

- Blue carbon refers to carbon that is absorbed by coastal and marine ecosystems and stored in their soils and biomass.
- Blue carbon has long-term sustainability for carbon sequestration, ranging from hundreds to thousands of years. Protecting blue carbon ecosystems not only contributes to climate change mitigation but also helps preserve biodiversity.
- For calculating CO_2 absorption based on the distribution area, satellite observation is effective for mangrove forests and seagrass beds.

Main Ecosystems of Blue Carbon

Zostera beds

Zostera marina beds

Salt marshes/Tidal flats

Mangrove forests

Source: Earthene

Satellite-based Land Uplift Observations in Peatlands

In peatland rewetting projects, groundwater levels are restored to suppress the aerobic decomposition of peat, thereby reducing CO_2 emissions and generating credits. By observing land uplift with satellites and estimating groundwater levels, rewetting is carried out efficiently, and continuous estimations are made from credit generation to utilization and invalidation.

Service

■ Service Overview

- Research and demonstration of a service that uses satellites to monitor land uplift caused by the decline in groundwater levels in peatlands over a wide area are underway.
- The service estimates groundwater levels based on the correlation between ground displacement and the values from on-site groundwater level sensors.

■ Observation Mechanism by Satellite

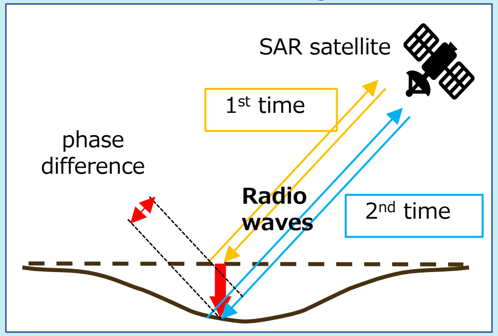
- The distance changes between the satellite and the ground surface are measured by performing an interferometric analysis of two images taken at different times using the radio waves emitted by the SAR satellite and calculating the phase difference (shift in the cycle).
- Other methods involve using the fact that SAR satellites' radio waves hardly return from smooth surfaces such as water, while they partially return from rough surfaces like soil. This allows for the mapping of peatland topography and watercourses. By combining satellite-observed precipitation data with on-site surveys to create hydrological data, groundwater levels can be inferred.

■ What is a peatland?

- Peatlands are a type of soil formed by the accumulation of plant material that has not decomposed in water.
- They store significant amounts of CO_2 but are highly susceptible to combustion when groundwater levels decrease and they dry out.

Source: Wetlands International Japan

The Phase Difference Measurement Using InSAR



Satellite observation for the creation, verification, and monitoring of credits

Satellite observation for monitoring the integrity of credit-eligible projects

Satellite-based CO_2 Leakage Monitoring for CCS and CCUS

The CCS and CCUS projects reduce CO_2 emissions by storing CO_2 underground or in other locations, generating carbon credits. Satellite observation is used to extensively verify that the stored CO_2 remains securely contained without leakage. Satellite-based observation of CO_2 storage sites is continuously employed to assess the project's impact, from credit generation to utilization and invalidation.

Service

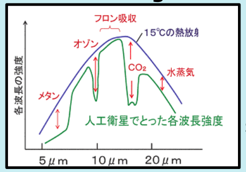
■ Service Overview

- Research is being developed by using satellite observations to monitor CO_2 concentration distribution and ground deformation, enabling the detection of CO_2 leakage from underground storage.

■ Observation Mechanism by Satellite

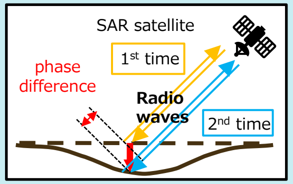
- Using an atmospheric spectroscopic sensor, CO_2 concentration is observed by analyzing the specific colors absorbed and the depth of absorption inherent to the gas species.
- Other methods involve using SAR satellite data to perform interferometric analysis of two images taken at different times, measuring surface displacement from phase differences to check for CO_2 leakage.

CO_2 Concentration Observation Based on Wavelength Differences



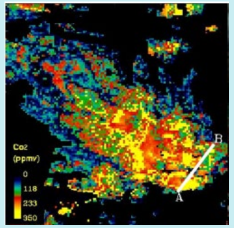
Source: Ministry of Education, Culture, Sports, Science and Technology (MEXT)

The Phase Difference Measurement Using InSAR

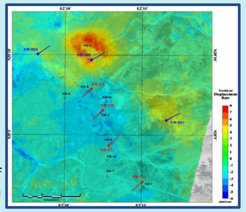


■ Example of Provided Service

CO_2 Concentration Distribution



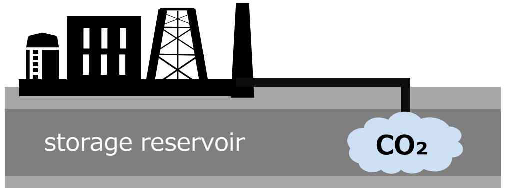
Visualization of Ground Deformation



Source: University of Nebraska

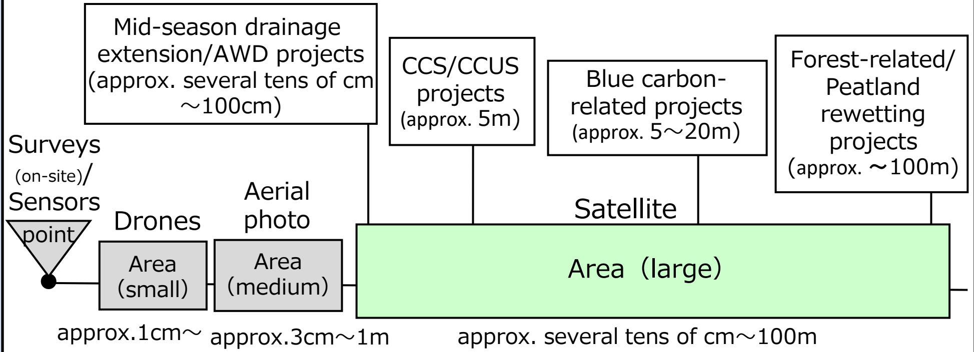
■ What are CCS/CCUS?

- CCS refers to the technology that separates and captures CO_2 for storage in underground sites or other locations.
- In contrast, CCUS not only focuses on the storage of CO_2 but also on captured CO_2 utilization as a resource.



CCS : Carbon dioxide Capture and Storage
CCUS : Carbon dioxide Capture, Utilization and Storage

■ Comparison with conventional information gathering methods

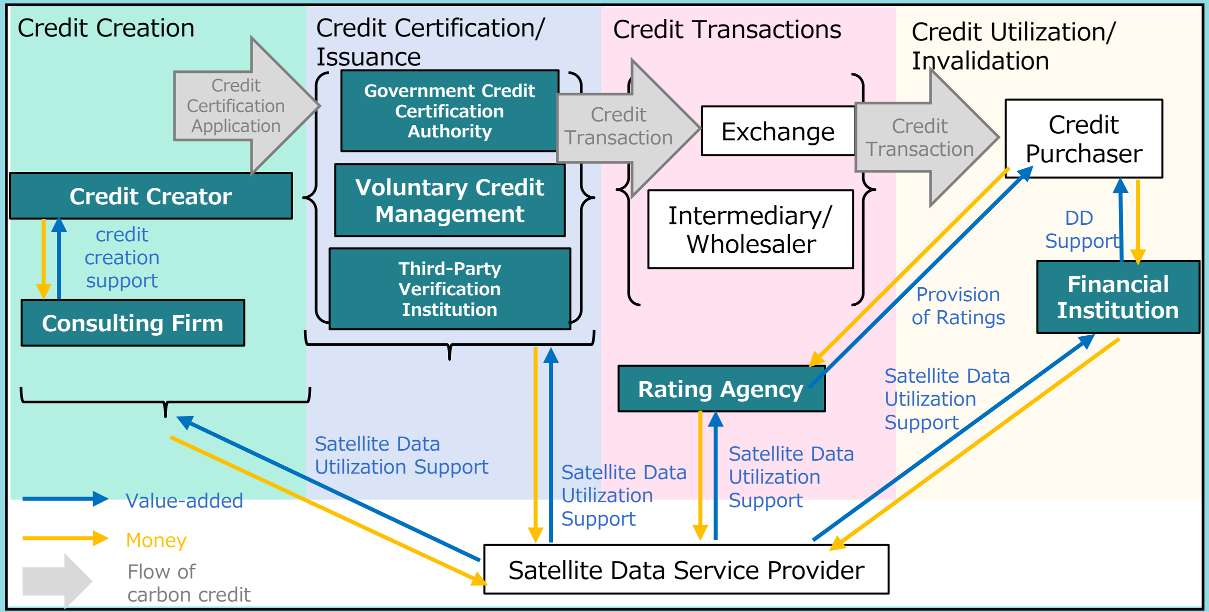
Imaging/ Observation	Sensor	On-site survey	Drone	Aerial photo	**Satellite**
Target Project	• Peatland rewetting projects • CCS/CCUS projects	• Forest-related projects • Mid-season drainage extension/AWD projects • Blue carbon-related projects			Applicable to all of the projects listed on the left
Regular or On-demand	Regular	On-demand	On-demand	On-demand	Regular
Required Time/Cost	Depends on the measurement frequency Sensor fees are determined by the installation costs and the number of sensors	On-demand imaging/observation are time consuming and expensive			Depending on the revisit cycle The cost per unit of area is low
Granularity of observation (Area or point observation)					
Objectivity	Without human intervention, and with high objectivity	With human intervention, and low objectivity			Without human intervention, and with high objectivity
Observation accuracy	High observation accuracy			Lower observation accuracy compared to the methods on the left	

Target Users and Applications

■ Target Users

- **Credit creators**: By utilizing satellite data as evidence for calculating project impacts and implementation, they can **create credits with higher transparency** than conventional methods.
- **Credit certification and verification institutions**: By utilizing satellite data to monitor the impacts and progress of projects, they can certify credits. **Reliable verification is possible based on objective and consistent data.**
- **Rating agencies**: By using satellite data to evaluate project impacts, they can assign ratings to credits. **Unbiased information will contribute to preventing greenwashing.**
- **Financial institutions**: By incorporating satellite data into the evaluation of project impacts, it supports due diligence. **Objective data allows for informed decision-making and reduces the risk of greenwashing.**

■ Transaction Flow Between Users and Carbon Credits

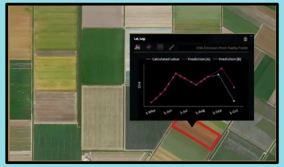


■ Example of Provided Service

Monitor CO_2 Absorption on a PC

Source: Archeda

Track the History of Water Management in Rice Fields



Source: Tenchijin

Blue Carbon Potential Map

Source: Think Nature

Evaluation of Environmental Dependency and Environmental Impact

Source: Think Nature

■ Companies Providing Similar Services

Support for Credit Generation

Biomass Estimation — **R&D** **PoC** **Impl.**
Ridge-i, Ernst & Young ShinNihon LLC, sustainacraft, Hitachi Systems, Archeda, Agritrio, etc.

Evidence for Mid-Season Drainage/ AWD — R&D **PoC** Impl.
Sagri/Faeger, Co/Archeda, Tenchijin, Green Carbon, etc.

Seagrass Bed Mapping — **R&D** **PoC** Impl.
Archeda, UMITRON, Seagrass-Watch, Global Mangrove Trust, DHI, etc.

Land uplift observations in peatlands — **R&D** **PoC** Impl.
Sumitomo Forestry/IHI, Hokkaido University/JST/JICA, MIT/Singapore, etc.

CO_2 Leakage Monitoring for CCS/CCUS — **R&D** PoC Impl.
TAISEI CORPORATION, INNO-CCUS, Halliburton, GEUS, U.S. Environmental Protection Agency, etc.

Credit Certification/Issuance

Biomass Estimation — R&D **PoC** Impl.
Verra/Pachama

Evidence for Mid-Season Drainage/ AWD — R&D **PoC** Impl.
Verra/Mantle Labs

Credit Transactions

Biomass Estimation — **R&D** **PoC** **Impl.**
BeZero Carbon/Plane, Renoster, Sylvera,etc.

Credit Utilization Support (Due Diligence)

Biomass Estimation — R&D PoC **Impl.**
Pachama, Orbify, Kanop, Treeconomy, sustainacraft, Earth Blox, Envirosense, etc.

Seagrass Bed Mapping — R&D PoC **Impl.**
Earth Blox

Land uplift observations in peatlands — **R&D** PoC Impl.
sustainacraft/Nippon Koei