Seagrass Mapper User's Manual

(ver 1.0)

Ministry of the Environment
Government of Japan

Revision records

Version	Uploaded date	Revised parts	Revision details and reasons
Ver1.0	2022/5/20	-	-

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Introduction

Seagrass Mapper is a web tool to map marine ecosystems such as seagrass beds in coastal waters, which is developed by using Google Earth Engine, a platform of cloud-based satellite images for science analysis. Seagrass Mapper is one of the services of the NOWPAP Marine Environmental Watch of the Ministry of the Environment, Japan, which is operated by the Northwest Pacific Region Environmental Cooperation Center (NPEC).

In this manual, functions and how to operate the tool are explained with examples.

Requirement

・Computer with Google Chrome installed

Other recommended tools and software

・Seagrass Trainer (WebGIS)
・QGIS (GIS software)
・Google Earth Pro (GIS software)

1. Main Function and Operation Flow

1. 1. Main Function

Seagrass Mapper is a web tool to map marine ecosystems such as seagrass beds in coastal waters by analyzing satellite images with Google Earth Engine. Seagrass Mapper can classify satellite images, and analyze and evaluate the classification results based on the information saved in a folder called "Asset". For registering Asset, user can use Seagrass Trainer, another web-based tool, or directly read Asset which is registered in user's Google Earth Engine account.

1. 2. Operation Flow

Figure 1 shows the procedure to be taken for analyzing satellite images by using Seagrass Mapper. AOI means "Area of Interest", which is map polygon data to be created when selecting target sea areas.

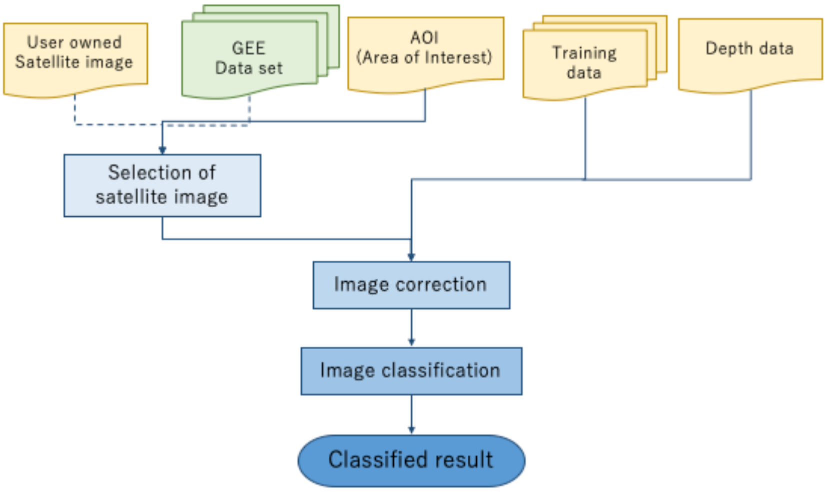

Figure 1-1 Procedure of satellite image analysis in Seagrass Mapper

2. User Interface

2. 1. Outline

Seagrass Mapper is composed of three panels: from the left, (1) Parameter-setting panel; (2) Map panel; and (3) Result-output panel. The result-output panel appears after completion of satellite image analysis.

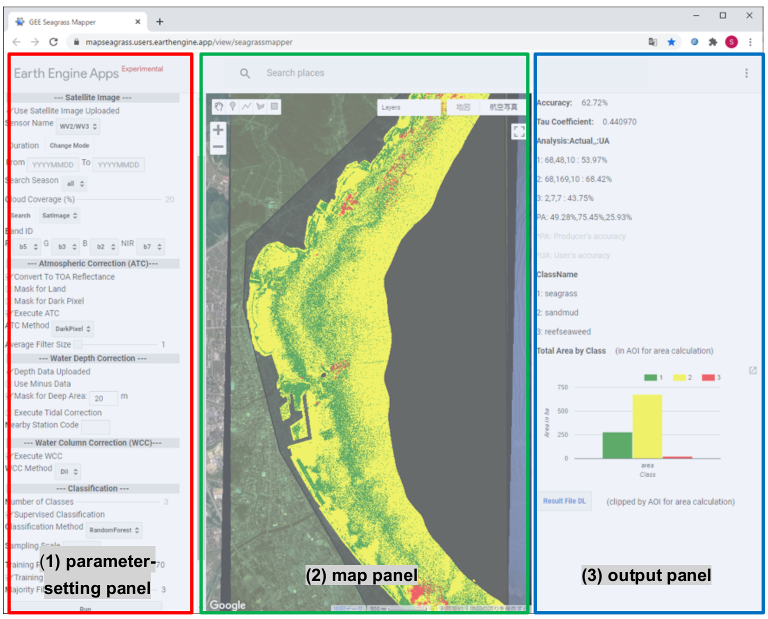

Figure 2-1 User interface of Seagrass Mapper (to be replaced).

In the parameter-setting panel, user can read on-site dataset and set conditions/parameters to prepare for analysis, such as selecting satellite images, image correction and classification methods. In the map panel, user can check selected satellite images, on-site dataset, and classification results. The result-output panel is displayed after image analysis is completed, and user can obtain results of accuracy assessment and the size of each class.

3. Preparation of Satellite Images

3. 1. Outline

In Seagrass Mapper, user can map seagrass beds in coastal waters by registering necessary information in Asset. This section explains types of necessary information and how to register them in Asset.

3. 2. Preparing necessary information for analysis

User must prepare information in advance, as shown in Table 3-1, for mapping seagrass beds on coastal waters by using Seagrass Mapper. This information should be either vector, raster or text data formats and saved with the file names specified in Table 3-1. For preparing vector data, user can use Seagrass Trainer or other GIS software such as QGIS or Google Earth Pro.

Table 3-1 Necessary information for mapping seagrass beds on coastal waters.

Information	Data format	File format (extension)	File Name**
Area of Interest (AOI) Data	Vector (Polygon)	SHAPE (shp, shx, dbf, prj, qpi, cpg), or ZIP (zip) *	AOI
Satellite Images	Raster	GeoTiFF (tif)	SatImage
TOA Reflectance (necessary for uploading satellite images)	Text	CSV (csv) (should be created manually based on metadata of satellite images)	TOAparam
Training Data for Atmospheric Correction (ATC)	Vector (Polygon)	SHAPE (shp, shx, dbf, prj, qpi, cpg), or ZIP(zip) *	Train_ATC
Training Data for Water Column Correction (WCC)	Vector (Polygon)	SHAPE (shp, shx, dbf, prj, qpi, cpg), or ZIP (zip) *	Train_WCC
Training Data for	Vector	- for Polygon	Train_CLS#

supervised classification	(Polygon) Or Point	SHAPE (shp, shx, dbf, prj, qpi, cpg), or ZIP (zip) * - for Point CSV (csv)	(# = number for each class)
Water Depth / Bathymetry	Raster	GeoTiFF	D
Tidal level	Point	Csv	tidaldata_# (# = area code)
AOI for area calculation	Polygon	SHAPE (shp, shx, dbf, prj, qpi, cpg), or ZIP(zip) *	Area

* Zip-compress the four files (shp, .shx, .dbf, and prj) of Shapefile,

** File Names are fixed and should not be changed.

3. 2. 1. Defining area for analysis

Draw a rectangular-shape polygon for the area to be analyzed by using GIS software (e.g. QGIS) and save it in a Shapefile. Then, zip-compress all file components of a Shapefile (at least 4 files: *.shp, *.shx, *.dbf, *.prj) with a name “AOI.zip”. AOI here stands for “Area of Interest”. Or, user can define the area for analysis by using Seagrass Trainer. See Seagrass Trainer Manual for details.

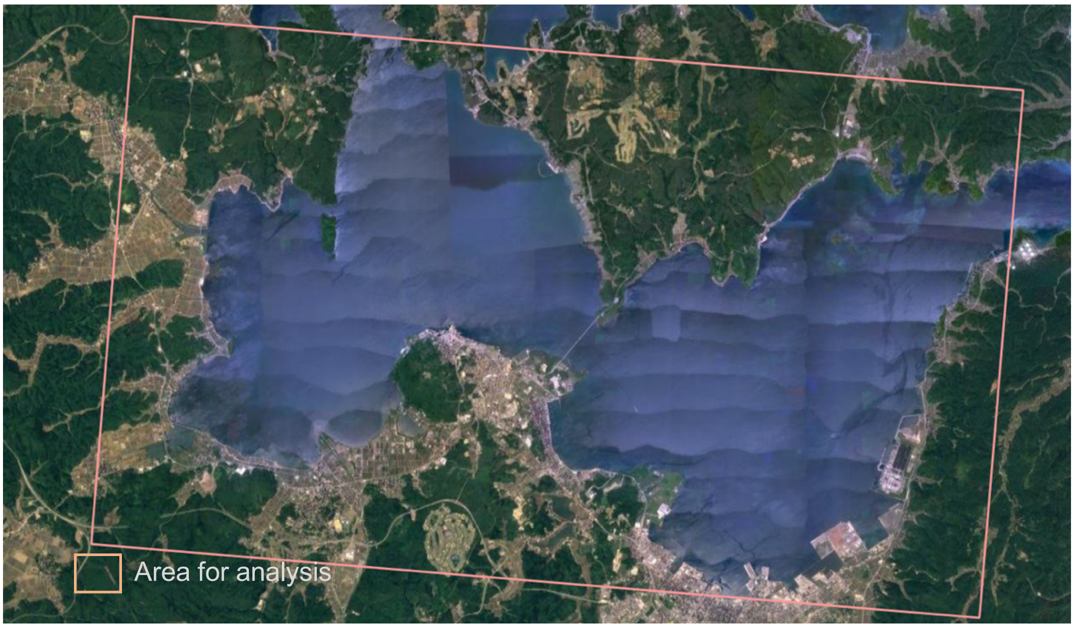

Figure 3-1 Example of AOI data (Area for analysis defined in Nanao Bay).

3. 2. 2. Preparing satellite images

In Seagrass Mapper, user can map shallow water ecosystems by using the following data available in the GEE Public Data Catalogue. When using these images, user does not have to prepare other satellite images.

- Landsat 4 Tier1 MSS TOA Reflectance
- Landsat 5 Tier1 MSS TOA Reflectance
- Landsat 7 Tier1 ETM+ TOA Reflectance
- Landsat 8 Tier1 OLI TOA Reflectance
- Sentinel-2 MSI L1-C
- ALOS/AVNIR-2 ORI

When user prefers higher resolution data, prepare commercial satellite images in Geo Tiff format. In this case, please note that user needs to load GeoTiFF data of one file that contains multiple bands information. The followings are a list of commercial satellite images compatible with Seagrass Mapper.

- WorldView-2 WV110
- WorldView-3
- GeoEye-1
- Any（Using satellite images taken by WorldView-4, SPOT, Planet, and others）

3. 2. 3. Preparing information of TOA Reflectance

Each pixel of a satellite image has a digital number, which is variable by the intension and degree of light and the time of taking satellite images. Before executing satellite image analysis, it is necessary to remove their influences by converting to Top of Atmosphere (TOA) reflectance. Necessary information for this conversion (e.g. sensor names, fixed or variable co-efficient used to correct information which is obtained from each satellite wave-length, the time of a satellite image, and the height of the sun) is recorded in metadata of each satellite image. Obtain such information from metadata in advance, create comma-delimited text data, and save it as “TOAparam.csv”. For more details, see Appendix (Section 7 preparation of TOA reflectance). User can skip this process by using data in the GEE Public Data Catalogue.

3. 2. 4. Preparing training data for Atmospheric Correction (ATC)

By using GIS software, draw a polygon of the reference area which is used for Atmospheric Correction (ATC) (Figure 3-2). When using dark-pixel-profile (DPP) method, the reference area should be deep-sea areas where light-reflection from the sea floor is negligible. When using near-infrared (NIR) method, user can include bright sea surface areas. The created polygons should be saved in a Shapefile. Then, all files (at least four files: .shp, .shx, .dbf, and .prj) should be combined and zip-compressed as one file (Train_ATC.zip).

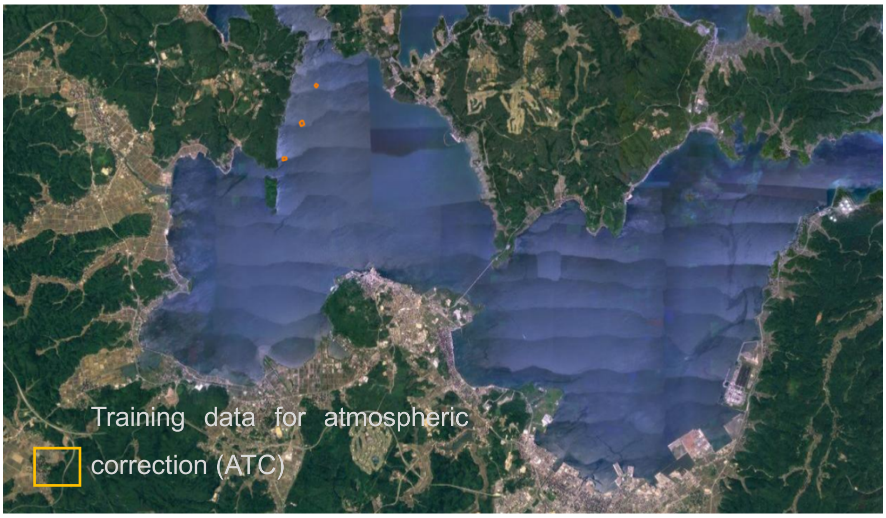

Figure 3-2 Example of training data (Train_ATC.zip) for Atmospheric Correction (ATC) in Nanao Bay.

Based on bathymetry and topographic maps, polygon data are created in deep sea areas where light-reflection from the sea floor is negligible.

3. 2. 5. Preparing training data for Water Column Correction (WCC)

By using GIS software, draw polygons for the reference area which is used for Water Colum Correction (WCC) (Figure 3-3). A reference area should be selected from areas presumed as sandy sediment and no seagrass, based on on-site observation and other information, covering from shallow water to a deeper area. Multiple polygons can be selected. The drawn polygons must also be saved as a Shapefile and zip-compressed as "Train_WCC.zip".

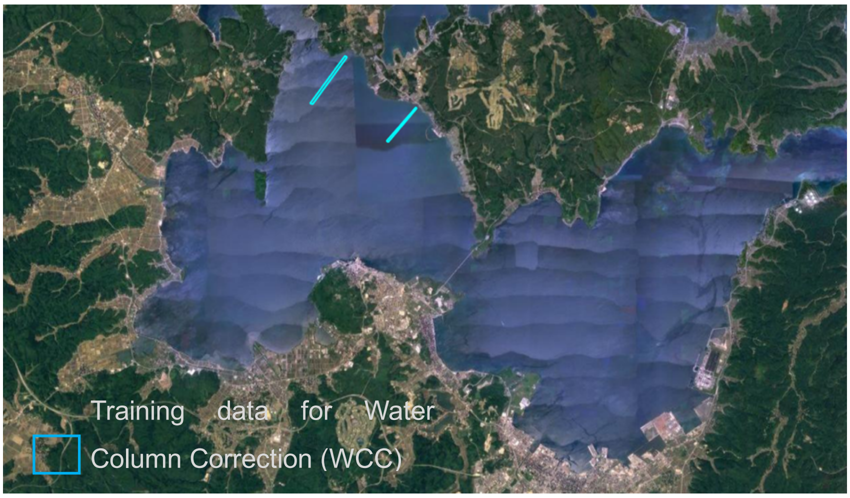

Figure 3-2 Training Data (Train_WCC.zip) for Water Column Correction (WCC) in Nanao Bay

3. 2. 6. Preparing data for Supervised Classification

By using GIS software, draw polygons or points of training data based on the information obtained by on-site observation, existing database, research papers and/or scientific reports (Figure 3-4). The created polygons or points should be saved as a Shapefile by each class and zip-compressed, same as the previous sections. Seagrass Mapper can handle 10 classes at maximum.

Figure 3-4 Training data for supervised classification (polygon data) in Nanao Bay (Train_CLS1, 2, 3, 4). The following 4 training data are prepared based on the sea bottom observation by underwater camera conducted in June 2015 and the position information by a GPS logger. Train_CLS1.zip (bottom: seagrass), Train_CLS2.zip (bottom: sandy-muddy), Train_CLS3.zip (bottom: seaweed), Train_CLS4.zip (bottom: sandy-muddy or sparse seagrass).

The color of each class has already set as sown in Table 3-2, so user needs to decide suitable color for each class in advance.

Table 3-2 Assigned colors for each class

class	color
Train_CLS1	darkGreen
Train_CLS2	yellow

Train_CLS3	red
Train_CLS4	purple
Train_CLS5	green
Train_CLS6	magenta
Train_CLS7	orange
Train_CLS8	cyan
Train_CLS9	gray
Train_CLS10	blue

3. 2. 7. Preparing Water Depth/Bathymetry data

Prepare a raster image with pixel values which contains water depth information (unit: meter, positive number: deeper). The data used in this example uses 2-meter-meshgrid GeoTiff data of West Bay in Nanao Bay, Japan covering northern latitude 37°03'58.26" ~ 37°08'12.33", and eastern longitude 136°51'09.73" ~ 136°56'56.84" (Figure 3-5). Water depth/bathymetry data are used for masking areas with water depth information (excluding from analysis targets), applying water column correction (WCC) and tidal correction, which is explained in Section 3.2.8. User doesn’t have to prepare water depth/bathymetry data when skipping these processes.

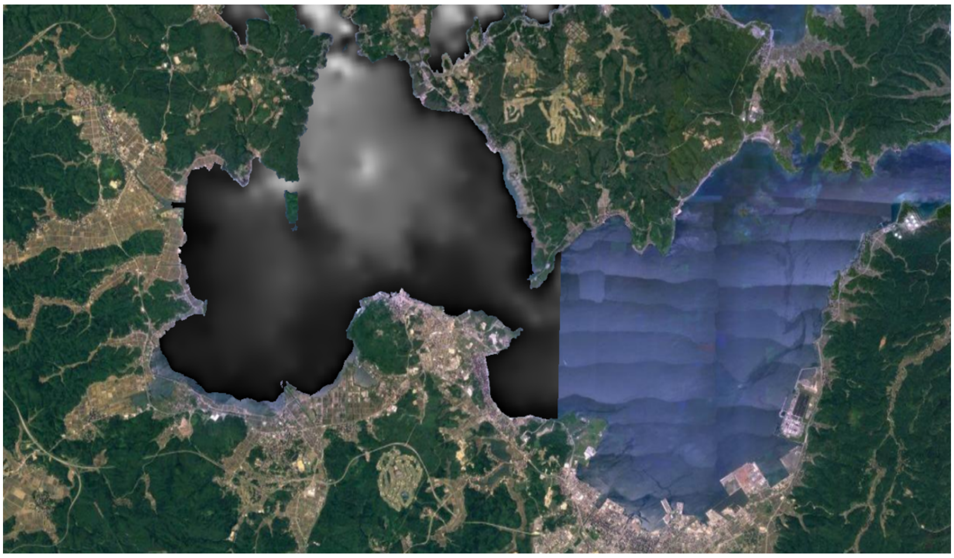

Figure 3-5 Water depth/bathymetry data (D.tif) for Nanao Bay.
(Water depth is shown in black and white.)

3. 2. 8. Preparing Tidal Level Data

When applying tidal correction, tide level information is necessary. In Seagrass Mapper, tidal level data from the Japan Meteorological Agency (open source) are already registered. When user plans to use other tidal level data, such data should be prepared in advance. For preparation of tidal level data, please refer to Appendix of Seagrass Trainer for details (Section 5 Tidal Correction with tidal level data from agencies other than the Japan Meteorological Agency).

3. 2. 9. Defining area for calculation

By using GIS software (e.g. QGIS), draw a polygon to calculate the area from the classification results, and save it as a Shapefile. Then, zip-compress all files (at least four files: .shp, .shx, .dbf, and prj) in a Shapefile with the name “Area.zip”. User can create the same data by using Seagrass Trainer. Please refer to the Seagrass Trainer User Manual.

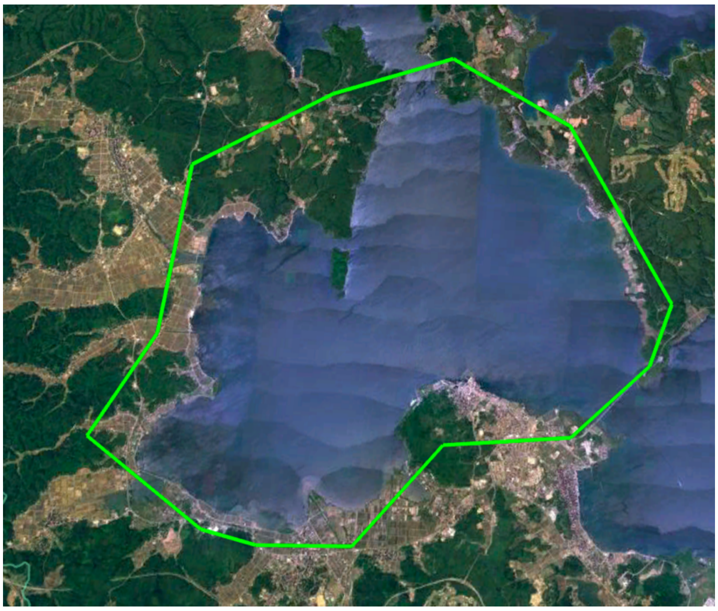

Figure 3-6 Example of Data for area calculation (Area.zip) for West Bay in Nanao Bay.

3. 3.Registration of Asset

This section explains how to register Asset which is essential for satellite image analysis. There are two types of registration: (1) using Seagrass Trainer; or (2) using Code Editor of the Google Earth Engine.

3. 3. 1. Asset registration by Seagrass Trainer

Seagrass Trainer is a convenient tool to register necessary data for satellite image analysis with Seagrass Mapper. By using these two tools, user can interactively map ecosystems in shallow waters. The procedure of how to register Asset with Seagrass

Trainer is explained in its manual. User Registration is necessary in Seagrass Trainer (https://seagrassmapper.mapseagrass.org/).

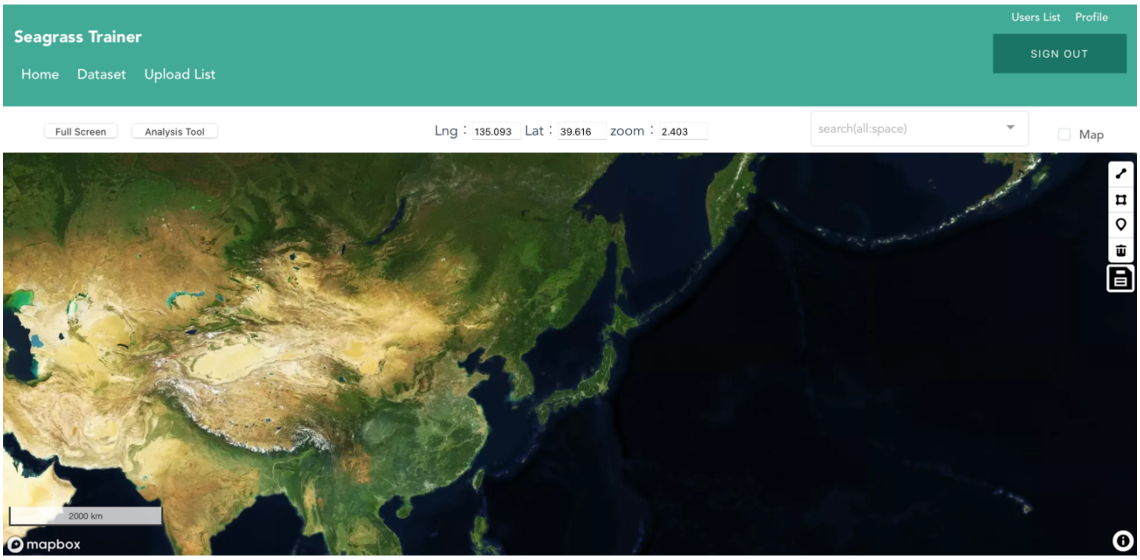

Figure 3-7 Home page of Seagrass Trainer.

This section briefly explains the procedure of registering necessary data to Seagrass Trainer. First, click “Dataset” on the top left of the Home page of Seagrass Trainer to open the “Input File Upload” window (Figure 3-8). Then, select one item from the list of “Select Input Data” and further select necessary data to be uploaded, which are prepared in advance, and click “Send Bucket” In this step, upload all necessary data one by one.

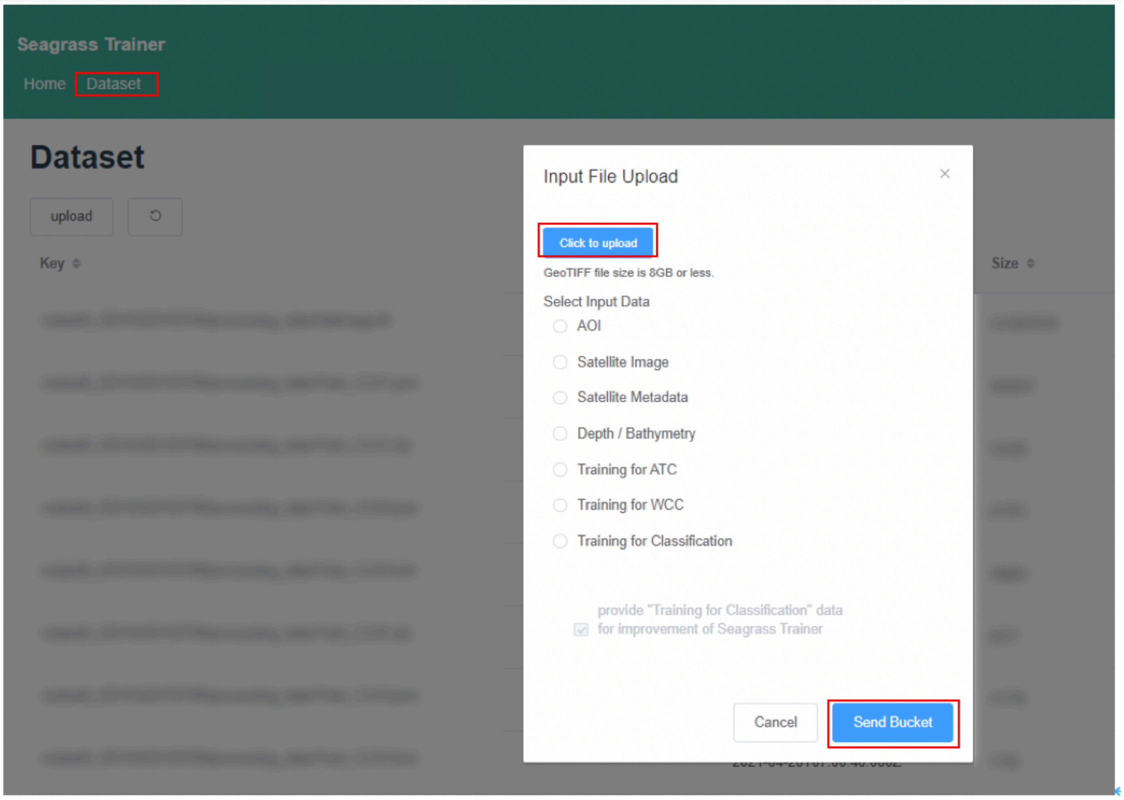

Figure 3-8 Data registration by using Seagrass Trainer.

All uploaded information is registered in Asset, and user can find and retrieve necessary data from Asset for satellite image analysis. For checking the name of Asset, click “Analysis Tool” on the Home page of Seagrass Trainer. The name of selected data is shown next to “Asset Folder Name” in “Satellite Image Analysis Parameters” window, which is automatically given when signing in to Seagrass Trainer (Figure 3-9).

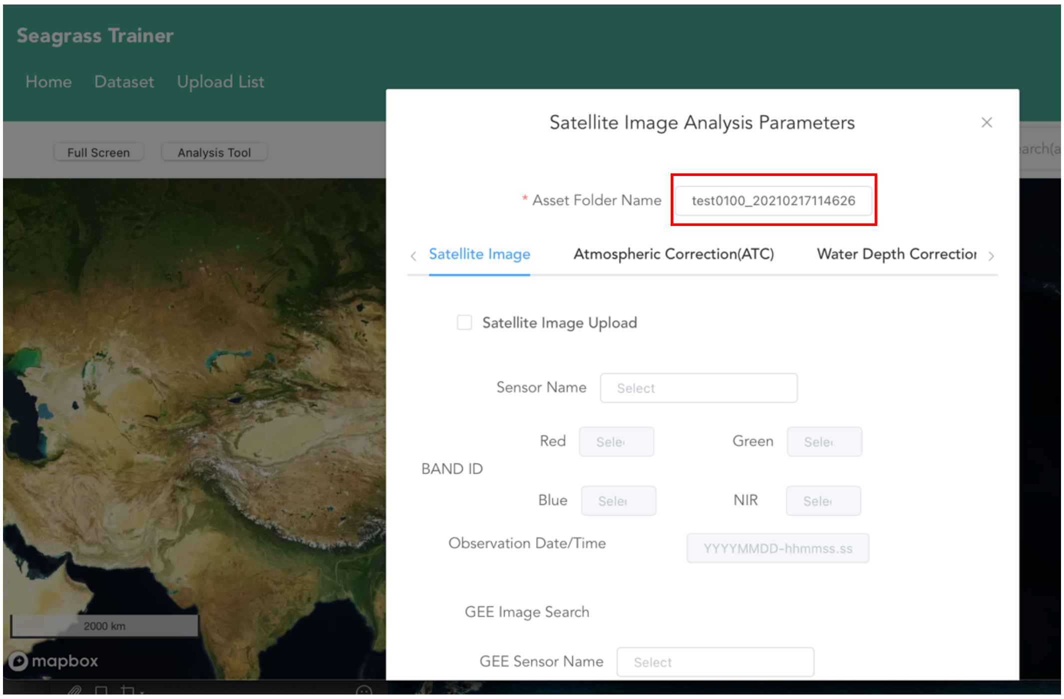

Figure 3-9 Data registration to Seagrass Trainer.

Asset folder name is automatically generated at the timing of signing in to Seagrass Trainer with the specified format of "User ID_YYYYMMDDHHMMSS". In case multiple Asset folders are prepared and managed, sign in and sign out Seagrass Trainer every time user prepares a new Asset folder. For more details, see Appendix (6 Reuse of Training data).

3. 3. 2. Registering Asset by Code Editor of the Google Earth Engine

In this section, the following procedure is given on the condition that user already has signed in Google Earth Engine with "mapseagrass" ID. Registration to Google Earth Engine can be done for free.

https://signup.earthengine.google.com/

(1) Starting up Code Editor of the Google Earth Engine (GEE)

Open the webpage (https://code.earthengine.google.com/#) on Google Chrome (recommended).

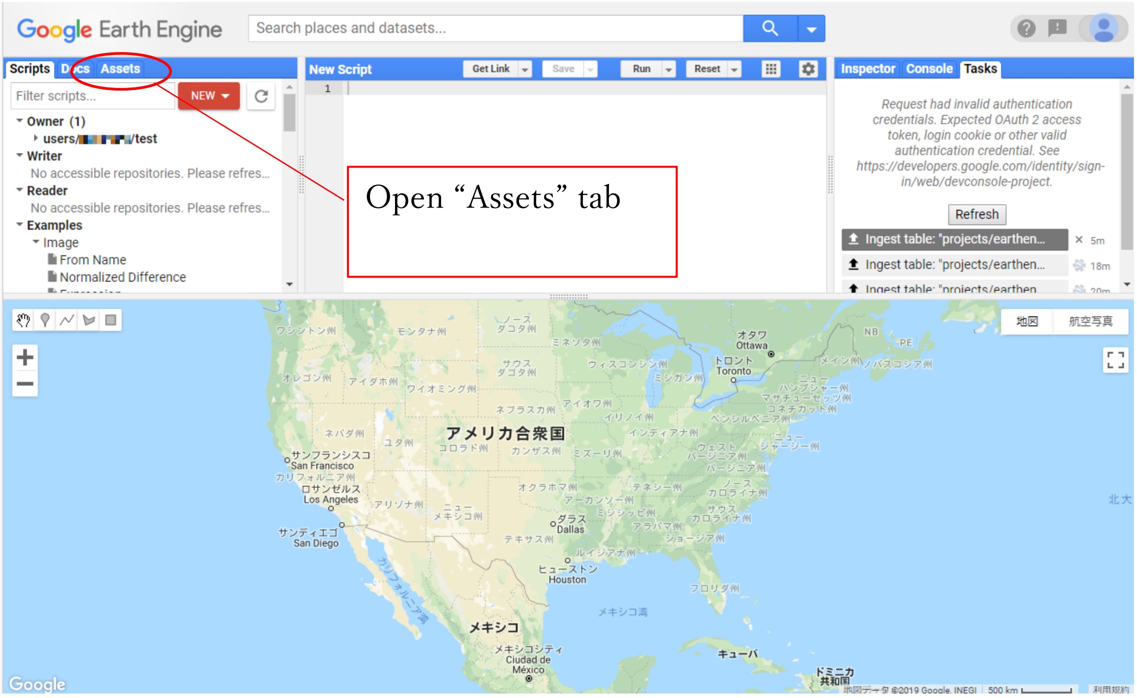

Figure 3-10 Interface of Code Editor of the Google Earth Engine

(2) Creating Asset folder

Click the red “New” button on the Asset panel and select “Folder” from the pull-down menu (Figure 3-11). In this manual, user creates a new folder named “testdata” in the “mapseagrass” account in GEE and registers necessary data for seagrass mapping. This testdata folder is created in respective GEE user accounts. So, while using Seagrass Mapper, user retrieves data from “user/mapseagrass/testdata” (changing “mapseagrass” to your own account name).

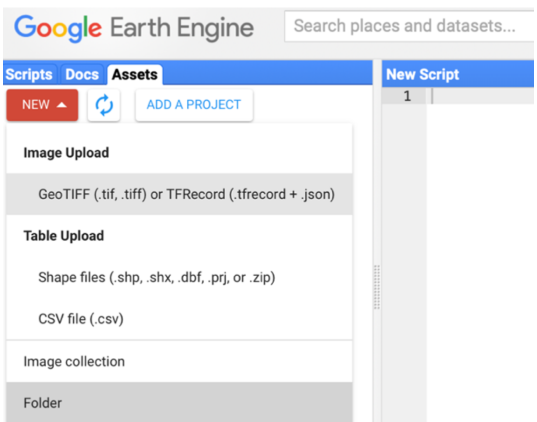

Figure 3-11 “New” button and items in the pull-down menu in the Asset panel.

(3) Uploading data

When conducting analysis with Seagrass Mapper, user needs to upload necessary data to the created Asset folder. Select corresponding items either in the "Image Upload" or "Table Upload" and click "Upload" for each file format. Make sure that the file names should be used as defined in Table 3-1 to enable Seagrass Mapper to understand the data contents. Also, enter the Asset folder name on top of the file name to assign the place of data to be saved (Figure 3-12). Without assigning the Asset folder name, an uploaded file will be saved in the folder of user's account name, not in "testdata". So, user needs to put the uploaded file in "testdata" manually.

* For loading Shapefile, user needs to select shp, shx, dhf, prj files all together.

By zip-compressing the four files in advance, user can also select the zip file.

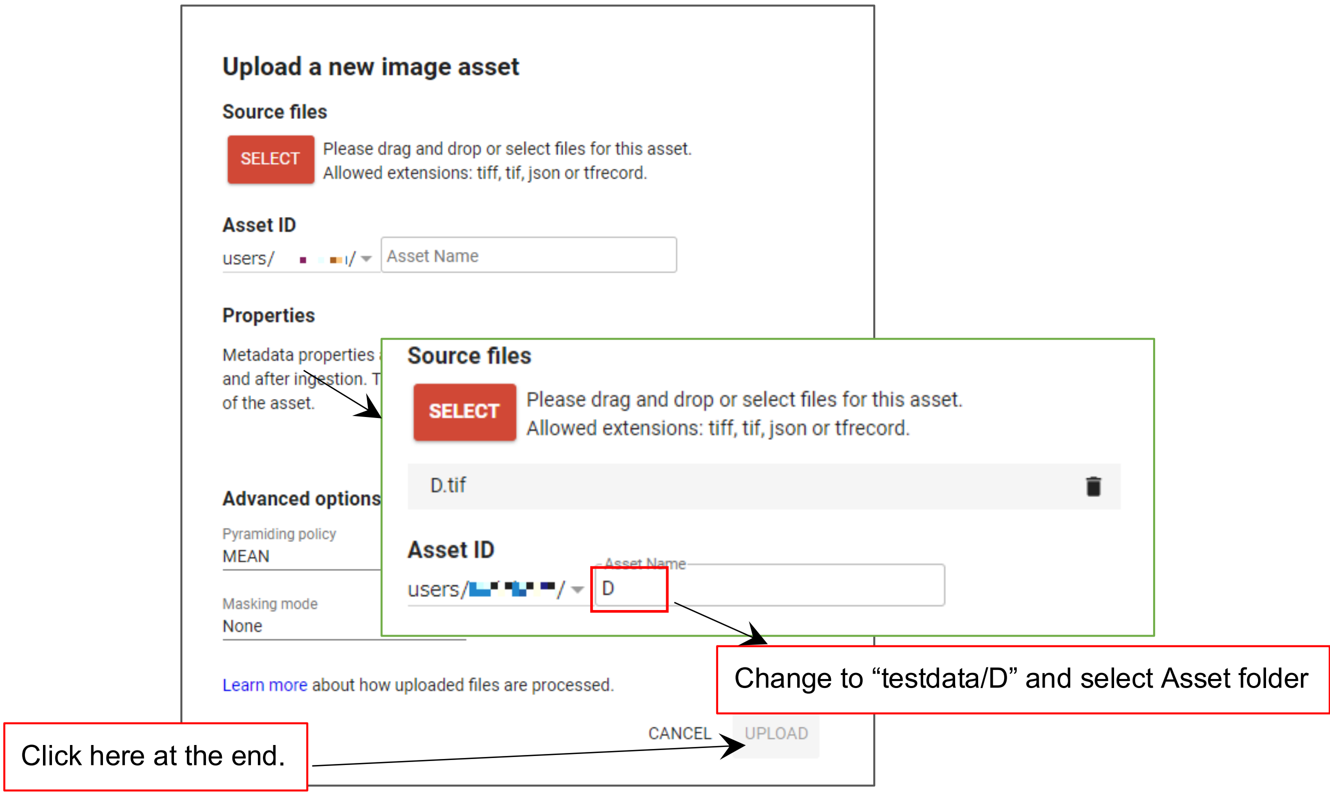

Figure 3-12 Example of uploading water depth/bathymetry information.

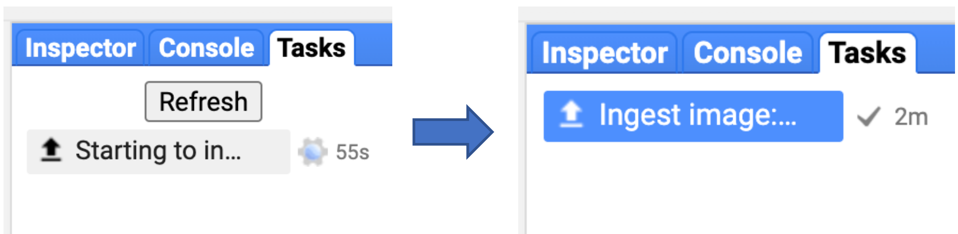

Figure 3-13 File uploading in process (left) and File uploading completed (right).

Check a new file is surely added in an Asset folder after completing its upload. If user cannot find the new file, click the "refresh" button next to the red "NEW" button in the Asset panel (Figure 3-14).

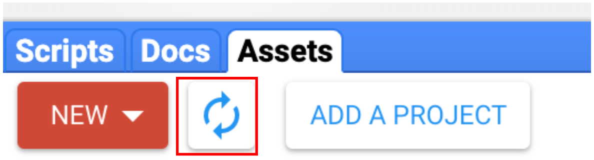

Figure 3-14 "Refresh" button next to "NEW" button in the Asset panel.

The time taken for uploading depends on the file size and the internet connection. User can check the status of uploading in the "Tasks" tab on the right top of the Code Editor page (See Figure 3-13).

(4) Setting Permission of Asset Folders and files in the folders

For reading the files in Asset folders by using Seagrass Mapper, it is necessary to set access permission for each uploaded file. Open each uploaded file in Asset folders and click "Share" (Figure 3-15) and tick "Anyone can read" (Figure 3-16). Repeat the same action for all files in Asset folders, which are used for analysis(Figure 3-17).

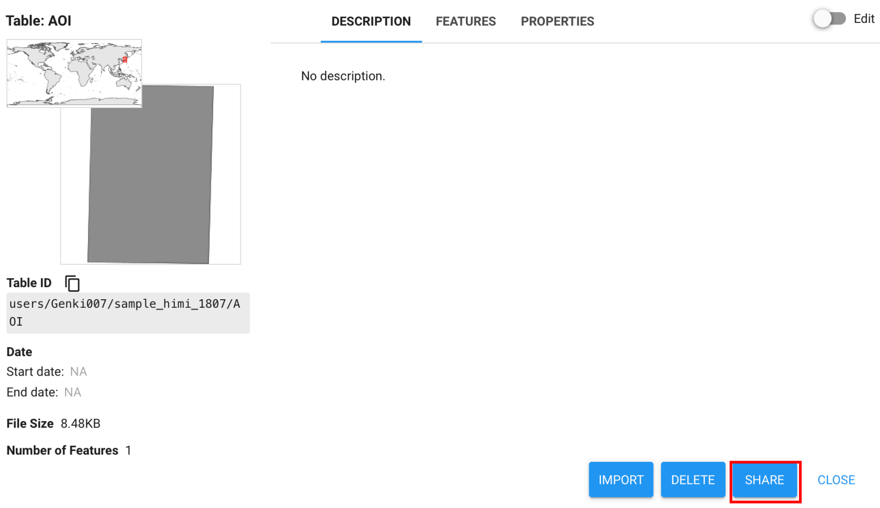

Figure 3-15 A window to be shown when clicking "AOI" in "testdata".

Click the “SHARE” button on the right bottom (Figure 3-15).

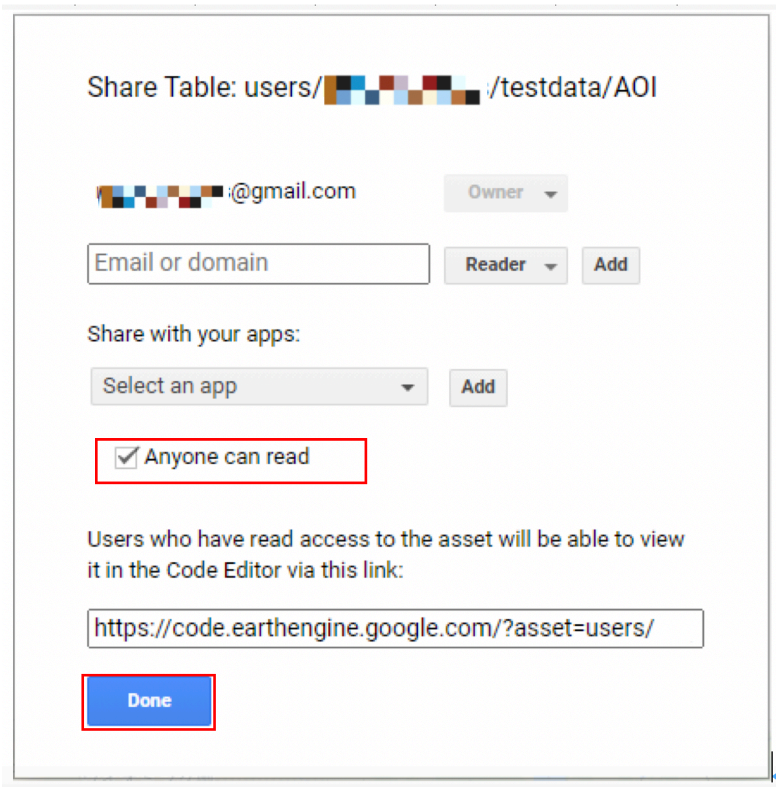

Figure 3-16 Setting access permission of files.

Tick “Anyone can read” and click the “Done” button (Figure 3-16).

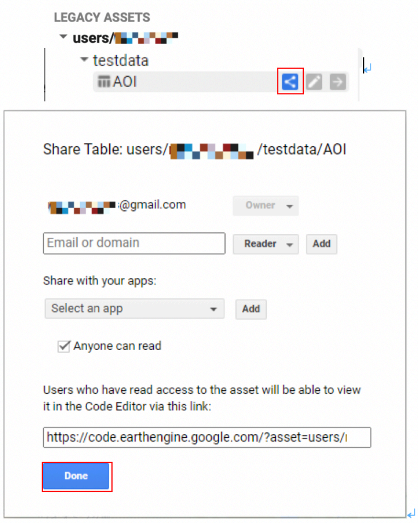

Figure 3-17” Share” button next to a file in an Asset folder (top).

Image of setting access permission (bottom).

(5) Setting the time information of satellite images

When user uses self-uploaded satellite images for analysis, it is necessary to enter the time information of satellite images. Click the registered “SatImage” file in an Asset folder, switch on the edit knob on the top right of the page, and enter the time information (YYYY-MM-DD HH:MM:SS)* in “Start date” by referring to metadata information of the satellite images (Figure 3-18).

*Be sure to enter “second” in the time information.

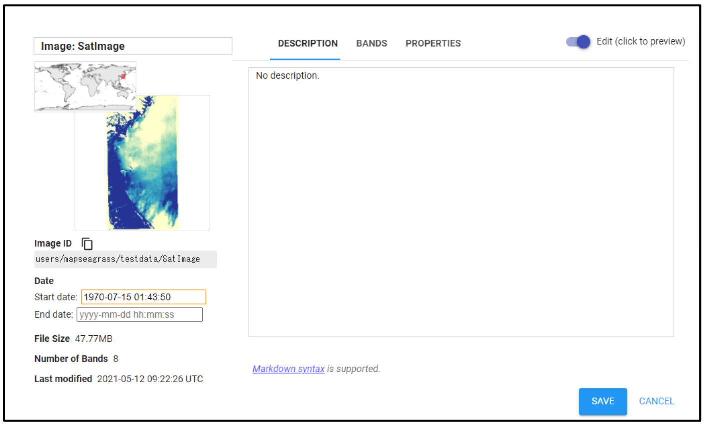

Figure 3-18 Setting up the time information of satellite images.

(6) Setting class properties

User can set up class properties (e.g. name of classification) to their uploaded training data. Click a “Train_CLS#” file of registered training data in an Asset folder, switch on the edit knob on the top right of the page and press “Add property”. On the page shown in Figure 3-19, type “ClassName” in the “Property” field and any name (e.g. seagrass) in the “Value” field, and press “SAVE”. The property set at this step is shown in the result output panel after completing analysis.

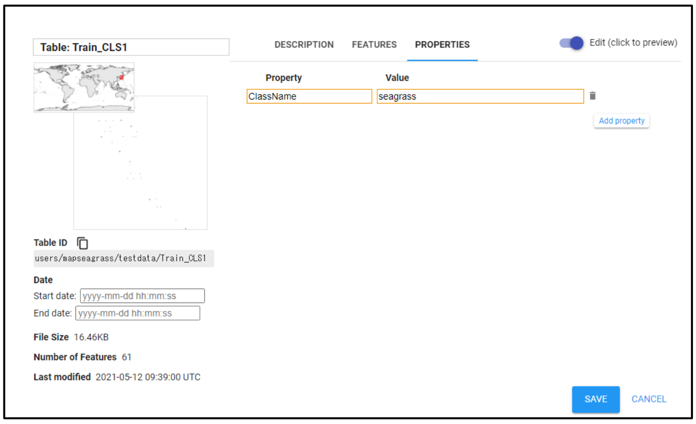

Figure 3-19 Setting class properties.

Preparation of all necessary information for satellite image analysis is now completed. Then, setting parameters and procedure for satellite image analysis are explained in the next section.

4. Setting parameters and procedure for satellite image analysis

In this section how to set analysis parameters and steps of image analysis are explained with the examples of Nanao Bay and Toyama Bay.

4. 1. Detecting seagrass beds in Nano Bay

Nanao Bay is an enclosed bay located in the middle of Noto Peninsula, and divided into North, West and South Bays. West Bay is well-known for its large-scale seagrass habitats. This section explains how to map seagrass by using the field observation by underwater video camera conducted by the Northwest Pacific Region Environmental Cooperation Center (NPEC) in June 2015 and a satellite image taken by Landsat-8 OLI, which is available from GEE Public Data Catalogue.

4. 1. 1. Starting Seagrass Mapper

Access to https://mapseagrass.users.earthengine.app/view/seagrassmapper

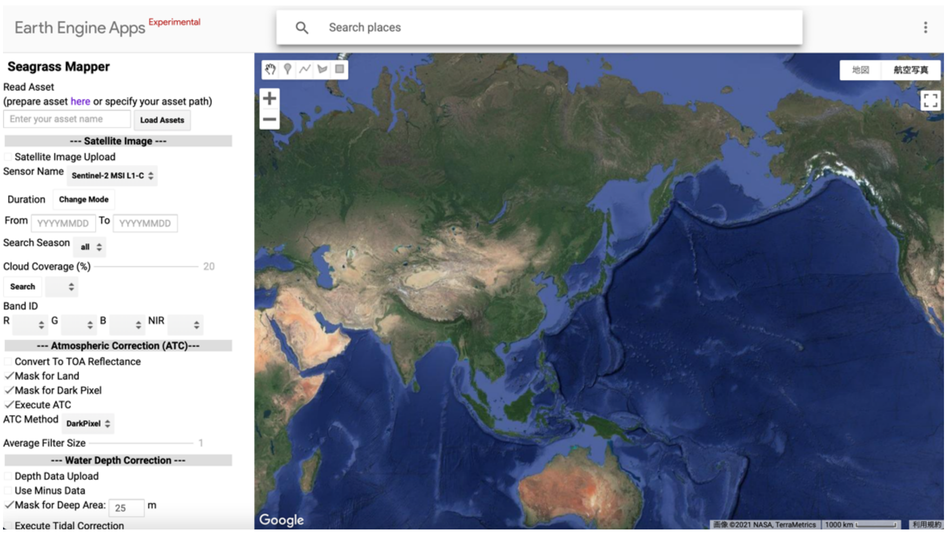

Figure 4-1 Interface of Seagrass Mapper

4. 1. 2. Loading Asset files

In this example, we use the data described in Section 3.3.1 registered in Asset folders (mapseagrass_YYYYMMDDHHMMSS) . This file includes data explained from Section 3.2.1 to 3.2.8: AOI data including Nanao Bay, training data for ATC, training data for WCC, training data for supervised classification, which is prepared based on field observation in June 2015, data for water depth/bathymetry, and data for area calculation.

Enter “mapseagrass_YYYYMMDDHHMMSS” in the field of “Read Asset” on the top left of the Seagrass Mapper interface and click “Load Assets” button. Then, a text message “Checking Asset” is shown on the map panel, and when it changes to “Asset Loaded”, necessary Asset folder is loaded to Seagrass Mapper (Figure 4-2).

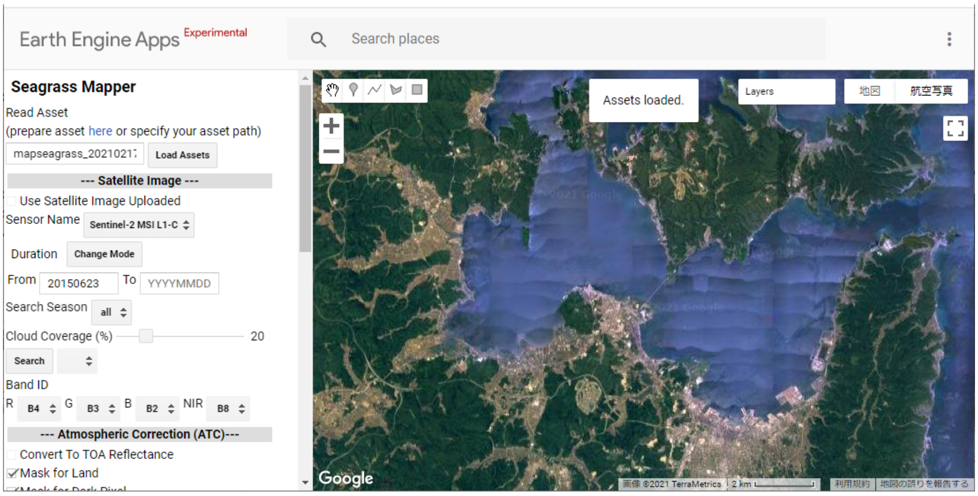

Figure 4-2 Completing loading Asset folder (mapseagrass_YYYYMMDDHHMMSS)

4. 1. 3. Searching and selecting satellite images

In the middle of the parameter-setting panel, there is a sign, “---Satellite Image---“. Select “Landsat 8 Tier 1 TOA Reflectance” from the list in “Sensor name”, enter “20150601” in the field of From, and click "Search” button. Then, in the pull-down menu next to “Search” button, select “June 1, 2015” image (LC08_109034_20150601*) from the other Landsat 8 OLI images taken after June 1, 2015, which is closest to the field observation in June 6 2015 (Figure 4-3). Regrading cloud coverage, which user can specify the maximum percentage., Here, we use 20 percent set by default. When GEE public data are loaded, BAND ID is automatically provided, so user doesn’t have to change it.

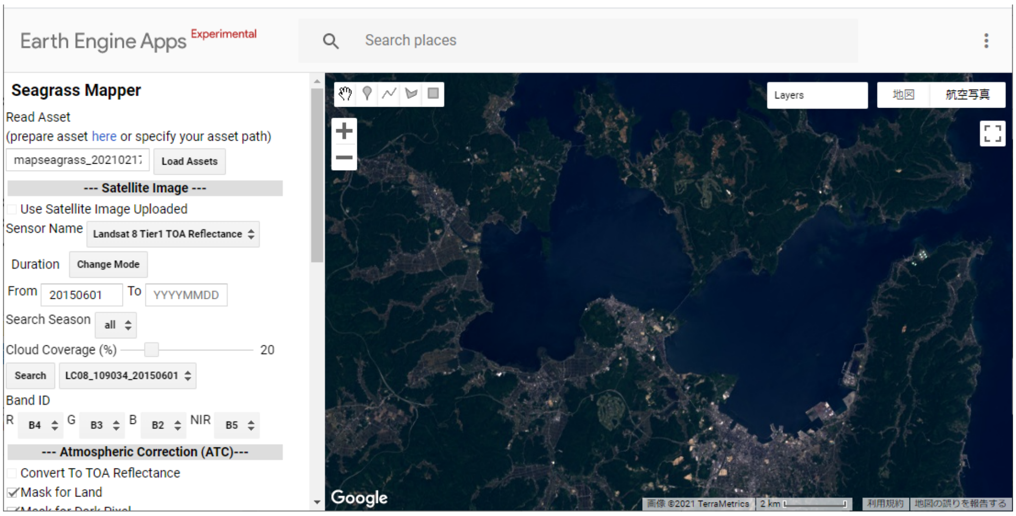

Figure 4-3 Completing loading of a satellite image taken by Landsat 8 OLI, June 1, 2015.

4. 1. 4. Setting parameters for Atmospheric Correction (ATC)

Move to the lower section of the parameter-setting panel, "--- Atmospheric Correction (ATC) ---", to set some conditions as shown in Table 4-1.

Table 4-1 Parameters for Atmospheric Correction

Convert to TOA Reflectance	Tick when converting to TOA reflectance
Mask for Land	Tick for masking land
Mask for Dark Pixel	Tick for masking dark pixels
Execute ATC	Tic for conducting ATC
ATC Method	Select from the two methods for ATC -- DarkPixel Method -- ATC is conducted using information of sea areas where light reflection from the sea floor is negligeable. -- NIRModel Method -- When the satellite image has some brighter spots (waves and/or sunglint), choose this method.
Average Filter Size	Set the filter size for smoothing. The unit of the size is given by pixel and the actual filter size depends on the resolution of satellite images.

In this example, only "Execute ATC" is ticked and Dark Pixel Method for ATC is specified (Figure 4-4). “Mask for Land” and “Mask for Dark Pixel” are not ticked in this example as these options may not properly mask land or dark pixel areas.

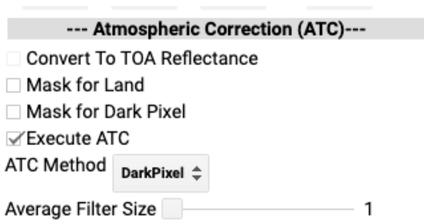

Figure 4-4 Setting conditions for ATC for Nanao Bay

4. 1. 5. Setting parameters for water depth/bathymetry correction

Move to the lower section of the parameter-setting panel, “--- Water Depth Correction ---“ to set parameters as shown in Table 4-2.

Table 4-2 Parameters for Water Depth/bathymetry Correction

Depth Data Uploaded	Tick when using uploaded water depth data
Use Minus Data	Tick when water depth data is recorded in negative value.
Mask for Deep Area Mask Depth(m)	When masking some sea areas based on the water depth data, set the smallest value. (For example, when masking the areas deeper than 10 meters, enter “10 m”.)
Execute Tidal Correction Near by Station Code	When conducting tidal correction, tick the box and enter the area code. In the area around Japan, see the list of tidal station code of the Japan Meteorological Agency. For other areas, user needs to enter their data manually. For more details, see Appendix (Section 5 Tidal Level Correction with tidal level data not from the Japan Meteorological Agency).

In this example, “Use Depth Data Uploaded” and “Mask for Deep Area” are ticked. In Nanao Bay, it is known that seagrass is rarely found at 10 meters or deeper under water. So, enter 10 (m) for “Mask for Deep Area”.

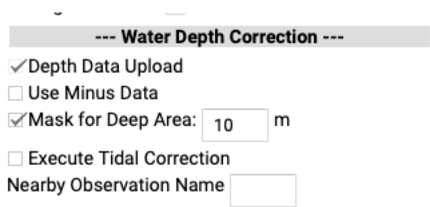

Figure 4-5 Setting parameters for water depth/bathymetry correction for Nanao Bay

4. 1. 6. Setting parameters for water column correction (WCC)

When conducting water column correction (WCC), tick “Execute WCC” and select either DII (depth Invariant Index) or BRI (Bottom Reflectance Index). In this example (Nanao Bay), tick “Execute WCC” and choose BRI (Figure 4-6).

Figure 4-6 Setting parameters for WCC for Nanao Bay

4. 1. 7. Setting parameters for image classification and analysis

At the end, set parameters for image classification as shown in Table 4-3 and start image analysis.

Table 4-3 Setting parameters for image classification

Number of Classes	Decide the number of classes. In Seagrass Mapper, set the same number as Training data for supervised classification (Train_CLS1), explained in Section 3. If it is set as “3”, Train_CLS1, Train_CLS2, and Train_CLS3 are used for classification.
Supervised Classification	Tick when supervised classification is conducted.
Classification Method	Select algorithm for image classification from the following options: -- Supervised classification -- <Random Forest> Random forests or random decision forests are an ensemble learning method for classification,

	regression and other tasks that operates by constructing a multitude of decision trees at training time and outputting the class that is the mode of the classes (classification) or mean/average prediction (regression) of the individual trees.[<Decision Tree> Decision tree learning is one of the predictive modelling approaches used in statistics, <Support Vector Machines (SVMs)> support-vector machines (SVMs, also support-vector networks) are supervised learning models with associated learning algorithms that analyze data for classification and regression analysis. <MaxEnt (Maximum Entropy Modeling)> Maxent is used to model species distribution probabilities using environmental data for locations of known presence and for a large number of 'background' locations. -- Without supervised classification -- <wekaKMeans> When there is no training data for classification, select this method.
Sampling Scale	Sampling scale of training data for supervised classification is specified from original, 10 meters, 5 meters or 1 meter. Basically, choose “original” (for Landsat-8, resolution is 30 meters, so “original” means 30 meters). When a polygon of training data is smaller than the size of the resolution of satellite image, all training data may not be used. In such a case, try to select a smaller sampling scale size. For more details,

	see Appendix (8. Setting Sampling Scale)
Training Rate (%)	Training data are divided into 2 groups: one group for image classification and the other group is for accuracy assessment. The percentage of the data used for supervised classification is decided in “Training Rate”, (and the rest is used for accuracy assessment). In general, 70-80 % of data are used for image classification, and the remaining 20-30% are used for accuracy assessment.
Training Data Split by Each Class	Tick the box when the same rate of training information is applied in each class.
Majority Filter Size：3(pixel)	This is used for smoothing analysis results. The size should be adjusted by comparing the resolution of satellite images with output results. In this example, Majority Filter Size is set as 3 (pixel).

Parameters for image classification set for Nanao Bay is shown in Figure 4-7. After setting each parameter, click “Run” button at the bottom to start executing image analysis.

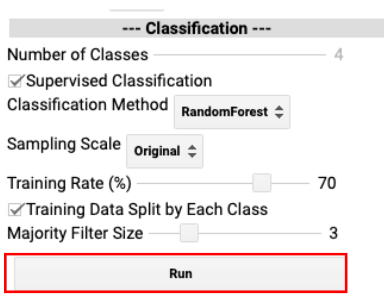

Figure 4-7 Setting parameters for image classification for Nanao Bay

4. 2. Detecting Seagrass in Toyama Bay (using images taken by WorldView-2)

In this section, steps to mapping seagrass in Toyama Bay are explained.

4. 2. 1. Staring Seagrass Mapper

See Section 4.1.1

4. 2. 2. Loading Asset folder

Prepare Asset folder (mapseagrass_YYYYMMDDHHMMSS) in advance, in which necessary training data with WorldView-2 are registered.

See Section 3.3. for data registration to Asset Folder, and Section 4.1.2. for loading Asset folder.

Table 4-4 is the list of used data in this example. The file (mapseagrass_YYYYMMDDHHMMSS) includes AOI data including Toyama Bay, training data for ATC, training data for WCC, training data for supervised classification, which is developed based on field observation in June 2018, data for water depth/bathymetry, and data for area calculation.

Table 4-4 Data used for satellite image analysis (Toyama Bay)

Type	Content (for Toyama Bay)	File name
Satellite Image	Satellite image (WorldView-2, GeoTIFF） taken on July 15, 2018	SatImage.tif
Satellite Metadata	TOA Reflectance converting parameter prepared based on metadata of satellite images (attached to WorldView-2 satellite image)	TOAparam.csv
AOI	Data for Area of Interest (AOI) (polygon Shapefile）	AOI.zip
Training for ATC	Training data for atmospheric correction (ATC) (polygon Shapefile）	Train_ATC.zip
Training for WCC	Training data for water column correction (WCC) (polygon Shapefile）	Train_WCC.zip
Training for Classification	Training data for supervised classification (polygon Shapefile）	Train_CLS1.zip Train_CLS2.zip Train_CLS3.zip
Depth / Bathymetry	Data for water depth/bathymetry (GeoTIFF）	D.tif

(1) Preparation of satellite images

Satellite images (SatImage.tif) which are uploaded to Asset folders should be a file that includes multi-band images. In this example, 4-band images (Blue, Green, Red and NIR) are used, and user should be aware of corresponding band numbers in advance.

WorldView-2 image, which is used here, has 8 band images in one file, and it is registered in an Asset folder. When setting analysis parameters, user specifies Band 2

(Blue), Band 3 (Green), Band 5 (Red), and Band 7 (NIR). Figure 4-8 is an example of multi-band image file of WorldView-2 image displayed in QGIS.

When a satellite image comes with separate files for each band, combine 4 band (Blue, Green, Red, and NIR) images into one file (SatImage.tif) containing multiple-band images. There is no specific order for combing bands into one file (in general, a shorter wave-length image is stored first, then longer follows). As long as the band wave-length and the band numbers are corresponding, it shouldn't be a problem.

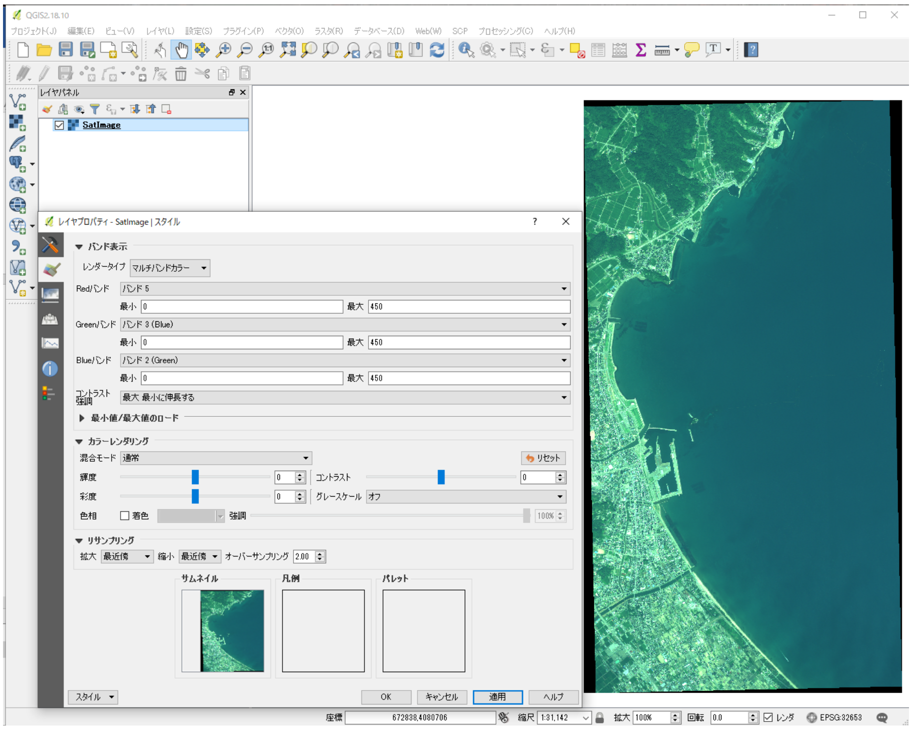

Figure 4-8 Multi-band image file (using WorldView-2).

(2) Preparation of TOA Reflectance Converting Parameters

When satellite images are recorded in radiance values, it can be converted to TOA reflectance in advance from metadata information attached to satellite images and upload it to Asset folders. This step is useful when classifying satellite images of different time-period because TOA reflectance is independent of light conditions determined by weather, seasonality, and so on.

Figure 4-9 is a sample of TOA reflectance converting parameters (TOAparam.csv) which is prepared based on WorldView-2 image metadata (.imd). For more details, see Appendix (Section 7 preparation of TOA reflectance converting parameters).

```
version = "28.3";
generationTime = 2019-01-22T13:37:22.000000Z;
productOrderId = "058973293010_01_P001";
productCatalogId = "A01001040F24B300";
childCatalogId = "203001040F24B400";
imageDescriptor = "Standard2A";
bandId = "Multi";
panSharpenAlgorithm = "None";
numRows = 3543;
numColumns = 1902;
productLevel = "LV2A";
productType = "Standard";
numberOfLooks = 1;
radiometricLevel = "Corrected";
radiometricEnhancement = "Off";
bitsPerPixel = 16;
compressionType = "None";
BEGIN_GROUP = BAND_C
        ULLon =  136.98186079;
        ULLat =   36.89902478;
        ULHAE =    93.99;
        URLon =  137.02450866;
        URLat =   36.89830548;
        URHAE =    37.00;
        LRLon =  137.02282486;
        LRLat =   36.83448576;
        LRHAE =    40.02;
        LLLon =  136.98021240;
        LLLat =   36.83520340;
        LLHAE =    40.18;
        absCalFactor = 9.295654e-03;
        effectiveBandwidth = 4.730000e-02;
        TDILevel = 24;
END_GROUP = BAND_C
BEGIN_GROUP = BAND_B
        ULLon =  136.98186079;
        ULLat =   36.89902478;
        ULHAE =    93.99;
        URLon =  137.02450866;
        URLat =   36.89830548;
        URHAE =    37.00;
        LRLon =  137.02282486;
        LRLat =   36.83448576;
        LRHAE =    40.02;
        LLLon =  136.98021240;
        LLLat =   36.83520340;
        LLHAE =    40.18;
        absCalFactor = 1.783568e-02;
        effectiveBandwidth = 5.430000e-02;
        TDILevel = 10;
END_GROUP = BAND_B
BEGIN_GROUP = BAND_G
        ULLon =  136.98186079;
        ULLat =   36.89902478;
        ULHAE =    93.99;
```

key	value
sensor_Type	WorldView-2
gain_B	1
gain_G	1
gain_R	1
gain_N	1
offset_B	0
offset_G	0
offset_R	0
offset_N	0
coef_radn_B	0.01783568
coef_radn_G	0.01364197
coef_radn_R	0.01851735
coef_radn_N	0.02050828
coef_radd_B	0.0543
coef_radd_G	0.063
coef_radd_R	0.0574
coef_radd_N	0.0989
time	2.01807E+19
sunelv	67.9
esun_B	1974.2416
esun_G	1856.4104
esun_R	1559.4555
esun_N	1069.7302
coef_ref_B	1
coef_ref_G	1
coef_ref_R	1
coef_ref_N	1

Figure 4-9 Information for setting TOA reflectance converting parameters (using WorldView-2. Content of .imd file (left), Content of .csv file (right)

4. 2. 3. Setting analysis parameters

Table 4-5 is the list of parameters to be set in this example. For each step for setting respective parameters, see the following sections.

4.1.4 Setting atmospheric correction

4.1.5 Setting water depth/bathymetry correction

4.1.6 Setting water column correction

4.1.7 Setting image classification and executing analysis

Table 4-5 Analysis parameters (Toyama Bay)

Parameters	Settings
--- Satellite Image ---	
Use Satellite Image Uploaded	☑（The box is automatically ticked when satellite images are uploaded stored in Asset folder.）
Sensor Name	WV2/WV3
Band ID	R: b5,G:: b3,B : b2,NIR:: b7
--- Atmospheric Correction (ATC) ---	
Convert to TOA Reflectance	☑（Tick）
Mask for Land	□（No tick）
Mask for Dark Pixel	□（No tick）
Execute ATC	☑（Tick）
ATC Method	DarkPixel
Average Filter Size	1 （pixel）
--- Water Depth Correction ---	
Depth Data Uploaded	☑（The box is automatically ticked when water depth/bathymetry data are uploaded in Asset folder.）
Use Minus Data	□（No tick）
Mask for Deep Area	☑（Tick）
Mask Depth(m)	20（m）
Execute Tidal Correction	□ (No tick）
Nearby Station Code	
--- Water Column Correction (WCC) ---	
Execute WCC	☑（Tick）
WCC Method	DII
--- Classification ---	
Number of Classes	3
Supervised Classification	☑ (Tick）
Classification Method	RandomForest
Sampling Scale	Original
Training Rate (%)	70 (%）
Training Data Split by Each Class	☑ (Tick）
Majority Filter Size	3 (pixel）

5. Evaluating analysis results

In this section, while using the analysis result for Toyama Bay, we explain how to display and interpret the result.

After completing satellite image analysis, the result is displayed as shown in Figure 5-1. The map panel shows (1) classification result image and AOI, while the result-output panel shows (2) the result of accuracy assessment (confusion matrix), (3) class properties, (4) area calculation chart, and (5) "Download" button of analysis result images. When both training data and data for area calculation are not registered in Asset folders, they are not displayed in the output panel.

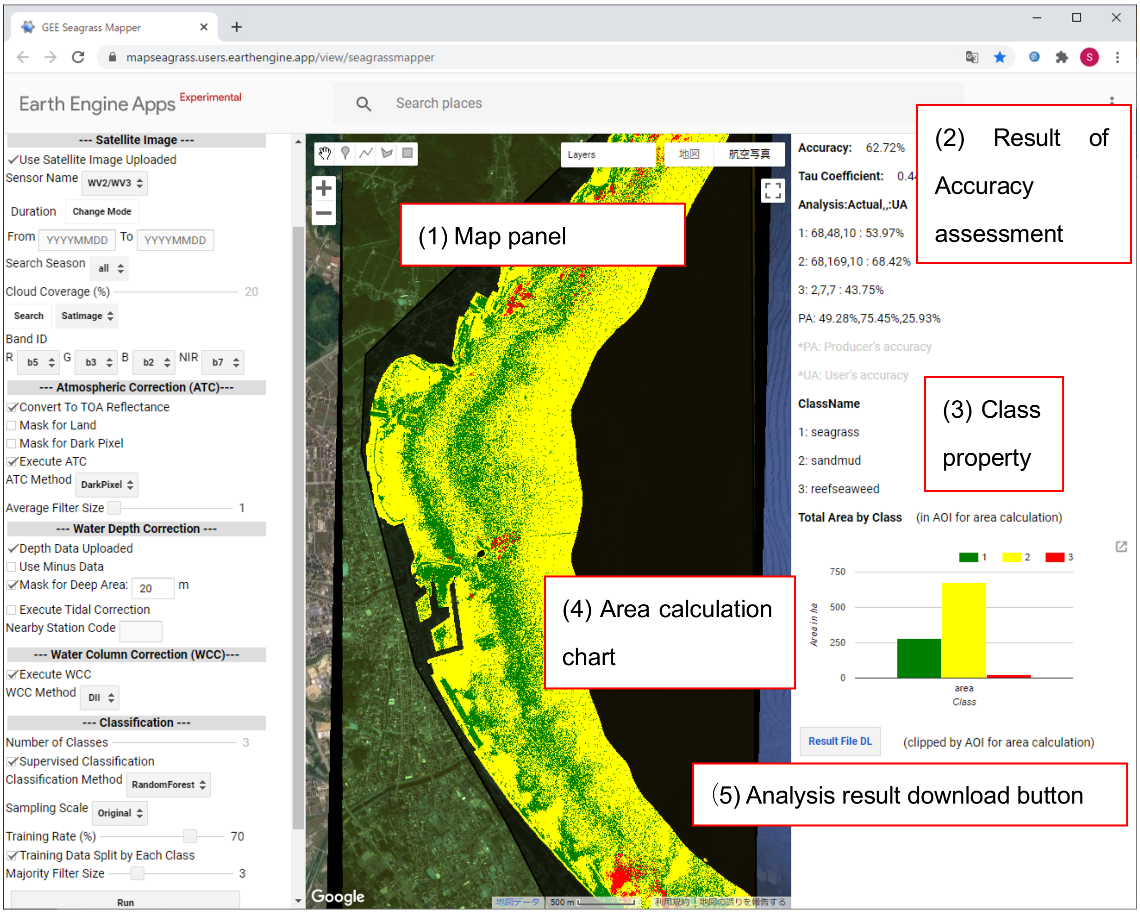

Figure 5-1 Analysis result for Toyama Bay.

Class 1 (seagrass): Green, Class 2 (sandy-muddy): Yellow, and Class 3 (seaweed on rocky reef): Red

(1) Map panel

An image of analysis result, AOI, and training data and others are displayed in the map panel. User can decide which information is displayed/not displayed in the panel. Result layers show only the data registered in the Asset folder.

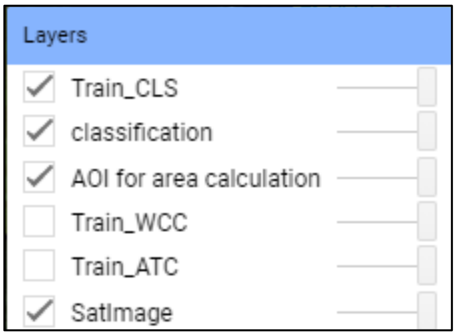

Figure 5-2 Layers of analysis result

(2) Result of accuracy assessment (confusion matrix)

The result of accuracy assessment for supervised classification is shown as confusion matrix in the panel. It is shown in text format, so after copying and pasting the texts to an Excel file, it is possible to save the data as a file. When pasting the data in Excel, choose “comma-separated or tabular data format” in “Data > text columns”. See Figure 5-3 for how to set the tabular format and Figure 5-4 for the image of confusion matrix table of accuracy assessment.

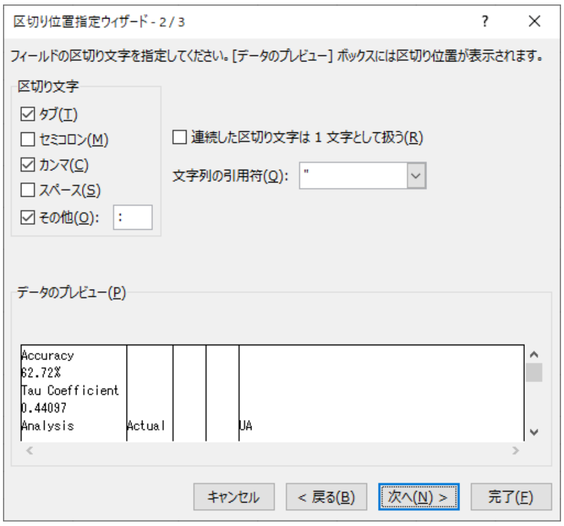

Figure 5-3 How to set the excel format for a result of accuracy assessment

The result of accuracy assessment is displayed only when training data is registered in Asset folder and user selects supervised classification. Be noted that the accuracy assessment targets at the entire satellite image(s) used for analysis.

Accuracy				
62.72%				
Tau Coefficient				
0.44097				
Analysis	Actual			UA
1	68	48	10	53.97%
2	68	169	10	68.42%
3	2	7	7	43.75%
PA	49.28%	75.45%	25.93%	
*PA	Producer's accuracy			
*UA	User's accuracy			

Figure 5-4 Result of accuracy assessment (Toyama Bay).

In this example, in Toyama Bay, the accuracy assessment result obtained from the location of training data for supervised classification indicates the following things.

- property: Class 1 = seagrass, Class 2 = sandy-muddy, Class 3 = seaweed on rocky reef

Class 1, 2, and 3 in the table are shown in (3) class properties of Figure 5-1.

- Points of Training data (Actual) for evaluation: Class 1 = 138, Class 2 = 224, Class 3 = 27

Number of point of correctly classified: Class 1 = 68, Class 2 = 169, Class 3 = 7

- Producer's accuracy (PA) is obtained by the following equation:

68/138 x 100 = 49.28%

169/224 x 100 = 75.45%

7/27 x 100 = 25.93%

- Number of point of each class by analysis: Class 1 = 126, Class 2 = 247, Class 3 = 16

Among them, number of points matched with training data for evaluation: Class 1 = 68, Class 2 = 169, Class 3 = 7

・User's accuracy（UA）is obtained by the following equation

68 / 126 × 100 = 53.97 %

169 / 247 × 100 = 68.42 %

7 / 16 × 100 = 43.75 %

- Percentage of correctly classified points against all evaluation points (overall Accuracy): 62.72 %

- Reliability index against overall accuracy (tau coefficient): 0.44097

(3) Class Properties

The names of class property are shown based on set training data. See section 3.3.2 (6) for how to set class properties. In case of no property information is set, file name such as "Train_CLS1" is displayed.

Be noted that Class Properties are shown only when training data are registered to Asset folder and user selects supervised classification.

(4) Area Calculation Chart

Each class size (ha) , which are calculated based on AOI for area calculation, is shown in the chart. Click the icon on the right top of the chart to download the result in csv format and/or png image format.

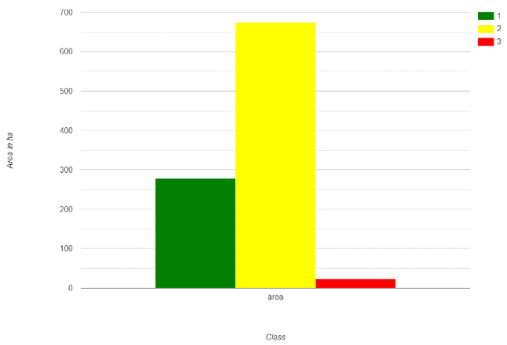

Figure 5-5 Area size chart.

Please note that these results are shown only when area AOI for area calculation is registered in Asset folder.

(5) Button for downloading classification result images

There is a button to download classification image results as a file. Click "Result Image DL" button to save the result images in GeoTIFF format. Please note that these result images are cut out from the AOI area calculation data (polygon), so the image might be different from the one (classification image) in the map panel.

Please note that these results are shown only when AOI for area calculation is registered in Asset folder.