# Micro-module C: Remote Sensing

## C2- Satellite Data and Aerial Photography

This guide includes an introduction to the basic overview of satellite remote sensing data, methods of obtaining commonly used satellite remote sensing data and data processing methods. It includes the data downloading methods of Landsat and Sentinel and the calculation of the Normalized Difference Vegetation (NDVI) to determine the density of green plants within a piece of land.
The guide consists of three main parts. The first and second parts including the data sources of the two commonly used remote sensing data, Landsat and sentinel, comparison of their advantages and characteristics, common software for processing remote sensing data and download methods. The third part focuses on the application of satellite remote sensing data in research, including an introduction to the concept of satellite remote sensing index NDVI, possible scenarios and calculation methods for application in urban design and social sciences.
By the end of this guide, you will have an overview of satellite remote sensing data and you will have gained a new approach to analysing urban problems and the current situation.

### 1. Introduction to Satellite Remote Sensing Data

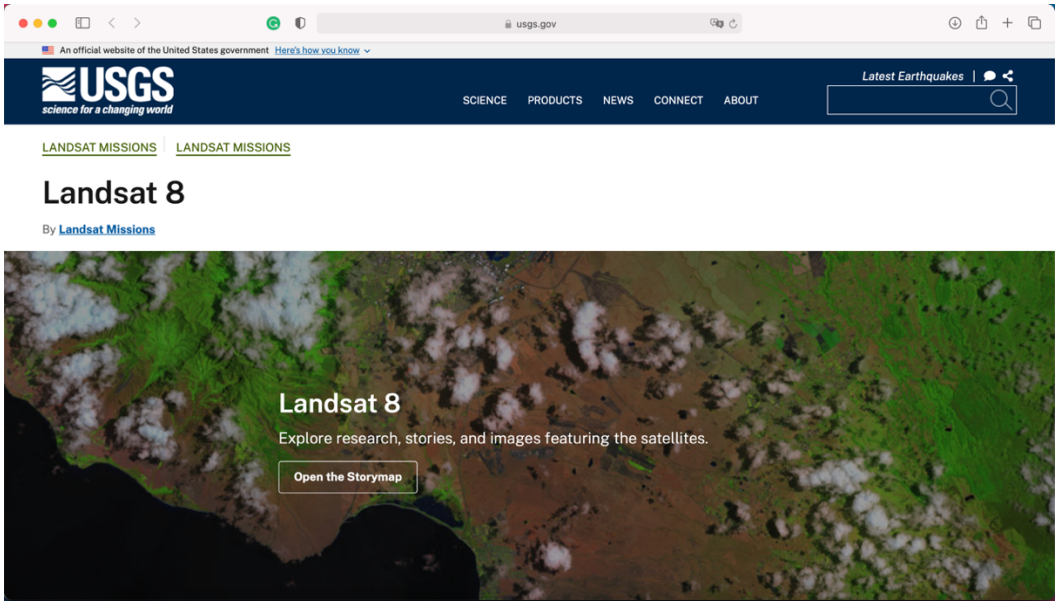
### 1.1 Data Sources

The most commonly used datasets in optical remote sensing research today are Landsat and Sentinel, which are open, free and have suitable spatial resolution and satisfactory temporal resolution.

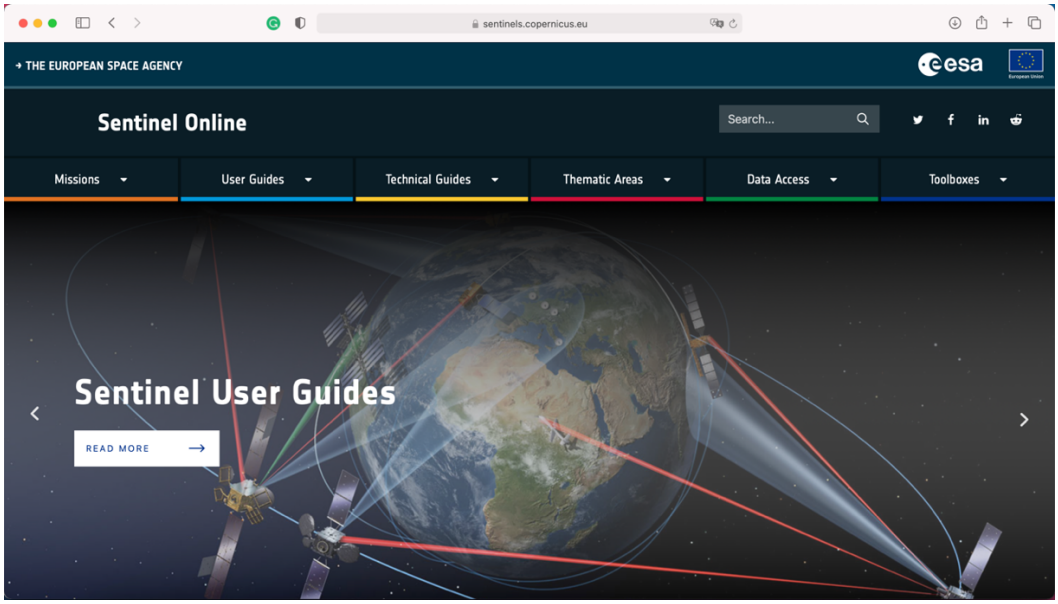
Landsat, a continuous Earth observation project hosted by the National Aeronautics and Space Administration (NASA), has provided 50 years of optical remote sensing data of the earth since the project's first satellite was launched on July 23, 1972. The project has had nine missions to date, the latest being Landsat-9 on 27 September 2021, and the most current application is the data from Landsat-8, launched on 11 February 2013.

The following link is to the official website of Landsat, where more information can be obtained.

https://www.usgs.gov/landsat-missions/landsat-8



Sentinel is an Earth observation satellite in the Global Monitoring for Environment and Security (GMES) conducted by the European Space Agency (ESA). The optical remote sensing image we used was derived from Sentinal-2, which was launched on June 23, 2015. More information on Sentinel data can be obtained from the following website.
https://sentinels.copernicus.eu/web/sentinel/home




## 1.2 Data characteristics

Three concepts need to be explained first: spatial resolution, temporal resolution and band.

The spatial resolution is N meters, which means that in the satellite image, each pixel corresponds to N meters of the earth surface;

The temporal resolution is N days, which means that the project's satellites will visit the same place every N days on average, which means that we can get new pictures of the same place every N days on average.

Band is the division of collected optical information according to the wavelength of light. Each pixel contains information of different wavebands. The performance of different objects in different bands is obviously different. We can automatically distinguish things in remote sensing images according to these differences. For example, vegetation is significantly stronger than other things in red band and near infrared band.

For the two groups of data commonly used at present, Landsat has a spatial resolution of 30m, a temporal resolution of 16 days, and 11 bands including visible light (RGB).
Sentinel has a spatial resolution of 10m and a temporal resolution of 5 days in 13 bands, including visible light.

For the field of social science, both data sets can be used, which can be selected according to the needs of research projects. Satellite remote sensing data can be used to obtain the proportion of ground objects, such as identifying plants on the ground to calibrate the relative plant quantity within the research scope.

### 1.3 Data processing

For the processing software of satellite remote sensing data, we introduce ENVI and QGIS in this guide.

ENVI is a professional software for processing geographic raster data, which integrates many functions used for optical remote sensing image processing, such as atmospheric correction, image enhancement, and geometric correction, and is therefore popular among remote sensing scholars.



QGIS is a commonly used free software for processing geographical data, because the downloaded satellite remote sensing data is a series of TIF data classified according to the band, which is typical raster data, so QGIS can be used for processing and calculation. For example, the index NDVI commonly used in remote sensing data can be calculated by the function of raster calculator in QGIS.

In the field of social science, for example, satellite remote sensing data can be used to distinguish the area ratio of green space and urban built-up area, and can be combined with data with geographic information to analyze the status quo of the city and understand the development process.

## 2 Data download

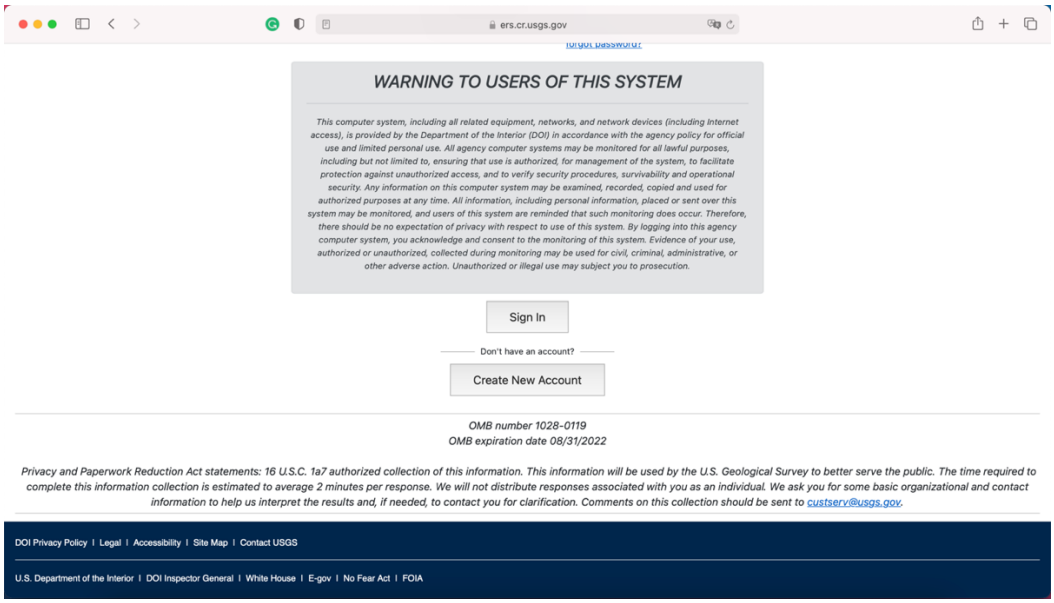
Both Landsat and Sentinel data are available from a website created by the U.S. Geological Survey (USGS), the USGS is the sole science agency for the Department of the Interior of USA. This website provides all kinds of satellite remote sensing data. Below is the link.

https://earthexplorer.usgs.gov/

In this guide, we take Landsat satellite data near the campus of the Chinese University of Hong Kong as an example to introduce how to download satellite remote sensing data.

First you need to register an account before downloading, click sign in on the upper right corner.

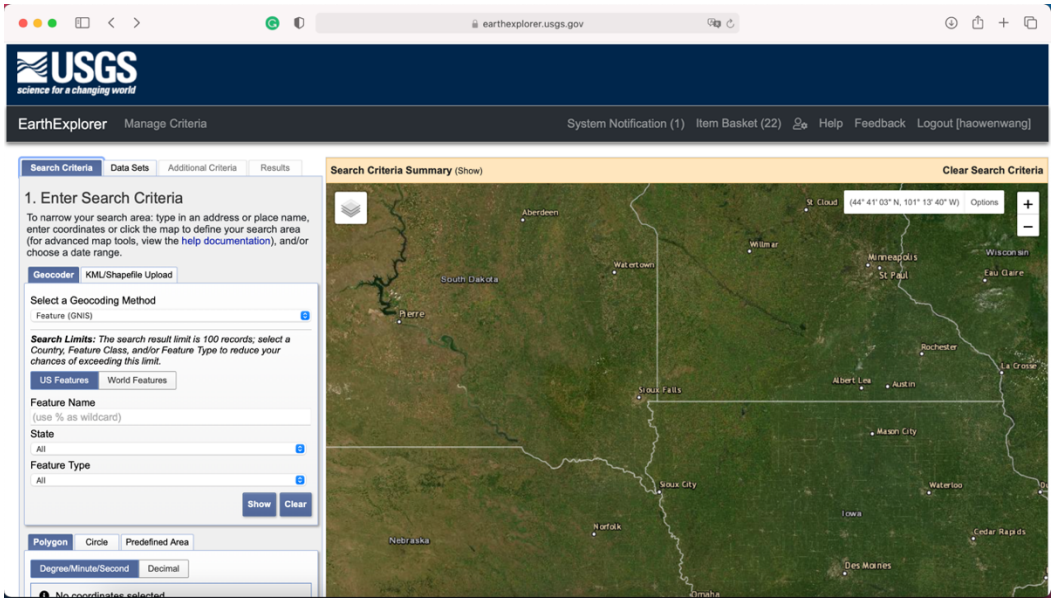
- Click ‘Create New Account’.




Follow the website instructions to register an account to complete the registration.

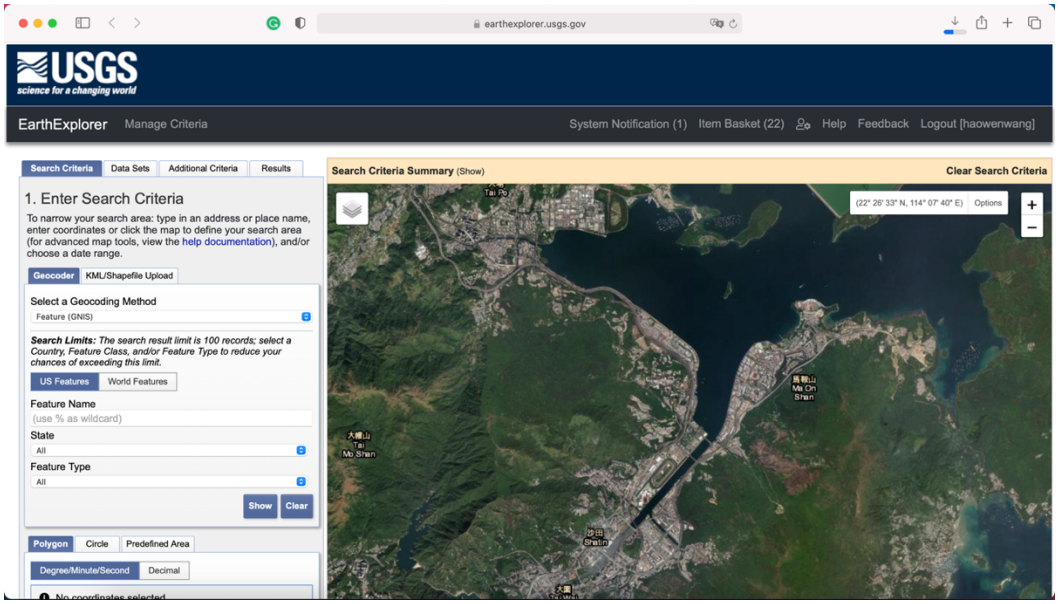
## 2.1 Select the download range and time period

Log in to the same site again after registration.




To download data, you first need to select the data download range.

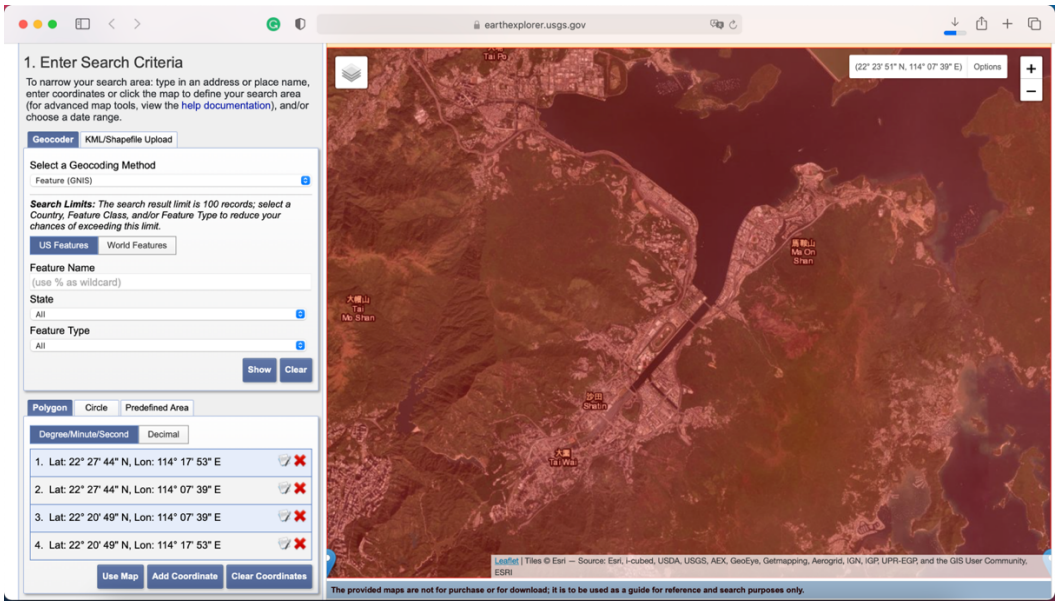
Drag or zoom in and out the map on the right to locate the map to a desired location, or enter an address as prompted on the left.




- Select ‘Polygon’ below.
- Click the ‘Use Map’,

It can be seen that the map range on the right is enclosed in a red box, and the data download range is the map range displayed on the right screen. At the same time, the Earth Explorer automatically locates the coordinates of the four registration points on the right screen, which can be manually adjusted according to your own needs, or the longitude and latitude of the desired location can be entered.

In this guide, we locate the area near the campus of CUHK.



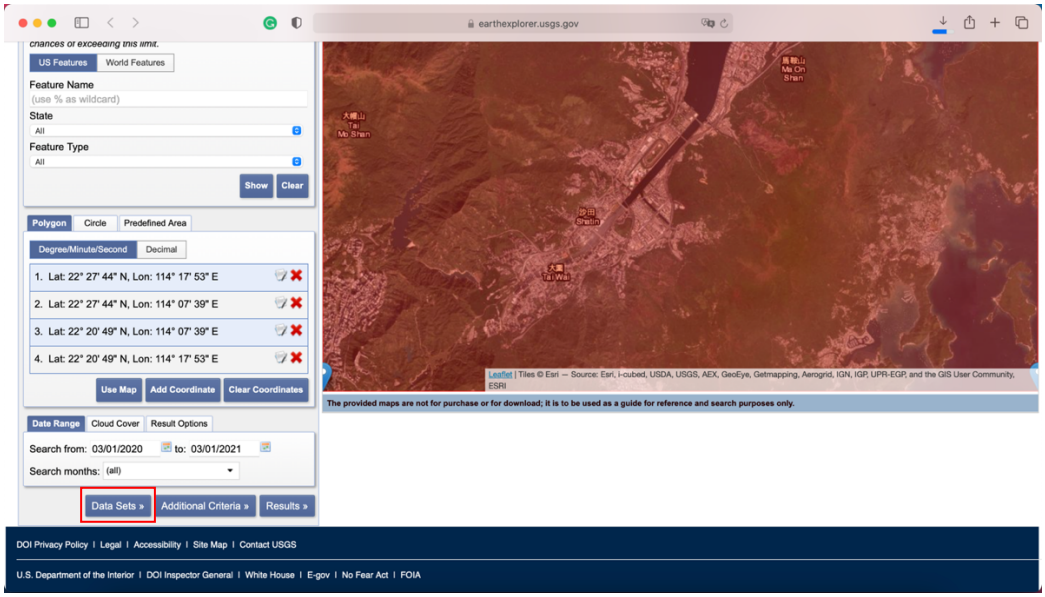

After selecting a range, you need to select a period for downloading data.

Search for the period you need to cover, because satellite photos are taken at intervals and are subject to weather. In principle, the greater the time range chosen, the more likely you are to get clear satellite data.

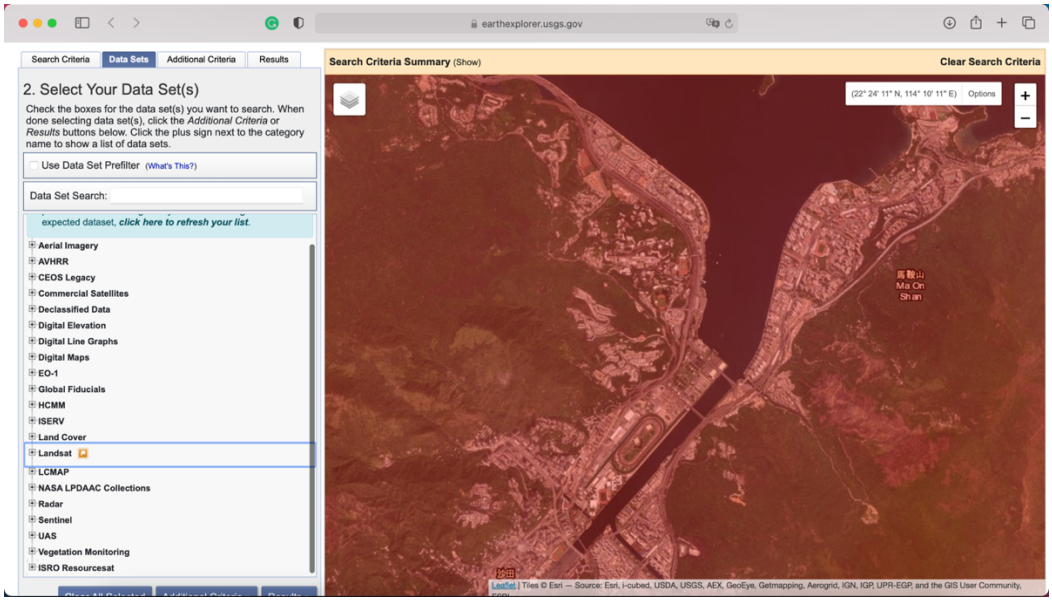
For this guide, we chose March 1, 2020 to March 1, 2021.

## 2.2 Select data set

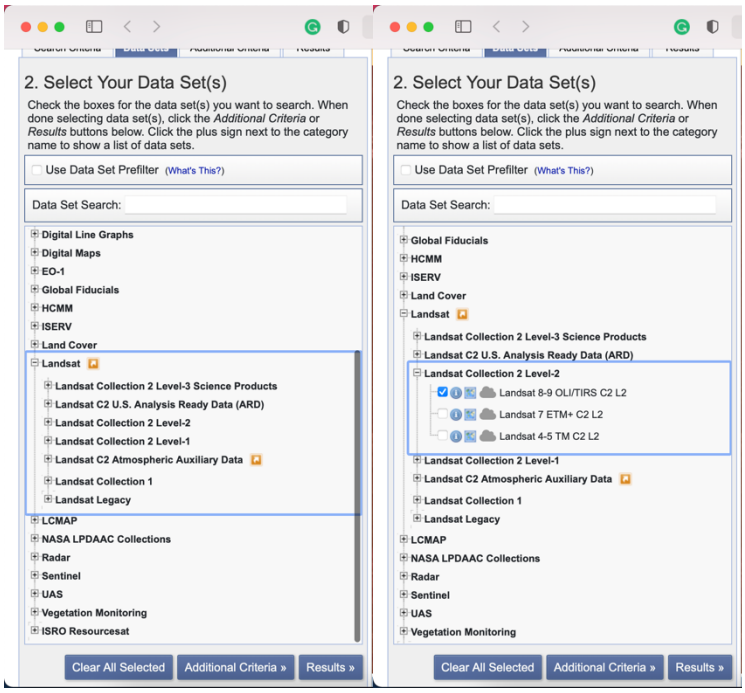
After selecting the time, click the 'Data Sets' below.




You can see that the site offers a wide variety of satellite remote sensing datasets. Select the Landsat data set we need to download.




After you click on Landsat, you can see that the site offers seven different Landsat datasets Here we select the 'Landsat Collection 2 Level-2' dataset and 'Landsat 8-9oli/tirs C2 L2'.

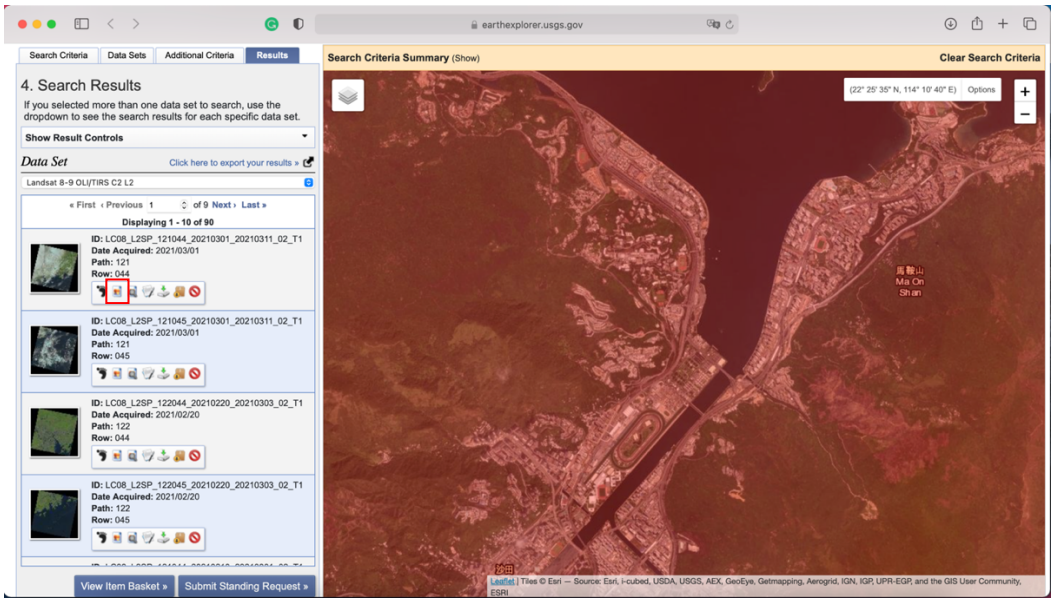



- Click ‘Results’.

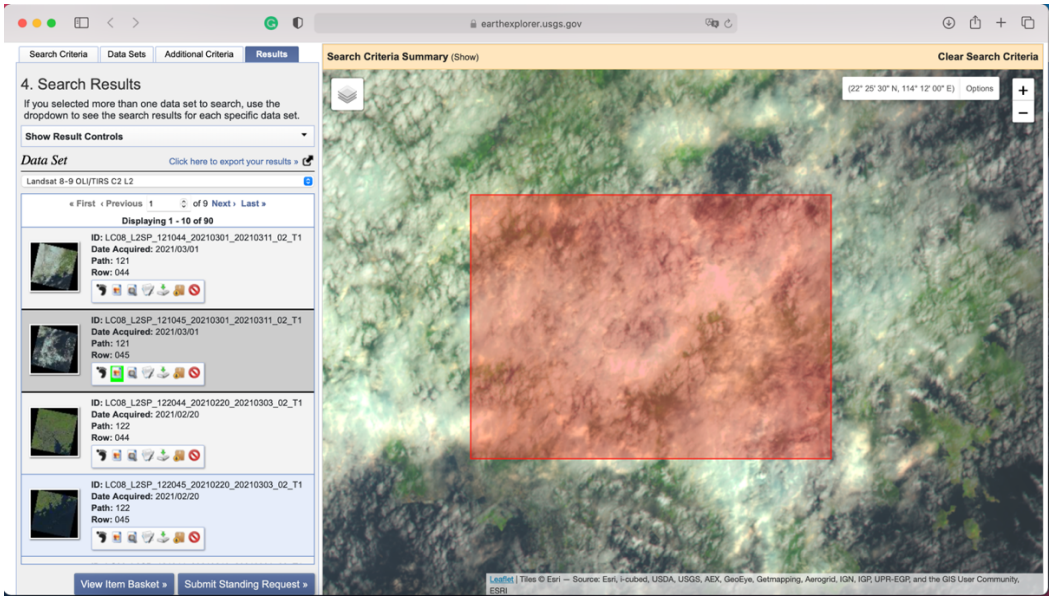
Here you need to wait a few seconds for the site to search the data.

Once the search is complete, the available data sets are listed on the left side of the site

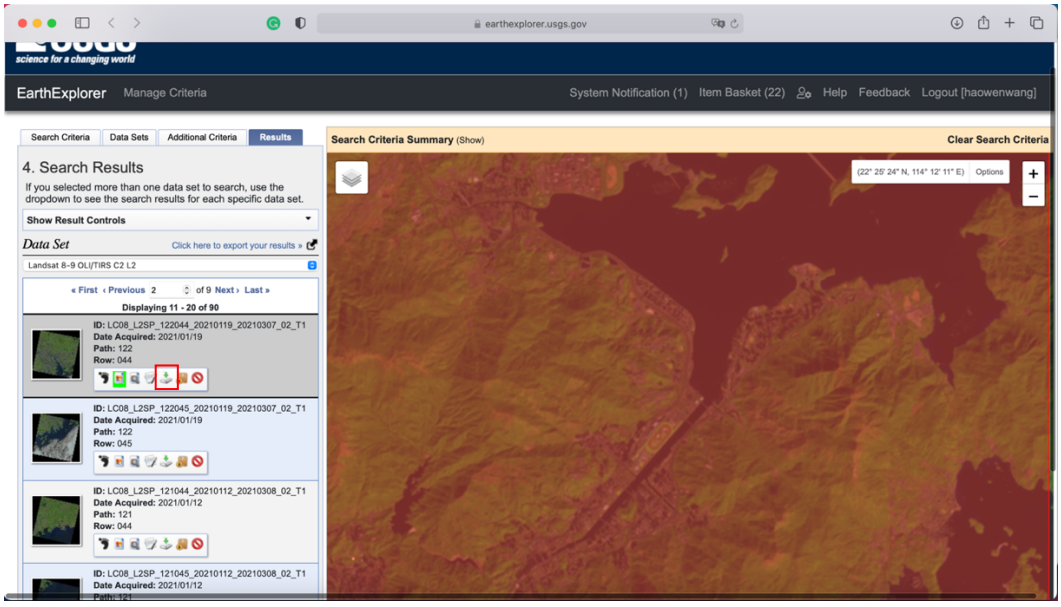
Shown here are all the data sets that intersect the requirements scope, and you can download one of them.




If you don't know which one you want to download, click the second icon to superimpose the dataset on the map on the right to zoom in.



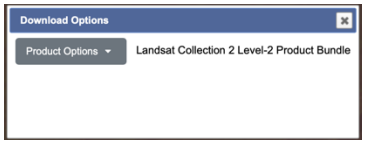

For example, we check the data of 2021 0301 here, and it can be seen that most of the selected areas are covered by clouds, which may not be conducive to our research. Therefore, we can look for a data set that can clearly show the current situation of The Chinese University of Hong Kong.



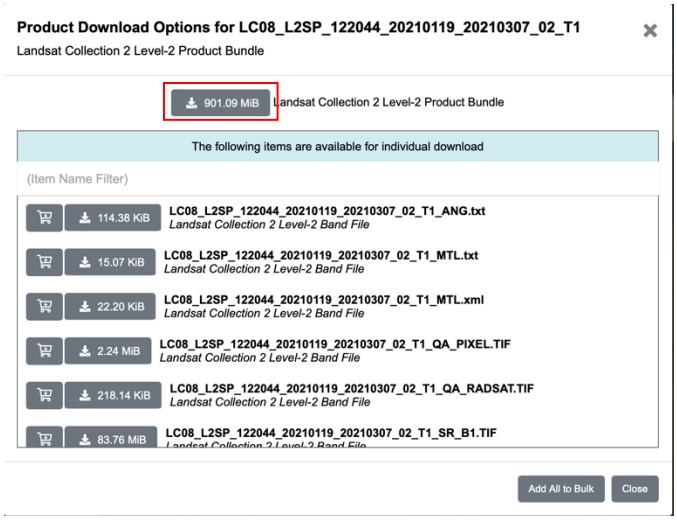

For example, the data on January 19, 2021 clearly shows the situation of CUHK.

It should be noted that in the search results of this step, it may appear that all the search results cannot clearly display the current situation within the search scope. In this case, it is necessary to return to the step of selecting data time and search in another time period.

- Click the fifth icon to download the data.




Click ‘Product Options’.




Click the download button at the top to download all the files in the list. If you have clear requirements, you can also select the required band files to download from the list according to the requirements.

At this point you've got all the ways to download satellite remote sensing data.

# 3 Application of remote sensing satellite data

## 3.1 Introduction to NDVI

The reflectance of different bands of light in remote sensing satellite data can reflect the information of objects on the ground. In this field, many feature values have been generated to distinguish surface objects, among which, Normalized Difference Vegetation Index (NDVI) is closely related to urban development. NDVI is an index that uses the difference between the reflectance of red and near infrared red in remote sensing data to calibrate the green density of the ground. The range of NDVI values is greater than or equal to -1 and less than or equal to 1. Negative value indicates that the ground is covered with cloud, water, snow, etc., which is highly reflective of visible light. 0 indicates that there are rocks or bare soil on the ground. A positive value indicates that the ground is covered by vegetation and it increases with the increase of coverage.

NDVI can indicate the density of green plants on a piece of land, which can reflect the real amount of green plants in a city compared with the land use distribution commonly used in the planning field. For example, in a park, the content within the park's red line is classified as green space, but in fact, there are also hard roads and squares in the park. In this case, NDVI can more accurately show the actual density of green plants in the park. In addition, from the overlooking point of view, covering one lawn in one piece of land is the same as covering three layers of trees, shrubs and lawns, but NDVI can reflect the difference between these two. Therefore, the relationship between human activities and the distribution of infrastructure and plant population can be studied. Therefore, remote sensing data can be used as a new tool for urban design or social science research, and can provide new methods for in-depth exploration of urban status and development history from different perspectives.

## 3.2 NDVI calculation formula

NDVI is calculated by using the reflectance of red and near infrared red in remote sensing data, and the calculation method is as follows.

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{Red})}$$

NIR and RED represent reflectance of near-infrared and RED band respectively. These two data can be found in the data set downloaded by us. The following table is the comparison table of band names in the data set. It can be seen that RED and NIR correspond to Band 4 and Band 5 respectively. After defining the needed band, we need to use QGIS to process the downloaded remote sensing data.

**Landsat 8-9 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)**

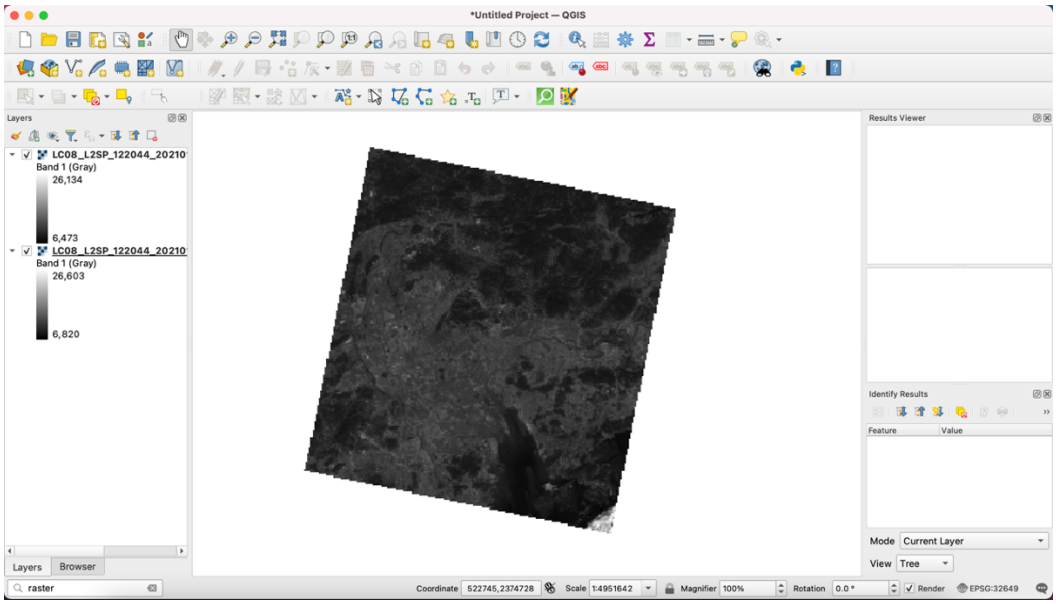
| Bands | Wavelength (micrometers) | Resolution (meters) |
|---|---|---|
| Band 1 - Coastal aerosol | 0.43-0.45 | 30 |
| Band 2 - Blue | 0.45-0.51 | 30 |
| Band 3 - Green | 0.53-0.59 | 30 |
| Band 4 - Red | 0.64-0.67 | 30 |
| Band 5 - Near Infrared (NIR) | 0.85-0.88 | 30 |
| Band 6 - SWIR 1 | 1.57-1.65 | 30 |
| Band 7 - SWIR 2 | 2.11-2.29 | 30 |
| Band 8 - Panchromatic | 0.50-0.68 | 15 |
| Band 9 - Cirrus | 1.36-1.38 | 30 |
| Band 10 - Thermal Infrared (TIRS) 1 | 10.6-11.19 | 100 |
| Band 11 - Thermal Infrared (TIRS) 2 | 11.50-12.51 | 100 |

## 3.3 NDVI calculation

- Open the QGIS.
- Create a new project in QGIS.

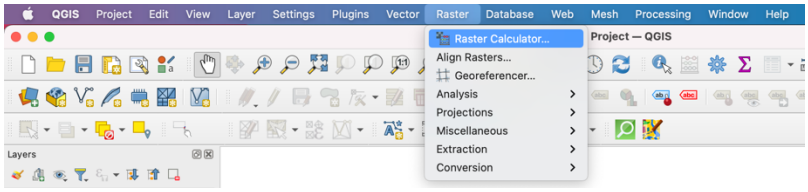
Locate the following two files in the downloaded dataset and open them in QGIS.

LC08_L2SP_122044_20210119_20210307_02_T1_SR_B5.TIF
LC08_L2SP_122044_20210119_20210307_02_T1_SR_B4.TIF

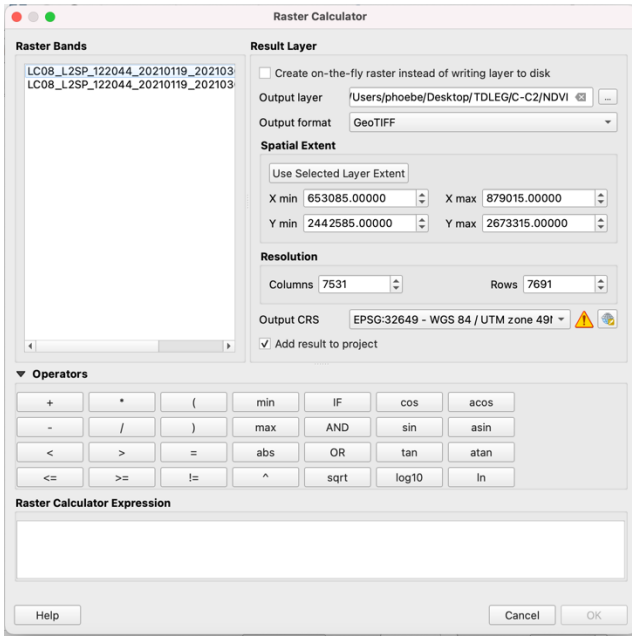


You can see that the downloaded data range is large. To facilitate calculation, you can first cut data based on requirements. If you need to trim, the method of trimming raster data is explained in 2.5 of A-A2 micro-module and will not be trimmed in this guide.
After the data is imported, the calculation can be performed.

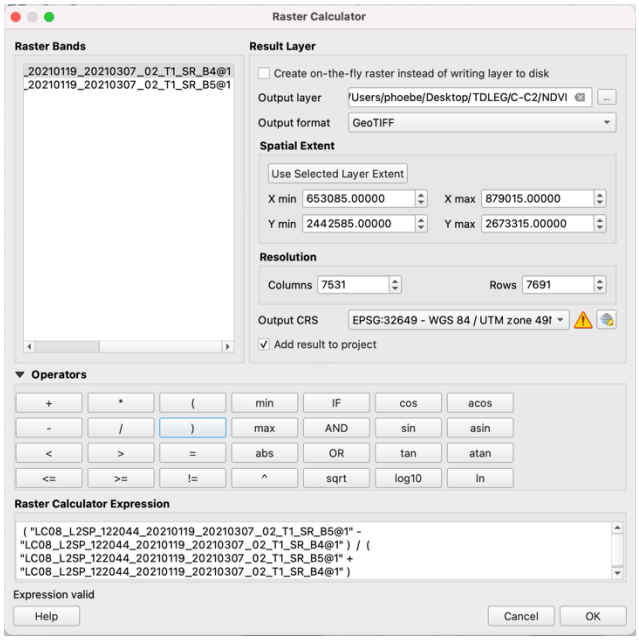
- Click the 'Raster-Raster calculator'.




Click the Output Layer to select the location where the calculation results are stored, and enter the NDVI calculation formula in Raster Calculator Expression.

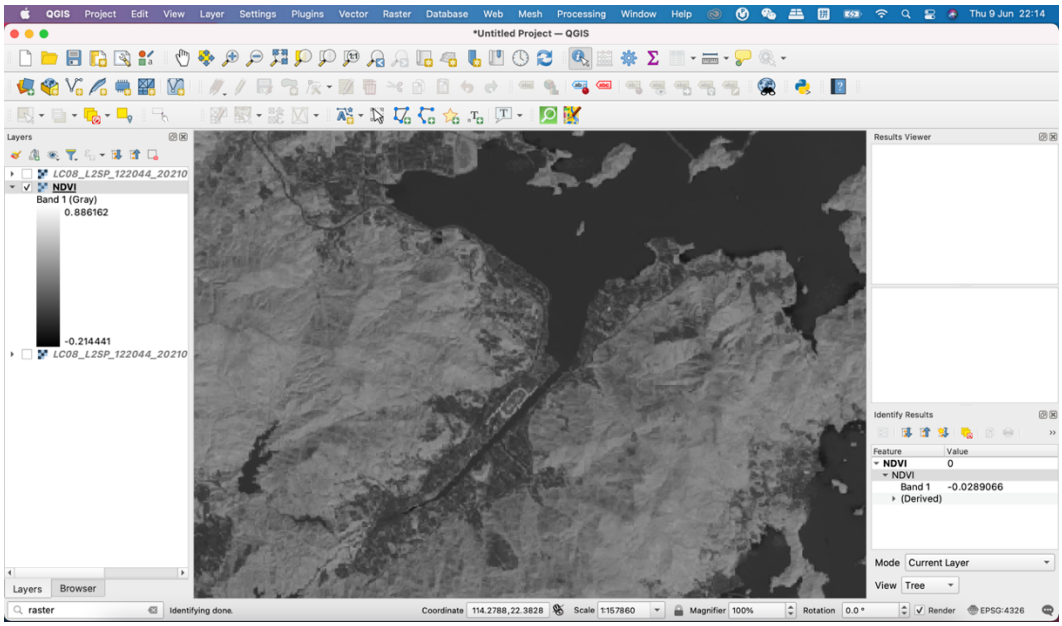



NIR in the NDVI formula corresponds to "LC08_L2SP_122044_20210119_20210307_02_T1_SR_B5@1" in this example.
RED is "LC08_L2SP_122044_20210119_20210307_02_T1_SR_B4@1"
According to the NDVI calculation formula, the input content is as follows.




It should be noted that when selecting bands, double click the name of raster Bands to add them into Raster Calculator Expression.

- Click OK when finished.



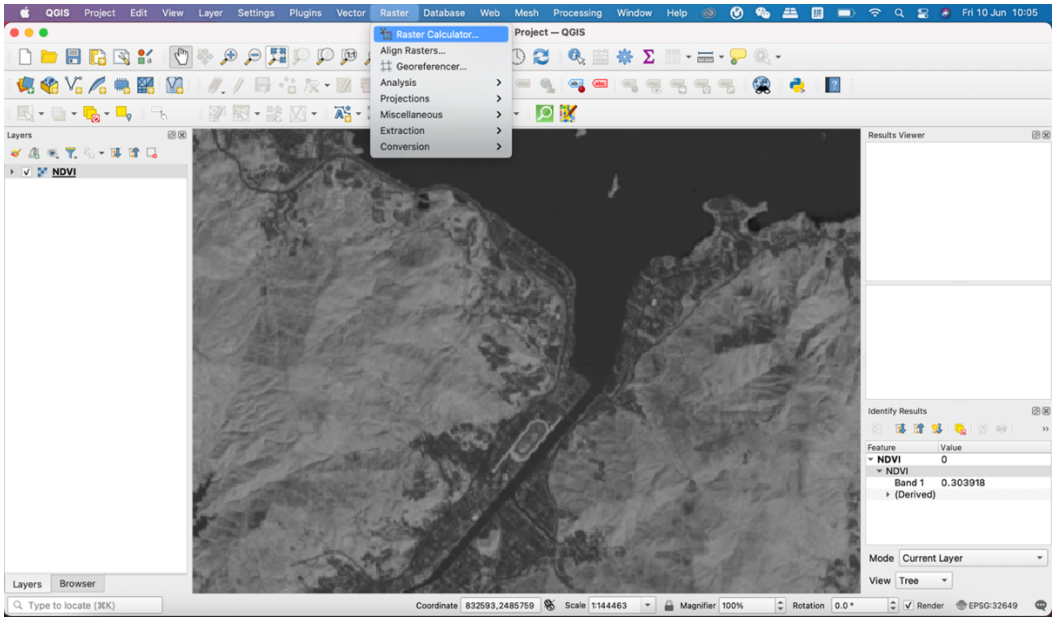

You can see the new layer displayed according to the NDVI.

Using the Identity Features tool, click on any pixel and you can see the NDVI value of that pixel in Identity Results on the right.

## 3.4 NDVI visualisation

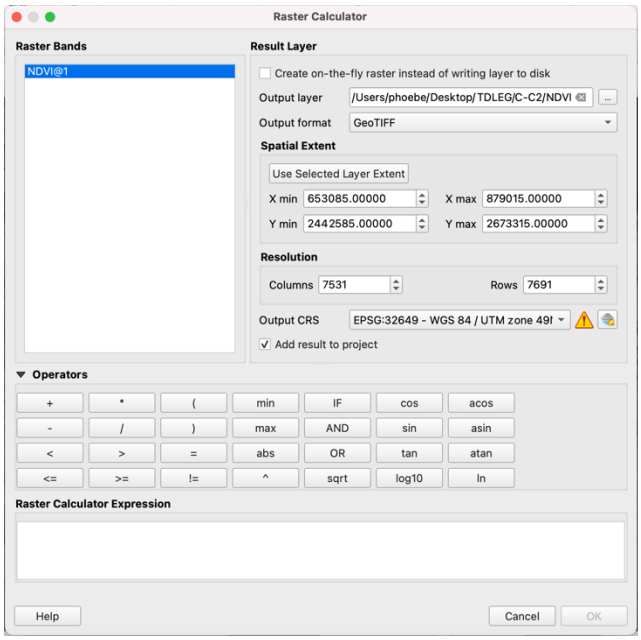
In order to more intuitively see the vegetation situation in the research area, Raster Calculator could be used to screen out the pixels covered by vegetation in the research area. According to the characteristics of NDVI value, land greater than 0 is considered to be covered by vegetation. However, since the spatial resolution of remote sensing data is 30m or 10m, using NDVI=0 as the boundary line may not accurately express whether a

piece of land is covered by vegetation. In the field of remote sensing, there is no clear standard to define the NDVI value of whether a land is covered by vegetation. In this guide, we will show how to filter pixels with NDVI greater than 0, and show the results of filtering with NDVI greater than 0, 0.1, 0.2, and 0.3 respectively. In the research can be based on your own needs to choose.

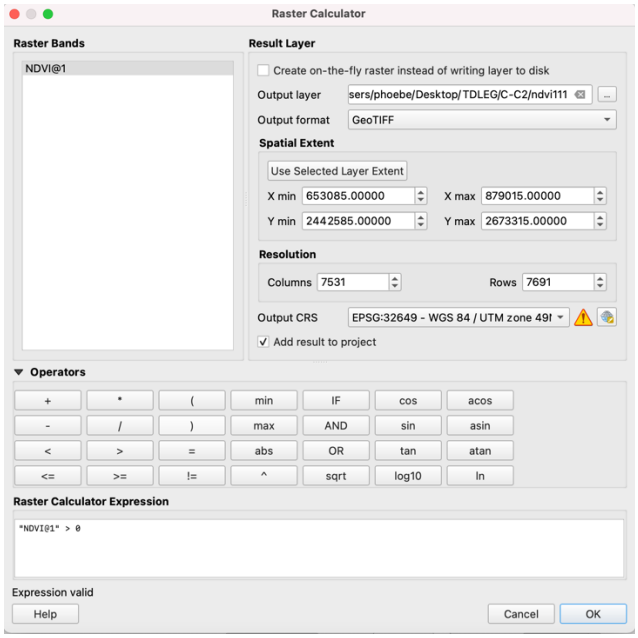



Load the NDVI results layer.

- Click ‘Raster-Raster calculator’.




Click Output Layer to select the new layer storage location and input the new layer name. Input '"NDVI@1" > 0 "into ‘Raster Calculator expression’, as shown in the figure below.

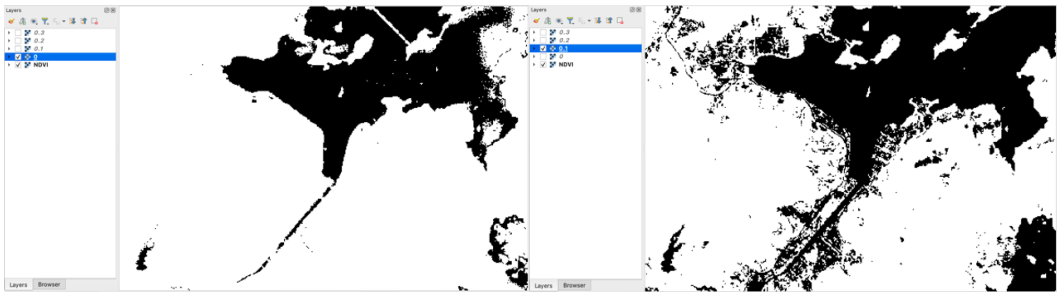



Click OK when finished.

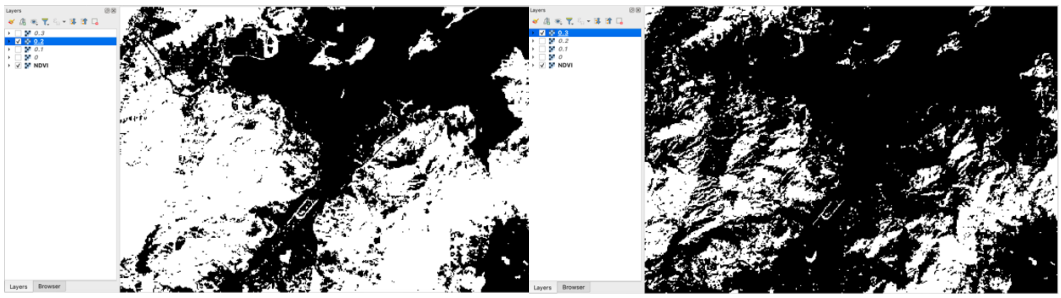
Wait a few seconds and see the new layer loaded after the operation.

The other result methods are the same as the above steps, simply changing the value at 'Raster Calculator Expression' to the value of the response. The following results show that NDVI is greater than 0, 0.1, 0.2 and 0.3 respectively. It can be seen that there are significant differences in the comparison of effects. In the study, we can determine the limit value of NDVI according to our own needs.

NDVI>0 NDVI>0.1



NDVI>0.2 NDVI>0.3



So far, you have obtained the acquisition method of satellite remote sensing data, data processing method and the calculation method of NDVI, the index of vegetation density in the calibration satellite remote sensing data.